



Namibia University of Science and Technology
Faculty of Computing and Informatics

Information Systems and Emerging Technologies (PROCEEDINGS OF ICISSET'23)

Editors

Dharm Singh Jat Isiaka
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**INFORMATION SYSTEMS AND EMERGING TECHNOLOGIES
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DATA SCIENCE, MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE
(PROCEEDINGS OF ICISSET'22 & DSMLAI'22)**

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ICISSET'23
Namibia University of Science and Technology

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Welcoming Remarks



Dr Eroid Naomab
NUST Vice-Chancellor
Namibia University of Science and Technology

Distinguished guests, ladies and gentlemen,

It is with great pleasure that I extend a warm welcome to everyone here present at the International Conference on Information Systems and Emerging Technologies (ICISSET). We are absolutely thrilled to have you join us today. This conference has been designed to tackle the pressing issues of our time and to address the national imperatives that necessitate the utilisation of technology in overcoming socio-economic challenges.

Our objective is clear – to propel Namibia's development forward and shape the future of sustainable progress. To achieve this ambitious goal, we have brought together a highly esteemed gathering of experts, scholars, and practitioners from across the globe. This event promises to provide a unique platform for the sharing of knowledge, the exchange of ideas, and the cultivation of collaboration – all with the ultimate aim of creating a better future for all.

Yesterday, we had the privilege of hosting a pre-conference workshop on Data Governance and Strategies, where delegates were occupied in the essentials of harnessing and utilising data to drive organisational value and informed decision-making processes. Throughout the course of this conference, you will have the remarkable opportunity to attend a diverse range of sessions, including illuminating keynote speeches, thought-provoking panel discussions, and enriching technical presentations from paper received from across the continent and beyond. The conference papers received cuts across Africa, Asia, Europe and America. The breadth of topics covered will be staggering, ranging from cutting-edge research in information systems to the practical applications of engineering and technology.

I urge everyone you to seize this opportunity presented before you – to actively engage with your fellow attendees, to share your unique insights, and to contribute meaningfully to the ongoing conversation surrounding the future of technology and its pivotal role in sustainable development. We wholeheartedly anticipate your lively participation and trust that you will find this conference both deeply informative and profoundly inspiring.

This conference represents so much more than just an intellectual gathering. It is a powerful catalyst for change, a forum for forging new regional cooperation, and a launch-pad for practical measures that will drive innovation in the ever-evolving realm of computing and emerging information technologies. The potential for this conference to shape the future is truly boundless.

Let me use this opportunity to welcome our inaugural address speaker Ms Emilia Nghikembua, *Chief Executive Officer*, Communications Regulatory Authority of Namibia (CRAN). I also express my utmost gratitude to our esteemed guest speakers who have generously travelled from afar to be with us today. Their expertise and wisdom will undoubtedly enrich our understanding and enhance our collective insights. I extend a warm welcome to inaugural keynote speaker Dr. Rita Obatolu and Dr. Victor Adejola who travelled all the way from the United Kingdom to attend this conference. I also welcome Ms Machaka Mosehana, Director of Centre for Entrepreneurship, Johannesburg Business School, University of Johannesburg and Professor Abejide Ade-Ibijola from the University of Johannesburg. We are honoured to have you share your knowledge and perspectives with us.

Furthermore, I would like to extend my sincere appreciation to the organising team for their untiring commitment and unwavering dedication to ensuring the success of this conference. It is their tireless efforts, coupled with the steadfast support from committee members, industry partners, sponsors, academic institutions, and all other supporting organisations, that have made an event of this magnitude possible.

With these words, I thank you all for gracing this conference with your presence. I wholeheartedly believe that our deliberations here will yield fruitful outcomes and facilitate a better tomorrow. I wish you all inspiring and enlightening discussions.

Thank you.

Windhoek, 17 October 2023

Dr Eroid Naomab

Message from Conference Local Chair



Prof Jude Osakwe
Faculty of Computing and Informatics
Namibia University of Science and Technology

Ladies and gentlemen,

On behalf of the program committee, it is my great pleasure to welcome you all to the second International Conference on Information Systems and Emerging Technologies (ICISSET). This International Conference truly reflects the global nature of research and innovation. It serves as a platform for scholars, professionals, and researchers from around the world to exchange ideas, collaborate, and drive forward the field of Information Systems and Emerging Technologies. We are confident that the knowledge shared during this conference will pave the way for future advancements and breakthroughs.

We are honored to have received 53 accepted papers from Africa, Asia, Europe, and America, with an acceptance rate of an impressive 0.42%. In addition, we have invited eight distinguished speakers who are experts in their respective fields. The papers presented at this conference cover a wide range of topics, focusing on the latest trends in Information Systems, Data Science, HPC, Digital Transformation and Artificial Intelligence

I am delighted to announce that all the accepted and presented papers will be hosted in an open-access online platform, the Elsevier SSRN. This means that the proceedings of the conference will be permanently showcased and freely accessible to SSRN users and the public. Moreover, ICISSET has recently become a member of Crossref, a partnership that will make it easier to find, link, cite, and assess scholarly articles. Each published paper in the ICISSET 2023 Proceedings will be assigned a DOI number (Digital Object Identifiers), making it effortless to reference and cite these valuable contributions.

Once again, I extend my warm welcome to everyone. Let us make the most of this opportunity to learn, network, and shape the future of our field.

Thank you

Prof Jude Osakwe

Smart Occupancy Monitoring System Using IoT Technologies for South African Minibus Taxis

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Abstract.

The motorist industry is one of the largest contributors to economic growth nationwide. In South Africa (SA), minibus taxis are the second most used mode of transportation due to their accessibility and affordability. The majority of taxi owners presently utilize traditional methods to handle the daily operations of their minibus taxis, thus there is still a challenge in managing the entire amount of minibus taxi fares made each day. As a result, they frequently voice their displeasure with the unethical handling of taxi fare revenue caused by dishonest drivers who commit fraud or use their income for personal advantage, resulting in significant losses for the taxi industry because it cannot be accounted for. This has raised the desire for the design of a smart technological solution to support taxi owners in monitoring their minibus taxis and managing their money effectively. This paper designed an IoT-based smart occupancy monitoring system (IoT-SOMS) prototype that affords the functionality of seat occupancy tracking, calculating distance travelled, and fees in real-time. The designed prototype utilizes a Force Sensitive Resistor (FSR) to detect occupancy; a proximity sensor to detect the presence of people and avoid overloading; an Ultrasonic sensor to calculate distance; GPS to monitor the location of the minibuses; and Arduino Uno as an IoT gateway. It was piloted by taxi owners, taxi drivers, and experts in the field to prove the accuracy, usability, and feasibility of research objectives. The findings demonstrate the accuracy and viability of the research's goals because they show that users highly valued the prototype's quality and were eager to utilize it.

Keywords: Internet of Things (IoT); Force Sensitive Resistor (FSR); Smart Seat Occupancy and monitoring; IoT Technologies; Intelligent Transport System (ITS)

1. Introduction

The high demand for commuter public transportation rises exponentially with the world's population, requiring a higher supply of public transportation to ensure the best possible passenger experience (Patel et.al., 2019). As time passes, cities are growing more generally, and people are moving to new regions of the globe to find places to live, work, travel, and visit, among other things (Kuchár et.al., 2023; Niyigena, 2021). However, to access various everyday living facilities like schools, hospitals, football stadiums, entertainment venues, work offices, and so forth, individuals typically must drive a long distance (Niyigena, 2021). Because of this, a lot of individuals need cars to get to work every day. The issue can only be solved by public transportation because owning a car is basically unattainable for all of us due to inadequate infrastructure and abilities.

The most important pillar of our public transportation system today in South Africa is the minibus taxi industry. It is not only the most widely used kind of transportation, but it is also the most reasonably priced. However, unlike other public transportation options, they operate late-night services, go to remote locations, pick up and drop off commuters at their homes, charge reasonable fares, make convenient stops along long distances, and reduce the time spent in lengthy lines at bus and train stations. For these reasons, they are popular across the country. Since practically everyone uses this service daily, this industry generates enormous amounts of income (Niyigena, 2021). However, most business owners frequently voice their displeasure over the mismanagement of income brought on by unscrupulous drivers and operation managers that commit fraud or use the income for their own gain. This fraud most likely occurs while a driver is on duty, for example, after a minibus taxi departs a

specific taxi terminal with a few seats available and passengers board on the way. This results in a significant loss for the minibus taxi industries and the nation due to unrealized taxes, which has raised the desire for a smart technical solution.

Numerous research has been done on the implementation of smart seat occupancy, reservation, and monitoring to provide passengers using public transportation with the luxury of checking seat occupancy status and reserving seats online without driver interaction (Kuchár et.al. (2023); Sharma et.al. (2021); Murdan et.al. (2020)) utilizing various IoT technologies. Although several studies were conducted in other countries regarding this most trending concept of smart occupancy and monitoring of transportations, only few were done in our country, which is South Africa. The available literature emphasizes a growing need for occupancy estimation and passenger detection systems across various industries (Dendi et.al., 2022). It is undeniable that the application of IoT promises a brighter future for public transportation industry (Bibri, 2015), but scholarly research is needed to determine how well transportation industry will embrace this trend considering its prospects and challenges. As a result, the transportation industry is not exempt from this phenomenon.

The goal of this research is to use knowledge from the literature to create an IoT-based smart occupancy monitoring system (IoT-SOMS) with five layers of IoT Architecture. The proposed solution will enable taxi owners to remotely monitor their minibuses and manage their funds. It utilizes a Force Sensitive Resistor (FSR) to identify seat occupancy, a proximity sensor to avoid overloading by detecting human presence, an accelerometer to measure distance, a GPS to track the location of the minibuses, and an Arduino Uno as an IoT gateway. Additionally, the system will improve how these companies run their operations and maintain public transportation's affordability, making it a competitive option to private vehicles. Not only that, but the technology also aids in the resolution of other problems or simply enables the opening of new service opportunities for taxi owners. Because there are more or fewer unrealised revenues, they can add or delete vehicles in particular directions. The rest of this paper is structured as follows: Section 2 provides an outline of the related work; Section 3 highlights the Design Science Research Method. Then, conclusions are drawn in Section 4.

2. Related Work

In recent times, many seat monitoring systems have been developed to monitor the seat occupancy status in transport settings. We reviewed some recent works developed in this field.

2.1 Overview of Internet of Things

The growth of the internet and its associated technological developments, which feeds the current rapid rate of change in the globe, have enabled the development of numerous intelligent systems, appliances, and devices (Alam et.al., 2021; Sundaravadivazhagan et.al., 2021). Even people who are not particularly drawn to technology have started to appreciate the convenience, comfort, and precious insights it provides (Upala & Wong, 2019). The Internet of Things (IoT) is one of the internet phenomena that has successfully disrupted our daily life. Hence, it has grown more popular and accepted in the transport industry to improve operations, thanks to the increasing use of smart devices and fast networks (Bibri, 2015). Thus, IoT has enabled devices to link directly to one another and to the cloud, improving service delivery and management strategic planning in businesses (Maepa & Moeti, 2021). Smart technologies are also being used in every aspect of transport services and workflows (Yahaya et.al., 2017). To improve the service experience for users, public transportations have shown persistence in implementing new technologies.

2.2 Intelligent Transport Systems

In recent years, intelligent transportation systems (ITS) have emerged as a major study area, transforming the way people move and navigate through traffic by offering a variety of cutting-edge services and tools (Murdan et.al., 2020). These data-driven services help to reduce significant issues brought on by the increasing requirement for transportation in our everyday lives (Niyigena, 2021; Patel et.al., 2019). Despite the advancements, a more sophisticated and distributed solution is still required to utilize the data from the sensors embedded on the seats and offer a timely and accurate response of seat occupancy status and monitoring for transportation in the taxi industry (Atayero et.al., 2015; Hoang Huy et.al., 2016).

2.3 Seat Occupancy Monitoring

In their 2021 research paper, Sharma et al. tackled the issue of bus seat management. They introduced a solution that integrates both hardware and a web application. This innovative system enables passengers to easily check the occupancy status of bus seats and verify who occupies them. The prototype they created effectively eliminates the problem of seat hogging and reduces the time wasted by passengers searching for available seats on the bus. Their research involved the development of a prototype system that utilized pressure- sensing resistors and an Arduino Uno module for monitoring bus seat occupancy. This system continuously sends real-time seat utilization data to a web application, which is accessible via a local interface, facilitated by Node Red software.

In the context of a campus library, Nguyen et al. (2016), paired a capacitance sensor with an IR sensor to present a simple yet successful solution that not only detects seat occupancy but also addresses the issue of seat hogging. The capacitive sensor determines whether the passenger is human while the IR sensor determines occupancy. The capacitive sensor is mounted on a neighbouring table rather than the chair; therefore, the seat hogging solution is indirect. As a result, the technology can be used in public spaces like restaurants and libraries but not in buses.

In their 2021 article, Maepa and colleagues developed a prototype called IoT-SLSOR (IoT- based Smart Library Seat Occupancy and Reservation) by harnessing Force Sensitive Resistor (FSR) and Radio Frequency Identification (RFID) technologies. They opted for this prototype due to its advanced features and capabilities, aimed at enhancing transparency and nurturing connections between library patrons and their study spaces. This innovative solution was specifically designed for South African universities of technology (SA), with the promise that it would enable users to conveniently make online seat reservations while also providing real-time seat status information.

In a distinct approach, Yahaya and his team, in their 2017 work, employed capacitance sensors as a pioneering method to create a Seat Occupancy Detector system. Similar to the system devised by Hoang Huy et al. in 2016, these solutions distinguished between seat occupancy by individuals or objects. Both implementations incorporated a capacitance sensor chip and utilized a Raspberry Pi as the central controller, integrated with a Wi-Fi module. These initiatives aimed to alleviate seat congestion, particularly during high- demand periods such as test and exam weeks.

3. The Design Science Research Methodology

The Design Science Research Methodology, or DSRM, was developed by Peffers et al. (2008) with the following three goals in mind: "(1) provide a nominal process for the conduct of DS research; (2) build upon prior literature about DS in IS and reference disciplines; and (3) provide researchers with a mental model or template for a structure for research outputs." To put it another way, the DSRM aspires to enhance the creation, presentation, and evaluation of design science research while adhering to its guiding principles and regulations. Figure 1 below shows the DSRM process for an IoT-SOMS prototype.

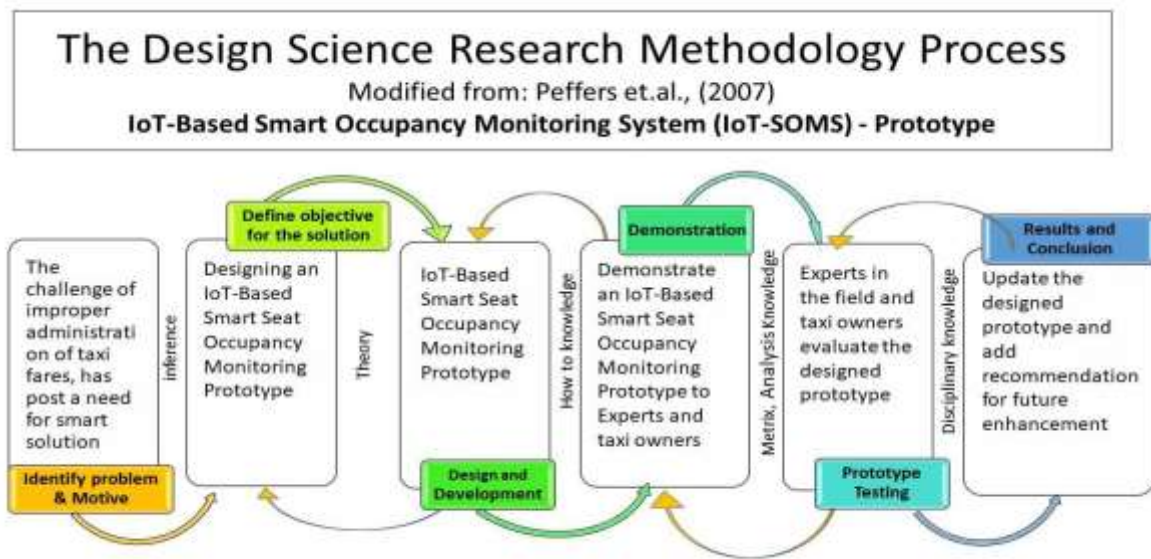


Figure 1: The DSRM process for an IoT-SOMS prototype: Modified from Peffers et.al., (2007)

3.1 Step 1: Problem identification and motivation

There are several issues that taxi managers and owners have, such as not knowing the precise income earned by their minibus taxi services due to the issue of unfair drivers who commit fraud, according to an investigation conducted at South African Minibus Taxi transportation in 2022 from various Associations. This fraud most likely occurs while an employee is on duty, for example, after a taxi departs a specific Taxi rank with a few seats available and passengers board on the way. In this case, dishonest drivers neglect to declare such revenue, which is classified as hidden income. Hence, Taxi owners frequently complain about how challenging it is to collect all the money from their drivers each day. The challenge of improper administration of taxi fares, has post a need to enable owners of taxis to have the luxury to observe daily operations of their vehicles and monitor the daily revenue without falling victim to their drivers' exploitation. Therefore, the need for smart solutions triggered the design an IoT-based smart occupancy monitoring system (IoT-SOMS).

3.2 Step 2: Objective of the solution

The objective was to design an IoT-based smart occupancy monitoring system (IoT-SOMS) to provide taxi owners the functionality of monitoring taxi seat occupancy online and knowing the precise amount of money that each taxi makes each day will be simpler. The system will effectively address the issue of residential theft by drivers in areas where managers lack access to local data. Additionally, the system will improve how these minibus taxi industries run their operations and maintain public transportation's affordability, making it a competitive option to private vehicles. The researcher examined previously published papers, articles, and journals on the subject to achieve this. Through a review of earlier articles, the researcher was able to learn what other researchers had discovered regarding SA minibus taxis' present operations, seat occupancy and monitoring systems, and any remaining gaps in their knowledge. To learn more about the actual situation, it was also investigated how earlier studies had portrayed the qualities of a ITS, emphasizing both its benefits and drawbacks.

3.3 Step 3: Design and Development

The tasks that were set up by the necessary hardware and software employed for the design of the suggested IoT-SOMS prototype are covered in this subsection.

3.3.1 Hardware Design.

The envisioned IoT-SOMS prototype integrated various hardware components, including a Force Sensitive Resistor (FSR) for occupancy detection, proximity sensors to identify the presence of individuals and prevent overcrowding, accelerometers for distance calculation, GPS for minibus location monitoring, and an Arduino Uno serving as the IoT gateway. On the software front, multiple tools were harnessed for the development of this proposed prototype. These encompassed MySQL, C++ IDE, and VB.Net. The pairing of C++ and the IDE software facilitated programming and communication between the sensors and the Arduino Uno. Meanwhile, VB.Net software played a pivotal role in crafting the user interface and establishing the database infrastructure for the envisioned prototype. Within this conceptual prototype framework, FSR sensors were employed as input devices, while output was channeled to computers, laptops, smartphones, and other compatible gadgets.

The seat occupancy sensor utilised is a flexible force sensing resistor made by IEE that was initially created for seat belt reminders in cars. When a seat is occupied, the occupancy sensor's resistance decreases to less than 20Ω , yet when it is vacant, it increases to more than $200M\Omega$. Even while in sleep mode, the occupancy sensor is powered via an Input/output pin. When the seat is occupied, it wakes the microcontroller, which is only powered for every 20 seconds and polled to check whether the "occupied" state is still accurate. To identify the presence or absence of occupants, FSR sensors will be strategically positioned beneath each seat. Whenever a passenger takes a seat within the minibus taxi, a dashboard display board located near the taxi's entrance will promptly relay information regarding the availability of seats.

The taxi owners could use their smartphones to examine the same information on the status of the taxi from the comfort of their home. When a person or object is detected, the FSR sensor will send the information to the database over a Wi-Fi connection. The proposed IoT-SOMS prototype's interface allows access to the database, which stores information such as the seat number, date, and time that the passenger occupies and vacates the seat, as well as data on the distance travelled and the time that a taxi departs from the taxi terminal and the location where it stops to drop off passengers. Figure 2 depicts how the key components of an IoT-SOMS prototype interact with one another.

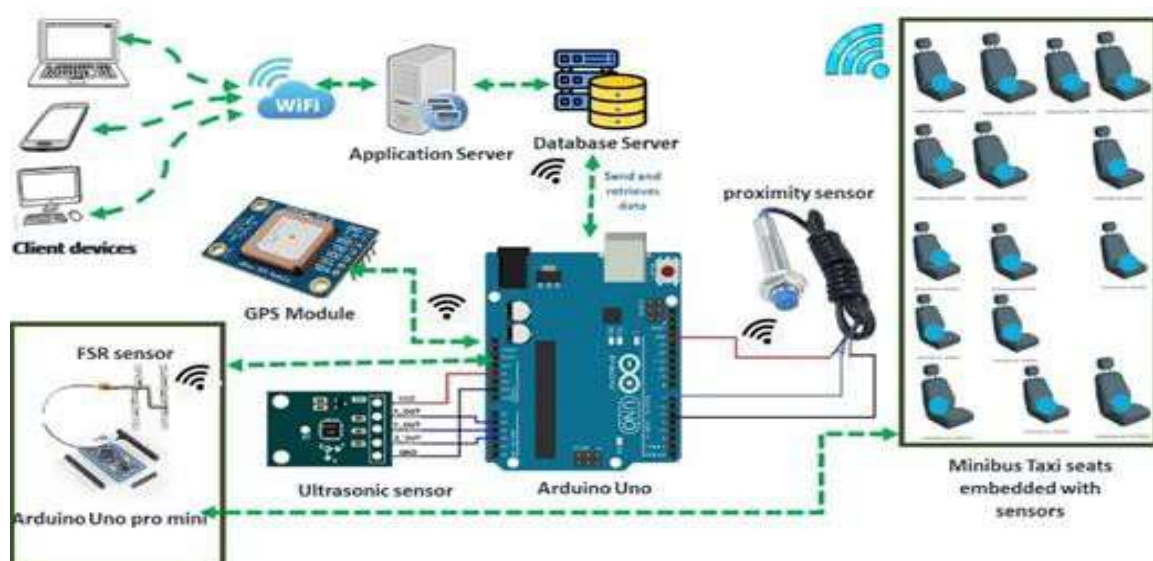


Figure 2: Block Diagram of an IoT-SOMS prototype

3.3.2 IoT-SLSORS System Architecture

The researcher used the data from both literature reviews to design a prototype, which consists of five layers listed as follows:

- ❑ **Perceptive layer**, sometimes known as the physical or hardware layer. This layer manages data collection and signalling.
- ❑ **Network layer** aims to connect all smart devices and facilitate data exchange between them. It securely transmits the seat data from the FSR sensors to the database using Wi-Fi technology.
- ❑ **Database Layer** - this layer contains seat status and its location for the requester. It is used to collect seat information from the network layer and store it in a database.
- ❑ **Application Layer** - this layer evaluates and integrate the information obtained from other layers and displays seat occupancy status.
- ❑ **View Layer** – this layer enables library user to access the IoT-SOMS applications to check seat occupancy status and research seats at their place of comfort.

Figure 3 illustrates all layers involved in the IoT-SLSORS prototype System Architecture.

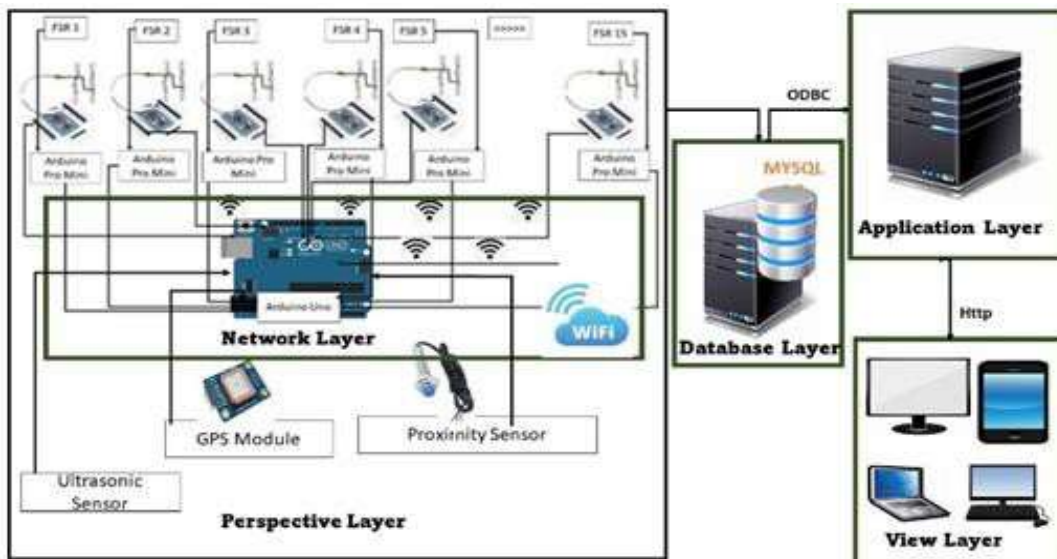


Figure 3: IoT-SOMS prototype System Architecture.

3.3.3 IoT-SOMS Flow Chart

The process for counting passengers and calculating the total taxi charge is shown in detail in the flowchart in Figure 4. The system resets the number of passengers to zero after each trip, using proximity sensors and FSR to identify passengers and determine seat occupancy, and then counts the passengers as they arrive. The database will receive updates on the overall number of travellers on a regular basis. The system will count the number of seated and standing passengers and notify the taxi owner if there are more than 14 people overall, excluding the driver. If not, it will determine whether the engine is moving. If the engine is running, the system will use a GPS module to track the location and an ultrasonic sensor to measure distance. It will continue this

process for each passenger, and if they exit the taxi, the total fare will be determined. The trip report will then be prepared and made available to the taxi business owners for viewing or downloading.

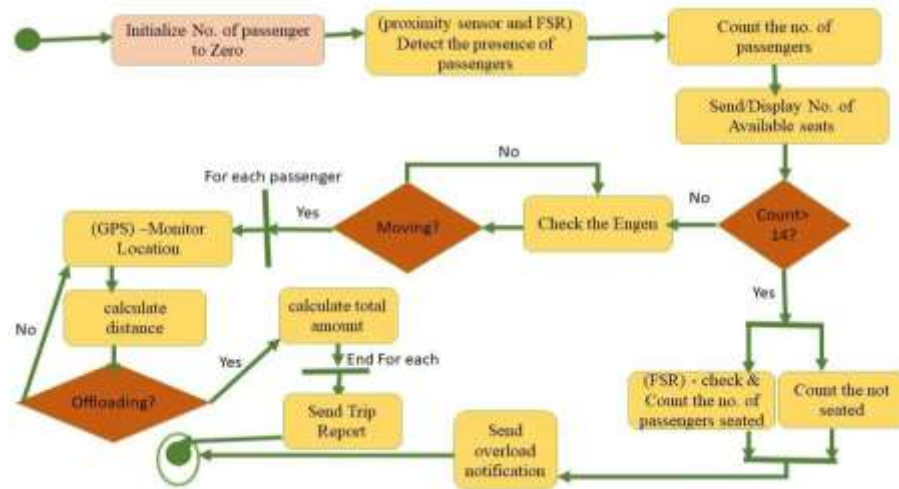


Figure 4: IoT-SOMS flow Chart

3.4 Demonstration

Following the development of an IoT-SOMS prototype, this innovative tool holds great potential for widespread adoption within the public transportation industry. The researchers intend to elucidate the prototype's functionalities and its suitability within the context of minibus taxi operations to industry experts. Additionally, they will share screenshots of various output screens for reference. As depicted in Figure 5 below, a web application has been designed to empower taxi owners with the ability to monitor several key aspects of their taxis. This includes tracking seat occupancy, taxi location, total trips, total passenger count, total taxi fare revenue, and the option to view or download comprehensive reports. Furthermore, the system allows taxi drivers to check seat availability status in real-time. To ensure the successful usability and performance of this IoT-Based Smart Occupancy Monitoring prototype, rigorous User Acceptance Testing methods were employed to address the performance issues. Continuous improvement efforts will be essential, guided by emerging performance requirements. Figure 6 provides a visual representation of the daily operations of a minibus taxi, offering insights into the number of trips, passenger counts, and the count of unoccupied seats during specific time periods.

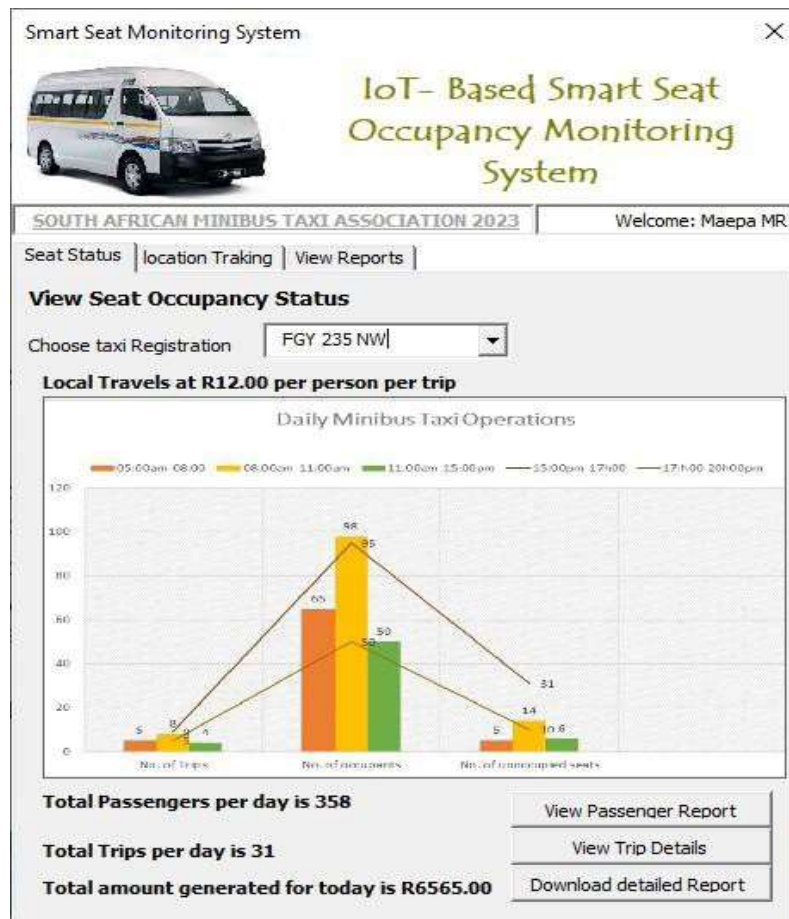


Figure 5: IoT-SOMS Application

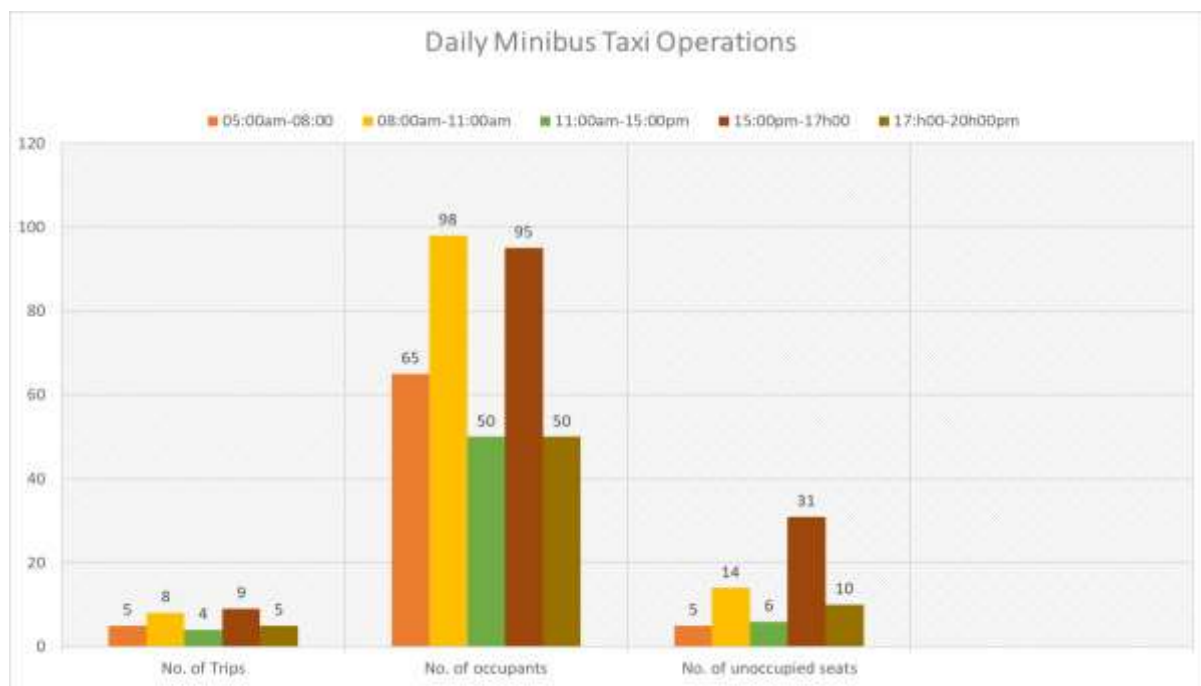


Figure 6: IoT-SOMS Daily minibus taxis operations

3.5 Prototype Testing

The usability and performance of the suggested prototype were assessed together with its compliance with all requirements. The User Acceptance Test (UAT) was carried out to make sure the prototype can do the necessary tasks in accordance with requirements and to see if it meets the users' acceptance criteria. A total of about 30 responders evaluated the user acceptance test for the proposed IoT-SOMS prototype. The respondents were given a demonstration of the system's operation before the experiment was carried out. Figure 7 below shows the interactions between the users and the system for the IoT-SOMS prototype.

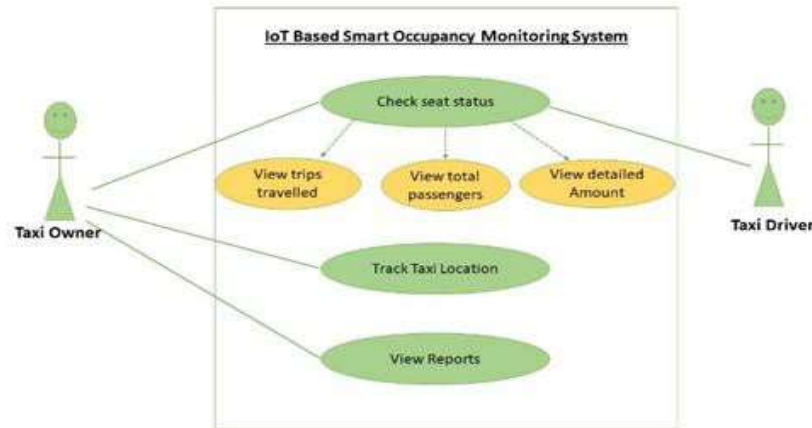


Figure 7: IoT-SOMS use case.

3.6 Communication of Results

The results of this study indicate that the issue was successfully solved because the system successfully counts the total number of passengers per trip and computes the total number of taxi fares per day. Furthermore, without exception, all respondents expressed unanimous agreement, including strong agreement, regarding the system's potential to enhance financial management. The unanimous consensus among participants, attesting to the application's effectiveness in facilitating real-time seat occupancy monitoring and providing flexibility for tasks such as viewing total passenger counts, tracking daily trips, and monitoring taxi locations remotely via internet access, underscores the successful attainment of this specific objective. A summary of the User Acceptance Test (UAT) outcomes for the IoT-SOMS prototype, derived from feedback from 20 respondents, is presented in Table 1. It suggests that while 5% of respondents are happy with the application, 95% of respondents are very happy with the design. In terms of application usability, the results show that 90% of respondents believe that the IoT-SOMS prototype is simple to use, 10% believe that it is incredibly simple to use, and the remaining 0% feel that it is usable in a moderate way. If the IoT-SOMS prototype is made available in the Google Play Store, we ask the respondents if they would like to download and use it, accordingly. 95% of respondents say they will.

Table 1: User acceptance test result.

	Frequency	Percentage (%)
Q.3 How well do you think is the application usability?		
Unsatisfied	0	0
Moderate Satisfied	0	0
Strongly satisfied	0	0
	20	100
Q2. Are you satisfied with all the features implemented in this prototype?		
Unsatisfied	0	0
Moderate Satisfied	0	0
Strongly satisfied	1	5
	19	95
Q1. Enhance financial		
Difficult	0	0
Moderate Easy	0	0
Extremely Easy	0	0
	25	100
Q.4 How is your experience on the usage of the application?		
Unsatisfied	0	0
moderate satisfied	0	0
Enjoyable	2	10
	18	90
Q.5 If the full version of this application is made available in Google Play Store, will you download and use it?		
Yes	19	95
No	0	0
Maybe	1	5%

4. Conclusion

This study investigated the adoption of an IoT-based smart occupancy monitoring system as well as its accuracy in detecting and minimizing taxi fare misadministration. A prototype called IoT-SOMS was designed and tested to accomplish this important goal. The prototype aims to automate the calculation of total taxi fare amount made per day using number of trips travelled and total passenger per trip based on seat occupancy detection using FSR sensors, accelerometer location tagging, GPS, and Arduino Uno as an IoT gateway concepts to calculate total amount made through autonomously detecting key parameters such as distance travelled, speed, and total passenger per trip, thereby relieving the user of manual calculations.

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An Assessment of the Implementation of Information and Communication Technology Platforms in Stakeholder Engagement in Namibia's Ministry of Home Affairs, Immigration, Safety and Security.

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Abstract.

This study examined Information and Communication Technology (ICT) platforms employed by Namibia's Ministry of Home Affairs, Immigration, Safety and Security (MHAISS) in stakeholder engagement and enabling remote access for prospective patrons to civic services in various departments in the Ministry. Specific objectives were to ascertain ICT platforms used by the Ministry for stakeholder engagement, and to assess implementation of ICT platforms in stakeholder engagement in the Ministry. Relevant conceptual and empirical literature were reviewed; study utilised two theories for theoretical framework, namely Social Shaping of Technology (SST) model and Stakeholder Theory. Mixed method design was adopted with study methods of survey for quantitative part and in-depth interviews for qualitative aspect. A total of 147 respondents (comprising 141 patrons and six senior officials in ICT and Public Relations divisions in different departments of MHAISS) constituted the study's sample size. Pilot study preceded the main research and provided relevant inspiration for the study's reliability and validity. Data collection was done using structured, self-administered questionnaire for quantitative data and interview guide developed by the researchers for qualitative data. Analysis of quantitative data was done using descriptive statistics in the Statistical Package for Social Sciences (SPSS, version 24) software in conjunction with Microsoft Excel spreadsheet; and qualitative data was analysed using thematic analysis. Among the findings are patrons' preference for physical contact in contrast to available ICT platforms for stakeholder engagement with the departments of MHAISS. It was evident that readiness issues from both the departments and patrons' perspectives are contributing factors to the partly embraced e-governance; and that patrons would be open to both ICT and in-person services and engagements. The study recommended integration of services across the departments of MHAISS to measure effectiveness; training on ICT platforms for public relations professionals, improved customer service across service delivery, and departments of MHAISS need to regularly sensitize their patrons on relevance of ICT platforms and tools for efficient service delivery in blended in-person and remote modes.

Keywords: E-governance; Home Affairs and Immigration; Information and Communication Technology (ICT) platforms; Namibian Correctional Service; Namibian Police Force; Stakeholder engagement

1. Introduction

Communication plays crucial role in contemporary times especially with the continuously improving technologies that enable access to information and the provision of services in the public and private sectors. Over the past two decades, the public sector has taken particular strides in adapting to the use of Information and Communication Technology (ICT) in efforts to improve service delivery as well as stakeholder engagement in the areas of public services (Ebrahim & Irani, 2005).

Organisations are maximising on real-time interactions with stakeholders that promote constant engagement through Information and Communication Technology platforms such as websites, social media platforms, the internet and intranet among others (Skinner, 2007). Information and Communication Technology refers to “the accessing of information using various technologies such as the internet, wireless networks, mobile phone and other communication mediums” (Christensson, 2010).

Although ICTs have been embraced by many, some studies conducted have highlighted concerns of digital divide among stakeholder groups which may serve as a challenge as far as stakeholder engagement efforts are concerned. Stakeholder engagement is defined “as the process of involving stakeholders” (Sloan, 2009). In essence, this involvement is facilitated by communication that relies on ICTs in boosting seamless and retrievable two-way communication and transparency which are fundamental to stakeholder engagement.

In Namibia, the Ministry of Home Affairs, Immigration, Safety and Security plays a key role in boosting immigration knowledge, the economy and it is central to communicating Namibia as a brand to the international community (National Development Plan, 2015).

The Government of Namibia launched the electronic governance (E-governance) policy for public service in 2005, and legitimised adoption of electronic services such as e-learning, ebanking and e-tax (Maritz, 2020). Government ministries were expected to be pillars of the implementation and boosting of e-governance through efficient service delivery and ensuring alignment with technological applications relevant to service delivery. Among these ministries is the Ministry of Home Affairs, Immigration, Safety and Security, which plays a critical role in citizenship issues, immigration as well as internal safety and security. There are indications of lack-lustre, delayed and poor customer service in some units of the ministry and near absence of technological orientation and utility of ICTs in some units like the police unit.

Given this background, it is imperative to evaluate this Ministry’s adoption of and adaptation to e-governance by utilising ICT platforms for stakeholder engagement since the launch of e-governance. Findings of this study are expected to assist the Ministry and the Namibian government with recommendations for probable improvement in e-governance and best practices. Ultimately, the findings are expected to lead to policy amendments at organisational level that will prompt seamless communication, swift service delivery and retrievable information. On national level, the findings will equally contribute to modifications that will lead to the integration of public services at across Offices, Ministry and Agencies (O/M/As) in Namibia.

1.2 Statement of the problem

In a fast-evolving society, where right to information is demanded, it is important for the Government of Namibia to recognise such an opportunity through the Ministry of Home Affairs, Immigration, Safety and Security in boosting immigration knowledge and the economy through high- level technology. Further observations made from ICT and social media platforms prove that the ministry as a key role player in promoting social and economic activities from a civic service perspective does not seem to engage stakeholders regularly. In addition, issues of long queues, slow response rate and poor service delivery are common

concerns at the Ministry, hence this study will be an opportunity to address these and other related challenges.

1.3 Research objectives and questions

1.3.1 Research objectives

The main objective is to evaluate how information and communication technologies (ICT) platforms have been utilized in the implementation of stakeholder engagement by the MHAISS in provision of civic services.

The specific sub-objectives are:

- To ascertain the ICT platforms used by Namibia's Ministry of Home Affairs, Immigration, Safety and Security and Immigration for stakeholder engagement.
- To assess the implementation of ICT platforms in stakeholder engagement at the Ministry of Home Affairs, Immigration, Safety and Security.

1.3.2 Research Questions

A research question is "a declaration with an intent of critically inquiring about the interconnections among variables that the researcher seeks to observe and/or gain more insight", (Creswell & Creswell, 2018).

The research questions for this study are:

- What are the ICT platforms being utilized by the Ministry of Home Affairs, Immigration, Safety and Security for stakeholder engagement?
- How has the Ministry deployed and been implementing ICT-based service delivery in its component units in stakeholder engagement?

1.4 Literature review

According to (Janardhanan et al. 2019), "Literature review in research is a process of compiling and appraising relevant research literature, available on a particular topic and provides context for new research.

The literature search was done mostly on various online databases of stakeholder engagement, public relations, and e-governance in public service delivery research including Google scholar and other repositories of social science scholarly work, for example, online university libraries such as Academia, Cambridge, Research Gate. The search was limited to literature not older than 12 years. However, few references older than 12 years were incorporated where no recent publications were found.

1.4.1 Information and Communication Technology

Information and Communication Technology also known as 'ICT', refers to "the accessing of information using various technologies such as the internet, wireless networks, mobile phone and other communication mediums" (Christensson, 2010). The rise of ICT technologies has offered new opportunities for people to participate in contributing to information, news sharing and commentary.

Initially, discussions of ICT focused on promoting convenience for "individuals, communities, businesses and organisations" by changing how they communicate and operate daily. ICT evolution continues to transform lives from having the world's information on news, services

and products for example, readily available to having instant communication with anyone, anywhere, any time. Most organisations across the world have fully embraced ICTs for flexibility and convenience as well as to minimise operational resources and costs. As a result of this on-going transformation, more people now have the opportunity to improve their livelihood by opting to pursue their studies online, telework, socialise, trade and shop online among other numerous possibilities. ICTs have shown that organisations continuously need to hasten their efforts as far as stakeholder engagement frameworks are concerned, from policy to practice (Lattimore et al., 2004). Also, there is need for organisations to work on their information and communication technologies framework as an essential aspect in achieving high-quality content that will not only entice their publics, but content that makes room for two- way conversations.

In Namibia, limited studies have been conducted to determine the extent to which platforms of Information and Communication Technologies (ICTs) have been embraced and the type of utility they are put into in meeting up with the national policy that is aimed at contributing to national development in the environment of this proposed study, namely Namibia Ministry of Home Affairs, Immigration, Safety and Security. There are indications of lacklustre, delayed and poor customer service in some units of the ministry and near absence of technological orientation and utility of ICTs in some units like the police unit. This situation necessitates investigation using this type of study in view of Namibian Government's intents and efforts to fully migrate to e-governance. Given this background, it is imperative to evaluate this Ministry's adoption of and adaptation to e-governance by utilising ICT platforms for stakeholder engagement since the launch of e-governance. Findings of this study are expected to assist the Ministry and the Namibian government with recommendations for probable improvement in e-governance and best practices.

1.4.2. Stakeholder Engagement

Stakeholder engagement is defined by Sloan (2009, p.26) as the process of involving stakeholders. A study conducted in the United Kingdom by Wakunuma and Jiya (2019) titled "Stakeholder Engagement and Responsible Research & Innovation in promoting Sustainable Development and Empowerment through ICT" asserted that with the ongoing evolution of ICTs, Public Relations as a discipline requires practitioners to fully respond to the evolution of ICTs and apply it to mind when serving their corporate agenda that holds them to a responsibility of serving as "gatekeepers of feedback" in a corporate environment. This process is known as "interacting". Therefore, the key aspect of stakeholder engagement as a Public Relations endeavour, shares the significance by focusing on the two-way communication that exists between organisations and stakeholders which is made possible through ICT platforms (Grunig and Hunt, 1984). Public Relations practitioners at the Ministry of Home Affairs, Immigration, Safety and Security oversee stakeholder engagement activities on the various ICT platforms such as the website, Facebook, Twitter, from conception, content creation and implementation/execution.

Organisations have had to change their communication strategies and approach to attract publics as well as stakeholders. Cornelissen (2017) indicated that the evolution of ICT platforms coupled with the ongoing social media trends have supplemented public relations efforts.

In essence, ICTs complement stakeholder engagement activities by boosting seamless and retrievable two-way communication and transparency, which are fundamental to stakeholder engagement.

1.4.3. Context of Namibia

The objectives for e-governance initiatives include providing “better service delivery to citizens; transparency; empowerment through information; and efficient government procurement”, asserts (Bernard et al., 2000).

As a developing country, Namibia has also embraced “E-governance” for the betterment of public service delivery. In 2005, the Namibian Government launched an “E-governance policy” for public services, which saw the country adopting electronic services (Maritz, 2020).

Therefore, with the country’s Vision 2030 and the National Development Plan (NDP5) as well as the Harambee Prosperity Plan (HPP) aligned frameworks, Namibia is set on successfully growing in a sustainable fashion. A greater part of that success is dependent on sustainability and excellence service delivery. With the year 2030 fast approaching, Namibia should be taking stock of the progress made thus far in terms of ICTs adoption which has been championed in various government Offices, Ministries and Agencies (O/M/As). The Namibian Harambee Prosperity Plan; popularly referred to as the (HPP, 2016) on E-Governance, emphasised the following concerning E-governance: “To promote transparency and accessibility, we will expedite the deployment of e-governance to cover all Ministries and public agencies by 2020. The Office of the Prime Minister in conjunction with the Ministry of Information and Communication Technology (MICT), as the central government agency tasked with the planning, design and implementation of all Government ICT solutions, will submit a detailed roll-out plan by July 2016. All Ministries and Public Agencies will be linked to e-governance during the Harambee period. To start with, the following ten O/M/As were prioritised in 2016/17: Office of the Prime Minister, Ministry of Finance; Ministry of Homes Affairs and Immigration, Ministry of Health and Social Services; Ministry of Industrialisation, Trade and SME Development; Ministry of Education, Arts and Culture; Ministry of Agriculture, Water and Forestry; Ministry of Environment and Tourism; Ministry of Land Reform and the Ministry of Justice”. In addition, the document had also indicated that government would rally Ministries to contribute to championing annual citizen satisfaction survey to measure e-governance implementation and adaptation. However, over five (5) years later, there are still some factors that need to be reviewed as far as e-governance framework in Namibia is concerned.

A paper titled “The Level of e- government Implementation: Case of Malawi” undertook a mixed method experiment on how Malawi as a developing country has adopted e-governance (Makoza, 2013). In his findings, he suggested that Malawi needed to “Improve its existing e-government services to increase growth of e-government through reviews of online public services with stakeholders i.e., Government administrators, the private sector organisations and citizens”. The purpose of the study was to understand the level of e-government implementation in Malawi focusing on examining websites for government ministries and departments. Quantitative and partly qualitative data was used to analyse seven websites for government ministries and departments. Additionally, the results showed slow growth in e-government implementation because of limited integration of public services. The study provides insights that may be useful in improving the implementation of e-government. In

this light, he stated that “improving collaboration in e-government initiatives to support the ministries and departments/agencies” that has not employed e-government for easy integration of public services delivery and communication with stakeholder groups.

In addition, ICT platforms present equally great benefits for organisations such as the Ministry of Home Affairs, Immigration, Safety and Security competitive advantage inexpensive collaboration, real-time communication, and online archiving.

To a greater extent, some studies have indicated that ICTs amplify stakeholder engagement efforts by improving efficiency in public service delivery and communication (Argenti, 2016). In the context of MHAISS, all communications pertaining to operations and services being disseminated on various official platforms and availability of downloadable documents on the website are all stakeholder engagement activities. The e-governance aspect focuses on the services being made accessible, functional, and efficient on various platforms. E-governance and stakeholder engagement can be improved using ICT platforms, which offer seamless opportunities in fostering effective and interactive communication in the areas of public services asserts (Ebrahim and Irani, 2005). A study investigated the use of electronic governance (e-governance) in Namibia, a study, which also includes insights on the important role that ICT offer as a governing tool (Uutoni et al., 2011). In the same study, the researchers also investigated “citizens’ awareness of e-governance, the level of Namibia’s e-governance adoption as well as a number of indicators that hinder Namibia’s progress in e-governance implementation”. In their findings, it was noted that “low usage of ICTs and affordability were some of the indicators that hinder implementation progress”. The study concluded that “Namibia was still at level one of its four- phase e-governance implementation strategy”. However, in addition to academic contribution to the research topic, the purpose of this study is to recommend some workable lessons from global peers thus mapping a way forward for Namibia with regards to e-governance.

Namibia’s goal to improve its service delivery using ICTs by the year 2030, hence the advancement of e-governance is not only on the shoulders of the government but the citizens through progressive engagements at various platforms to ensure that this national goal will be realised timely (National Planning Commission, 2004).

It has been over 16 years since the launch of the Namibia e-Governance Policy in 2005, which committed to the implementation of e-government likely to lead to better e-governance, transparency, and accountability. As a point of departure, e-governance in Namibia has been aimed at bringing public administration and services closer to the patrons and thereby promoting inclusiveness, among others. Therefore, the potential deployment of fully fledged ICT services in most if not across the country would require “state-of-the-art approaches and intensive efforts from stakeholders across the public and private sectors” (The Namibian, 2016). Concerns that suggested that there is a widespread lack of ICT literacy skills among the general population in Namibia, both serve as challenges for e-governance implementation in the provision of public services such as those provided by the Ministry of Home affairs, Immigration, Safety and Security have been shared (Remmert, 2019).

A study in Namibia by (Kashuupulwa, 2018) recognised public relations and media practitioners as “key players in e-governance “that would make a huge contribution to its thriving or declining growth. On the downside, some of the challenges that organisations face with regards to their stakeholder engagement efforts include difficulty to control the flow of

information and respond to issues of transparency, accuracy and balancing in a world that strives for immediacy. The public relations fraternity has expressed further concerns of e-governance particularly with issues that organisations are faced with when it comes to controlling reputational matters online.

Additionally, considering closing the digital transformation gap, Namibia has identified some key challenges that need to be addressed as a good measure to stand a realistic chance of implementing successful e-governance undertakings which would guarantee adequate user uptake. These include “citizen-centricity (clear understanding of customers’ characteristics and their involvement in the design and implementation processes); how to lift the veil and break the silo walls towards connected government); how to build capacity to stand a chance of delivering results; realising the benefits of e-governance by common industries and patrons; and having the capacity to continuously revolutionise given the evolving technology design platforms”. Among these, “the key challenge has been promoting trust for patrons so that they can access information and services on O/M/As through online platforms. Thus, Namibia will need to come up with strategic programmes that boost the cultivation of confidence amongst the would-be e-governance patrons” (Sharma, Guttoo & Ogra, 2014) as cited by (Bwalya, 2021).

Using ICTs in the form of e-governance could yield great benefits in the reform and modernisation of the public sector. The experience of e-governance in several developed and developing countries has shown that ICTs can be tools for greater service delivery with the goal of improving service quality. The departments of MHAISS i.e., the Home Affairs and Immigration, Namibian Correctional Service and Namibian Police Force, as key departments delivering public service in various aspects; are continuously striving to increase capacity both in proactive and reactive ways in ensuring that there is efficient and consistent service delivery and engagement with their stakeholder groups. E-governance can also promote ‘good governance’, that is, greater civic engagement can increase opportunities for direct representation and voice, and support for increased democracy.

A study by Burger (2021) titled “E-governance could improve service delivery by the public sector” in South Africa revealed that “public sector digitalisation offers other advantages to government such as the financial benefits accrued through cost efficiencies and material savings, the competitive edge garnered by a more attractive investment landscape, greater ease of business and swifter, more efficient interaction with a more transparent, accountable bureaucracy.

Another study done in Fiji by (Naz, 2009) titled “E-Governance for Improved Public Service Delivery in Fiji” posits that “the concept of electronic governance (e-governance) is defined as the application of Information and Communication Technology to the government processes to bring Simple, Moral, Accountable, Responsive, and Transparent (SMART) governance”. The above findings from a Namibian, African and international point of views, the next section of this chapter will offer further understanding in linking perspectives that inform this study.

1.5. Theoretical Framework

This section sought to examine the relationship of theories of ICTs and Stakeholder Engagement.

1.5.1 Social Shaping of Technology

Social Shaping of Technology (SST) emerged in the 1980s as a model of technology, with Donald MacKenzie and Judy Wajcmann's influential collection (William & Edge, 1996). The SST model scrutinises ways in which social, institutional, economic, and cultural factors shape issues, hence its relevance for this study in evaluating how the Ministry in this study technologically interacts (socially shapes ICT) to engage their internal and external stakeholders, demonstrated (William, 2019). Howcroft & Taylor (2022) asserts that the SST model brought together researchers from various academic backgrounds who shared common concerns on implications of technological change for well-being, the equality of life, professions, the environment etcetera. The intent was "just not to monitor impacts made but also to inquire about the ongoing technological rise that was giving impacts".

Through the Social Shaping of Technology approach, this study observes that stakeholder groups use and negotiate with technology for their engagement purpose.

A key assumption of the SST suggests that organisations may choose not to engage on issues affecting their stakeholders, however given the 21st century contemporary issues that are typically mediated on ICT platforms, they may be forced to make that call consciously. Therefore, the shaping of meaningful engagement is not far-fetched within the public service setting, provided that ICT platforms are penned to provide services, facilitate stakeholder engagement and address challenges and opportunities as they arise.

Social theorist, Pierre Bourdieu's school of thought builds on this notion by asserting that the rise of digitally mediated communication technology has created an entirely new dimension for stakeholder engagement as revealed in a study in the United States by Ignatow & Robinson (2017) titled "Pierre Bourdieu: theorizing the digital". This theory was criticized for being not up to date with the modern-day business agenda e.g., shared success among stakeholder groups and organisation as well as amending policies and regulations that govern them.

As part of its evolution, the highlight of the SST framework has been placed at the centre of 'convenience', challenges that are experienced through the functions of ICTs. Challenges experienced by stakeholder groups may include network issues, language barrier and absence of technological savviness. In elaborating on this evolution, a study by (Merrick, 2021), titled "A year of crises has heightened the debate about what corporations owe society" made use of the social responsibility theory by Friedman (1970) which revealed organisations should be responsible to society regarding its mediated content and its effects on the society.

Although the highlight of the SST framework has been placed at the centre of 'convenience', challenges that are experienced through the functions of ICT platforms have been identified as among stakeholder groups e.g., issues of end-user challenges such as network issues, language barrier and absence of technological savviness. Therefore, the assumptions made around the social shaping of technology on maximising technologically mediated engagements are in support of the already existing in-person communication endeavours by the Namibian government, ministries, agencies and MHAISS.

This theory was criticized for being not up to date with the modern-day business agenda e.g., shared success among stakeholder groups and organisation as well as amending policies and regulations that govern them; in this case the e-governance framework along with the stakeholder engagement and communication by the MHAISS and the Government of

Namibia. Further criticisms of the SST theory include “not being human-centred approach”. Contrary to this claim, human sciences scholars within various disciplines have highlighted how ICTs are being utilised to effectively carry across meaningful, two – way communication to stakeholder groups.

1.5.2 Stakeholder Theory

The second theory useful in this study is the Stakeholder Theory. Originated by Robert Edward Freeman in 1984, the Stakeholder Theory suggests that “an organisation’s success relies on the satisfaction of its stakeholders” (Freeman, R., Harrison, J., & Zyglidopoulos, 2018). It assumes that stakeholders’ needs are crucial (Grunig & Hunt, 1984). Skinner (2007) notes that strategic interactions between an organisation and its internal and external stakeholders could improve significantly through mutual dialogue. Therefore, the stakeholder model will offer an understanding on how engagement between stakeholder groups and the Ministry can be mutually beneficial for both.

The first person to define stakeholder theory was organisational theorist Ian Mitroff in his book *Stakeholders of the Organisational Mind*, which came out in 1983. Shortly thereafter, an article about stakeholder theory was released in 1983 in the *California Management Review* by philosopher and professor of business administration R. Edward Freeman. Freeman does not cite Mitroff as a source, rather he attributes stakeholder theory to discussions at the Stanford Research Institute. He went on to publish his own book, *Strategic Management: A Stakeholder Approach*, shortly after the article.

In Freeman’s book, he identifies and models stakeholder groups within a corporation, describing and recommending ways to manage their interests and determine who really counts from the perspective of the company. Increasing value for stakeholders will improve the business in all aspects. Freeman declares he stood on the shoulders of giants, such as building from research in strategic management, corporate planning, systems theory, organization theory and corporate social responsibility, the latter of which was first discussed by the Italian economist Giancarlo Pallavicini in an article published in 1968.

More recently, in 1995, ethicist Thomas Donaldson has argued that stakeholder theory has descriptive, instrumental, and normative aspects that are mutually supportive. Descriptive is used in research to identify and define characteristics and behaviours of companies and how they are managed. Instrumental uses empirical data to find connections between management of stakeholders and reaching corporate goals. Normative is a core theory on the function of the corporation and how it can morally carry out its processes, ensuring that management sticks to positive philosophical guidelines.

Stakeholder theory posits that a company is only successful when it delivers value to its stakeholders, and those values can come in many forms beyond financial benefits. One of the values produced by stakeholder theory includes greater productivity across the organisation. Stakeholder theory drives more than profits and productivity. There are ethical benefits of practicing it as well. Although, the general feeling about public service efficiency is not always positive, the stakeholder theory poses as a key measure to re-looking at organisational efforts across all departments, in this case the three for the MHAISS. Companies find that the mental health of the workforce is greatly improved as their job satisfaction increases. It will also elevate the status of the company’s social-economic status in the local community. This translates that even though the three departments are under the MHAISS umbrella, the one

that gets to practice stakeholder theory, will eventually set a standard for the others, where all can thrive, and support benefit their stakeholders.

Some critics, such as political philosopher Charles Blattberg, stated that “stakeholder theory is problematic”. They claim that the interests of various stakeholders cannot be balanced against each other. This is because stakeholders may be made up of large and diverse groups, which in the case of the departments of MHAISS would be the same too as they serve various stakeholders. It would be very impossible for the departments of MHAISS to please all their stakeholders. One or more stakeholders will have to take a backseat to other, more dominant ones, which is likely to create dissonance and as a result it would unsettle the benefits associated with stakeholder theory. As the research uncovers various key aspects, the referred to or similar drawbacks would be uncovered and discussed for this study.

1.6 Research methodology

This study employed pragmatism paradigm, which (Creswell, 2018), asserts as a “paradigm that is not dependent on precise assumptions as it rejects the choice associated with the philosophical wars, it focuses on what works to address a research problem, hence the birth of mixed method research design”. The study made use of a mixed method design, employing study methods of survey for the quantitative part and in-depth interviews for the qualitative aspect to gather data on the use of ICTs employed for stakeholder engagement by the Namibian MHAISS.

1.6.1 Research & Data collection instruments

A structured, self-administered questionnaire and interview guide were developed by the researcher. For qualitative data, semi-structured interviews were conducted to gain information on the ICT platforms employed for stakeholder engagement in the different departments of MHAISS.

The questionnaire and interview guide used in this study were based on the study’s objectives, the conceptual framework, and the literature review; to answer the research questions. Therefore, the items were related to the implementation and effectiveness of ICTs employed in stakeholder engagement by the Namibian MHAISS.

English is the only official language used at the departments of MHAISS under study. The questionnaire has six sections namely section 1, section 2, section 3, section 4, section 5 and section 6:

Section 1: Demographic data

This section aided the collection of the participants’ demographical data, namely gender, age, nationality/residency status and the relevant department of MHAISS the responses are offered to.

Section 2: Questions related to frequency, purpose and methods of engagement between patrons and departments of MHAISS.

Section 3: Questions related to service delivery and stakeholder engagement in the departments of MHAISS.

Section 4: Questions related to access to the department(s) of MHAISS’ ICT platforms.

Section 5: Questions related to patrons' experiences of service efficiency in general with the chosen department(s) of MHAISS' ICT platforms.

Section 6: Questions related to appraisals and recommendations on stakeholder engagement by patrons for the chosen department(s) of MHAISS' ICT platforms.

In addition, the interview guide had eight questions as outlined below:

Question 1: Which department of MHAISS and division do you fall under?

Question 2: What is your position and what does your role entail?

Question 3: What are the key functions of your division and how do they contribute to the overall mandate of the department?

Question 4: Which ICT platforms does the department make use of, to engage with stakeholders?

Question 5: For what purpose(s) does the department engage stakeholders on the afore mentioned ICT platforms?

Question 6: What is the turnaround time on responses to stakeholder communications channelled via the department/service unit's ICT platforms?

Question 7: Does the department have communications/social media and related policies? If yes, please share for referencing purposes. If not, which framework guides these efforts?

Question 8: What challenges and opportunities are there pertaining to ICT platforms employed for stakeholder engagement by your specific department (i.e., Home Affairs and Immigration, Namibian Correctional Service or Namibian Police Force) in general and your division (ICT or Public Relations) in particular?

Table 1: Sample for the study

Category	Total population (N) per Sample	0%	P
Category			C
Patrons of MHAISS Departments	141	96%	
Senior officials per department	6	4%	
Total	147	100	

1.6.2 Population Sample

The term 'population' in research is defined as "set or group of all units on which the findings of the research are to be applied" (Satishprakash, 2020). The departments within the ministry under study make use of various ICT platforms namely, website, Facebook, Twitter, Instagram, WhatsApp, and YouTube to engage with stakeholders. A total of 147 (including 141 patrons plus 6 senior officials in ICT and Public Relations divisions) in different departments of MHAISS where the population of interest was drawn.

This study focused on two populations, primary and secondary population. The primary population consisted of officials from the Ministry's three departments namely Home Affairs and Immigration, Namibian Correctional Service and Namibian Police Force. The secondary population comprised of members of the public as specific stakeholders in the research. For the primary population, a non-probability sampling was used to purposively select (purposive sampling) two senior officials in ICT and Public relations divisions from each of the Ministry's three departments, in Windhoek, namely, the Director of ICT and Chief Public Relations Officer.

The non-probability sampling was appropriate for this population as it enabled the researcher to collect relevant and specific information from the appropriate experts using the in-depth interview method. For the secondary population, the researcher used probability sampling to conveniently select (convenience sampling) prospective respondents who are patrons of the three departments under the ministry namely: Home Affairs and Immigration, Namibian Correctional Service and Namibian Police Force. Using convenience sampling, the researcher distributed a total of 141 copies of the questionnaire (survey instrument) among individual adult members of the public in the operational location of the three departments in Windhoek, at 40 copies of the questionnaire in each location. The probability sampling which the researcher adopted for the secondary population enabled responses from a sample of the population who would have stood a fair chance of being represented or selected from the population.

The number of responses results from the participants recorded are as shown in Table 2 respectively.

Table 2: Response Rate

Category	Total per category
Home Affairs and Immigration Patrons	50
Namibian Correctional Service	43
Patrons in Namibian Police Force	48
Key officers from the departments of MHAISS	6
Total	n= 147

1.6.3 Data Collection for Pilot Test

Table 3: Sample for the pilot study

Category	Total population (N) per Category	Pilot sample (n) Per Category
Patrons of MHAISS	141	12
Officials in ICTS and PR	6	0.6
Total	147	13

Data collection in the pilot study was like that of the one adopted in the main study. The self-administered open and closed-ended questionnaires sought to examine the available ICT platforms of the departments of MHAISS that enable patrons remote access to civic services and information with minimal to no communication and/or technological challenges that may be experienced due to modern day technology trends were administered to the patrons. Upon signing the consent form by each participant, the researcher distributed the questionnaires in a sealable envelope and an e-version link of Microsoft forms via email and/or WhatsApp. The researcher was present during the pilot test and provided information and clarity whenever needed. The questionnaires were independently completed by the participants within 20 minutes for the hard copy and were collected immediately after completion. It took participants 10 -15 minutes to complete the e-version of the questionnaire. All questionnaires were completed, representing a 100 percent response rate.

3.6.2 Feedback from Pilot Participants

The participants were encouraged to give their feedback and comments, if any, regarding their understanding of the questions and the most feasible time for completion that could need improvement in the main study. They responded that the questions were clear, but some terminologies were complicated e.g., platforms, stakeholders, and surface mail, physical contact, therefore, in the main study, the researcher added the more understandable terminologies (channels/methods, publics, letter; in-person communication).

Secondly, the participants expressed that the questionnaire was too lengthy, age group started from 21 – 30 years of age, only had an option “male and female” for gender which could cause a backlash from other stakeholder groups. Based on this feedback, the adjustments were made to condense the questions where applicable, include 18 – 20 years of age for the “age option”, added “prefer not to say” for gender to the final questionnaire used in the main study. On the feasibility of the study, the participants indicated that the best time to collect data was between 08h30 – 12h30 and 14h00 – 16h00. These two sessions were most convenient for them as they were at the departments mostly between those times. Participants also indicated that the questionnaire was lengthy, hence the researcher condensed it.

Thirdly, the interviews indicated that interview guide was not well understood due to flow of questions and appeared somewhat vague. The interview questions were revised in accordance with the feedback from the participants.

The results of the pilot test were not included as part of the main study’s results.

1.6.4 Data Analysis

For data cleaning, the researchers manually reviewed the compiled dataset to confirm that all sections were correctly completed. All questionnaire captured data on the required variables and were suitable for data analysis.

All questionnaires were allocated unique identification numbers so that they could be easily traced. Data were captured from the numbered questionnaire by the researcher and transferred to the Excel spreadsheet to facilitate data analysis. Final spreadsheet of data was encrypted and sent by password protected email to the statistician for analysis and interpretation.

Transcribing interviews responses – with the permission of the interview, only three interviews were recorded. The other three interviewees preferred responding to the interview questions in writing for record tracking.

An independent statistician conducted the analysis and interpretation of the data. The Statistical Package for Social Sciences (SPSS, version 24) software in conjunction with Microsoft Excel spreadsheet was used for data analysis. After data analysis was completed, the statistician sent back the results to the researchers.

Descriptive statistics are summary statistics used to describe and summarize data. It allows researchers to organise data in ways that give meaning and facilitate development of insight about the research data. They are calculated to describe the sample and key study variables (Creswell,2018).

Descriptive statistics was used to summarise the demographic variables including age, gender, department of MOHAISS the patrons were responding for. Since the data for these variables were categorical (nominal and ordinal), absolute counts and relative frequencies were calculated and presented in tables and graphs.

1.7 Results and findings

Copies of questionnaire were allocated unique identification numbers so that they could be easily traced. Data were captured from the numbered questionnaires by the researchers and transferred to the Excel spreadsheet to facilitate data analysis. Final spreadsheet of data was encrypted and sent by password protected email to the statistician for analysis and interpretation.

Transcribing interviews responses – with the permission of the interviewer, only three interviewees were recorded. The other three interviewees preferred responding to the interview questions in written for record tracking.

An independent statistician conducted the analysis and interpretation of the data. The Statistical Package for Social Sciences (SPSS, version 24) software in conjunction with Microsoft Excel spreadsheet was used for data analysis. After data analysis was completed, the statistician sent back the results to the researcher. The researcher made use of descriptive to describe the demographics of the participants and to explore the relations between the items and categories.

Socio- demographic features were clearly defined and critically assess whether patrons' age group, gender, nationality/residency status and the department(s) of MHAISS they were responding for clarified the responses to the statements presented in the questionnaire.

For the in-depth interviews, a thematic analysis approach was used to get accurate findings. The target sample size was 12 officials, consisting of two (2) senior officials i.e., the Director of ICT and Chief Public Relations Officers and their deputies, therefore four (4) interviewees from each of the three departments of MHAISS.

1.7.1 Results

Age (n=141)

Most of the participants were young adults aged 18-20, 21-30, middle aged adults 31-40 adults aged 41-50, 51-60 and 61 -70 (78%).

Gender (n =141)

The table below shows that female patrons included most of the respondents, n=73 (51.8 %) while male patrons were n=63 (44.7%) and those who “prefer not to say” were only n= 5 (3.5%).

Nationality/ Residency Status (n=141)

Majority of the participants were Namibian citizens n=101 (71.6%), while n=19 (13.5%) of the respondent were foreign nationals, Namibian citizens living abroad were n=6 (4.3), Namibian by marriage/domicile holders n=10 (7.1) and n=5 (3.5%) comprised of Namibians by naturalisation.

Department of MHAISS (n=141)

Majority of the responses were for the department of Home Affairs and Immigration n=50 (35.5%). The department of Namibian Correctional Service comprised n=43 (30.5%) of the respondents. Those who responded for the department of Namibian Police Force represented n=48 (34.0%).

Purpose of engagement with the departments of MHAISS (n=141)

Majority n=47 (33.3%) of the participants were engaging the department of Namibian Correctional service for “inmate visitation”. Those n=35 (24.8) were engaging the departments for application services with the Home Affairs and Immigration and Namibian Police Force departments, particularly.

Methods of communication used to engage with the departments of MHAISS in the last three years (n=141)

In-person communication is the most preferred method of communication as indicated by most of the participants n=98 (69.9%).

Device (s) used to access the department’s ICT platforms (n=141)

The majority n=40 (28.78%) of the participants indicated that they used their mobile phones to access ICT platforms, however only n=12 (8.63%) indicated that they access the platforms using their laptops.

Challenges experienced whilst accessing the Ministry of Home Affairs, Immigration, Safety and Security’s ICT platforms (n=141)

Most of the participants n=37 (26%) indicated that long queues are a challenge in public services, whilst other participants n = 35 (25%) experienced slow customer service.

- **Access to departments of MHAISS's ICT platforms**

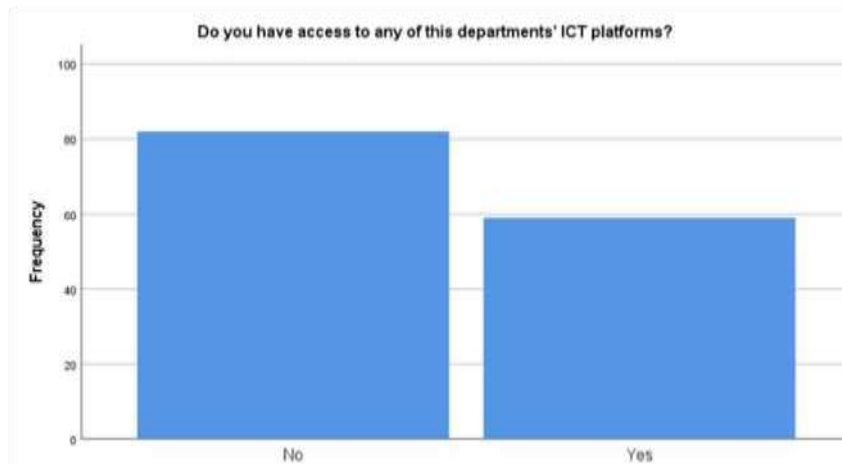


Figure 1: Access to departments of MHAISS's ICT platforms.

According to Fig.1, over 80% of the respondents indicated that they did not have access to the departments of MHAISS's ICT platforms whilst close to 60% of the respondents stated that they have access.

ICT platform(s) that participants have access to, for this department of MHAISS (n=141)

ICT platforms serve as a technology enable between departments of MHAISS and their stakeholders. The majority n=81 (57.4%) of the participants agreed that they have access to Facebook and Twitter as well as the website. In addition, n=47 (33.3%) participants strongly emphasised that they preferred in-person communication even though they have access to most of the ICT platforms in general. It is worthy to note that this was the question where most of the participants indicated that they would be happy to engage through ICT platforms when the departments improve on service efficiency for in-person administered services.

Preferred channel(s) to engage on with the departments of MHAISS?

Participants n=98 (69%) responded with "in-person communication".

Service(s) and communication(s) patrons preferred to access/get through this department of MHAISS's ICT platforms?

On general updates and announcements, n=30 (21.3%) participants further claimed that the departments of MHAISS were not constantly engaging/communicating on ICT platforms which was mainly the findings of the departments of Home Affairs and Immigration as well as the Namibian Correctional Service. Additionally, n=12 (8.5%) participants indicated that they would be happy with scheduling appointments online. Majority of the responses on this showed n=34 (24%) participants were not interested in any ICT based services or communications at the time; however, they would be willing to try such options when the departments show capacity to serve them on that level.

- **Findings on Interviews**

Roles of Respondents

The media and public relations divisions were all responded for by females who occupy senior roles as Heads and Chief, whereas the ICT roles were all responded for by males who occupy Head of ICT roles. In both Namibian and international settings these roles match the domination of gender representation in the two field of expertise i.e., the media and public relations roles are more female dominated, whereas the ICT roles are male dominated in most parts of the world.

- **Key Functions of the Divisions**

In fulfilling the mandates, vision, and mission of the respective departments of MHAISS, the Public and Media Relations divisions n=3(50%) interviewees, highlighted their divisions serve as links between the public and departments thus creating and maintaining strong relations between the departments internally and externally with stakeholders in various areas including regulators, government offices, ministries, agencies, media and other departments locally and internationally.

The other n=3(50%) interviewees for ICT divisions indicated their divisions include serving as ICT enables that serve the end-users, ensuring and managing access issues that create environments to improve organisational performance and service delivery, creating secure and reliable communication systems for the departments and adopting to modern ICT frameworks to sharing and processing information for immigration, correctional and policing purposes.

ICT Platforms are used for Stakeholder Engagement The ICT platforms are as follow:

On ICT platforms employed in stakeholder engagement by the departments of MHAISS, n=3 (50%) for Public and Media Relations confirmed as follow:

Home Affairs and Immigration – Internet, Website, Facebook, Twitter, Instagram, WhatsApp, LinkedIn, Short Message Service (SMS), Emails.

Namibian Correctional Service – Internet, website (however, it was offline at the time the research was being carried out due to ongoing updates to make it more interactive ad user friendly), Facebook, Twitter, YouTube, Instagram, WhatsApp, LinkedIn, Emails.

Namibian Police Force - Internet (website), Facebook, Twitter, YouTube, Instagram, WhatsApp, LinkedIn, Short Message Service (SMS), Emails.

- **Purposes of Stakeholder Engagement on ICT Platforms**

Understanding the purpose of stakeholder engagement on the ICT platforms by the departments of MHAISS and vice versa from stakeholders is crucial to the findings of the study. Therefore, the n=3 (50%) for Public and Media Relations confirmed indicated the:

Home Affairs and Immigration – The Home Affairs and Immigration department communicates on ICT platforms for various reasons including but not limited to new developments, regular information, responds to frequently asked questions (FAQ), updates on administration processes, annual reports media releases, interviews, events, and related events (M. Kalo, personal communication, 2022).

Namibian Correctional Service – The NCS communicates on ICT platforms for various reasons including but not limited to press conferences, interviews, meeting and events, information of new developments and promote NCS to the public. Additionally, video infomercial to

educate the public about the dangers of contraband among others (S. Hangula, personal communication, 2022).

Namibian Police Force – As for the Namibian Police Force, the purpose for communicating on ICT platforms includes but not limited to media releases, press releases, interviews, citizens, and stakeholders' participation through information sharing of reports, complaints, feedback, queries, and related policing activities (S. Hangula, personal communication, 2022).

Communication and/or Social Media Policies that Guide Stakeholder Engagement Efforts of the Departments of the MHAISS

Public and Media Relations n=3 (50%) interviewees indicated the departments make use of the main Communication Plan and Social Media Use Policy for the Government of the Republic of Namibia, used across Offices, Ministries, Agencies (O/M/As), Regional Councils and Local Authorities. The documents are reviewed every five years and the current versions were reviewed in 2019, hence "COMMUNICATION PLAN 2016/17 – 2019/20" and the "SOCIAL MEDIA USE POLICY AND IMPLEMENTATION PLAN 2016/17 – 2019/20".

- **Challenges and Opportunities Pertaining to ICT Platforms Employed for Stakeholder Engagement**

Challenges - From a Public and Media Relations perspective, n=3(50%) interviewees indicated the need for PROs to be trained on ICT platforms management, particularly on websites. The other challenge highlighted is the lack of equipment e.g., those for live streams, that would improve the administering of ICT platforms more efficiently.

On ICT, n=3 (50%) interviewees indicated the cost of ICT equipment as a challenge in general and given the ongoing technological changes, which would prolong completion of projects and tasks as a result.

On down time, n=6 (100%) of the interviewees indicated that downtime is a costly challenge for their respective departments.

Opportunities - From a Public and Media Relations perspective, n=3(50%) responded with "optimal use of ICT platforms to reach a larger audience instantly and run campaigns in a cost-effective manner. Other opportunities include having a certain degree of official obligation and accountability as communicator within a department of the government of the Republic of Namibia. Having international stakeholders is equally an opportunity to access to global guidance in best practices and regularly updated features use of social media. The interviews also emphasised that ICT platforms have offered opportunities to market departmental programmes, projects and activities, which are shared further by the patrons who are part of the online community.

The ICT n=3 (50%) interviewees recognised the ongoing opportunities offered by 4th industrial revolution, which will enable departments to integrate services as widely as possible for the improvement of immigration, correctional and policing processes.

1.8 Conclusion

Based on the findings of this study, the researchers note that it is important for the departments to invest in making their ICT platforms more interactive and engage more regularly, minimum three times a week. Another call is for the departments of MHAISS to

integrate services across the Ministry to maintain retrievable data as deliberated on in the much-anticipated Vision 2030 policy. Majority of the participants indicated that one of the common challenges they experience with the departments of MHAISS are issues of long queues and slow customer service. Therefore, to avoid patrons forming part of the long queues e.g., without the required documents which may cause staff members to get overwhelmed and public awareness campaigns should run across all communication platforms to ensure that they have the knowledge of the required documents and applicable. However, this challenge may be beyond the staff members' ability, for example staff shortage and security reasons of having to go through manual records to verify especially for patrons who seek amendments and/or rectifications.

Some of the participants also agreed that the departments need to incorporate engagements in Namibian indigenous languages. This response is evident that even though digital divide is a contributing factor to less participation in e-governance, there are other factors that contribute to the myriad of challenges which are socially and economically linked. An example may be that a patron who is proficient in English may not have the means to access ICT platforms, whereas another patron that may have access to ICT platforms therefore cannot resonate with the content on such platforms due to language barrier. though the official language is national official language is English.

1.9 Recommendations

Based on the study findings the following recommendations are made.

1.9.1 E-governance

- i. Public services benefit the largest percentage of the population, both locally and internationally. The MHAISS has an advantage to maximise on e-services not only to provide civic services but also to promote Namibia as a brand.
- ii. The efforts of Offices, Ministries, Agencies (O/M/AS) in championing e-governance should be recognised and supported as the output is to benefit the larger part of the population, which in this case refers to swift service delivery, seamless communication, and retrievable data.
- iii. Public service organisations, such as the MHAISS are encouraged to strengthen and empower civil servant senior officials to offer support occasionally to their juniors, which will lead to improved services and engagements with stakeholders. This may include training programmes and refresher courses for civil servant at all levels in various aspects of immigration, correctional service and police service administration encompassing key topics in customer service, emotional intelligence, crisis management, frontline administration etiquettes including telephone and body language, professional attires for frontline staff members, communication skills, technical training where required aspects of human resource management such as orientation of staff members, motivating staff members, dealing with staffing challenges, team building, health and wellness in the departments.
- iv. On the issue of training, a common discussion that arose was on the dire need for Media and Public Relations to get training on all ICT platforms, thus having to rely less on ICT divisions to assist with website management and admin related tasks (Ankur Kathuria, personal communication, 2022).

- v. Additionally, the departments of MHAISS should commit to regular stakeholder engagement session, both in – person and virtually to accommodate immediate and remote stakeholders;

an exercise that will help them gain insight on what is working and what is not (Smith, 2010). Civic challenges may never be resolved to the patrons' full satisfaction, and they are experienced in most if not everywhere in the world as revealed in the literature, hence the need for ongoing support to optimise civic services and interactions which will contribute positively to the drive e-governance through social and economic activities.

- vi. The use of ICT platforms for stakeholder engagement should be advocated for and Government Offices, Ministries and Agencies (O/M/As) encouraged to continue increasing their efforts in administering services and engagement through the available platforms.

1.10 Recommendations for Future Research

Future research on the evaluation of ICT platforms employed in stakeholder engagement in a public setting is proposed as follow:

- Qualitative study exploring the role of ICT in supporting stakeholder engagement activities to gain an understanding from the Media and Public Relations professionals' subjective perspectives and worldviews.
- Correlation study to link demographic variables with no relation to ICT platforms or stakeholder engagement.

ICT platforms offer an important supporting role in administering stakeholder engagement activities. Although relatively a new experience for Namibia; the topic needs further investigation. The study evaluated ICT platforms employed in stakeholder engagement by the departments of the Ministry of Home Affairs, Immigration, Safety and Security in Windhoek, Namibia. ICTs being enabler for both internal and external stakeholders, security is very key to the departments of MHAISS who have national mandate to protect and serve domestic and international communities linked to the Government of Namibia as stressed by (Daniel Nelumbu, personal communication, 2022).

The results of the study indicate that most of the participants offered more insight to the statements posed to them regarding the ICT platforms employed in stakeholder engagement. However, a --significant percentage of the participants were both neutral/ noncommittal in some statements. Finally, the research aim and objectives were met by the study.

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Identifying Persuasive Strategies that Promote the Uptake of STEM Courses by Women and Girls: A Scoping Review

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Abstract

Science, Technology, Engineering and Mathematics commonly known as STEM is an essential input in the development of economies. Literature on persuasive strategies is broad and well researched, making it important to incorporate them in motivating girls and women to take STEM-related courses. The purpose of this paper was to review and identify persuasive strategies from existing literature that can be used to motivate and encourage girls and women to pursue STEM-related careers. The scoping review identified theories of persuasive (Aristotle's theory of logos, ethos, pathos, Cialdini's 6 principles of influence) and various persuasive strategies (Linguistic persuasion strategies, the use of rewards, familiarity, primary task strategies, ARCS (Attention, Relevance, Confidence & Satisfaction) model of motivation, etc.) used in application to persuade people. Based on the study findings, the paper recommends the use of Aristotle's theory of logos, ethos and pathos and narration and storytelling persuasion strategies to motivate girls and women to uptake STEM-related courses.

Keywords: Persuasive Strategy, Persuasive Application, STEM, Motivate

1. Introduction

Science, Technology, Engineering and Mathematics, commonly known as STEM, is an essential input in developing economies. Government bodies over the years have attempted to narrow the gender gap in STEM (UNESCO, 2017). The reason is that careers relating to STEM are viewed as future jobs. Even though there has been an increase in the number of women in the STEM industry over the years, there is still an under-representation of women in STEM careers (Cantley et al., 2017). Globally, regarding higher education, only 35% of STEM students are females; more so, only 3% of these women choose Information and Communication Technologies-related courses (UNESCO, 2017). This translates into the underutilization of human capital, which affects the STEM professions' skills gap. It is proven that the female population is about 52 per cent in Africa, and only 30% of women are pursuing careers in STEM when looking at Sub-Saharan Africa (UNESCO, 2017).

The literature on persuasive strategies is broad and researched, making it important to incorporate them in motivating girls and women to take STEM-related courses. Yunika (2018) defines persuasion as "human communication intended to influence others by changing their beliefs, values, or attitude. More so, utilising one's resources, whether they be personal or professional, to influence others' actions or attitudes is another definition of persuasion. The technique of using arguments from logic and reason to influence attitudes or opinions is known as systematic persuasion (Yunika, 2018). The study by Yunika (2018), further argued that for something to be considered persuasive, the sender, the method, and the recipient must all be satisfied. Persuasive strategies are interactive strategies designed to influence behavioural change in human beings (Yunika, 2018).

While persuasive strategies have found application across various domains such as advertising, education, sales, diplomacy, politics, religion, and military training (Harris et al.,

2017), the specific use of persuasion strategies to motivate girls and women to enter STEM fields has remained unexplored. This gap becomes even more significant in light of existing data indicating the persistent underrepresentation of women within STEM, as emphasized by Marinova et al. (2022).

The purpose of this study was to provide the results of a scoping review aimed at identifying the literature on persuasive strategies that motivate people to pursue STEM courses and identifying the most suitable persuasive strategies that can be used to motivate women and girls to take STEM courses.

This paper is structured as follows: The next section describes the methodology. After which the findings of the study are presented. The results are discussed, and conclusions are made.

2. Methodology

2.1 Search Strategy

A scoping review was conducted on IEEE Xplore, Science Direct, Elsevier and Springer to find relevant publications on using persuasive strategies in applications to motivate people. To broaden the scope of the search, Google Scholar was also searched. The search keywords include persuasive strategy, motivate, encourage, and STEM. The search period was from 2017 to 2023.

2.2 Inclusion and Exclusion Criteria

The review only included studies published in English. It only included studies describing the factors that motivate people to pursue STEM careers or courses. We included journal articles and conference papers. Papers that did not focus on STEM were excluded.

2.3 Data Analysis

Data was analyzed using thematic analysis. The findings were analyzed based on the five themes that emerged from the research.

3. Results

3.1 Findings on influencing girls and women to take STEM-related courses

Sáinz et al. (2022) conducted a thorough study focusing on encouraging girls and women to get more involved in STEM fields, like engineering and computer science, where they are often underrepresented. The research emphasized the need for well-designed interventions backed by solid theories, such as expectancy-value and social learning theories. These interventions showed more success in motivating and engaging girls and women in STEM.

The study reviewed various interventions, including STEM training programs, workshops, and summer camps, aimed at boosting STEM skills and self-confidence among female participants. Some of these initiatives, like Brock's math workshop and Isiksal and Askar's software program, effectively closed gender gaps in math performance (Sáinz et al., 2022). Denner's STEM training program specifically enhanced girls' computer skills and support networks, challenging stereotypes about gender and STEM.

The review also stressed the importance of long-term evaluations to ensure that girl's and women's interest in STEM persists over time. Additionally, it emphasized the need for interventions that include both boys and girls, exposing them to female role models and promoting gender equality in STEM. These interventions should broaden interest beyond traditional STEM subjects to create an inclusive environment.

3.2 Findings on persuasive strategies in education and teaching

Persuasive strategies in education can help students learn better. Abdullahi et al. (2018) studied how personalized persuasive techniques can enhance students' cognitive abilities. They looked at 402 students and used three persuasive strategies: Reward, Social Learning, and Trustworthiness. The study found that students who were good at remembering and evaluating responded well to rewards, while those with a strong understanding ability preferred trustworthiness. Students who excelled in applying, analyzing, and synthesizing leaned towards social learning.

Akkaya (2020) also emphasized the role of persuasion in teaching. They analyzed the strategies used by Turkish language teachers and found both positive and negative approaches. Positive strategies included rewarding, motivating, and empathizing, while negative ones involved competition and punishment. The study noted that teachers used more persuasion strategies related to logos than ethos and pathos.

Orji et al. (2021) experimented to engage students in a large classroom setting. They used persuasive strategies like social learning, upward social comparison, and competition in an online learning environment. The results showed that students became more engaged, especially when the strategies were personalized. However, further research is needed to determine if this increased engagement leads to better learning and performance.

3.3 Findings on the use of persuasive strategies that have been used in applications for motivating people

The scoping review on persuasion strategies used to motivate individuals identified various persuasive strategies. These strategies included both negative and positive persuasive strategies. The strategies from all reviewed literature were categorized into 5 main themes, including theories of persuasion. The below section describes each of the themes, starting with the theories used in the reviewed literature.

3.3.1 Aristotle's Theory of Ethos, Pathos and Logos

The scoping review revealed that most publications utilized Aristotle's theory of ethos, pathos, and logos, which was developed by the Greek philosopher. This theory suggests that any communication aiming to persuade should include three key rhetorical components: logos (logical reasoning and facts), ethos (the communicator's character and credibility), and pathos (the emotional aspect) (Elhai, 2020).

In the context of promoting interest in STEM courses among women and girls, examples of using Aristotle's theory include Ethos to showcase successful STEM role models and emphasize STEM's credibility as a career choice. Pathos can be used to share inspirational stories of women in STEM, and Logos can provide data and facts highlighting the benefits of STEM education and careers, such as job opportunities and societal impact.

The findings from the selected literature on using persuasive strategies identified 7 publications on Aristotle's theory of ethos, pathos, and logos. The studies on persuasive strategies in the context of Aristotle's theory were researched in different areas: Print media (Torto, 2020), Advertisement (Amos et al., 2022; Apriyanti & Sumira, 2021; Yaseen et al., 2022), Medical Crowdfunding (Wu et al., 2021) and Political Speeches (Elhai, 2020).

3.3.2 Cialdini's 6 Principles of Influence

The scoping review on using persuasive strategies to motivate individuals identified publications on the six principles of influence by Cialdini (1984). Cialdini's principles tend to be straightforward heuristic cues that "consumers may use as a general guideline in a given influence setting." Additionally, marketers use these ideas to persuade customers to comply in a certain situation (Tölken, 2017). Tölken (2017) study further revealed that these strategies operate on the subconscious processes covertly and indirectly meaning that in most cases targets are unaware that the persuasion is taking place.

The findings from the selected literature on using persuasion strategies to motivate people identified 4 publications that applied Cialdini's 6 principles of influence. This publication that used Cialdini's method to persuade covered different areas: Coronavirus (Ibrahim et al., 2022), Artificial Intelligence (Alslaity & Thomas, 2021), Marketing (Tölken, 2017) and mobile fitness applications (Halttu & Oinas-Kukkonen, 2022).

3.3.3 Linguistic Persuasion Strategies

The scoping review on the use of persuasive strategies to motivate people further identified publications that applied linguistic persuasion strategies. Over the years linguistic strategies have been used by companies/business advertisers to make their communications seem more appealing, relatable, and interactive to their audience (Mbui & Ireri, 2019).

The findings of the scoping review on the use of persuasion strategies to motivate people identified 7 publications that applied linguistic persuasion strategies. The publications that used language as a means of persuasion ranged from different research areas: Advertisement (Mbui & Ireri, 2019; Momayezalashjar & Shuraki, 2022; Popova, 2018), Relationships (Lulu & Alkaff, 2019), social media (Chang et al., 2021), and Health (Blondé & Girandola, 2018).

3.3.4 Narration and Storytelling

The scoping review on using persuasive strategies to motivate individuals identified publications that applied narration and storytelling as a persuasion strategy. According to (Bullock et al., 2021), the information given within a story persuades people more effectively. Based on the literature, exposure to narratives results in various desired effects, including a change in attitude, an increase in risk perceptions related to health issues, and prosaically behavioural intentions (Bullock et al., 2021).

The findings of the scoping review on using persuasive strategies to motivate people identified 4 publications that applied narration and storytelling as a persuasion strategy. These publications were conducted in different research areas: Health (Tien & Chung, 2019), Teaching and Learning (Csikar & Stefaniak, 2018; Nwakuba & Mintah, 2023) and Virtual technology (Faddoul & Chatterjee, 2020).

3.3.5 Other: Anecdote, ARCS Model of Motivation, Primary Tasks Strategies, Familiarity, Rewards, Threats Etc.

The scoping review on the use of persuasive technology to motivate individuals further identified other persuasive strategies that have been used to motivate people over the years. These strategies include; the use of anecdotes and personal experience as persuasive strategies (Andriani & Marlina, 2019; Rudito & Anita, 2020), the ARCS model of motivation (Orji et al., 2019; Oyeboode & Orji, 2022), primary task strategies which will personalization, self-monitoring, simulation, tailoring, tunnelling, and reduction (Alhasani et al., 2020; Krishnamoorthy & Merchant, 2023).

Moreover, the scoping review also identified advertising strategies used to influence customers on brands and marketing products/services (Beckert & Naderer, 2023; Fitria, 2021; Greco, 2018; Kamleitner & Marckhgott, 2021; Wang et al., 2023). The scoping review also discovered the use of Familiarity (Liebers et al., 2023; Ruijten, 2021), Rewards and Threats (Blondé & Girandola, 2018) as persuasion strategies that can be used to motivate people.

4. Discussion

4.1 Comparison of persuasive strategies used in the applications to motivate people.

The findings from the scoping review revealed that various issues have been discussed regarding persuasive strategies used to motivate individuals. While there is evidence of publications on different persuasive strategies used to motivate people during the identified period (2017-2023), publications on persuasive strategies that incorporated Aristotle's theory, linguistics, and narration were more prevalent than publications on other strategies (Cialdini's principles, anecdotes, ARCS model of motivation, and Primary tasks). This could be because these persuasion strategies (Aristotle, linguistics, and narration) appeal more to human emotions, reasoning, and behavior.

More specifically, the scoping review revealed that the publications that applied Aristotle's theory believe that the theory appeals more to individuals as it is based on logical reasoning, feelings, and proof, which establishes trust within targeted audiences (Elhai, 2020; Torto, 2020). Moreover, information presented within a story or through linguistic persuasion strategies tends to be more effective in influencing people (Bullock et al., 2021; Mbui & Ileri, 2019). Evidence also indicates that linguistic persuasion strategies are commonly used in political speeches and fundraising charities (Chen & Yang, 2021).

The scoping review thoroughly searched for persuasive strategies used to influence people; however, none of the included publications addressed the issue of STEM and influencing individuals to pursue STEM-related courses. This could be due to persuasive applications in STEM still being an emerging concept. It is also worth noting that most of the strategies reviewed were applied in the context of marketing and advertising products, with very few publications applied in an academic context.

4.2 Comparison of Aristotle's Theory of Ethos, Pathos and Logos

The reviewed studies consistently highlight the relevance and effectiveness of Aristotle's persuasive strategies, Ethos, Pathos, and Logos, in dealing with women's emotions and feelings to motivate them to pursue STEM courses. These methods address the emotional aspects of decision-making by tapping into women's aspirations, interests, and passions. The

findings suggest that these strategies are highly recommendable for encouraging women to choose STEM fields (Elhai, 2020; Rudito & Anita, 2020; Wang et al., 2023; Tölken, 2017; Orji et al., 2021; UNESCO, 2017; Sáinz et al., 2022).

Ethos, as applied in these studies, underscores the importance of credibility and trustworthiness. By showcasing credible STEM role models, educators, and mentors, women are more likely to emotionally connect with the idea of pursuing STEM courses. When women perceive STEM professionals as trustworthy and dependable, it appeals to their emotions and feelings of security and confidence in choosing STEM (Elhai, 2020; Tölken, 2017; UNESCO, 2017; Sáinz et al., 2022).

Pathos, another key aspect, involves the power of storytelling and the emotional connection with women's dreams and desires. These studies show that sharing success stories of women who have excelled in STEM fields invokes a sense of empowerment, passion, and emotional resonance. When women hear stories of others who have overcome challenges and achieved success in STEM, it sparks their emotions and ignites a desire to follow a similar path (Elhai, 2020; Rudito & Anita, 2020; Wang et al., 2023; Sáinz et al., 2022).

Logos play a role in dealing with women's emotions by providing rational and logical reasons for pursuing STEM. Presenting data on the benefits of STEM education and careers, such as job opportunities and societal impact, caters to the rational thinking and decision-making processes of women. It offers them a logical foundation to support their emotional aspirations, making STEM more relevant and appropriate (Elhai, 2020; Tölken, 2017; UNESCO, 2017; Sáinz et al., 2022).

These studies underscore the effectiveness of Aristotle's Ethos, Pathos, and Logos strategies in dealing with women's emotions and feelings, making them appropriate and recommendable for motivating women to pursue STEM courses. Ethos establishes trust and credibility, Pathos connects on an emotional level, and Logos provides logical reasons, collectively creating a persuasive approach that addresses women's emotional needs and aspirations, thus making STEM a compelling choice. These strategies have the potential to significantly contribute to bridging the gender gap in STEM fields.

5. Conclusion

This paper conducted a scoping review to explore persuasive strategies for influencing and motivating individuals, with a specific focus on motivating girls and women to pursue STEM courses. The review had a twofold purpose: to examine the existing literature on persuasion for motivation and to identify applicable strategies that can encourage girls and women to pursue STEM courses. The scoping review unveiled multiple persuasive theories (including Aristotle's logos, ethos, and pathos, and Cialdini's principles of influence) and a range of persuasive strategies (such as linguistic persuasion strategies, rewards, familiarity, primary task strategies, and the ARCS model of motivation) used to persuade individuals.

Based on these findings, the paper recommends the utilization of Aristotle's logos, ethos, and pathos, in addition to narration and storytelling strategies, to motivate girls and women to engage in STEM-related courses. Aristotle's theory of persuasion proves to be particularly well-suited for this purpose, as it incorporates three vital components: logos, emphasizing logical reasoning and facts to address gender disparities in STEM fields; ethos, highlighting trustworthiness and credibility, often represented by female STEM role models; and pathos,

appealing to emotions and empowerment. These strategies effectively address women's emotional dimensions and make STEM fields more relatable and engaging for them. Ethos strategies provide emotional reassurance by showcasing trustworthy female role models in STEM, instilling confidence in the field. Pathos strategies use compelling narratives to evoke emotions, igniting inspiration and passion among women to pursue STEM. Logos strategies offer logical reasoning and factual data, addressing women's emotional needs for financial security and the desire to contribute positively to society.

In conclusion, these methods recognize and cater to women's emotional aspects, rendering STEM fields more relevant, appropriate, and recommendable. By acknowledging and addressing these emotional complexities, they motivate more women to take up STEM courses. Furthermore, this scoping review underscores the scarcity of publications on the use of persuasive strategies specifically aimed at motivating women and girls to pursue STEM-related courses. It highlights the necessity for additional research in this area to bridge the existing gap and further contribute to the field of STEM education and gender equality.

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Interactive Machine Learning Framework for Predicting Non-Performing Bank Loans

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Abstract

The aim of this study is to develop an Interactive Machine Learning framework, based on outlier hunting techniques to predict non-performing bank loans. Multivariate Gaussian Anomaly Detection technique was used for the outlier hunting to ensure that every incoming data observation to be learnt (as an update to the interactive classifier) during usage, is not anomalous, malicious, fictitious, or having erroneous measurements. The framework was applied to predict credit facilities such as loans in financial institutions that are not non-performing, and to enable the system keep learning new trends while in use. The loan classification model was trained using Support Vector Machine (SVM) algorithm because of its ability to perform well as observed in literature. The model built from the experiments was evaluated using standard machine learning evaluation metrics which include precision, recall, accuracy, area under the curve (AUC) and was also benchmarked against other models built with different algorithms. Results of the experiments show that SVM model has 96% accuracy which is the highest percentage of AUC obtained among the models trained. This study would enable users to verify the validity of data or feedback in an interactive machine learning environment before deciding whether or not the observations will be used in updating the model. This method would also help reduce the training time in the learning process. This study is significant in guaranteeing financial security of banks for the future and helping to maintain stability in the credit lending rates.

Keywords: Outlier Hunting, Support Vector Machine, Bank Loans, Framework, and iML.

1. Introduction

Financial institutions such as banks, provide loans to individuals and businesses. Non-Performing Bank Loans (NBLs) are loan types in which bank customers have delinquencies due to their inability to make scheduled payments for a period of time (Segal, 2021). Non-Performing Bank Loans is a product of customers' or businesses' inability to pay back money borrowed from banks (Segal, 2021). It could also be as a result of financial problems faced by individuals, customers and businesses (Balgova et al., 2016). Some of the consequences of NBLs is the inability to borrow any extra money or get new funding from banks. NBLs predictions is an interesting subject in data science. One of the problems in banks is the keeping track of individuals, customers, and businesses with NBLs and predicting those who are likely to have NBLs in the future, based on available data and how these trends could negatively impact on the overall standings of banks. Many banks are investing in their business models with the recent advances in machine learning algorithms, models and big data analytics. As of year 2015 to 2020, there were about 1 trillion euros of Non-performing Bank Loans (NBLs) according to the International Monetary Fund (IMF) Euro Area Policies (IMF, 2015). In recent years, especially, during the COVID-19 pandemic, there were cases of Non-performing Bank Loans (NBLs) in the United Kingdom and Brazil (Diniz and Costa (2022). Diniz and Costa, conducted research to minimise COVID-19 pandemic impact on

credit lending environments in the United Kingdom and Brazil, through the Central Bank's monetary policies (Diniz and Costa (2022). Boussaada and colleagues (Boussaada et al., 2023), conducted research on bank performance and non-performing loans in European banks, and the role social responsibility plays on them. Asemota and colleagues concluded that restrictions in money supply can have huge negative and detrimental effects on defaults and Non-performing Bank Loans (NBLs) in Sub-Saharan Africa (Asemota et al., 2023). The problem of Non-performing Bank Loans (NBLs) is global in nature, cutting across different continents of the world. This research developed an interactive Machine Learning (iML) framework, based on outlier hunting techniques, to verify the validity of the user input (feature feedbacks), to predict Non-performing Bank Loans (NBLs).

In interactive Machine Learning (iML) the human iteratively interacts with the learning algorithm in an online fashion by providing inputs, feedbacks or confirming/modifying class labels and/or data observations with the aim of improving the performance of the model (Grønsund & Aanestad, 2020). However, this can be counterproductive if the data or feedback provided to the learning algorithm by the user are anomalous, invalid, fictitious or of low quality (Justo, Torres, & Alcaide, 2017; Pandey, Purohit, Castillo, & Shalin, 2020). Hence the need to verify the validity (or 'goodness') of the input and ensure that only valid and high quality feedbacks are used in updating the model (Jiang et al., 2019).

One technique to ensuring this normality is the use of anomaly detection (also known as outlier hunting in this paper) to understand the patterns or behaviour of a data distribution and be able to identify abnormal patterns that are not in conformance with the normal behaviour of the system. Anomaly detection is widely applied in different domains such as medical health, care, fraud detection, intrusion detection, video surveillance et cetera (Ma, Wang, & Yuan, 2014; Mozaffari & Yilmaz, 2019). This allows for a situation where observations of unwanted behaviour or events in the underlying system are easily pointed out and can be specially dealt with. Because anomalies in a data set or data stream potentially poses catastrophic consequences if undetected before settling in, it is important to accurately and quickly identify them and further necessary action taken about them (Mozaffari & Yilmaz, 2019). The objective of this study is to develop an outlier hunting-based interactive machine learning (iML) framework for predicting non-performing bank loans. The remaining parts of this paper are organised as follows: section 2 contains literature review. Section 3 describes the iML framework. The results and discussion are contained in section 4, while section 5 concludes the paper.

2. Literature Review

Machine learning has various applications ranging from health, education, governance, agriculture, to banking, amongst others (Dada et al., 2022; Oyewola et al., 2022; Al-Emran et al., 2023; Alshurideh et al., 2023; Krosney et al., 2023; Buhmann & Fieseler, 2023). Machine learning techniques are largely classified as either supervised or unsupervised learning techniques. Support Vector Machine (SVM) has shown ability to provide good generalisation, convergence and higher performance than other methods for loans predictions (Eweoya, Adebisi, Azeta, & Amosu, 2019; Eweoya, Adebisi, Azeta, Chidozie, et al., 2019). In this section, we conduct literature review in the areas that pertain to this research in outlier hunting, interactive machine learning and fraudulent loans prediction.

Laux, Cutiongco, Gadegaard, & Jensen (2020), proposed an interactive machine learning approach for cell profiling using Bayesian Optimisation and their results showed that the interactive machine learning approach outperformed the conventional method of pipeline optimisation as it provided improved quality of segmentation, ease of use and speed of the optimisation process. It also required little domain expertise of the user. Holzinger, et al. (2019), presented an experimental insight into using an interactive machine learning approach where human intelligence is used to complement computational intelligence using Ant Colony Optimisation (ACO) framework. They also proposed unifying human intelligence with the computing power and the interaction skill of an artificial system. The ACO framework was used to solve the Traveling Sales Man problem. With a MAX-MIN Ant System (MMAS) in the background, they used gamification for evaluation. The MMAS algorithm was extended such that the ants can be directly interacted with and influenced by a human. The result show that there is a substantial impact of humans (performing one tour through the graph) on finding the shortest path by MMAS. Hence, machine intelligence can be positively influenced by human intelligence. Martínez et al. (2020) performed an extensive review of literatures and found a range of application areas that have implemented iML systems and the necessity to standardise the evaluation of those systems. The result of their work can serve as a reference guide to inform interactive machine learning systems implementation. Yang et al.(2018), investigated how machine learning solutions can be built by non-experts in real life (through the use of surveys and interviews) revealing the pitfalls, they are susceptible to their unique potentials. Their work further suggested that, though it is not so easy, building robust and easy machine learning systems should be the priority in developing novice-facing machine learning tools. They also presented design implications and demonstrated how non-experts can be guided by designers to build machine learning solutions that are robust in an easy way.

Dudley & Kristensson (2018), presented characterisation and review of interactive machine learning from the perspective of interactive systems. They also proposed behavioural and structural model of an iML system on a general note, and also identified principles for designing effective iML interfaces. Reference to literature in human-computer interaction literature in a broad sense contextualized these solution principles. Wu et al. (2021), improved high-impact bug report prediction with combination of interactive machine learning and active learning. Because early identification of high-impact bug reports (HBR) is crucial to ensuring software quality and gathering labelled data is difficult in practice, they proposed an hbrPredictor (high-impact bug report Predictor) which combines interactive machine learning and active learning to make HBR predictions. The hbrPredictor outperforms the two baselines with maximum F1-score (0.7939), AUC (0.8789). It reaches best performance with just 45% and 13% for small and large-sized dataset. This reduces labelling time maintains the effectiveness of the model.

Ananthachari & Makhtumov (2021), proposed and used genetic algorithms for population selection and interactive machine learning for labelling. ANOVA measurement results proved to be better for evaluating both the implementation. MAPE-K feedback loop in iML yielded enhanced results. Beil & Theissler (2020), proposed an interactive cluster-clean-label approach. Then HDBSCAN clustering is used to identify similar class membership, while autoencoder is applied for anomaly detection until the class is pure. This approach yielded an accuracy of 98.99%.

Rahmawati, Sarno, Fatichah, & Sunaryono (2017) noted a rise in fraudulent activities in banks and identified that the reason for this is that these frauds are not identified earlier enough. Hence, they proposed a method by which fraudulent business processes in credit card applications can be detected using the activity recorded in the bank's event log and Hidden-Markov Models. 94% was the result of their experiment making them conclude that Hidden Markov Model can be used to appropriately detect fraud. Przekop (2020) investigated the possibility of improving the predictive power of a fraud prediction model by adding new variables. They employed two algorithms to generate unique variables that contribute to the predictive power of fraud detecting models. The study showed an improvement to the models' predictive power and improves the interpretability of the anti-fraud models. However, they also noted that this comes at a cost of increased complexity of the model. Aniceto, Barboza, & Kimura, (2020), explored machine learning techniques to analyse the adequacy of borrower's classification models using data from a Brazilian bank. They developed Support Vector Machines, Decision Tree, Bagging, AdaBoost and Random Forest Models. In their findings, they suggested that machine learning techniques could still be explored to discover more value creating opportunities to improve default prediction models.

Furthermore, Zhong, Miao, Shen, & Feng, (2014), compared the effectiveness of some learning algorithms for predicting corporate credit ratings. Their result showed that SVM performed better than others in the output distribution; however, they suggested that its reliability could still be improved upon. (Demestichas et al., 2021), Comparative analysis of machine learning-based approaches for anomaly detection in vehicular data. Their work attempted to monitor and evaluate driving behaviour to increase safety and avoid accidents using sensor data from vehicles, machine learning for both univariate and multivariate anomaly detection. Their results show that the Minimum Covariance Determine (MCD) performed remarkably well for the univariate analysis in accuracy, F1 – Score, Mean Average Error (MAE) and the least execution time. In the future, they intend to expand number of features, use pre-trained models in order to enable real-time outlier detection. Zhan & Yin, (2018), noted that fraudulent behaviours can change quickly and avoid detection and because of this, simple rules or features may not be sufficient. They proposed another way of automatically extracting features from the network graph of a borrower's phone (call history data) using neural networks to address the above-mentioned problem. This approach further helps capture features that are difficult and fake. Although they noted that, this data can be noisy.

Thudumu et al., (2020), surveyed the state of anomaly detection and identified that lot of anomaly detection techniques are unable to retain sufficient accuracy due to big data and curse of dimensionality issues. They used triangular model of vertices: the problem, technique, and tools to consider researches on the subject and provided limitations faced by traditional and current techniques of high dimensional data and big data techniques necessary for the optimisation of anomaly detection. They suggested further works on novel frameworks the identification of anomalous points in data of large volume and having dimensionality issues. Ding et al., (2019), posited that anomaly detection with high quality could be very beneficial to a wide variety of applications like fraud detection, intrusion detection, disaster precaution et cetera, however, most existing algorithms for anomaly detection cannot guarantee both real-time and effectiveness capabilities at the same time. They proposed LGMAD a real-time anomaly detection algorithm based on Long-Short Term Memory (LSTM) and Gaussian Mixture Model (GMM) for univariate time-series detection and joint multidimensional detection respectively on both NAB

dataset and custom dataset. LGMAD outperformed other anomaly detection algorithms with precision of 90.1%, recall of 93.8 and F1 – score of 91.9. For future work, they propose expanding LGMAD algorithm to handle a higher dimensional scenario.

3. The Interactive Machine Learning (iML) Framework

The section presents contains overview of the experiment, the various stages of its design, the existing framework, proposed framework, evaluation, data preprocessing and modelling techniques. This research work designed an anomaly-based interactive machine learning framework for predicting fraudulent bank loans.

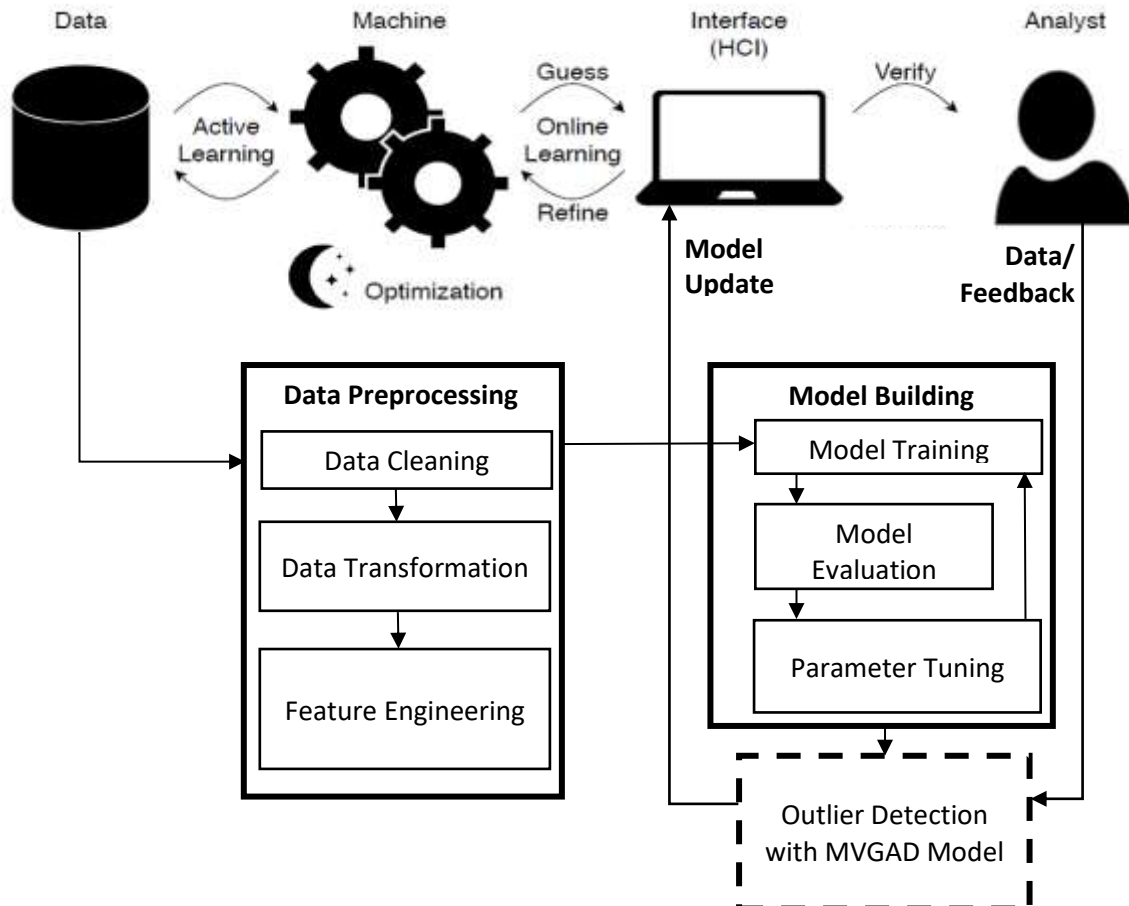


Figure 1: The Interactive Machine Learning Framework

In designing outlier hunting-Based iML framework, the following methodology was used: Schematic Diagrams using Visio, Support Vector Machine Algorithm, and Multivariate Gaussian Anomaly Detection (MVGAD) technique. Moreso, Python – Google Colab. Recall, Precision, F1-Score, Accuracy, for model evaluation. Google’s Collaboratory (Colab for short) Python version 3.7.11 [GCC 7.5.0] were used for model building. The proposed framework in Figure 1 was designed in this study, it introduced an outlier hunting component to the existing framework to verify that subsequent data points to be applied as updates to the interactive fraud prediction model are not anomalous, fictitious or malicious. The dotted lines in the proposed framework in Figure 1 were added to the framework as part of the contribution of this study.

The system runs on two models. A model trained on a labelled data for classification (SVM), classifying each observation into either Approve or Reject loan application, while the other model is trained with a dataset without labels for anomaly detection (multivariate Gaussian). Both models are then deployed and structured in a hybridized manner so that for every application or data point or observation fed into the system, the anomaly detection system first checks the veracity of the data point by using the anomaly detector to check if it is within the normal distribution of the initial data set or it is anomalous to the dataset's distribution. If found to be normal, same data point is automatically passed to the classifier for classification and then update the model, else if it is found to be abnormal, such an application is pending for a human user to reconsider the application and manually pass it as approved to be learnt, rejected to be learnt or one-off approval.

4 Results and Discussion

The initial results were represented graphically (see Figure 2 and 3) with the aid of visual elements to enhance the understanding of patterns, outliers and trends in the data. Data can be visualised using plots, graphs, charts, maps, histograms etc. The essence of visualisation is to illustrate knowledge in the data that are complex to explain the words or identify in tables or the raw form of the data, making it easier to quickly understand the information presented. To visualize the data in this study, Python Matplotlib and Seaborn libraries were used. The data was visualised in univariate plots (visualizing using just one variable), bivariate analysis (visualizing or plotting the relationship between two variables) and multivariate visualisation of all the features in the datasets simultaneously. These visualisations were generated from the data after some initial preprocessing activities.

4.1 Univariate Categorical Visualisation

Figure 2 is the distribution of 'Weekday_Appr_Process_Start', and it shows that the count per day of the week for when transactions approval process started.

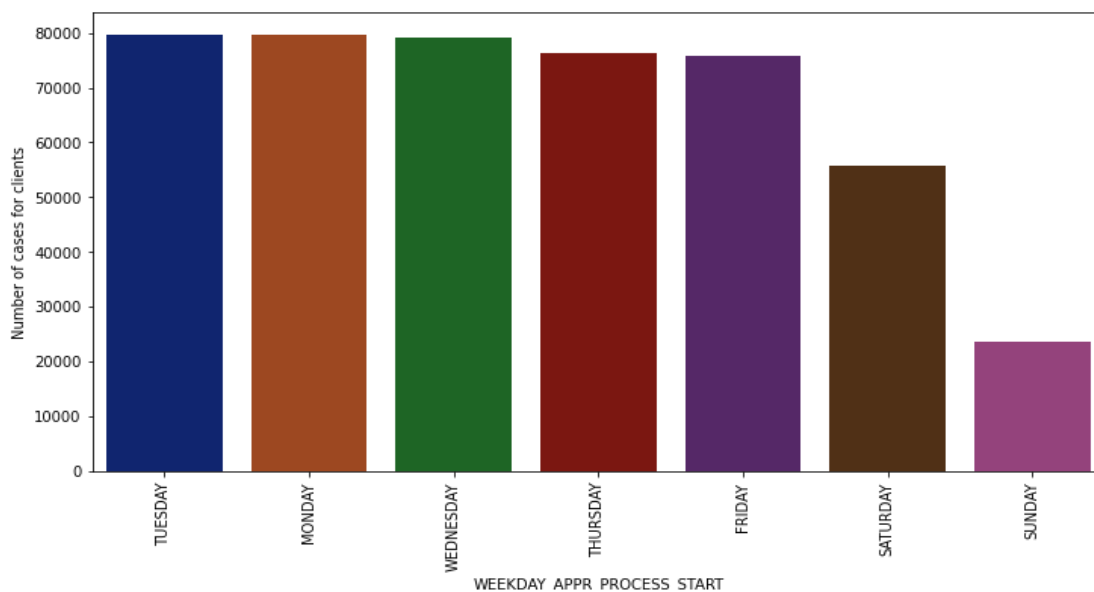


Figure 2: Distribution of WEEKDAY_APPR_PROCESS_START

The days with the highest counts are Tuesday (79,725), Monday (79,651) and Wednesday (79,163) in this order while bottom two are Saturday (55743) and Sunday (23594). From the trend in the distribution, the counts per day reduces as the weekend days approach.

Figure 3 is the distribution of the purpose for which the cash loan is being applied for and from the chart, it is seen that XNA has the majority of the purpose for loan application with other purpose significantly lower in count like repairs, other, urgent needs, buying a used car, building a house, everyday expenses, medicine, payment for other loans, education et cetera. Others, purposes such as refusal to name the goal, money for a third person, hobby, buying a garage, gasification/water supply and so on were not visible at all on the chart.

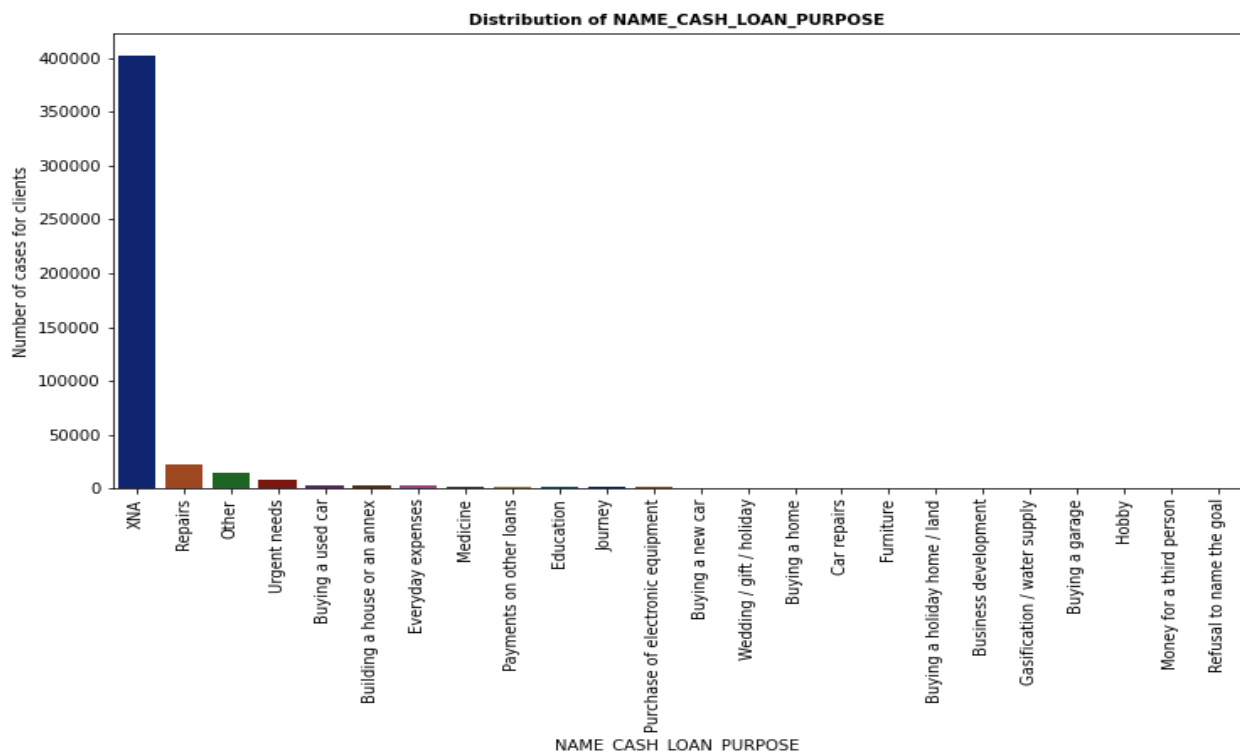


Figure 3: Distribution of Cash Loan Purpose

4.2 Univariate Continuous Analysis

Figure is the distribution of Annuity Amount for each clients. It shows a normal distribution where the annuities spread between 0 and about 400,000. However, the significant counts are distributed between 0 and 100,000.

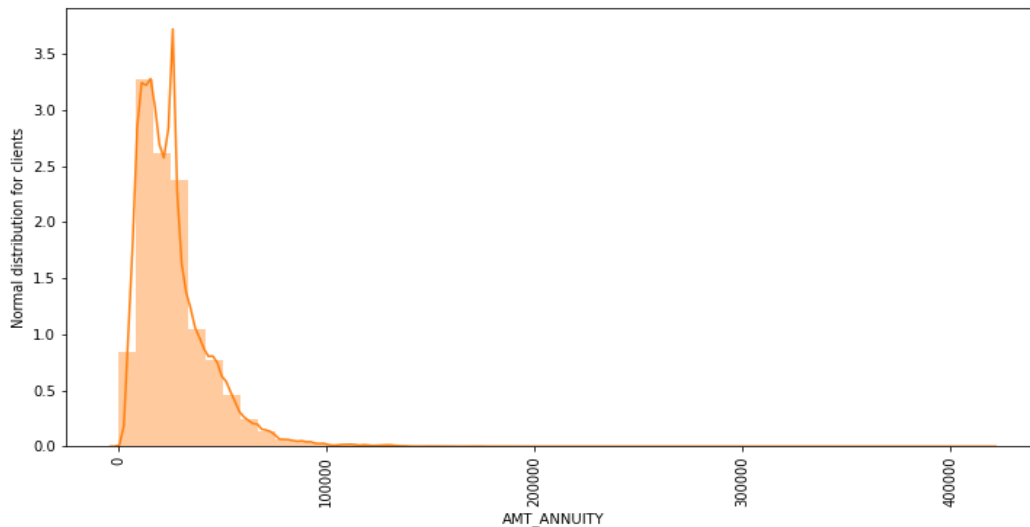


Figure 4: Distribution of Annuity Amount

5. Evaluation

This section contains the main evaluation metrics for a classification algorithm, which are Precision, Recall, Accuracy and F1-Score both in micro and macro averages. The following Tables 1 to 2 shows the classification report of the classifiers developed in this study.

Table 1: Classification Report of Support Vector Machine (Oversampled Data)

	precision	recall	f1-score	support
Accept	1.00	0.93	0.96	4025
Refuse	0.93	1.00	0.96	3975
accuracy			0.96	8000
macro avg	0.97	0.96	0.96	8000
weighted avg	0.97	0.96	0.96	8000

Table 2: Classification Report of Support Vector Machine (Undersampled Data)

	precision	recall	f1-score	support
Accept	0.93	0.93	0.93	3967
Refuse	0.93	0.93	0.93	4033
accuracy			0.93	8000
macro avg	0.93	0.93	0.93	8000
weighted avg	0.93	0.93	0.93	8000

The metrics described in the classification report in Tables 1 to 2 include precision, recall, f1-score and accuracy.

Precision: This is simply a measure of how many true positive predictions were made out of all the positive predictions. In other words, it measures how many of the refused cases predicted were truly refused. **Error! Reference source not found.** to 4 shows the mathematical formula for Precision, Recall, F1-Score, and Accuracy respectively.

$$Precision = \frac{TP}{TP + FP} \quad (1)$$

Recall: This is a measure of the number of true positive out of the number of total actual positives. In the light of this work, it measures number of correctly classified refused cases out of all the actually refused cases in the dataset. **Error! Reference source not found.** shows the mathematical formula for Recall Equation.

$$Recall = \frac{TP}{TP + FN} \quad (2)$$

F1-Score: This measures the harmonic mean of both recall and precision. **Error! Reference source not found.** provides the mathematical formula to calculate the F1-Score Equation.

$$F1 - Score = \frac{Precision * Recall}{Precision + Recall} \quad (3)$$

Accuracy: This measures the total number of correct predictions for both positive and negative cases out of the total number of cases. In other words, the number of correctly classified refused and approved cases out of all the data points presented. **Error! Reference source not found.** provides the mathematical representation for Accurate Equation.

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} \quad (4)$$

5.1 Area Under Curve-Receiver Operating Characteristics (AUC-ROC) Curve

AUC-ROC is an acronym for Area Under the Curve-Receiver Operating Characteristics Curve. It is one of the most important evaluation metrics for checking the performance of a classification model at various threshold settings. While the Area Under the Curve represents the degree of separability, the Receiver Operating Characteristics is a probability curve. The AUC helps to understand capability of the model in distinguishing between the target classes. That is, the higher the AUC the better the distinguishing ability of the model. To obtain the ROC curve, the True Positive Rate (sensitivity) is plotted on the y-axis against the False Positive Rate (1 - Specificity) on the x-axis. The AUC-ROC curve plots for the different models built with different versions of the data are on the right column of Table 3. The SVM model has 96% accuracy, which is the highest percentage of AUC obtained among the models trained.

Table 3: Macro Average Summaries

S/N	Algorithm (Clean Data)	Precision	Recall	F1-Score	Accuracy	AUC-ROC
Clean Original Data						
1.	Decision Tree	0.92	0.92	0.92	0.93	0.92
2.	Support Vector Machine	0.94	0.96	0.95	0.95	0.96
3.	Naïve Bayes	0.94	0.96	0.95	0.95	0.96
Oversampled Data						
1.	Decision Tree	0.94	0.94	0.94	0.94	0.94
2.	Support Vector Machine	0.97	0.96	0.96	0.96	0.96
3.	Naïve Bayes	0.97	0.96	0.96	0.96	0.96
Undersampled Data						
1.	Decision Tree	0.93	0.93	0.93	0.93	0.93
2.	Support Vector Machine	0.93	0.93	0.93	0.93	0.93
3.	Naïve Bayes	0.97	0.96	0.96	0.96	0.96

Macro average values are averages of the performance metrics for the two classes for each of the models developed. It shows the performance of the system on the overall considering all the classes that were predicted. Table shows the summaries and the AUC-ROC scores.

From the macro average summaries Table 3, it can be deduced that the decision tree algorithm performed worse for all the metrics and on all the data samples, while the support vector machine and the naïve Bayes jointly performed better on all the metrics and data samples. It was also observed that all the algorithms performed better learning from the oversampled data. Except that both decision tree and support vector machine had same performance on the under sampled data with naïve Bayes outperforming them, but not any better than the performance of the oversampled data. Therefore, the support vector machine model is chosen as the loan classifier to be deployed and used in the system

In the case of the loan classifier, the aim is to try to minimize the number of errors in the prediction results for the refused applications. The errors are on the anti-diagonal cells of the confusion matrix. Because we can infer that being wrong about approving an application that should have been refused is far worse than being wrong about refusing or rejecting an application that should have been approved. In other words, predicting a transaction as refused when it is actually to be approved is not as risky as predicting an application as approved when it is actually meant to be refused or declined. So, using accuracy as the only classification criterion may be considered insufficient. Therefore, for the SVM classifier, the criterion will consider recall, precision, on the refused applications more important than the general accuracy even though the accuracy of the model is also tested.

6. Conclusion

In this study, the concept of interactive machine learning was studied and the review identified two gaps. One of which is the basis of this work – verifying the validity of data points or feature feedbacks before applying them as update to the lifelong learning model to avoid misleading the learning model being misled, because a model is only as good as the data with which it was built. The data used in the work is a multivariate and imbalanced dataset from a loan offering financial institution. Exploration and other machine learning preprocessing activities were done on the data to decide the choice of models.

The model built from the experiments was evaluated using standard machine learning evaluation metrics which include precision, recall, accuracy, area under the curve (AUC) and was also benchmarked against other models built with different algorithms. Results of the experiments shows that SVM model *has* 96% accuracy which is the highest percentage of AUC obtained among the models trained. Further research in the area of interactive machine learning can be done to standardise the evaluation of iML systems across different fields. There is also a need to understand the impact of interaction on user's level of trust of the model built. The model developed can be incorporated into loan administration system in order to speed up and leverage artificial intelligence in loan application review and increase customer satisfaction.

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Feature Selection Strategies for Enhancing the Accuracy for Detecting Polycystic Ovary Syndrome (PCOS) Health Problem

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Abstract.

A hormonal condition called Polycystic Ovarian Syndrome (PCOS) results in larger ovaries with tiny cysts on the margins. Although the exact etiology of Polycystic Ovary Syndrome is unknown, it may be a result of both hereditary and environmental factors. One of the endocrine diseases that most frequently affect women of reproductive age is Polycystic Ovary Syndrome (PCOS). Artificial intelligence (AI)-based machine learning models has the capacity to classify and predict the potential for PCOS condition. The dataset used in this study was obtained from Kaggle repository which consists of 45 features (attributes) and 541 data points. This dataset was balanced using the Synthetic Minority Oversampling Technique (SMOTE) and features were selected by employing firefly and fruitfly optimization algorithms. The firefly optimized algorithm with Random Forest obtained an accuracy score of 95.205% with 18 selected features. The KNN with firefly algorithm used 13 features and obtained an accuracy of 91.096%. The SVM with firefly algorithm uses 14 features and obtained an accuracy of 93.151%. The fruitfly algorithm with KNN, SVM and RF obtained and accuracy of 86.986%, 90.411% and 93.151% respectively.

Keywords: Data balancing, Firefly, Fruitfly, Polycystic Ovary Syndrome, Synthetic Minority Oversampling Technique.

1. Introduction

The failure of the ovary to release the egg is referred to as infertility. One of the many causes of infertility is the development of an unusually high volume and number of follicles during the ovulation phase, which is thought to be the first sign of Polycystic Ovarian Syndrome (Alamoudi *et al.*, 2023). Polycystic Ovarian Syndrome (PCOS) is a hormonal disorder causing enlarged ovaries with small cysts on the outer edges. The cause of Polycystic Ovary Syndrome is not well understood, but may involve a combination of genetic and environmental factors. One in ten women of reproductive age may have Polycystic Ovary Syndrome (PCOS), a hormonal disease. When a woman's ovulation is inconsistent or nonexistent, this condition is suspected. An excess of androgen is what defines PCOS both biochemically and clinically (Bharati *et al.*, 2022).

Ovarian dysfunction and an excess of androgen are the two main signs of PCOS. Many factors are thought to cause this syndrome, including genetics, puberty, physiological changes, mental state, and environmental influences. Menstrual abnormalities, hirsutism, obesity, insulin resistance, and cardiovascular disease are all common among PCOS patients (Lv *et al.*, 2022).

In order to overcome this difficulty, some clinical methods, including in vitro fertilization (IVF), have been created and used. Infertility has become a global health concern due to the rising

number of couples seeking in vitro fertilization (IVF) worldwide, which highlights how devastating the problem is. Some couples still have no children even after numerous IVF cycles due to misdiagnosis. IVF for women entails increased risks and expenses. One of the most common disorders affecting premenopausal women is Polycystic Ovary Syndrome (PCOS), a complicated condition with a variety of phenotypes that involves abnormalities in metabolism, reproduction, and endocrine function (Hussein & Karami, 2023). However, many research efforts have been focused on exploitation of the most cutting-edge technology in order to assure precise and proper identification of the illness indicators.

An innovative use of these technologies is machine learning models based on artificial intelligence (AI), which have the potential to categorize and forecast the possibility of PCOS condition. Examples of these models include Support Vector Machine (SVM), K-Nearest Neighbour (KNN), Random Forest (RF), Logistic Regression (LR), Naïve Bayes (NB), Multi-Layer Perceptron (MLP) and XGBoost (Denny *et al.*, 2019 ; Liu *et al.*, 2020 ; Hassan & Mizra, 2020 ; Nilofer & Ramkumar, 2021 ; Madhumitha *et al.*, 2021; Inan *et al.*, 2021). Of course, many researchers in this field have made several efforts to use these models to effectively identify the condition based on the available dataset. However, the level of accuracy has been limited and warped as a result of the unbalanced nature of datasets or a lack of resilience in carrying out the feature engineering process effectively. In support of this advancement, Nandipati *et al.*, (2020) used SMOTE as a data sampling approach. On the aforementioned datasets, seven machine learning (ML) techniques were employed to evaluate the performance of the classifiers, followed by five feature selection methods from Python (Spyder as an IDE) - Scikit Learn package and RapidMiner. Despite the many techniques utilized, Random Forest (93.12%, RapidMiner) has the highest accuracy with the entire dataset. KNN and SVM, on the other hand, exhibit comparable accuracy (90.83%, RapidMiner) with 10 selected characteristics.

Furthermore, based on literature there are other feature engineering techniques that could be used. Feature engineering techniques can be feature selection, feature extraction or data preprocessing. The process of selecting which relevant characteristics and qualities to include in predictive modeling, as well as which ones to leave out, is known as feature selection (FS). It is an essential task that supports machine learning classifiers in lowering error rates, processing time, overfitting, and enhancing classification accuracy (Alyasiri *et al.*, 2022). Finding the most pertinent features from provided data with a broad feature space is the process of feature selection (Bashir *et al.*, 2022).

Yang introduced the Firefly algorithm in 2008 as a Meta-heuristic, biologically inspired swarm intelligence. The flashing activities of the firefly population serve as attracting partners, communication, and warning from predators. Based on previous work, Aziz *et al.* (2015) developed the Firefly algorithm, which was inspired by the flashing light of a firefly. This flashing light aids in luring prey or a mate. Yang built classic FA using attraction behavior. There is a collection of preliminary solutions obtained from the population. Every firefly has the potential to be useful in the search space. Consider the following: 'N' is the population size, and X_i is the i th population solution with $i = 1, 2, \dots, N$. Light intensity (I) decreases with increasing distance (Maheswari *et al.*, 2020).

The LF strategy approach can ensure algorithm diversity during the optimization process and boost the convergence rate. The modified FOA approach, LFFOA, was used to optimize the

two important parameter pairs in the ANN method, including weight and bias, and achieve the best model (Nilofer & Ramkumar, 2021).

This manual counting may lead to problems of variability, reproducibility and low efficiency. Automating this mechanism will resolve these problems. The objective of the present work is to propose an automated ovarian classification method for classifying an ovary as normal or not in an ovarian ultrasound image by using the fruit fly and fire fly based feature selection technique. Therefore, the remaining sections of the research are organized as follows: section 2 presents the account of the related works, and the proposed methodology is presented by section 3. Others are results discussion and conclusion, which are presented by sections 4 and 5 respectively.

2. Related Works

Enormous attempts have been made to diagnose and examine ailments utilizing diverse classical machine learning models and feature engineering techniques. This section provides an extensive review of effort made in this field to identify the contribution of this investigation with PCOS diagnosis perspective. To this end, the literature of Sreejith *et al.*, (2022) aims to create a classification framework for the creation of a clinical decision support system that will help doctors keep track of PCOS. The selection of features was done via a wrapper method which comprises of Red Deer Algorithm (RDA) and a RF classifier. The RDA was used by the researchers to identify the best characteristics, and the random forest classifier was used to assess them. From the Kaggle repository, a total of 541 data points with 37 instances were obtained. The preprocessing subsystem uses the z-score statistical measure to deal with outliers and noise that are present in the dataset. The evaluation matrices used in this study are accuracy (89.81%), specificity (90.43%) and sensitivity (89.73%).

The research by Dutta *et al.*, (2021) aims to identify and predict PCOS using SMOTE and classical machine learning models. A total of 541 items with 14 attributes from the UCI collection was obtained. This study employed five machine learning models (RF, LR, DT, SVM, and KNN). Principal Component Analysis (PCA) was employed as the feature extraction technique. Standard scalar preprocessing was utilized to prepare the data, and SMOTE was employed as the optimization method. In terms of accuracy, training time, F1 score, recall, prediction, and area under the ROC, the SMOTE-based LR scored best (97.11%, 0.010 sec., 98%, 98%, 98%, and 95.6%).

By prioritizing the most promising oocyte for implantation and evaluating the ability of follicular fluid (FF) Raman Spectra to predict oocyte development and pregnancy outcome, Huang *et al.*, (2021) want to lessen the physical and financial constraints that PCOS patients experience. Artificial neural networks were used in this study as the machine learning method. Between October 2017 and December 2019, 300 participants (150 without PCOS and 150 with PCOS) who underwent in vitro fertilization (IVF) at Shanghai First Maternity and Infant Hospital were enrolled in the study. The feature extraction method used in this investigation was an unsupervised Principal Component Analysis method. Additionally, Raman Spectroscopy was used in conjunction with multivariate statistical techniques by the researchers to identify metabolic alterations in FF from PCOS-afflicted women. The machine-learning algorithms using the fully connected artificial neural network (ANN) properly assigned oocyte developmental potential and clinical pregnancy based on the Raman spectra of PCOS FF with overall accuracies of 90% and 74%, respectively.

The work of Prapty & Shitu,(2020) aim at detecting the presence of PCOS in a patient by developing an efficient decision tree. The researchers employed four different traditional machine learning models in this study which are SVM, RF, KNN and Naïve Bayes classifiers. A total of 542 dataset with 31 features was obtained from ten different hospitals out of which 177 patients are PCOS positive and 365 patients are PCOS negative. The Principal Component Analysis (PCA) was employed as the feature selection technique in this study. Out of these algorithms Naïve Bayes and Random Forest performed best with accuracies of 93% and 93.5% respectively.

Due to the bad effects of PCOS in women infertility, Thomas & Kavitha, (2020) aim to identify PCOS before it worsens. Doctors from several clinics and hospitals in and around Thodupzha Municipality provided the clinical diagnostic and prescription for this study. The Nguyen-Widrow initialization strategy was adopted by the researchers as their optimization method since it boots the weights and biases of each layer. Additionally, MATHLAB R2018a was used as the tool for data mining together with NB, ANN, and a hybrid of the two classifiers. In terms of accuracy (95%), recall, and f-measure, the hybridized classifier fared better than the NB and ANN.

Thufailah *et al.*, (2018) research aims to use ultrasound scans to classify PCOS using Elman Neural Network (ENN). PCO and non-PCO were categorized using SVM and ENN. The feature extraction approach employed was the Gabor wavelet method. Gray scalability, histogram equalization, picture binarization, morphology, invert image, and data cleaning were used for data preprocessing. The Canny operator was used to segment the image into its component parts for edge detection and follicle cutting. It may be inferred that the Gabor wavelet's extraction results utilised 16, 24, and 32 features. The feature set examined three different settings (layer delays, hidden sizes, and training function). For 16, 24, and 32 features, the accuracy of the set data is 68.8%, 66.7%, and 78.1%, respectively.

There are many features which helps in determining the PCOS status of a patient to this end, Nandipati *et al.*, 2020 discover which machine learning model is more effective at detecting the PCOS disease, as well as the features that contribute to the disease's prognosis. In this study a dataset with a total of 541 from surveys, doctor consultations, and clinical examinations was taken into account. Eight features were taken from a total of 23 features, which included clinical and metabolic data using SPSS V.2.0. KNN, SVM, RF, NB, NN, Bagging and Adaboost are the seven machine learning models used in this study to assess the disease. For Rapidminer's accuracy (93.12%), random forest performed best. The data were preprocessed using Synthetic Minority Oversampling Technique (SMOTE).

In conclusion, the suggested PCOS data prediction is promising based on the relevant literature evaluated in this study, since the accuracy result outperforms the related literature of the same dataset and those with close range.

3. The Methodology

This study used multi-stage strategy which started from data collection to model optimization. The dataset utilized in this experiment was obtained from the Kaggle repository, in accordance with the suggested methodology as shown in Figure 1, and it is the same dataset used in the research of Nandipati *et al.*, (2020) It is evident from prior studies that researchers and physicians use various disease datasets to evaluate machine learning classification algorithms, much like the PCOS dataset. The original PCOS dataset consists of 541 instances

with 42 attributes, including one attribute for the patient file number (which is ignored during data analysis). Finally, there are 41 attributes in all, with 40 of them being input attributes and PCOS serving as a class label [Positive (Yes) and Negative (No)]. The dataset demonstrates the unbalanced nature of the class labels (364 instances of class label = 0 and 177 instances of class label = 1) and missing values.

Due to the imbalanced nature of the data set SMOTE oversampling technique was employed to balance the dataset. Data preprocessing is necessary, including data cleansing, data scaling, and data balancing. Inconsistencies, missing values, and extraneous variables like patient file number and patient ID are removed from the dataset as part of the data cleaning process because they have no bearing on determining PCOS status. The conversion of some features' non-floating values into floating point values is similar. This is done to make sure that the highly scattered floating-point values in the data are scaled to match the value of the features. For this stage of the process, the Min-Max Scaling (value between 0 and 1) technique is used.

$$\text{Scaled\_value} = (X - \text{Min}) / (\text{Max} - \text{Min}) \quad (1)$$

Where, X is the original value of the data point.

Min is the minimum value of the features in the dataset.

Max is the maximum value of features in the dataset.

This research uses the Synthetic Minority Oversampling Technique at this phase to balance the data before features are chosen. With this method, data samples can be generated for the minority class (the "Yes" class). As a result, with 364 samples from each class, both classes would have the identical collection of data points. More importantly, the lack of balance across the data classes would make it difficult for the firefly and fruitfly algorithms' feature selection techniques to function correctly.

The feature selection process includes selection of essential features or attributes that have high contribution to the final prediction class. Therefore, in this study Fruitfly and Firefly Optimization techniques were considered. The firefly algorithm is first used to pick key features from the raw dataset by assigning a penalty score or threshold to each feature. Similar to how the optimal feature for a dataset with numerical input and output were chosen, it might utilize the Fruit Fly feature technique. It is used to choose the best features that can forecast the output, or dependent variable. Finally, the datasets preprocessed and chosen features are divided into training and testing sets in proportions of 80% to 20% for the purposes of training and evaluating the model, respectively. While the testing data is analyzed using the metrics of accuracy, precision, recall, and f1-score, the training data is supplied into the classifiers.

Google Colaboratory forms the experimental environment for the implementation of this methodology. It is crucial to note that the goal of this research is to increase the PCOS model's accuracy by using optimization strategies for feature selection. This is better represented by the flow chart below.

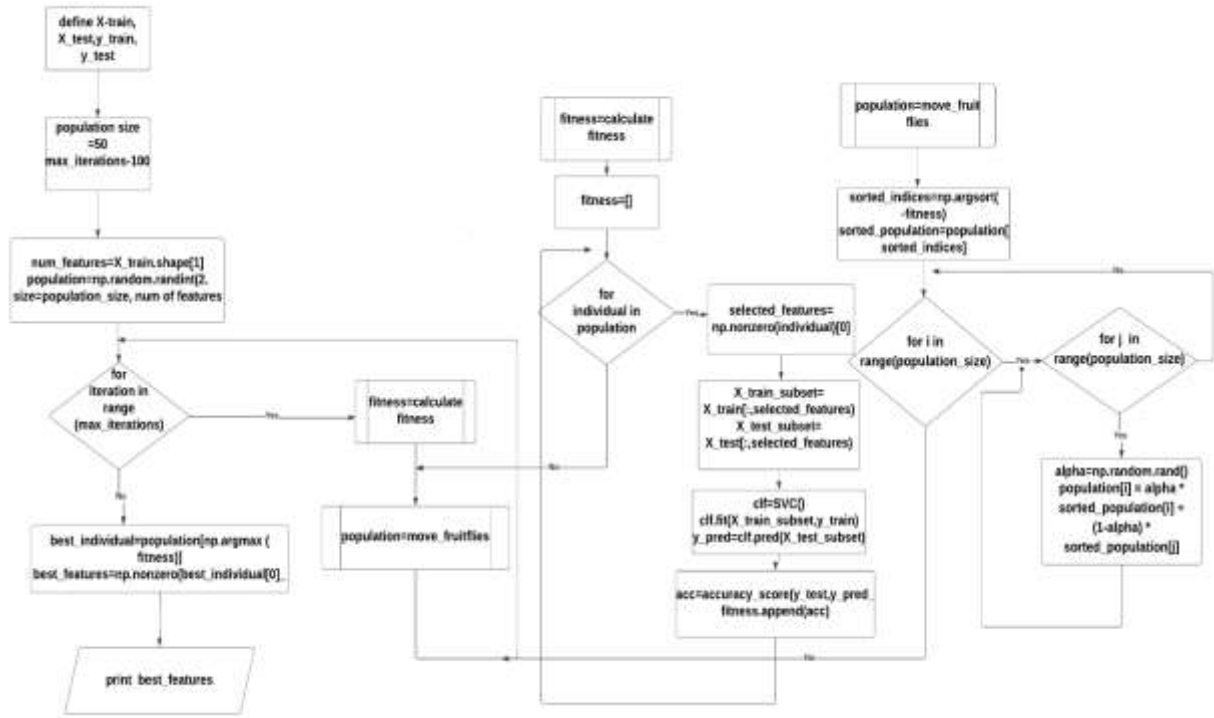


Figure 1 : Fruitfly Optimum Feature Subset Flowchart

Where:

Population_size: Number of fireflies (individuals) in the population.

Max_iterations: Maximum number of iterations the algorithm will run.

Alpha: The initial attractiveness coefficient for the movement of fireflies.

Beta: Coefficient for determining the attractiveness of brighter fireflies.

Gamma: Coefficient controlling the light absorption rate (distance influence).

Min_alpha: The minimum number of which alpha will be decayed over iterations.

The population of fireflies is initialized randomly with binary values (0 or 1), where each bit represents whether a specific feature is selected or not. The calculate_fitness module in the flow chart calculates the fitness (accuracy) of each firefly's feature selection using a machine learning (ML) support vector classifier (SVC) model. It trains specific ML model on the selected features and calculates the accuracy on the test data. The move_fireflies module in the flow chart implements the movement of fireflies towards brighter fireflies. It initializes the population, iteratively calculates the fitness and moves the fireflies. The alpha value decays over iterations to control the exploration-exploitation trade-off. After the algorithm finishes running, it selects the best individual (firefly) based on the highest fitness and returns the selected features as best_features.

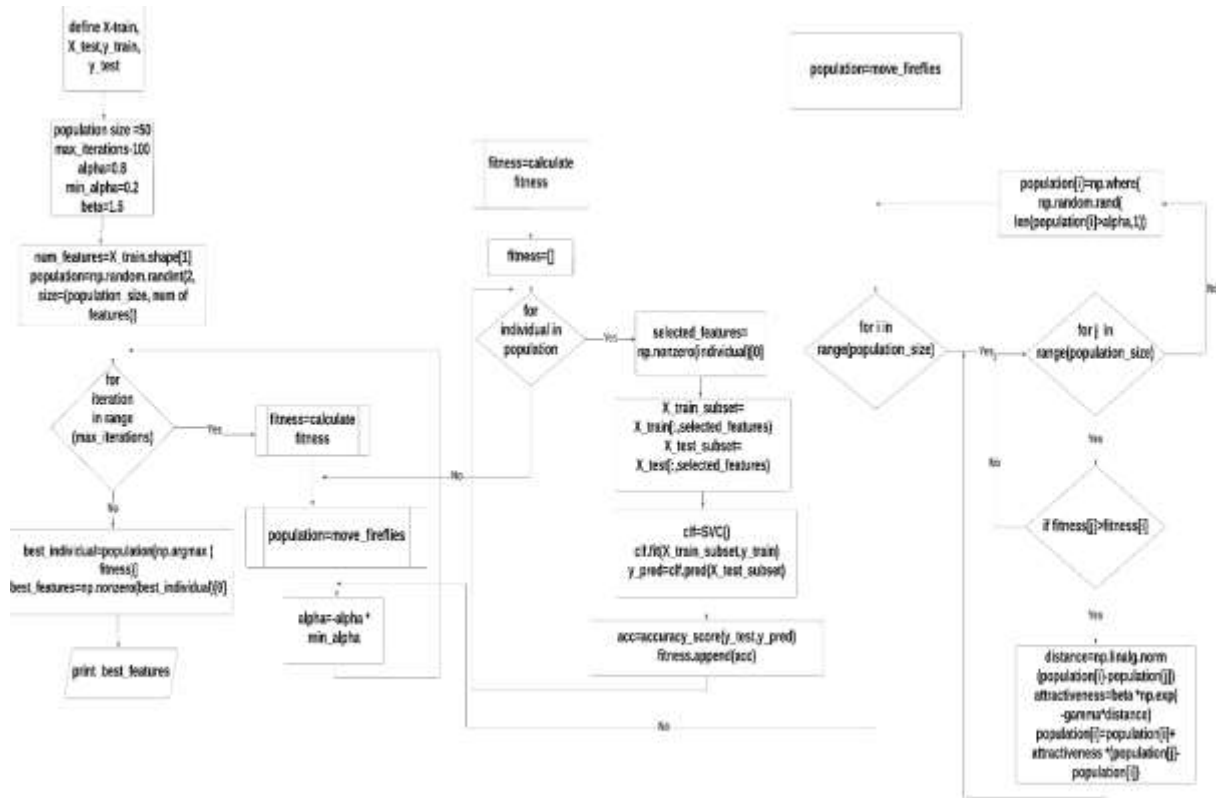


Figure 2 : Firefly Optimum Feature Subset Flowchart

Population_size : number of fruitflies (individuals) in the population.

Max_iterations: Maximum number of iterations the algorithm will run.

Num_features: The total number of features available in the dataset.

The population of fruitflies is initialized randomly with binary values (0 or 1), where each bit represents whether a specific feature is selected or not. The calculate_fitness module in the flow chart calculates the fitness (accuracy) of each fruit fly's feature selection using a ML (SVC) model. It trains the specific ML model on the selected features and calculates the accuracy on the test data. The move_fruitflies module performs the movement of fruit flies in the population based on their fitness. It sorts the fruit flies based on their fitness (accuracy), and then each fruit fly moves towards the more fit ones. When the fruit fly algorithm is used for feature selection. It initializes the population, iteratively evaluates fitness, and updates the position of fruit flies. The algorithm repeats this process for the specified number of iterations. After the algorithm finishes running, it selects the best fruit fly (individual) and returns the selected features as best_features.

4. Result and Discussion

The selected optimized feature subsets provided from these algorithms are used as input features into three different machine learning models namely KNN, SVM and RF. The key model performance metric used for comparison across the three different ML algorithms is the accuracy score. The study spans across seven main sections starting with data source, data analysis, data preprocessing, data balancing, feature selection, model building and model optimization.

There was an invalid value of 'a' in one of the numerical columns and it was cleaned by replacing with the mean of the data values in the column. Also, there was a data column with an invalid value which was fixed by replacing with the corresponding valid float value. The Feature engineering technique applied on the dataset include Data balancing using oversampling of the minority class (class 1: PCOS positive patients) by the synthetic minority oversampling technique. The number of PCOS positive patients is 177 while for negative patients is 364, which infers the need to balance the dataset in order to avoid model bias during training. Another feature engineering technique that was leveraged is feature scaling on the numerical features using Normalization technique to bring the values between 0 and 1 as the units of the numerical columns were in different ranges.

The feature selection is done with aid of the fruitfly and firefly algorithms. Fruitfly algorithm works by representing a subset of features as a position in a search space. Fruitfly agents then move within this search space, where the movement is influenced by the fitness (quality) of the solution they represent. Firefly is inspired by the flashing behavior of fireflies, where the brightness of a firefly attracts other fireflies. The algorithm aims to find the most relevant features by simulating this light attraction behavior. The selected features are then passed into the three different ML algorithms used in this research. The table below summarizes the results obtained in terms of the precision, recall, accuracy and F1 score. Training and testing were done with the balanced dataset with 80% as the training dataset and 20% as the test dataset.

Table 1: Model Result Comparison

Optimization Algorithms	Firefly Algorithm			Fruitfly Algorithm		
Machine learning Algorithms	KNN	SVM	RF	KNN	SVM	RF
Accuracy	91.096	93.151	95.205	86.986	90.141	93.151
Precision	91.107	93.151	95.277	86.988	90.434	93.188
Recall	91.096	93.151	95.205	86.986	90.141	93.151
F1-Score	91.097	93.151	95.201	86.983	90.406	93.152

As shown in table 1, for all three ML algorithms experimented with, the firefly algorithm was a better feature selection tool than the fruitfly algorithm as it has shown significant higher performance across the used performance metrics in comparison to the fruitfly algorithm. The firefly optimized algorithm with Random Forest gave the accuracy score of 95.205%. With reference to the bench paper, highest accuracy for KNN (90.83%) was obtained using RapidMiner algorithm with 10 features selected, while the KNN with firefly algorithm uses 13 features and obtained an accuracy of 91.096%. With regards to the SVM algorithm, the highest accuracy for SVM (90.83%) was obtained using RapidMiner algorithm with 10 features selected, while the SVM with firefly algorithm uses 14 features and obtained an accuracy of 93.151%. With regards to the RF algorithm, the highest accuracy for RF (93.12%) was obtained

using RapidMiner algorithm with the complete dataset, while the SVM with firefly algorithm uses 18 features and obtained an accuracy of 95.205%. It can be inferred that the ML algorithms combined with the firefly algorithm have surpassed the corresponding counter parts in the bench mark paper.

Table 2: Selected Number of Features by Firefly and Fruitfly Algorithms

Optimization Algorithms	Firefly Algorithm			Fruitfly Algorithm		
Machine learning Algorithms	KNN	SVM	RF	KNN	SVM	RF
Number of Features	13	14	18	22	11	21

Table 2 summarizes the numbers of features selected by the fruitfly and firefly algorithms. The lowest number of features selected was 11 by the fruitfly algorithm using the SVM model while the highest number of features selected was 22 by the fruitfly algorithm using the KNN model. There were two relevant features selected by the two optimization algorithms for all the three ML algorithms used which are the TSH (mIU/L) and Follicle No. (R). There are also other significant features like Skin darkening, No.of abortions, Fast food and endometrium.

The line graph below summarizes the performance metrics for the three different ML algorithms categorized by fruitfly and firefly optimization technique.



Figure 3: Performace matric linegraph

5. Conclusion

It is undeniable that ongoing attempts have been made in recent years to improve the accuracy of PCOS data based on machine learning techniques. That does not, however, exclude future efforts to raise the accuracy. In light of this development, the goal of this research is to rigorously evaluate the proposed multi layers methodology in order to increase

the precision of PCOS's data prediction model. The approach is divided into seven parts, starting with the data source, exploratory data analysis, data preprocessing, data balancing, feature selection, model training and model evaluation. The comma separated value dataset is imported via Google Drive after being downloaded from the Kaggle repository. It initially included 541 datapoints and 45 features. The data was scaled using the minmax scaling method, and the synthetic minority oversampling technique was also used to balance the classes. The combination strategy for efficient feature selection utilized Fire Fly and Fruit Fly optimization techniques.

More so, owing to the sizeable numbers of learning models that the benchmark research had earlier employed, which include SVM, KNN, RF the proposed model of this research was trained based on fruitfly and firefly algorithms. The result of accuracy of RF with firefly performed best with an accuracy of 95.20%. However, this research experiment is still work in progress; interested researchers could in future, consider rule-based models and/or combination to test the results.

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An Xray on the Challenges of Blended Learning in Educational Management: Teachers Perspective

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Abstract

There has been a great improvement in the learning method used to ensure all student needs are catered for over the years. The combination of various learning methods better defined as blended learning is being practiced to ease the learning process. Blended Learning includes student-centered environment, independent learning, peer learning, collaborative learning and reflective thinking. This paper investigates the challenges that blended learning imposes in the management of education from a teacher's viewpoint and further offers strategies on addressing these challenges. The quality design of instructional materials and activities is an important role to be implemented by teachers; if the quality is questionable, it can easily lead to the down flow of learning and easily turn into one of the challenges. . The study employed an in-depth literature review in order to dig deep into the various hindrances of blended learning in educational management and proffered solutions to them. The study identified some challenges and proposed achievable solutions that policymakers, educators and school administrators can implement to ensure success in blended learning. The research further encourages on a continuous exploration and dedicated researches in implementing various strategies used world wide that have been proved effective.

Keywords: Blended learning, teachers, students, technology, skills

1. Introduction

One of the most significant developments in the educational landscape is the emergence of blended learning. This pedagogical model seamlessly integrates both online and face-to-face learning experiences, offering a promising potential for enhancing student learning and engagement. As a result, blended learning is being increasingly adopted in the field of educational management. Throughout the advent of digital technologies, the prevalence of blended learning in educational management has grown exponentially. By seamlessly integrating traditional classroom teaching methods with online education, blended learning offers a unique hybrid educational experience (Rodriguez and Martinez, 2015). Its growing adoption is driven by the vision of creating more diverse and enriching learning opportunities for students.

Although blended learning offers a promising educational landscape, its implementation poses various challenges, particularly for teachers. Thompson and Davis (2017) noted that gaining a deeper understanding of these challenges contributes to the ongoing digital transformation in education and aids in the development of comprehensive strategies to facilitate a smooth transition. Examining the challenges posed by blended learning from the perspective of teachers becomes vital in ensuring its success. Teachers play a crucial role in this model, but they face various obstacles in adapting their teaching practices, dealing with technical issues, and managing their professional development. Understanding these challenges is imperative for improving the effectiveness and long-term viability of blended learning.

Blended learning is used to describe learning that mixes various event-based activities: self-paced learning, live e-learning and face-to-face classrooms. Self-paced learning is what the

learner does by executing the e-learning process. Self-paced activities can be taken at the learner's leisure irrespective of time and place. The important thing these days is not only to access knowledge but timely access of relevant and interesting knowledge. The value of self-paced learning is not only that it can reach everyone at anytime and anywhere, but that it can teach the learner appropriately, providing the right skills at the right time. Live e-learning takes place in a virtual classroom at a scheduled time at which learner undertakes to attend. Thus, enable learners to collaborate with one another, share ideas, and ask questions in real time.

Higher education in the 21st century aims to achieve three goals: to develop the activities of specific knowledge in the major disciplines, to promote the development of essential generic skills and to stimulate the reflection of the lessons learned in the application of everyday life (Halverson, Graham, Spring, Drysdale & Henrie, 2014). For Naaj, Nachouki and Ankit (2012), ideal learning environments should address individual differences, motivate students, avoid information overload, create a real-life context, drive social interaction with practical activities, and drive reflection.

Many educators recommend the importance of making adjustments in the curriculum to keep up with the age of computer and information technology. However, according to progress Mirza (2016), there is no agreement on the type and amount of the required modification. Most parents, students and teachers believe that the preparation of young generations and arming them with the basics of computer science and use is the most appropriate way to rehabilitation. So, they can stay in the changing world; the prevailing viewpoint in the developed societies is that the school has no choice but to adapt to the information age because this adjustment has become necessary for the continued survival and progress (Mirza, 2016).

Given the low basic level of blended learning in educational management techniques used for these targets, the study problem was identified through searching for the effectiveness of the blended learning in educational management by developing the achievement of students through the help of the teacher. The most significant challenge faced by people developing and delivering blended learning in Educational Management is identifying the instructional strategies that match well with the conditions that are present in these two quite different environments. This challenge is complex because it relates to achieving the right blend, both from a learning and cost-effective point of view of teachers. Therefore, this study explored challenges of blended learning experienced by educational managers. This study conducted a literature review that focuses on identifying and explaining the challenges encountered by educators when implementing blended learning. The insights gained from this review will be crucial in providing guidance to policymakers and educational institutions, helping them enhance the overall experiences and outcomes of blended teaching. Furthermore, the questions that will be answered in this study are as follows:

- What are the primary challenges teachers experience when implementing blended learning?
- How do these challenges influence the learning outcomes of students?
- What effective strategies can be employed to overcome these challenges?

2. Literature review

Blended learning is a pedagogical approach that combines traditional face-to-face

instruction with online learning activities and resources. It offers a flexible and personalised learning experience, allowing students to engage with course content and interact with classmates and instructors both in physical and virtual environments (Smith & Johnson, 2019). Blended learning typically involves a mix of in-person lectures, discussions, and activities, as well as online components such as multimedia materials, discussion forums, and virtual assignments (Brown & Jones, 2018).

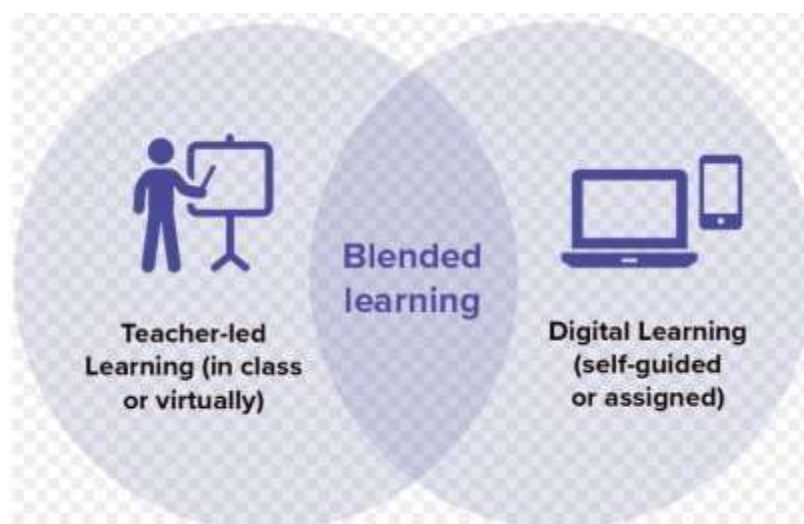


Fig 1.1 blended learning

Blended learning, also known as hybrid learning, is an innovative approach that combines traditional face-to-face classroom instruction with online learning activities. It seeks to leverage the benefits of both physical and virtual learning environments, providing students and teachers with a more flexible and personalised learning experience. Blended learning in educational management has gained significant attention in recent years due to its potential to enhance educational outcomes and student engagement (Garrison & Vaughan, 2018).

2.1 Benefits of blended learning for educational management

Blended learning offers numerous advantages in educational management. It allows for a more personalised learning experience, catering to the diverse needs and learning styles of students. By integrating online resources and multimedia tools, blended learning promotes active learning, critical thinking, and problem-solving skills. Moreover, it provides opportunities for real-time feedback and assessment, enabling teachers to track student progress effectively. Research has shown that blended learning can improve student achievement, motivation, and retention rates (Picciano & Dziuban, 2007; Graham, 2013).

Student engagement plays a pivotal role in the success of blended learning. In the online environment, where teachers have limited physical presence, ensuring high levels of engagement becomes even more crucial. Engaged students display a proactive approach towards the learning process, gain a deeper understanding of the content, and achieve superior academic outcomes (Rodriguez & Wilson, 2015).

Educators can employ various strategies to promote and sustain student engagement in an online environment. First and foremost, fostering a sense of community and belonging can significantly enhance student engagement. This can be achieved through the establishment of virtual discussion boards, online group projects, and collaborative activities that

encourage peer-to-peer interaction (Rodriguez & Wilson, 2015).

Secondly, providing regular and timely feedback plays a crucial role in maintaining student engagement. Offering personalised feedback and acknowledging student contributions can create a sense of responsibility and motivation for active participation (Rodriguez & Wilson, 2015). Moreover, designing interactive and multimedia-rich learning materials can effectively enhance student engagement. By utilizing videos, simulations, and interactive exercises, the learning process becomes more appealing and immersive (Rodriguez & Wilson, 2015). Lastly, integrating real-world applications and problem-solving activities enables students to connect their learning to practical situations, making it more meaningful and engaging (Rodriguez & Wilson, 2015).

2.2 Role of teachers in the blended learning environment

The role of teachers is crucial in the success of blended learning.

Teachers need to undergo a transition from a traditional classroom to a blended learning environment. This transition involves:

- Adapting teaching practices
- Integrating technology into instruction
- Managing time and resources effectively

Additionally, teacher-student interaction and communication play a vital role in online learning. Teachers must establish effective communication channels and maintain regular contact with students to provide guidance, feedback, and support throughout the blended learning experience, as emphasised by Thompson and Davis (2017).

3 Overview of challenges of blended learning

In addition, designing effective instructional materials and activities is an essential aspect of the teacher's role in blended learning. Teachers need to create engaging and interactive online resources, such as multimedia presentations, videos, and simulations, to enhance student learning and facilitate active participation, according to Wilson and Thomas (2016).

However, despite these advantages, the implementation of blended learning also poses challenges.

- Technical issues and access to technology: Reliable internet access, appropriate devices, and technical support are required for effective blended learning, as noted by Rodriguez and Martinez (2015).
- Fostering student engagement in online settings presents several challenges. Firstly, the absence of face-to-face interaction can lead to feelings of isolation and detachment, making it difficult for students to connect with their peers and instructors (Rodriguez & Wilson, 2015). Additionally, the lack of immediate feedback and accountability can diminish motivation and result in reduced engagement levels (Rodriguez & Wilson, 2015). Lastly, the reliance on technology may introduce technical difficulties and distractions, posing obstacles for students to remain focused and engaged (Rodriguez & Wilson, 2015).

Teachers need to develop new instructional strategies, acquire technological competencies, and adapt to the unique demands of online learning platforms, as discussed by Smith and

Johnson (2019). According to Jumanj, Malik and Akram (2018), the major categories of challenges facing effective implementation of blended learning include;

- **Finding the Right Blend:** The most significant challenge faced by people developing and delivering blended learning is identifying the instructional strategies that match well with the conditions that are present in these two quite different environments. This challenge is complex because it relates to achieving the right blend, both from a learning and cost-effective point of view. The learning environments have affordances that endow them with particular strengths and weaknesses. The affordances enable the effective use of particular instructional methods within the specific learning environment. By blending learning instruction, the range of possible instructional strategies that can be used is greatly increased. From a pedagogical standpoint, the goal of blending learning environments for a particular context and audience is to find an appropriate combination of the two environments that takes advantages of the strengths of each environment and avoids their weaknesses (Bo Tso, 2015).
- **Increased Demand on Time:** Instructors and trainers are generally comfortable with creating and presenting instructional materials either in the learning environment, but not necessarily in both learning environments. When an institution or teacher decides to utilise both learning environments for teaching a single course, the time demands of the instructor or trainer increase because instructional materials must be developed for both educational managers and Teachers. Additionally, instructors or the teacher incur an increase in the time they spend interacting with learners in blended learning Environment. Adding an online component to a learning course puts increased time demands and stress on the teacher as well as the department or the institution as the case may be in developing and delivering the blended course (Caner, 2010).
- **Overcoming Barriers of Institutional Culture:** There are cultural barriers for both learners and instructors that must be overcome in order to use blended learning. The components of blended learning require a large amount of self-discipline on the part of the learners because learning in that setting is largely independent (Donnelly, 2010). In current higher educational online learning environments, students tend to procrastinate when they have little required contact (Caner, 2020).
- **Limited Access to Technology and Resources:** Teachers face a significant challenge when it comes to implementing blended learning due to the limited access they have to technology and resources. The digital divide, which refers to the unequal distribution of technology and resources among different individuals or groups, becomes evident in the context of blended learning where teachers experience disparities in the availability and quality of devices, internet connectivity, software, and other technological tools (Williams & Davis, 2017).

The consequences of such limited access to technology and resources are far-reaching and have a profound impact on the successful implementation of blended learning. Teachers who lack access to adequate technology and resources may encounter difficulties when trying to incorporate online platforms, digital content, and interactive tools into their teaching practices, ultimately resulting in a less engaging learning experience for students and inhibiting the achievement of desired learning outcomes (Williams & Davis, 2017).

Addressing the issue of limited access to technology and resources requires a collaborative effort from educational institutions, policymakers, and other stakeholders. There are several potential solutions that could be pursued:

- Providing training and professional development programs to enhance teachers' digital literacy skills and equip them with the necessary tools to effectively integrate technology in the classroom (Williams & Davis, 2017).
- Allocating sufficient funds to ensure the availability of up-to-date devices and software in schools, with particular attention given to underprivileged areas (Williams & Davis, 2017).
- Promoting partnerships between schools, technology companies, or non-profit organizations to facilitate access to technology and resources for teachers (Williams & Davis, 2017).
- Establishing policies and initiatives aimed at narrowing the digital divide and ensuring equitable access to technology and resources for all teachers (Williams & Davis, 2017).
- **Limited access to Internet facilities:** The cost of acquiring, installing and maintaining internet services are quite huge. Such exorbitant cost can only be afforded by government and some private institutions where tuition fees are better imagined that mentioned. Most Colleges of Education and High Schools lack functioning Internet centers required to implement important learning approaches like cloud computing, blended learning, m-learning
- **Insufficient allocation of fund to education:** A review of previous educational programmers the country shows that resource inadequacy has long been a central factor in chronic education shortcomings (Marsha, 2012). This inadequacy is compounded by the meager budgetary allocations for education in recent years, which have been steadily declining over the past two decades. While in 2007 the education sector was allocated 11% of the national budget, this rose to 13% in 2008 and fell to 8% and 6% in 2009 and 2010 respectively (National Bureau of Statistics, 2017). Moreover, due to the general level of poverty in the country, the contributions of rural communities and households to support educational resources have been grossly negligible.
- **Lack of Technical Skills among Teachers:** The absence of technical skills among teachers poses a significant challenge in the realm of blended learning. Proficiency and knowledge in using technology tools and platforms are essential for its effective implementation. These skills encompass the ability to navigate through various digital resources and troubleshoot technical issues (Smith & Johnson, 2019). The importance of technical skills can be attributed to their facilitation of seamless integration of technology into teaching practices, enabling teachers to efficiently deliver content and engage students in the blended learning environment.

Various technical skills are crucial for successful blended learning. Let us take a look at some examples:

- i. Proficiency in learning management systems (LMS), such as Canvas or Moodle, for organizing and distributing course materials.
- ii. The ability to use video conferencing software, like Zoom or Google Meet, for synchronous virtual classroom sessions.
- iii. Familiarity with multimedia tools, such as Adobe Creative Cloud or Camtasia, for

creatingengaging instructional content.

The absence of technical skills among teachers can have far-reaching implications for the successful implementation of blended learning. Teachers lacking these skills may encounter challenges in effectively using technology tools, resulting in suboptimal instructional experiences for students. Moreover, the inability to navigate digital resources and resolve technical issues may lead to increased frustration and reduced confidence, thus hindering teachers' willingness to fully embrace blended learning (Smith & Johnson, 2019).

To tackle the deficiency in technical skills, educational institutions and policymakers should considerimplementing the following strategies:

- i. Professional development programs: Providing comprehensive training programs that equipteachers with the necessary technical skills for blended learning.
- ii. Peer mentoring and collaboration: Facilitating opportunities for experienced teachers to mentorand support their colleagues in developing technical competencies.
- iii. Access to resources and support: Ensuring teachers have access to a range of resources, such asonline tutorials and support services, to help them acquire and improve technical skills.

Evidences abound that many learners do not complete online courses because they lack the discipline orthe motivation to complete the courses. If BLEs are to be highly successful, there is need to ensure that learners imbibe the spirit of persistence. Another factor is the issue of organizational and management support. In higher educational institutions, some lecturers and instructors may hesitate to try blended approaches because they are not sure that they will get the support of administration (Halverson, Graham, Spring, Drysdale & Henrie, 2014). Similarly, management support for BLEs is therefore very essential if they are to succeed as teaching and learning model in teacher education programmers.

Changing instructional approaches in education is no mean task particularly when technology is involved.Adopting and integrating computer-based instructional strategies has a myriad of challenges though persistent effort has led to development of insight on how to achieve success with them. In the context to follow, effort is made to discuss the limiting factors to the successful implementation of blended learning in classrooms.

- **Resistance to Change:** When it comes to adopting blended learning, teachers often encounter a sense of inertia due to various reasons. These reasons include fear of the unknown, the potentialfor additional workload, and a lack of confidence in technological skills.Brown and Anderson (2018) have pointed out that these factors are the primary reasons behind the resistanceexperienced by teachers. The rapid shift from traditional teaching to digital engagement can be adaunting prospect for teachers who are not accustomed to working with technological platforms.

The resistance to change can significantly undermine the success of implementing blended learning. It can result in incomplete uptake of digital teaching strategies as well as inconsistent usage of these strategies.Ultimately, these outcomes have the potential to decrease the overall quality of the learning experience for students.

In order to mitigate resistance, several approaches can be undertaken:

- i. Implementing comprehensive training programs: These programs should address both the technological and pedagogical aspects of blended learning in order to alleviate any apprehensions that teachers may have.
 - ii. Providing ongoing professional development: Intensive and ongoing professional development sessions can enhance teachers' comfortability and proficiency with digital tools, thereby facilitating a smoother shift from traditional to blended teaching methods (Smith and Johnson, 2019).
 - iii. Fostering a supportive and collaborative culture: Encouraging peer-learning and the sharing of best practices among teachers can help create an environment that supports change.
 - iv. Promoting open communication: Communicating the benefits of blended learning and the changes it will bring about can help reduce resistance and promote better understanding.
- **Increased Workload for Teachers:** Blended learning presents teachers with various factors that contribute to an increased workload. One crucial factor is the requirement to adapt and create online learning materials, which adds significant time and effort to their responsibilities (Thompson & Martinez, 2016). Additionally, the management of virtual classrooms, timely feedback provision on online assignments, and facilitating online discussions demand more time and attention compared to conventional face-to-face teaching methods. These elements collectively contribute to an overall surge in the workload experienced by teachers in blended learning environments.

Furthermore, the increased workload in blended learning can have profound impacts on teacher performance and well-being. An excessive workload can lead to teacher burnout, diminished job satisfaction, and compromised mental health. It can also negatively impact teaching quality and student outcomes (Thompson & Martinez, 2016). Maintaining a healthy work-life balance becomes a challenging task for teachers, resulting in increased stress and potential difficulties in meeting professional expectations. Thus, it becomes crucial to understand and effectively manage the increased workload in order to ensure positive teaching experiences and optimize student learning outcomes.

In order to address the challenges posed by the increased workload in blended learning, several strategies can be employed:

- i. Providing professional development opportunities focused on time management and efficient use of technology can assist teachers in better organizing their workload (Thompson & Martinez, 2016).
- ii. Collaborative planning and resource sharing among teachers can alleviate the burden of individually creating online materials.
- iii. Leveraging automation and educational technology tools can streamline administrative tasks such as grading and feedback, freeing up time for instructional activities.
- iv. Establishing supportive policies and structures within educational institutions that prioritize teacher well-being and workload management are crucial for sustainable implementation of blended learning.

3.1 Synthesis and Analysis of Existing Literature on Challenges

Various studies have been carried out to investigate the challenges encountered by teachers when implementing blended learning. In their survey, Smith and Johnson (2019) highlighted the lack of technical skills as a primary hurdle. Brown and Anderson (2018), on the other hand, focused on understanding teachers' attitudes and behaviors towards blended learning, emphasizing the significant obstacle of resistance to change. Exploring the implications of limited access to technology and resources on blended learning, Williams and Davis (2017) underscored the importance of digital inclusivity. Thompson and Martinez (2016) delved into the increased workload of teachers in blended learning environments, emphasizing the necessity for effective workload management strategies. Rodriguez and Wilson (2015) shed light on approaches for maintaining student engagement in an online environment, providing insights into strategies to promote and sustain involvement.

- **Smith and Johnson (2019)** conducted a survey among educators and identified the lack of technical skills as a primary challenge.
- **Brown and Anderson (2018)** focused on understanding teachers' attitudes and behaviors towards blended learning, emphasizing the resistance to change as a significant obstacle.
- **Williams and Davis (2017)** examined the implications of limited access to technology and resources on blended learning, highlighting the relevance of digital inclusivity.
- **Thompson and Martinez (2016)** investigated the increased workload of teachers in blended learning environments, emphasizing the need for strategies to manage workload effectively.
- **Rodriguez and Wilson (2015)** explored approaches for maintaining student engagement in an online environment, shedding light on strategies to promote and sustain engagement.

3.2 Identification of common themes and trends

Upon thorough analysis of these studies, several common themes and trends emerged. Firstly, all studies unanimously recognised the pivotal role of teachers in the successful implementation of blended learning. Secondly, a consensus was reached that addressing these challenges requires a multifaceted approach, comprising professional development, ongoing support, and resource allocation. Lastly, the studies emphasised the urgency for educational institutions and policymakers to prioritise the development and implementation of comprehensive strategies to overcome these challenges.

- Recognition of the crucial role of teachers in the successful implementation of blended learning across all studies.
- Consensus on the need for a multifaceted approach involving professional development, ongoing support, and resource allocation.
- Emphasis on the importance of educational institutions and policymakers prioritizing the development and implementation of comprehensive strategies to overcome challenges.

4. Gaps in the literature and areas for further research

While the existing literature provides valuable insights into the challenges faced by teachers in blended learning implementation, there are still some gaps that need to be addressed. For example, there is limited focus on specific strategies and interventions to address resistance to change among educators. Additionally, further research is needed to explore the relationship between

limited access to technology and resources and student outcomes in blended learning environments. Future studies should also investigate innovative approaches for managing and reducing teachers' workload in blended learning settings. Lastly, there is a need for more research on the long-term effects and sustainability of student engagement strategies in an online environment.

- Addressing the limited focus on specific strategies and interventions to address resistance to change among educators.
- Exploring the relationship between limited access to technology and resources and student outcomes in blended learning environments.
- Investigating innovative approaches for managing and reducing teachers' workload in blended learning settings.
- Conducting further research on the long-term effects and sustainability of student engagement strategies in an online environment.

5. Research methodology

For this study, a systematic literature review was employed as the primary research design. This approach involved conducting a comprehensive survey and analysis of existing studies that explored the challenges of implementing blended learning in educational management from teachers' perspectives. The work of Horn & Staker (2015) served as the main source utilised for this study.

Data was gathered from a variety of sources, including books, scholarly articles, and research reports related to the topic. In order to ensure thoroughness, quality, and validity, meticulous search strategies were utilised to identify relevant literature. The data collection methods employed were informed by the valuable insights provided by Graham (2013). When selecting the literature sources, various criteria were taken into consideration, such as relevance to the topic, reputation of the author(s), and year of publication. Priority was given to renowned authors and recently published studies, as they provide the most current perspectives on blended learning. Picciano & Dziuban (2007) offer a comprehensive understanding of the criteria used for the selection of sources.

The inclusion criteria were based on the relevance of the study to the topic, the reliability of the findings, and the specificity of the study with regards to the teachers' perspective. Research studies that did not specifically focus on blended learning in educational management or those lacking a strong emphasis on the teacher's perspective were excluded. Bonk & Graham (2012) provide valuable insights into the specific inclusion and exclusion criteria utilised.

The data analysis procedures incorporated the synthesis of the collected literature. This involved identifying patterns, themes, and relationships in the data, and drawing interpretations that guided the development of the findings of this study. Garrison & Vaughan (2018) provide valuable insights into the data analysis procedures that were utilised.

6. Discussion

Having examined and explained the various challenges educators face while implementing blended learning, this review highlights the significance of addressing these challenges. The most prominent challenges include the lack of technical skills, resistance to change, limited

access to technology and resources, increased workload, and maintaining student engagement in a digital environment. To enhance the course of blended learning, it is crucial to address these challenges. By improving educators' experiences with the implementation of blended teaching, we can pave the way to a smoother, more effective digital transformation in education, offering rich learning opportunities for students.

In order to ease the transition to blended learning, it is recommended that comprehensive strategies be developed. These strategies may consist of training programs that target the enhancement of technical skills, initiatives to promote digital inclusivity, effective workload management strategies, and methodologies that foster student engagement in online settings. Despite the challenges it presents, the process of implementing blended learning remains a promising development in the landscape of educational management. By acknowledging and addressing these issues, the future of blended learning becomes a potential tool for transformative, inclusive, and engaging teaching and learning experiences.

6.1 Discussion of the findings in relation to existing literature

The findings of this study align with previous research on the challenges of blended learning in educational management. Smith and Johnson (2019) identified technical difficulties, adaptation of teaching practices, and professional development as key challenges for teachers in implementing blended learning. Furthermore, Rodriguez and Martinez (2015) emphasised the need for comprehensive support systems for teachers transitioning to the blended learning environment, including ongoing professional development opportunities.

However, this study also contributes unique insights to the existing literature. By specifically focusing on challenges from the teachers' perspective, the current research provides a deeper understanding of the complexities and nuances they face in the blended learning environment. It emphasises the importance of tailored support and resources to address the unique needs of teachers in effectively implementing and sustaining blended learning initiatives.

6.2 Strategies for overcoming the challenges

To address the challenges faced by teachers in implementing blended learning, various strategies can be employed:

- Professional development and training opportunities: Providing comprehensive training programs and professional development opportunities for teachers to enhance their technical skills and knowledge in blended learning (Garrison & Vaughan, 2018).
- Creating a supportive school culture: Fostering a supportive and inclusive school culture that encourages collaboration, sharing of best practices, and experimentation with different teaching strategies (Bonk & Graham, 2012).
- Collaboration and sharing of best practices: Encouraging teachers to collaborate, share their experiences, and exchange best practices regarding blended learning implementation (Horn & Staker, 2015).
- Providing resources and technical support: Ensuring that teachers have access to adequate resources, including technology, software, and technical support, to facilitate the effective integration of blended learning (Horn & Staker, 2015).
- Designing effective assessment and evaluation methods: Developing appropriate assessment tools and evaluation methods that align with the blended learning

environment, including formative feedback, self-assessment, and peer assessment (Garrison & Vaughan, 2018).

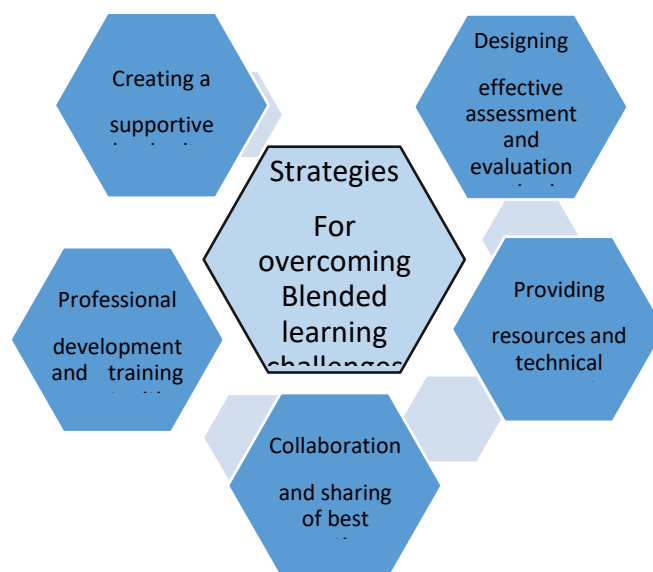


Fig 1.2 Strategies for overcoming Blended learning challenges

7. Summary of the main findings

This study delves into numerous challenges encountered by teachers when implementing blended learning in educational management. Among the key findings, the study discovers that teachers often lack the technical skills and training necessary for effective blended learning. Additionally, teachers face resistance to change, struggle with time constraints in preparing blended learning materials, find it difficult to manage student engagement and motivation, encounter limitations in access to technology and infrastructure, receive inadequate support from administrators and colleagues, and grapple with assessment and evaluation issues in the blended learning environment. To address these challenges, the paper proposes several strategies, including providing professional development and training opportunities, fostering a supportive school culture, promoting collaboration and the sharing of best practices, offering resources and technical support, and designing effective assessment and evaluation methods.

7.1 Importance of addressing the challenges of blended learning

The significance of addressing the challenges tied with blended learning cannot be overstated. By doing so, we have the opportunity to shape a more conducive educational environment that fosters optimal learning outcomes, leverages technology, and supports the holistic professional development of teachers. Graham (2013) emphasises the critical need for adequate training and support to enhance teachers' technological skills, while Garrison and Vaughan (2018) stress the importance of overcoming resistance to change among teachers. Furthermore, Bonk and Graham (2012) highlight the value of collaboration and the sharing of best practices in improving blended learning experiences. Therefore, failure to address these challenges could potentially create a counterproductive learning atmosphere that hinders the achievement of educational objectives.

7.2 Overall contribution of the study to the field

This study provides a comprehensive and nuanced understanding of the intricacies involved

in implementing blended learning from the perspective of teachers. By identifying the challenges and proposing viable solutions, the study offers valuable guidance for policymakers, educators, and school administrators looking to implement blended learning more effectively. This, in turn, has the potential to

enhance the learning environment and positively impact student outcomes. The work conducted by Picciano (2017) underscores the importance of addressing the challenges faced by teachers in blended learning environments. The integration of face-to-face and online teaching methods, as elucidated by Horn and Staker (2015), is a critical element that significantly influences the overall success of blended learning initiatives. Moreover, Singh and Reed (2001) emphasise the need for comprehensive strategies that support teachers in effectively managing the complexities of blended learning. Therefore, this study's contribution to the field is invaluable, as it consolidates research findings and provides tangible recommendations for successful implementation.

In conclusion, this research underscores the pressing need for a concerted effort in resolving the challenges of blended learning. Continued exploration of these challenges and dedicated research into devising effective strategies can propel the field of educational management towards the ideal utilization of blended learning methodologies. Hung (2018) aptly highlights the necessity for blended learning models that align with the demands of the 21st-century work environment, while Picciano and Dziuban (2007) draw attention to the importance of ongoing research to inform the design and implementation of blended learning practices. By adopting innovative approaches and addressing the challenges head-on, we can ensure the resounding success of blended learning in educational management, ultimately benefiting teachers and students alike.

7.3 Analysis of the identified challenges

The challenges encountered during the implementation of blended learning can be categorised as follows:

- Insufficient technical skills and training among educators
- Resistance to change exhibited by teachers
- Time constraints when preparing blended learning materials
- Difficulty in managing student engagement and motivation
- Limited access to necessary technology and infrastructure
- Inadequate support from administrators and colleagues
- Assessment and evaluation issues in blended learning
- Integration of face-to-face and online teaching methods

7.4 Discussion of the strategies for overcoming these challenges

To address the challenges raised by teachers regarding the implementation of blended learning in educational management, it is vital to establish effective strategies and deliver essential support. Drawing from existing literature, several strategies have been proposed:

- Providing professional development and training opportunities: Empowering educators with the necessary skills and training will enable them to effectively utilise blended learning methods (Graham, 2013).
- Fostering a supportive school culture: Promoting a culture that supports teachers in their efforts to implement blended learning can minimise resistance to change and encourage collaboration among educators (Garrison & Vaughan, 2018).
- Encouraging collaboration and sharing best practices: By promoting collaboration and the exchange of experiences and best practices among educators, the

challenges can be addressed and innovative solutions can be generated (Hung, 2018).

- Ensuring access to resources and technical support: Providing teachers with adequate resources, technology, and technical support is crucial for the successful implementation of blended learning (Picciano & Dziuban, 2007).
- Developing effective assessment and evaluation methods: Creating appropriate methods for assessing student learning and evaluating the effectiveness of blended learning can help resolve assessment issues (Singh & Reed, 2001).

7.5 Implications of the findings for educational management

Teachers face a multitude of challenges when implementing blended learning, and these challenges have significant implications for educational management. Firstly, addressing these challenges can greatly enhance the overall effectiveness of blended learning, ensuring that students receive a high-quality education and achieve their desired learning outcomes. Secondly, by understanding and tackling these challenges, educational management can provide support for the professional development of teachers and enhance their capabilities in effectively utilizing blended learning. Thirdly, addressing these challenges can facilitate the adoption and integration of technology in education, creating a more innovative and forward-thinking learning environment.

The findings of this study have significant implications for educational management in the context of blended learning. It is crucial to recognise the importance of addressing the challenges that teachers face when implementing blended learning. These challenges include technical difficulties, adapting teaching practices, and issues related to professional development. They can hinder the successful implementation and outcomes of blended learning initiatives. Therefore, educational managers need to allocate resources and support for teachers to overcome these challenges effectively.

Moreover, the study emphasises the need for strategies to overcome the identified challenges in blended learning. For instance, providing adequate technical support and training to teachers can help alleviate the technical difficulties they may encounter. Additionally, designing professional development programs that focus on adapting teaching practices to the blended learning model will better support teachers in effectively integrating both online and face-to-face instructional activities. By addressing these challenges and implementing suitable strategies, educational managers can enhance the quality of blended learning experiences for both teachers and students.

8. Recommendations for future research in the field of blended learning

The findings of this study provide several recommendations for future research in the field of blended learning. Further investigation is needed to explore specific strategies for teacher training and support in blended learning environments. This research could delve into the best practices for preparing and empowering teachers to teach effectively in blended learning settings, considering the unique demands and complexities associated with this pedagogical approach.

Furthermore, future research should focus on exploring alternative platforms for engagement in blended learning. This could involve investigating the use of different online tools and technologies that promote student interaction, collaboration, and active learning. Understanding the effectiveness and impact of these platforms on student learning

outcomes and engagement can provide valuable insights for practitioners and educational managers.

For blended learning in Educational Management to be effective, Management may organise an advance level of blended training session(s) to the teaching faculty and students. There is need to improve the assignment grading and feedback practice on the part of teachers. Enhanced audio/video connectivity of Skype sessions may be ensured for maximizing student-teacher interaction and communication. Based on open ended responses, number of discussion forums may be minimised and exempted from grading. Course instructors may include creative questions in discussion forums to improve critical thinking of learners. An orientation regarding blended learning tools and technologies may be arranged before the

start of semester. Teachers' workload may be reduced for better time management in the planning of blended learning activities.

Based on the findings regarding the challenges faced by teachers in implementing blended learning, several recommendations can be made for both teachers and administrators. Firstly, it is crucial to provide teachers with ample professional development and training opportunities to equip them with the necessary technical skills and knowledge required for successful blended learning implementation. Secondly, fostering a supportive school culture that encourages collaboration and the sharing of best practices can help teachers overcome resistance to change and ensure a smooth implementation process. Thirdly, administrators should allocate adequate resources and provide technical support to alleviate the time constraints faced by teachers, as well as furnish them with the necessary tools to create engaging and effective blended learning materials. Lastly, designing assessment and evaluation methods specifically tailored to blended learning can ensure accurate measurement and evaluation of student progress and learning outcomes.

9. Suggestions for future research

While this study has provided valuable insights into the challenges faced by teachers in implementing blended learning, there are several areas that require further research. Firstly, additional investigation is needed to explore the effectiveness of the recommended strategies in overcoming these challenges. Secondly, research could focus on the impact of the suggested solutions on student outcomes and learning experiences. Additionally, future studies could delve into the role of educational administrators and policymakers in providing support for teachers in blended learning implementation. Lastly, comparative research could be conducted to examine the challenges and strategies in different educational contexts and settings.

10. Conclusions

It can be concluded on the basis of findings that success of Blended Learning included student-centered environment, independent learning, peer learning, collaborative learning and reflective thinking. Furthermore, on the part of teachers, blended learning has enhanced pedagogical practice like personalised instruction catering diverse learning styles. Similarly, assessments and feedback also improved students' understanding of the content. Students' satisfaction with blended learning technology, blended learning activities, provision of sufficient resources on blended learning, communication, training sessions and quality of support services provided to resolve technical issues were also regarded as predictor of

success in Blended Learning. Challenges of Blended Learning included technical problems hindering internet access, technological competency gap, teachers' workload, and delay in feedback on students' assignments.

The implementation of blended learning in educational management presents a myriad of challenges for teachers. This paper delves into these challenges, shedding light on various key findings. Among these findings are the lack of technical skills and training, resistance to change among teachers, time constraints, difficulties in student engagement, and limited access to technologies. It is important to acknowledge that these challenges are further compounded by low institutional support and pressing issues in assessment and evaluation methods within blended learning. Drawing upon relevant literature sources and a thorough analysis of field data, this paper also offers strategies to address these challenges.

Recognizing the significance of addressing the challenges associated with blended learning is crucial to enhancing the effectiveness of this teaching approach. By taking deliberate steps to tackle these obstacles, we can shape a more conducive educational environment that fosters optimal learning outcomes, harnesses the power of technology, and supports comprehensive professional development for teachers.

Failing to address these challenges could potentially result in an ineffective learning atmosphere, hindering the achievement of educational objectives.

This study contributes significantly to the field by providing an in-depth understanding of the intricacies involved in implementing blended learning from a teacher's perspective. By identifying the challenges and proposing feasible solutions, it paves the way for policymakers, educators, and school administrators to potentially implement blended learning more effectively. This, in turn, can enhance the overall learning environment and positively impact student outcomes.

In closing, this research underscores the need for a collective effort in resolving the challenges of blended learning. It emphasises the importance of continuous exploration and dedicated research in devising effective strategies. By doing so, we can propel the field of educational management towards the ideal utilization of blended learning methodologies.

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Combined Hardware and Software System Failure Analysis Based on a Mapping Model

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Abstract

Failure analysis of modern computer-controlled systems is becoming difficult and time-consuming for system analysts. Firstly this is due to an increase in demand for new functions made possible by the proliferation of technologies. Secondly, a computer-controlled is a composite system comprising hardware and software. Thus its analysis is a complex one. This study investigates the analysis of a computer-controlled system. Literature has shown that for a composite system, the hardware and software systems are analysed separately. It would therefore be helpful if these two systems could be mapped where further analysis could be performed. This is exactly the focus of this paper. Each system is analysed using failure modes and effects analysis (FMEA) and then mapped to produce a composite analysis where further analysis using fault tree analysis (FTA) is performed to identify components with single-point failure (critical components). Analysing the fault tree through the minimal cut sets in our use case, all the components were found to be single point of failure. As a recommendation, the safety engineer could then focus on redesigning or drawn a preventive maintenance schedule on all the components. The Gear-Drive Electromechanical Actuator System is used as a case study.

Keywords: FMEA, FTA, Mapping model, Composite system.

1.0 Introduction

Contemporary engineering systems design comprises hardware and software systems to improve productivity and meet up with demand requirements. The failure of engineering systems, especially critical systems such as aircraft, ships, automobiles, trains, power plants, etc., can be catastrophic affecting the eco-system. Hence, the reliability of such systems is of utmost importance to safety engineers. Although the analysis of computer-controlled systems is becoming more difficult, several failure analysis techniques have been developed to address some of the problems (Isermann, Schwarz & Stotzl 2002; Baleani, et al. 2003; Sangeetha & Saravana, 2016; Yu et al. 2015). System failure investigation provides vast information on the safety and dependability of a computer-controlled system. The information enables safety engineers to use safety and reliability as a major concern when designing a computer-controlled system.

Currently, the failure analysis process has evolved to deal with changes in the design of computer-controlled systems. However, these bring about additional emerging standards and maintenance policies, for example, most hazard and failure analyses focus on the central part of the system design process. Such standards and policies are developed by “The Motor Industry Software Association and IEC-61508” (Papadopoulos and McDermid, 1999). Recent standards define vast methods in which failure analysis exceeds the structure of the architectural design. The required methods typically start early in the design with hardware

and software failure modes assessment and then proceed to the analysis of the complete system design architectures using a variety of different failure analysis techniques (Anthony, 2008). Example of such technique includes The Failure Modes and Effect Analysis (FMEA), Fault Tree Analysis, Failure Mode Effect and Criticality Analysis (FMECA), and Preliminary Hazards Analysis (PHA) Techniques (Deyun et al., 2016; Andrews & Dunnett, 2014; Clifton, 1999; Papadopoulos et al., 2011).

Recent attempts to adapt the above classical techniques for the software part of computer-controlled systems have not yielded accurate and in-depth results that will enhance their impact in complex systems (Nggada, 2012; Lazarus et al. 2018). Leveson et al. (1991) conducted a software FTA that defined the effect of failure modes specified at the code level. Hence, the approach is not applicable to a software architecture.

In this paper, the hardware and software FMEA results were adopted from a research study conducted on the computer-controlled system case study (Ejembi and Nggada, 2022). Furthermore, an FTA analysis was then performed on the composite system. The FMEA analysis of both the hardware and the software components of the system were combined using an activity diagram, and thereafter a mapping model was formalised. The mapping model could then be applied directly to hardware and software failure expressions to evolve with a composite failure expression without having to create an activity diagram of failure expressions. This research study is built upon the study conducted by Ejembi & Nggada. (2022). This paper also demonstrates processes of identifying critical components by developing FTA. The FTA effectively addressed lapses generated from both the hardware and software FMEA processes conducted on the computer-controlled system. Lastly, the paper also contributed to improving the analysis processes by determining the failure propagation at the component's output level, and evaluating further, the minimal cut set.

The FTA is generated based on the combined internal failure modes of the hardware components and the input/output deviation of the software components. The minimal cut-set was evaluated to identify the component with a single point of failure. This process can help to identify the design imperfections or components that are prone to failure, and thereafter, provide solutions to refine or upgrade the initial design.

This paper is structured as follows. Section 2 discusses related studies on FTA and FMEA Techniques. The designed model for the hardware and software system case study is presented in section 3. Section 4 presents the mapping model, and the result for the composite system failure analysis based on FTA is presented in Section 5. Section 6 concludes the paper and discusses future studies.

2.0 Related Work

Classical failure analysis techniques are the commonly used traditional method of system failure investigation. However, most system analysts or safety engineers prefer the use of FMEA and FTA techniques for safety assessment practice (Mahmood et al. 2019). A lot of research study has been conducted to integrate or modify the use of FMEA and FTA, which can effectively meet the demand for failure analyses on emerging computer-controlled systems.

FTA was first designed and tested on the Minuteman launch control system by the United States Airforce, circa 1961 (Clifton, 1999). Dave Haasl took note of the importance of FTA and

applied the technique to a known “minuteman missile system” with his team members of the Boeing Company. FTA was later used during the design of commercial aircraft by other partitions of the company (Clifton, 1999). Sohage et al. (2019) incorporate the failure rate and failure probability analysis of a system using FTA techniques. Furthermore, the selection of maintenance intervals for the turbine set of power units was carried out with the use of FTA (Andrzej & Adam, 2012).

Purnendu (2011) presented an approach to analysing a “fail-operational brake-by-wire system at the architectural design stage”. Their approach adopted three failure analysis techniques, such as “Preliminary Hazards Analysis (PHA), Reliability Block Diagram (RBD), and Fault Tree Analysis (FTA)” in the assessment process. Gabriel *et al.* (2017) used FTA to analyse the reliability of a computer web server at the hardware level. The minimal cut set and the probability of failure occurrence were considered at the hardware component of the webserver. Ren et al. (2009) proposed an approach to analyse river-traversing oil pipelines using FTA. In their approach, the least cut sets are obtained from the fault tree basic events, and the likelihood of the top events was determined using statistical methods. Feng et al. (2019) performed a fault tree analysis on a complex system, using a universal grey operating model. They determined the likelihood of failure from the top event using the grey operating model. Their proposed model was established on the “landing gear retraction system of an aircraft”.

FMEA-FTA methods of system analysis have been verified to be effective, they are mostly applied by system analysts or safety engineers in system reliability. An integrated FTA-FMEA provides an in-depth analysis of system failure mode (Whiteley *et al.*, 2016). FMEA and FTA integration provides a detailed assessment of system safety (Whitely et al., 2016). Potential FMEA is an aspect of predictive safety analysis that emerged in the 1990s and was used in the automotive industry (Murdoch & McDermid, 2004). Predictive safety analysis involves projecting possible failure modes from the proposed system design. Papadopoulos and David (2004) proposed the FTA-FMEA technique and automatic tools to analyse failure modes on safety-critical systems. In their study, they analysed the failure effects caused by the logical combination of component failure using FTA. Mahmood et al. (2019) proposed an “integrated FTA-FMEA model for risk analysis of an engineering system.” The analyses generated from FTA, and FMEA were integrated, and the result was placed on an FTA-FMEA table. Bluvband, Rafi, and Pavel (2005) in a combined bouncing FTA-FMEA method used a single-point FMEA as a basis to identify multiple points of component failure such as the double, triple, and n-point failure. Their approach was conducted through an interaction matrix, which is a key improvement to the classical FMEA. However, vast information on the method and the system under study is required because the matrix’s interactions between the techniques increased in complexity.

This Paper used FTA techniques to analyse the output failure modes of the composite system. HIP-HOPS logical method of failure expression (Papadopoulos et al., 2011), and the failure type classification of system functions developed by Bonadavali and Simoncini (1990), were adapted for this paper. However, these methods were used to present a clear view of the system failure modes expression, and its failure propagation.

3.0 Case Study (Gear-Drive EMA)

The gear-drive electromechanical actuators (EMA) system found in (Ejembi & Nggada, 2022), was adapted as the hardware system model of this paper. The gear-drive EMA system is a type of actuator used in a power-by-wire system. Its primary function is to convert electrical energy into mechanical motion. EMA actuators are used mostly in aviation industries as landing gear braking. The system consists of hardware components such as the mechanical actuation assemblies and the electronic control unit, with the actuator module containing the mechanical components and a servo-electric motor, as shown in Figure 1. The functions of the Gear-drive EMA hardware components are described widely in the article presented by Ejembi and Nggada, (2022).

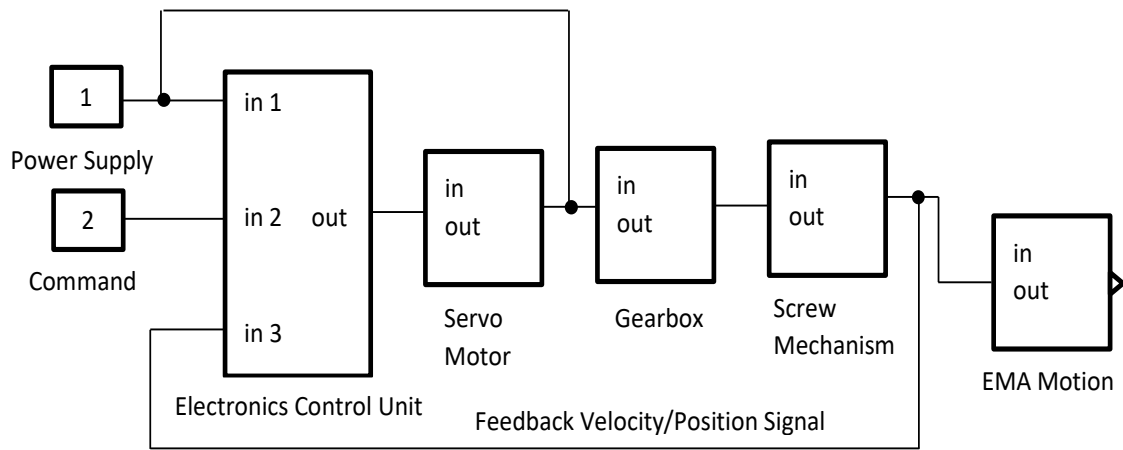


Figure 1. Gear-Drive EMA System.

The annotations found in the hardware model were adopted and used to design the software model, as presented in Figure 2. Thus, the model was designed with the use of a UML class diagram. The class diagram consists of three main components such as class, attribute, and operation. However, the class is referred to as the software component, and the attribute describes the properties of the class. Furthermore, the operations are referred to as the functions performed by the class. More details of the gear-drive EMA system UML class diagram can be seen in the paper presented by Ejembi & Nggada, (2022).

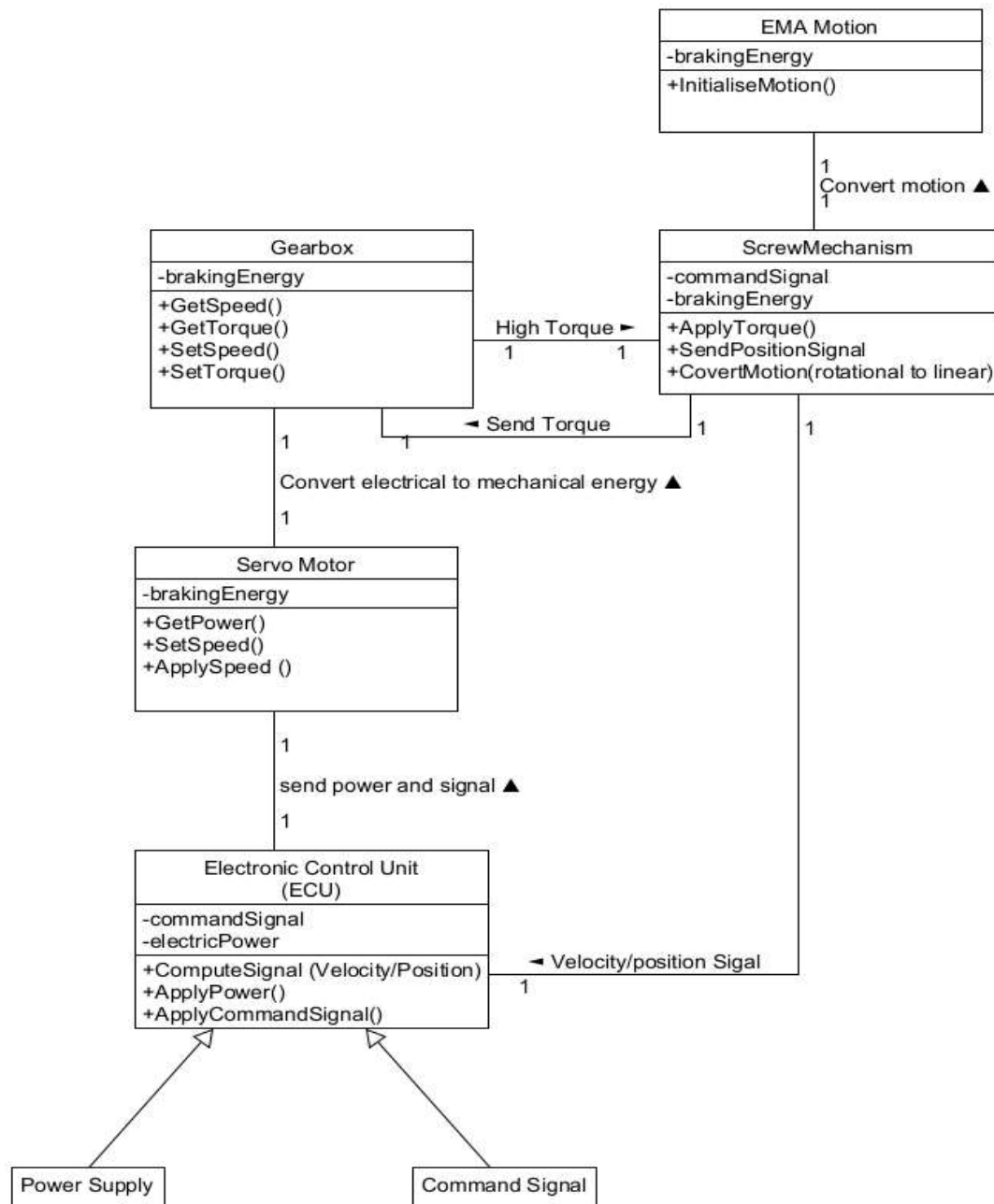


Figure 2. Class Diagram for gear-drive EMA system.

FMEA failure analysis were performed separately on the hardware and software models of the gear-drive EMA system. Thus, the results of the analysis can be seen in the article presented by Ejembi Nggada, (2022). Their FMEA results showed the hardware and software components' failure modes and their severity effect on the gear-drive EMA system. This paper extends their study, by analysing further the output failure of the gear-drive components. Since all the components were observed to be prone to failure. Hence, the components and their failure modes expression were adopted from the FMEA results, as seen in Tables 1 & 2.

Table 1. Gear-drive EMA hardware components and failure modes expression.

Component	Failure Modes Expression
Electronic Control Unit (ECU)	ECU Power Failure or ECU Command Failure
Servo Motor	Servomotor Failure
Gearbox	Gearbox Failure
Screw Mechanism	Screw Mechanism Failure
EMA Motion	EMA Failure

Table 2. Gear-drive EMA software class and failure modes expression.

Class	Failure Modes Expression
Electronic Control Unit (ECU)	O-in1 or O-in2, N-V or H-V
Servo Motor	O-in
Gearbox	O-in
Screw Mechanism	O-in
EMA Motion	O-in

Table 1 shows the hardware components and their failure modes expression, While Table 2 shows the software classes and their failure modes expression. The software failure expression is specified logically as lists of functional deviations at the software class outputs. Furthermore, the components and their failure modes expression were mapped with the use of a well-defined mapping model. The mapping model aims at integrating the components failure modes of the system models, which is considered the major novelty of this paper. Thus, the generalise failure modes expressions of the system were derived from the mapping model. The failure expression is used to perform FTA on the composite system.

4.0 Mapping Gear-drive EMA FMEA Results

A typical computer-controlled system comprises its constituent hardware and software components interacting via messages or signals. Although the hardware and software layers of the system could be analysed separately for failure, where propagation of failure could be observed via fault tree analysis (FTA), it will be more useful to combine the analysis of both to view the relationships among the components of the different system layers. This could further be analysed to obtain minimal cut-sets of the system for further analysis.

The approach taken to map the failure modes of components of hardware and software, as demonstrated in Figure 3, assumed that any hardware component that has an equivalent class diagram

shares the same name. Hence, the composite (or combined) failure mode expression of such components will be the resultant logical OR of the failure expressions of the separate components (hardware and software). The use of an activity diagram is applied to visually demonstrate this approach (Figure 3), a composite failure mode activity diagram for gear-drive EMA.

The activity diagram clearly shows the view of the components, with their respective failure modes expression. The output failure modes for each component are caused by the input deviation (O-in) and internal failure modes of the components. For example, the diagram presented the omission at the output level of ECU (O-out (ECU)), which is caused either by ECU PowerFailure, ECU CommandFailure modes or by (N-V, H-V, O-in1, O-in2) (ECU) modes. The output deviation at ECU leads to the omission at the input level (O-in) of the Servomotor component. In the same process, either the ServomotorFailure or the omission at the input level O-in (SV) will lead to the omission at the output level of the component.

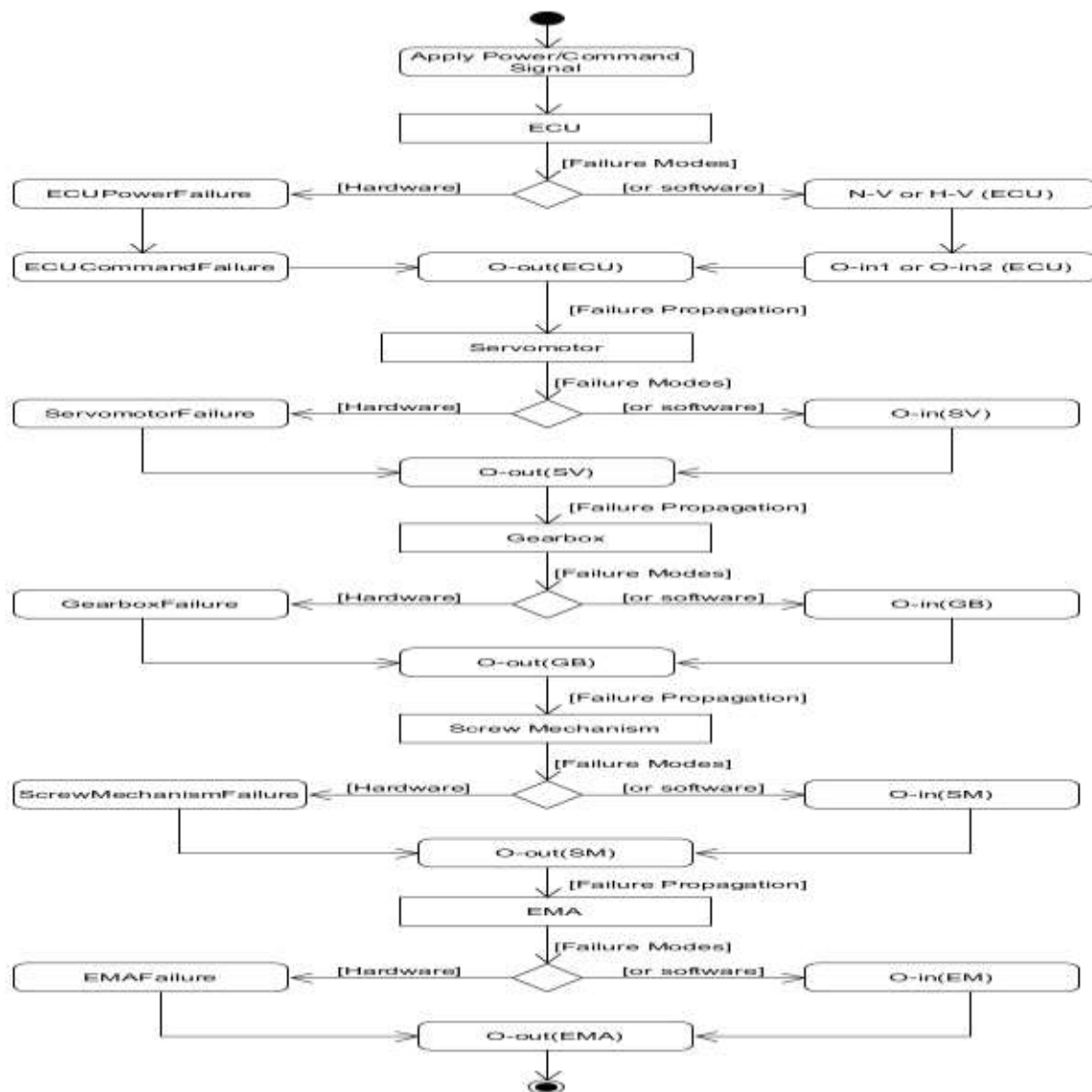


Figure 3. Hardware and software FMEA mapping.

Other components output failures, such as the Gearbox, Screw Mechanism, and EMA are caused by their respective internal and input omission failures. However, each of the components has a direct point of failure to other components as shown in Figure 3. The new failure modes expressions are

presented logically, as shown in Table 3. The failure logic for each component was extracted from the activity diagram, and therefore, defined in Table 3.

Table 3. Failure logical expression for gear-drive EMA components.

Components/Classes	Composite Failure Modes Expression
Electronic Control Unit (ECU)	O-out (ECU) = ECUPowerFailure or ECUCommandFailure or (N-V or H-V) (ECU) or (O-in1 or O-in2) (ECU)
Servo Electric Motor (SEM)	O-out (SM) = SEMFailure or O-in (SM)
Gearbox (GB)	O-out (GB) = GBFailure or O-in (GB)
Screw Mechanism (SM)	O-out (SM) = SMFailure or O-in (SM)
EMA Motion	O-out (EM) = EMFailure or O-in (EM)

4.1 Formal Mapping Model.

This study uses the concept of regular expression and formal methods using the Zed language to formally represent the mapping. Regular expressions, or regexes, come from the theory of formal languages. In theory, a regex is a finite character sequence defining a search pattern. We often use these search patterns to test whether a string matches a search expression, find some characters in a string, replace substrings in a string matching a regex, process or format user input, etc. (Nagy, 2018). The following representations and notations are defined and will be used in defining the mapping.

A. Basic Definitions

- 1) *nameRegex* will be a regular expression that will contain a finite nonempty set of characters.
- 2) *the name* will be a type of *nameRegex*.
- 3) $\alpha_i = \alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n$, will be used as variables of type *name*, where i is the index of the i -th hardware component while n is the number of hardware components.
- 4) $\beta_j = \beta_1, \beta_2, \beta_3, \dots, \beta_m$, will also be used as variables of type *name*, where j is the index of the j -th software component while m is the number of software components.
- 5) $\forall i, j: \mathbb{N} \mid 1 \leq i \leq n, 1 \leq j \leq m$, defined for all i, j supplied natural numbers, such that 1 is less than or equal to i , and i is less than or equal to n , and 1 is less than or equal to j , also j is less than or equal to m .
- 6) if $\alpha_i = \beta_j$, then it would mean that the names of the hardware and software components are the same and therefore their failure modes expression could be logically ORed.

B. Established Formal model

To establish the formal mapping for both hardware and software failure modes expression, let C_i be considered as a hardware component, where i is the index of the i -th component, for $i = 1, 2, 3, \dots, n$. Let C_f be the component failure mode expression, where f is the index

of the $f - th$ failure mode expression, for $f = 1, 2, 3, \dots, n$. Then, C_{if} denote the component failure mode expression of the $i - th$ hardware component.

Similarly, let S_j be software classes, where j is the index of the $j - th$ class, for $j = 1, 2, 3, \dots, m$ let S_{jf} be the software failure mode expression, where f is the index of the $f - th$ failure mode expression, for $f = 1, 2, 3, \dots, n$. Then, S_{jf} denotes the software failure mode expression for the $j - th$ software class.

Hence, according to the basic definitions:

$$nameRegEx = [A, B, C, \dots, Z, a, b, c, \dots, z]^+ [\backslash d]^*$$

where $[A, B, C, \dots, Z, a, b, c, \dots, z]$ implies the validity of upper- and lower-case English alphabets, and the choice operator $+$ matches the preceding character 1 or more times. Moreover, $\backslash d$ is a numeric character, which is specified as $[0, 1, 2, 3, \dots, 9]$, and the Kleene operator $*$ matches the preceding character 0 or more times. However, the regular expression can be simplified as:

$$nameRegEx = [A, B, C, D, \dots, Z, a, b, c, d, \dots, z]^+ [0, 1, 2, 3, \dots, 9]^*$$

Let $name$ be a type of $nameRegEx$

$$name = [nameRegEx]$$

Thus, variables of type $name$ could be defined as follows.

$$\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n : name;$$

$$\beta_1, \beta_2, \beta_3, \dots, \beta_m : name;$$

Where:

$\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n$ represent names of hardware components,

$\beta_1, \beta_2, \beta_3, \dots, \beta_m$ represent names of software components.

If $\alpha_i = \beta_j$, then their failure modes expression will be the OR of both failure expressions.

This could be established as follows.

Let W_k represent a composite failure mode expression where $k = 1, 2, \dots, p$. Where p is the number of possible composite failure mode expressions.

Hence, using predicate calculus the following could be established.

$$\forall i, j, p: \mathbb{N} \mid 1 \leq i \leq n, 1 \leq j \leq m, 1 \leq k \leq p \mid \alpha_i = \beta_j \bullet W_k = C_{if} \vee S_{jf}$$

The above expression is defined as, for all i, j and p of type natural number such that i, j , and k are between 1 and n , 1 and m and 1 and p respectively, such that if the name of the hardware component matches a certain software component. Thus, it produces a composite failure mode, which is the logical OR of the failure mode expressions of the respective components.

5.0 Fault Tree Analysis

One important feature of the FTA analysis process is that the analysis presents the components failure modes at their respective output level and show how the failure modes

propagate to affect the entire system function. The gear-drive EMA components are further analysed manually with the use of FTA techniques as shown in Figure 4.

The FTA uses the top system failure modes (Gear-drive EMA mechanical Energy “Omission (O-out)”) as the top system failure event, and the top component's failure modes are presented as the top component's event. While the internal failure modes for each component represent the basic event. Thus, the input deviation is propagated and further leads to the output deviation, as seen in the fault tree diagram. The analysis presents each component's output omission as a sub-fault tree, this output omission is caused by the internal failure of the component and the output failure propagation of other components.

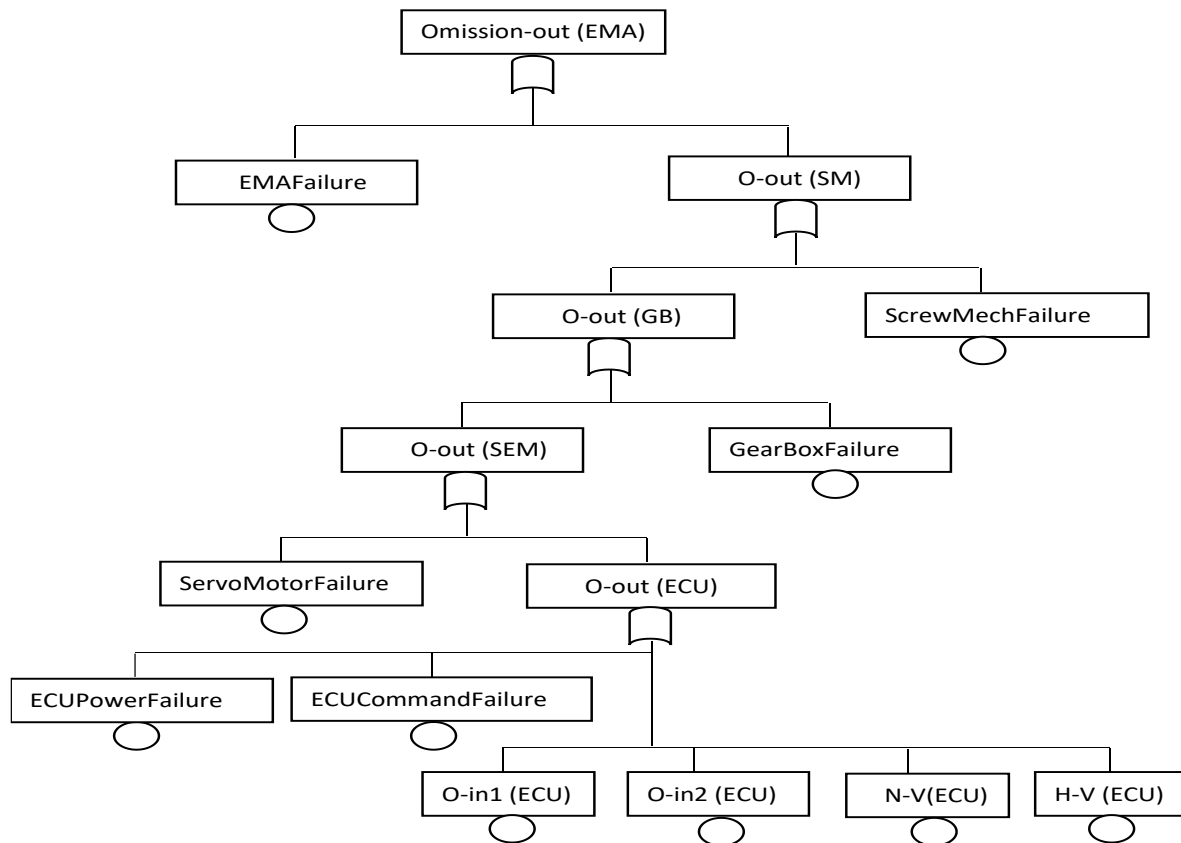


Figure 4. FTA of Gear-drive EMA system.

5.1 Fault Tree Evaluation (Minimal Cut Sets)

One of the main purposes of applying the use of the FTA method in complex system analysis is to determine the minimal cut set. The minimal cut set of the fault tree can be determined based on the occurrence of the basic events. The top failure event occurs when the entire basic event in the fault trees occurs. For further gear-drive EMA system design and analysis, a minimum cut set is generated manually to help the system analyse and identify the gear-drive EMA components that are very weak in the initial design model. This process will be a

contributing part of the paper, and this can help system engineers to direct their effort on weak components when improving and redesigning the initial system models.

A similar procedure of minimal cut set presented by Stamatelatos et al. (2015) is adopted for this paper. This procedure expressed the top system failure mode of the gear-drive EMA fault tree shown in Figure 4, as a Boolean Function of the components internal failure and output Omission. The equivalent Boolean equations for the gear-drive EMA fault tree are presented by starting with the top event, as shown below.

$$\begin{aligned}
 \text{Omission-out (EMA)} &= \text{EMAFailure} + \text{O-out (SM)} \\
 \text{O-out (SM)} &= \text{ScrewMechFailure} + \text{O-out (GB)} \\
 \text{O-out (GB)} &= \text{GearBoxFailure} + \text{O-out (SEM)} \\
 \text{O-out (SEM)} &= \text{ServoMotorFailure} + \text{O-out (ECU)} \\
 \text{O-out (ECU)} &= \text{ECUPowerFailure} + \text{ECUCommandFailure} \\
 &\quad + \text{O-in1 (ECU)} + \text{O-in2 (ECU)} + \text{N-V} + \text{H-V}
 \end{aligned}$$

The minimal cut set for the gear-drive EMA fault tree is obtained, by starting the Boolean expression from the top failure event and expanding the equations downward. Hence, the minimal cut sets generated from the expression are EMAFailure, ScrewMechFailure, GearBoxFailure, ServoMotorFailure, ECUPowerFailure, ECUCommandFailure, O-in1 (ECU), O-in2 (ECU), N-V and H-V. Hence the Boolean equation for the top event can then be written as:

$$\begin{aligned}
 T &= \text{EMAFailure} + \text{ScrewMechanismFailure} + \text{GearboxFailure} + \text{ServoMotor} + \\
 &\quad \text{ECUPowerFailure} + \text{ECUCommandFailure} + \text{O-in1} + \text{O-in2} + \text{N-V} + \text{H-V}
 \end{aligned}$$

10 minimal cut set is generated manually from the gear-drive EMA fault tree. Hence, each of these minimum cut sets defines a failure modes event whose occurrence will cause the system top event to occur. Thus, the components with the minimum cut set represent the single point of failure for the design model. Therefore, replicating, or scheduling maintenance on these components will be of utmost importance to system engineers, during the early stage of the system design.

6.0 Conclusion

This paper has investigated the failure analysis of a composite (computer-controlled) system by analysing the constituent systems (hardware and software) separately. For the hardware, FMEA was performed on the hardware model of the system while for the software, FMEA was performed on the class diagram of the system. The failure mode expressions obtained for the two systems were then combined or mapped using an activity diagram, and from this procedure, a formal mapping was established. The formal mapping suggests that the same rule could be used for the failure analysis of any composite system. The composite system was further analysed for failure using FTA to obtain minimal cut-sets which indicated components requiring further attention. The result showed that all the components were found to be single point of failure. Thus, as a recommendation, the components could be redesigned or a preventive maintenance schedule should be drawn.

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Factors Affecting Information Systems Audit Conclusion

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Abstract

This paper examines the elements that significantly affect an information system audit's conclusion. The importance of guaranteeing the effectiveness, efficiency, and security of information systems has been underlined by the ongoing advancement of technology and the growing reliance on digital infrastructure. An information system audit's main goal is to assess the systems' overall integrity and to reassure stakeholders that they are trustworthy and sufficiently protected against any hazards. The paper identifies and examines the important elements that affect the outcome of information system audits by drawing on a thorough examination of the literature and empirical studies. Conducting a thorough and accurate information systems audit requires an understanding of these aspects and the proper handling of them. The results of this study give significant contributions to the field of information system auditing and provide a foundation for auditors, IT managers, and policymakers to create efficient plans for carrying out thorough and insightful audits. The ultimate goal of this article is to increase the resilience of information systems in a constantly evolving digital environment and to create a greater awareness of the elements that support audit conclusions.

Keywords: Information System Audit, Risk assessment, CIA, Internal controls.

1.0 Introduction

Modern enterprises are built on information systems, which support crucial activities and store sensitive data. Information technology is becoming more and more important, so it is crucial to examine the efficiency and security of these systems through audits. However, a number of variables can impact the findings of an information systems audit. In order to increase the dependability of audit results, this study will investigate and examine these issues.

1.1. Methodology

The review uses a systematic approach to identify relevant literature from reputable databases and publications. Selection criteria include an emphasis on information system audit (ISA), relevance to government departments, state-owned companies, and private institutions, and rigor of the research methodology. The selected works are critically analyzed and common themes and insights are worked out.

Below are the findings review on Factors Influencing Information Systems Audit Conclusion:

1.2 Audit Objectives and Scope

According to Isaca (2019) and INTOSAI (2019), audit objectives and scope have an influence on ISA conclusions. The author stated that the result of information systems audits is substantially influenced by the alignment of audit objectives and scope. Auditors can concentrate on important risk areas, vulnerabilities, and compliance requirements inside the information systems when they have clear and appropriate audit goals. Similar to this, a clear audit scope guarantees that the audit team will evaluate the pertinent aspects and actions,

preventing overlooks of important components. The audit process becomes more focused and successful when the audit objectives and scope are in line, producing accurate and pertinent conclusions and practical recommendations to improve the security, effectiveness, and dependability of information systems. The audit's overall efficacy can be hampered by misaligned objectives and scope, which can result in inadequate assessments and missed opportunities to detect potential control deficiencies the authors stated. To preserve the audit's relevance and increase its impact on information system auditing processes, flexibility in defining the audit's objectives and scope is essential as technology develops and business demands change.

1.3 Risk Assessment

Information systems audit conclusions are greatly influenced by risk assessment (Isaca, 2019; INTOSAI, 2019). Auditors can concentrate their attention and resources on the most important areas by methodically finding, assessing, and rating potential hazards within the information systems. Auditors can more effectively target their audits by understanding the underlying vulnerabilities and threats that the organization's IT environment faces with the help of a thorough risk assessment. Furthermore, the risk assessment procedure offers a foundation for evaluating the sufficiency and efficacy of current controls, enabling auditors to generate wellinformed conclusions and suggestions regarding the overall security and resilience of the information systems. As a result, a thorough risk assessment approach improves the accuracy and applicability of the audit conclusion, allowing stakeholders to learn important details about the organization's risk environment and the steps required to effectively manage possible threats.

1.4 Quality of Evidence

The outcome of the information systems audit is largely influenced by the quality of the evidence (Isaca, 2019; INTOSAI, 2019). The audit findings are guaranteed to appropriately reflect the state of the information systems by a solid and trustworthy body of evidence gathered via thorough and well-organized audit methods. Stakeholders have faith in the legitimacy of the assessment results because of the high caliber evidence supporting the audit conclusions. On the other hand, incomplete, out-of-date, or improperly gathered evidence may result in incorrect conclusions and misguided suggestions, which would compromise the audit's overall efficacy. In order to ensure that their judgments are supported by reliable facts and that companies can make informed decisions and take the necessary action to increase the security and effectiveness of their information system, auditors must highlight the quality and integrity of the evidence.

1.5 The Expertise of the Audit Team

The information systems audit's conclusion is strongly influenced by the audit team's level of knowledge (Isaca, 2019; INTOSAI, 2019). A highly competent audit team has the ability to successfully navigate complicated technical environments, pinpoint key risk areas, and thoroughly assess the effectiveness of controls. Their knowledge enables them to carry out in-depth assessments, spot minor vulnerabilities, and reach well-informed findings, which results in more accurate and pertinent audit outcomes. Additionally, seasoned auditors are better able to evaluate the data, ensuring that the assessment results are founded on a complete comprehension of the organization's particular IT environment. On the other hand, a lack of experience within the audit team could lead to risks being missed, evaluations being

insufficient, and insights being limited, thereby putting the integrity and worth of the audit results in jeopardy. As a result, putting together an expert and experienced audit team is essential to producing evaluations that are meaningful and offer suggestions for improving the security, effectiveness, and overall performance of information systems.

1.6 Regulatory and Compliance Requirements:

Information systems audit conclusions are significantly influenced by regulatory and compliance requirements (Isaca, 2019; INTOSAI, 2019). In order to guarantee the security, privacy, and confidentiality of sensitive data and information, these regulations set the norms and principles that businesses must abide by. The audit team evaluates the organization's adherence to these standards during an audit to ascertain whether the information systems adhere to the relevant statutory and industry criteria. The organization has put in place the necessary controls and procedures to meet these requirements, as shown by a successful audit finding. Legal repercussions, reputational harm, or financial losses could come from noncompliance with regulations or insufficient attention to them, according to audit findings. As a result, regulatory and compliance issues are crucial in determining audit results because they encourage firms to adhere to best practices, reduce risks, and uphold stakeholders' trust by ensuring the dependability and compliance of their information systems.

1.7 Complexity of the IT Environment

The result of the information systems audit is substantially influenced by the complexity of the IT environment (Isaca, 2019; INTOSAI, 2019). Numerous interconnected systems, applications, and data repositories can provide a wide range of potential hazards and issues in complex IT ecosystems. To effectively identify crucial control points and vulnerabilities, auditors must traverse through numerous layers of technology, interfaces, and dependencies. The audit's thoroughness could also be impacted by its complexity, as some areas might be more difficult to access or comprehend. Intricate IT systems may also make it more likely that mistakes or oversights will be made throughout the audit process, which will affect how accurate the results are. To address the complexity of the IT environment, a highly qualified audit team, specialized audit methodologies, and a thorough understanding of the organization's technology infrastructure are necessary. This will ultimately improve the security, effectiveness, and resilience of the information systems.

1.8 Internal Controls

Internal controls have a significant impact on the outcome of the information systems audit (Isaca, 2019; INTOSAI, 2019). These measures are intended to protect assets, guarantee data integrity and accuracy, and stop fraudulent and unauthorized activity within the information systems. To identify the organization's risk exposure and overall security posture, the audit extensively evaluates the effectiveness and sufficiency of these measures. Strong internal controls give auditors assurance that the systems are dependable and that the data they generate is accurate. The internal controls of the corporation are effectively established, monitored, and in line with both business goals and legal requirements, according to a positive audit conclusion. The need for remedial actions to improve the governance and protection of information systems may be signaled by flaws or gaps in internal controls, on the other hand, which could result in unfavorable audit findings. As a result, the organization's capacity to protect its assets and uphold data integrity and confidentiality is directly impacted by the

quality and robustness of internal controls, which also significantly affect the results of the information systems audit.

1.9 Data Quality

A significant component affecting the outcome of the information systems audit is data quality (Isaca, 2019; INTOSAI, 2019). The validity of audit findings and the efficacy of control evaluations are directly impacted by the correctness, completeness, and reliability of data within the systems. Auditors need high-quality data to make wise decisions and precise assessments of the organization's IT infrastructure, risks, and controls. On the other hand, bad data quality might produce false suggestions, overlooked vulnerabilities, and incorrect conclusions. Data is used by auditors to spot patterns, trends, and anomalies as well as to confirm the efficacy of controls and regulatory compliance. As a result, businesses must give data quality management top priority because it immediately improves the validity and applicability of the audit conclusions, empowering stakeholders to take well-informed actions to increase the security and operational effectiveness of information systems.

1.10 Discussion

Despite the factors affecting the conclusion of the information systems audit, the discussion on how to improve the information systems audit (ISA) is still ongoing to improve the whole ISA process to ensure a high-quality conclusion from the audit, which leads to good recommendations for improving organizations' IT infrastructures and ensuring confidentiality, integrity, and availability (CIA) of data. Other streams of audit also rely on internal controls tested by information systems auditors. When assessing the standard of information systems auditing, three studies in particular (Stoel et al. (2012), Havelka & Merhout (2013), and Putri & Mardijuwono 2020, as cited in Alagi, Turulja & Bajgori, 2021) stand out, and no measuring scale has been adopted, even though these authors discussed the subject of information systems auditing quality. Moreover, the current auditing models are insufficient to be applied in practice due to the complexity of modern IT Systems and their inability to detect sophisticated cyber threats, and the limited ability to analyze large amounts of data in different formats, which have led to the rise in cybercrime, and data breaches (Siponen & Vance, 2010; Alexiou, 2019; Nabil, 2021; Youngjoo and Sooyong, 2021; Martin et al., 2022).

1.11 Conclusion

The results of the audit of information systems clearly illustrate the complex interaction of numerous influencing factors. Every aspect affects the accuracy, reliability, and relevance of audit results, from the definition of precise audit objectives and scope to the competence of the audit team, from the rigor of risk assessment to the robustness of internal controls. The complexity of the technology, regulatory compliance, and data quality all add to the complexity of this process. The convergence of these variables underscores the need for an all encompassing approach to auditing information systems. Organizations need to proactively address these different dimensions to ensure audit conclusions are both meaningful and actionable. This includes continually adjusting audit objectives and scope, building an experienced and competent audit team, managing changing technical environments, and promoting a data quality management culture. By understanding the complex interplay and value of these factors. Additionally, Information systems auditing (ISA) is a critical process in business informatics. However, the process and tools used are not

enough to detect complex cyber threats. As a result, there can be undetected security breaches, compromised data confidentiality, integrity, and availability, and an increased risk of cyberattacks. This can affect the overall effectiveness of the ISA process and the validity of evidence collected by IS auditors, potentially leading to inaccurate system assessments.

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A Comparative Analysis of Information Systems Audit and Digital Forensics Processes

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Abstract

This paper provides a comparison of two essential cybersecurity disciplines: Information Systems Audit (ISA) and Digital Forensics (DF) by drawing on a thorough examination of the literature and empirical studies. The security and integrity of digital systems are critical in today's connected and data-driven world. Both ISA and DF play a critical role in protecting digital assets, detecting incidents, and facilitating an effective incident response. This study examines the methodology, goals, tools, and strategies used in these two fields, emphasizing their parallels, contrasts. Organizations can improve their cybersecurity strategy and strengthen their defenses against evolving cyber threats by understanding the unique yet interconnected nature of ISA and DF. The rapid spread of cyber threats and the potential impact of cyber incidents on organizations underscore the critical importance of comprehensive and effective cyber security measures. Therefore, this paper seeks to make a significant contribution to the topic of cybersecurity by providing an in-depth comparative analysis of two critical areas. The importance of this paper lies in exploring how these disparate but interconnected areas could work together to strengthen an organization's cybersecurity posture. Additionally, it highlights the relative contributions of ISA and DF to protecting digital assets, identifying and responding to incidents, and maintaining regulatory compliance by looking at their approaches, goals, tools, and techniques. Moreover, it will highlight the potential synergies between the two areas and provide insights into how organizations can leverage the strengths of ISA and DF to improve their overall cybersecurity resilience. Organizations can optimize their strategies, streamline procedures, and develop a more coherent and proactive approach to cybersecurity by acknowledging the symbiotic relationship between ISA and DF.

Keywords: Information Systems Audit, Digital Forensics, Cybersecurity, Comparative Analysis, Incident Response

Introduction

Organizations rely heavily on information technology to run, communicate, and manage critical processes in the age of digital transformation (Pertiwi, 2021). As a result, ensuring the security, confidentiality, integrity, and availability of digital assets has risen to the top of the priority list. Information Systems Audit (ISA) and Digital Forensics (DF) are two disciplines that use rigorous procedures and methodologies to solve these challenges. While both ISA and DF are concerned with cybersecurity, they serve distinct but complementary roles. This research aims to provide an in-depth comparative review of ISA and DF procedures, methodology, tools, and objectives, shedding light on their respective contributions to cybersecurity.

ISA is a systematic assessment of an organization's information systems, controls, and procedures to determine their efficacy, compliance, and overall security posture (Spremi, 2017; Alagi, Turulja, & Bajgori, 2021; ISACA, 2019; INTOSAI, 2019b). Auditing entails evaluating risk management procedures, internal controls, data integrity, and regulatory compliance. ISA procedures are guided by a variety of frameworks and standards, including COBIT, NIST SP

800-53, and ISO 27001. The ISA process is divided into three stages: planning, fieldwork, and documentation, as well as reporting (ISACA, 2019; INTOSAI, 2019b). In contrast, DF entails the systematic gathering, preservation, analysis, and presentation of digital evidence to aid investigations into cyber events, data breaches, and cybercrimes (Ahn & Lee, 2018). It includes identifying hacked systems, reconstructing events, and attributing hostile behaviors. Evidence collecting, examination, analysis, and reporting are all part of the systematic method used in DF processes. Tools such as EnCase, FTK, and Autopsy are routinely utilized in DF investigations, according to NIST (2019). Identification, preservation, collecting, examination, analysis, and documentation are the major aspects of DF. Furthermore, DF adheres to legal norms and preserves the chain of custody (NIST, 2019).

Comparative Analysis

- **Objective**

According to ISACA, (2019) and INTOSAI, (2019b), ISA attempts to examine the whole control environment, risk management, and compliance, whereas DF focuses on identifying and responding to individual cyber events, according to NIST, (2019), and Ahn & Lee, (2018). The goals of Information System Auditing (ISA) and Digital Forensics (DF) highlight their separate but complementary roles in cybersecurity. The primary purpose of ISA is to give a thorough assessment of an organization's control environment, risk management procedures, and adherence to regulatory and compliance standards. It is concerned with the big picture, with the purpose of ensuring the integrity, effectiveness, and alignment of information systems with organizational goals. The analyses provided by ISA provide significant insights into systemic strengths and weaknesses, allowing for continuous improvement and proactive risk reduction. In contrast, the primary goal of Digital Forensics is to respond to specific cyber occurrences. DF is a reactive technology that involves the methodical identification, investigation, and resolution of cyber issues like as data breaches, illegal access, and malware attacks. DF focuses on locating digital evidence, recreating events, and identifying specific actors' activities. Its targeted approach helps to determine the breadth and impact of occurrences, allowing for fast and effective incident response. DF enables enterprises to limit damages, prevent new occurrences, and support prospective legal proceedings by pinpointing the origin and nature of threats.

In summary, whereas ISA involves a comprehensive examination of controls and compliance, DF's goal is to investigate and respond to particular cyber occurrences. The combination of these goals ensures a holistic approach to cybersecurity, from risk management to incident response.

- **Methodologies:**

According to ISACA (2019) and INTOSAI (2019b), ISA evaluates controls using a risk-based methodology, whereas DF reconstructs digital events using a structured investigative technique (NIST, 2019; Ahn & Lee, 2018). The approaches used by Information System Auditing (ISA) and Digital Forensics (DF) reflect their separate functions within the field of cybersecurity. ISA is a risk-based strategy, concentrating on analyzing and controlling potential vulnerabilities and threats within an organization's information systems. This technique entails

identifying key assets, assessing associated risks, and prioritizing control measures to mitigate those risks. ISA's risk-based methodology enables firms to effectively allocate resources, focusing on areas of greatest concern and guaranteeing a thorough assessment of the control environment. In contrast, Digital Forensics employs a structured investigation approach that is suited to studying and recreating digital events following a cyber-incident. DF specialists use defined methods to collect and maintain digital evidence, assuring its integrity and admissibility in judicial proceedings. The process entails methodical evidence collection, thorough analysis, and reporting of findings. DF's investigative technique aids in piecing together the sequence of events, identifying potential culprits, and establishing a detailed description of how the incident occurred. This method is critical for developing a coherent narrative and facilitating informed decision-making during incident response and any legal actions.

While ISA's risk-based technique focuses on proactive risk management and control evaluation, DF's structured investigative approach strives to unearth the truth behind individual cyber occurrences. Together, these techniques contribute to a holistic and multifaceted approach to cybersecurity, covering both preventative and response aspects in an increasingly complex digital context.

- ***Tools and Techniques:***

According to ISACA (2019) and INTOSAI (2019b), ISA employs control testing, documentation review, and process evaluation, whereas DF applies forensic tools and techniques to evaluate digital artifacts and evidence (NIST, 2019; Ahn & Lee, 2018). Information System Auditing (ISA) and Digital Forensics (DF) use different sets of tools and approaches to achieve their goals in the cybersecurity landscape. To examine an organization's control environment, risk management, and compliance with set standards, ISA employs control testing, documentation review, and process evaluation. Control testing is analyzing the efficiency of controls via simulations and tests to ensure they function as intended, paperwork review evaluates rules, procedures, and paperwork to ensure compliance, whereas process evaluation investigates the efficiency and effectiveness of operational processes. The ISA tools are designed to assess the overall control structure and regulatory alignment. Digital Forensics, on the other hand, analyses digital artifacts and evidence in reaction to cyber incidents using specialized forensic tools and procedures. Forensic tools are software and technology that are designed to capture, retain, and analyze digital data while maintaining its integrity. Data recovery, chronology reconstruction, and virus analysis are among the techniques used. To reconstruct events and assign actions, DF professionals methodically harvest and analyze data from numerous sources, including devices, networks, and logs. DF's tools and procedures are designed for post-incident investigation, assisting in the identification of perpetrators, determining the breadth of the breach, and recovering damaged systems.

In summary, whereas ISA's tools are focused on control evaluation and compliance validation, DF's specialized forensic tools and methodologies are focused on unearthing digital evidence, assisting investigations, and aiding incident response in the aftermath of cyber incidents.

- **Timing:**

ISA is often conducted periodically (ISACA, 2019; INTOSAI, 2019b) while DF is activated in response to specific incidents (NIST, 2019). Timing is critical in separating the operational contexts of Information System Auditing (ISA) and Digital Forensics (DF). ISA is often performed on a regular basis as a proactive approach to assess the overall health, compliance, and efficacy of an organization's information systems. It entails planned reviews aimed at ensuring continued conformity to regulatory standards, corporate policies, and best practices. ISA focuses on maintaining a continual state of readiness by identifying vulnerabilities, reviewing controls, and recommending changes. Digital Forensics, on the other hand, is engaged reactively in reaction to specific situations such as cyberattacks, data breaches, or suspicious activity. When an incident happens, DF experts are relied upon to gather and analyze digital evidence as quickly as possible in order to ascertain the nature of the occurrence, determine its impact, and support incident response operations. The necessity to quickly minimize damage, identify criminals, and restore system functionality drives the urgency of DF.

This chronological difference highlights the opposing agendas of ISA and DF. ISA strives to prevent and anticipate possible hazards, whereas DF responds to incidents that have already occurred. These distinct temporal orientations mirror the greater goals of each domain: ISA for continuous assurance and improvement, and DF for post-incident analysis and resolution. Understanding the temporal dynamics of various disciplines, as a result, assists firms in developing a holistic cybersecurity plan that includes both proactive and reactive methods.

- **Collaboration:**

According to ISACA (2019) and INTOSAI (2019b), ISA engages stakeholders from numerous sectors, whereas DF necessitates tight engagement with legal teams and law enforcement (NIST, 2019). Collaboration is a key factor in distinguishing the operational scopes of Information System Auditing (ISA) and Digital Forensics (DF). Collaboration in ISA entails bringing together stakeholders from many departments within a company. This all-encompassing strategy ensures that auditing methods cover the entire scope of information systems, from technology to business operations. To completely examine controls, risks, and compliance standards, ISA requires collaboration among IT, financial, compliance, and management teams. Collaborative efforts in ISA promote a better knowledge of organizational risks and make it easier to connect information systems with strategic goals. DF, on the other hand, demands a more specialized style of collaboration that focuses on close coordination with legal teams and law enforcement organizations. When DF investigates cyber incidents, the digital evidence gathered must meet legal criteria and be usable in court. Working with legal specialists ensures that the inquiry adheres to proper processes, respects privacy rights, and preserves the chain of custody. Furthermore, DF professionals collaborate with law enforcement to assist in the detection, prosecution, and resolution of cybercrimes.

The diverse collaboration features of ISA and DF reflect their distinct duties - ISA's varied organizational engagement and DF's precise legal and law enforcement relations. Recognizing

the collaborative subtleties of each area is critical for optimizing their respective contributions to an organization's cybersecurity strategy.

Comparative Analysis Summary

Aspect	Information Systems Audit (ISA)	Digital Forensics (DF)
Objective	ISA aims to assess the control environment, risk management, and compliance.	DF focuses on identifying and responding to individual cyber events.
Methodology	ISA uses a risk-based approach to analyze vulnerabilities and prioritize controls.	DF employs a structured investigative technique to recreate digital events.
Tools	Control testing, documentation review, and process evaluation are employed in ISA.	DF uses forensic tools and techniques to evaluate digital evidence.
Timing	ISA is conducted periodically to ensure ongoing compliance and control effectiveness.	DF is activated in response to specific cyber incidents.
Collaboration	ISA involves collaboration among stakeholders from various departments.	DF requires close coordination with legal teams and law enforcement.
Conclusion	ISA assesses the broader cybersecurity landscape, while DF reacts to specific events.	Combined, ISA and DF provide a comprehensive approach to cybersecurity.

Conclusion and Recommendations

The importance of Information Systems Audit (ISA) and Digital Forensics (DF) as basic foundations of cybersecurity cannot be emphasized in today's dynamic and sophisticated digital ecosystem. As enterprises contend with growing cyber threats and an ever-expanding digital footprint, the role of ISA in anticipating risks, ensuring compliance, and bolstering control environments has become critical. Similarly, the critical role of DF in responding to incidents, detecting malicious activity, and piecing together digital evidence adds a layer of post-incident resilience to the cybersecurity structure. ISA and DF work in tandem, with ISA's proactive evaluations impacting incident response methods and DF's reactive investigations benefiting from ISA's foundational insights. In a world where cyber-attacks are becoming more complicated, integrating these domains provides enterprises with a complete and proactive strategy to defend their digital assets, ensuring a robust cybersecurity posture in the face of the intricate and developing digital environment.

Recommendation

The foregoing comparative analysis has shown that there are critical similarities and peculiar differences between Information Systems Audit processes and those for Digital Forensics. It is therefore recommended that research be carried out to find the best possible way of augmenting digital forensics process components to information systems audit processes so as to come up with more robust systems that not only perform auditing but are able to also provide information about who tampered with information, where and how.

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An integrated content co-creation framework for Public Relations and Digital Media: A case study of a Namibian commercial organisation

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Abstract.

Communication is the driving force fostering a good reputation for any business and is critical to managing business-to-customer and business-to-employee engagement while mitigating reputational risks. The birth and adoption of digital media as part of the public relations channel mix has increased the need for companies to embrace strategic communication. Strategic communication embodies a hybrid approach that integrates digital and traditional channels. However, there is resistance to fully adopting digital media as a communication channel. Often digital media and public relations are seen as independent practices and are required to craft two different strategies (For Digital and another for Public Relations). This has fuelled silos between Digital Media and Public Relations functions and has prevented these roles from co-creating and driving in-depth engagement with relevant audiences. This study aimed to develop a strategic framework to facilitate a collaborative approach between public relations and digital media content co-creation to drive customer engagement. This study used a mixed method whose results culminated in a framework. Some findings indicated that most participants believe that public relations and digital media are interdependent and that improving processes within the team could enhance performance that is currently negatively affected. They further revealed that the silo had caused a split in the brand's personality. The findings of this study have implications for communications practitioners.

Keywords: Digital Media, Strategic Communication, Public Relations and Content co-creation

1. Introduction

A framework for integrating public relations and digital media to drive content co-creation study is geared to build a bridge between traditional and hybrid public relations. Traditional media has been the vehicle that translated public relations to the audience until the birth of digital media. Traditional media puts the business at the centre of the message. In contrast, digital media, such as social media, has disrupted this standard form of business communication and has created a two ways communication trend. Earlier, Skinner (2011) advised that there are many digital channels and platforms of importance to communication practitioners, and these include websites, blogs, and social media. These channels should not be seen as separate entities but as part of modern communication (p. 150). In most organisations, the case study entity is no different; digital media and public relations are viewed and treated as separate practices, so much so that they are required to have two independent strategies. These conceptions create a space where about 80 – 90% of the content distributed by respective functions is developed in a silo.

Digital media has proven impactful to the business through its ability to produce analytics and provide a tangible return on investment. Before the effect of the Covid-19 pandemic, traditional media, more specific print media, was the most preferred and considered the most highly effective communication channel due to its reach. This belief is still strong within some practitioners and might take time to reshape this thinking. Succeeding in a fast-moving digital and social media world necessitates enormous adjustments in the communications strategy,

creating few profiles on different digital media channels is not nearly effective Forsgård & Frey 2010, 19 (as cited in Salla Eskola, 2015, an English paper). Figure 1 below indicates that, as of 2020, there has been a decline in the use and reach of print media. After engaging in a survey, think Human being (2020) discovered that print media, labelled as “Air Daily” in figure 1, has the lowest reach in Namibia compared to other media.

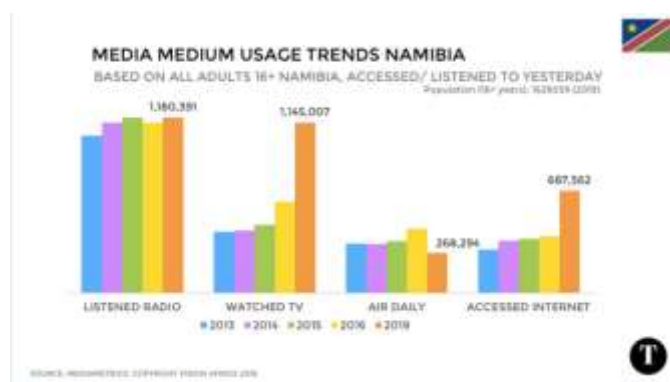


Figure 1. Media medium usage trends in Namibia
 Source: think Human being (2020)

Therefore, the study’s main objective is to develop a strategic framework that will facilitate a collaborative approach between public relations and digital media content co-creation to drive customer engagement. The rest of this paper is organised as follows, we provide a contextual background of the study through literature review, then explain the methods used to collect and analyse the study data. We then present the results and analysis, then present the integrated framework. We end with conclusions, recommendations, and future work.

This rest of this paper is organized as follows, we present the literature review in section 2, then the methodology utilized in this study is presented in section 3. Section 4 presents the results and analysis, and we present the developed integrated framework in section 5. Lastly, we conclude and chart a future work in section 6.

2. Literature review

According to Grunig (2009), “history shows that when new media are introduced, communicators use them the same way they used the old media. For example, journalists first used television just as they used radio. Accustomed to reading news on the radio, they continued to read it on television without using the pictures that the new medium allowed. In the same way, public relations practitioners first used online media as an information dump and used it in the same way that they used traditional media, newsletters, and publications” (p.6-7). This proves that there is a high need to change the culture and mindset of media practitioners. Grunig (2009) further mentioned that if the public relations function is sublimated to other functions such as marketing, finance, law or human resources, the message becomes less important—as an integrated function can (p.2).

2.1 What is digital media?

Digital Media are electronic communication channels organisations, or individuals use to manage reputation and build brand equity within the targeted market. An exercise that Public

Relations is also geared to drive. Brid.tv (2021) says that “digital, sometimes called online or new media is all media encoded and can be viewed, distributed, or stored on digital electronic devices”. This invention gave marketers an entirely new method to reach consumers. According to Andrew and Peter (2014), “some definitions of digital media focus exclusively upon computer technologies while others stress the cultural forms and contexts in which technologies are used” (p.9). In this context, we will look at how technologies can be used to support public relations. Technologies commonly used by the organisation include E-mail, SMS, Social networking sites, and other web 2.0 and 3.0 services.

2.2 Public Relations in the age of digital media

Skinner et al. describe “Public relations practice as a science of analysing trends, predicting their consequences, counselling organisations' leaders, and implementing planned activities which will serve the interest of both organisation and the public” (2011, p.4). PR is planned and sustained via engaging activities to influence or change behaviour, perception, and reputation, building mutual understanding and trust between the community members and the company. It uses events, donations/sponsorship, media, and content such as media releases/thought leadership articles and publications to appeal to the ethos and influence behaviours of the public. Public relations have, over the years, used traditional media to disseminate its content. Traditional media can be split into two categories, namely Print channels (Daily /weekly newsletters and Magazines) and Digital channels: Radio and TV. However, according to Matthew (2022), “the internet and digital media have become a large part of our daily and work lives. Consequently, the need for digital media skills is recognised”.

2.3 Co-Creation

According to Venkat (2017), the term “co-creation” has been linked and raised with various subjects such as new product or service design and development, creating with end-users as innovators, and participatory roles of consumers in product development. Co-creation goes beyond two or more humans coming together in activities. Instead, it involves a variety of collaborative system environments afforded by technological platforms augmented by digital technologies (p.195 – 205). There has been a disconnect between what companies value and what consumers value. This disconnects back to the early 20th century when companies did not value consumer opinion when developing products or services. Prahalad (2004) states that being customer-centric makes the consumer an integral part of the value creation system. The consumer influences the place, time, and how value is generated. The consumers searching for value disregards company efforts that do not cater to their needs, and this competes with companies' needs for value extraction. There are several exchange points where the consumer and company can co-create to build products and services that offer value to both customers and drive business growth. Companies co-create to establish valuable experiences with customers. (P. 5-14) In this context, there is a high need to co-create with clients to drive meaningful content and build relationships with clients.

2.4 The impact of content co-creation

Digital media has empowered organisations to co-create with customers and allow clients to add value in relationship management, new product development, and brand awareness. Most successful companies have embraced co-creating with clients and internally amongst staff. Through the internet-facilitated media, customers have undoubtedly acquired power and are now the key stakeholders of any business operation (Maryam, 2017, p.20). It is

important to include clients in the co-creation stream. Customers relate better to companies that are lifestyle driven than product-driven companies. Co-creation should not only be done within the team but should also include customers and allow customers to give input in the content created. Companies cognisant of such archetypes are reaping the benefits of customer engagement in their business process (Maryam, 2017, p.21).

2.5 Relationship between digital media and public relations

The core of public relations practice is carrying out deliberate, planned and sustained efforts to build relationships between an organisation and its stakeholder. Wolf (2018) Public relations effort can be viewed as a long-term investment into the brand. The focus is on consistently managing the company's reputation and communication channels, most of which are digital media. Digital media are critical in supporting public relations efforts and have reshaped public relations practice for the better. In a sense where public relations has become a two-way conversation instead of one-sided (pp. 494-509).

The impact of digital media on the public relations profession is positive. Grunig (2009) If digital media is used to its full potential, it will relentlessly make public relations practice more strategic and interactive (p. 1). Digital media brings dialogue and globularness into public relations, making it perfectly suited as a strategic management archetype.

3 Methodology

Research methodology is an approach to solving a research problem (Kothari et al., 2019). This defines the method of how research is prepared and designed methodically. A research design framework is used as a guide to collect and analyse information. According to Churchill and Iacobucci (2005), "there are three main research designs: explorative research, descriptive research, and causal research." This study used descriptive research.

Descriptive research combines quantitative findings in numbers and graphs, and qualitative results are expressed in words. According to Leedy and Ormrod (2010), hybrid approaches are used when both quantitative and qualitative research approaches are combined. This tactic gives an in-depth insight into the topic than a single approach. Most researchers use this approach to gain more insight into the research problem. We conducted eight interviews; with both open and closed-ended questions. The interview participants came from the Marketing and communication departments.

An equal number of participants had either a Marketing or Public Relations degree. Table 1 below provides the positions held by participants. Participants were selected using a non-probabilistic sampling technique. They are as follow: two participants are at executive level, two senior managers, two middle managers and two junior staff. We selected a sample population based on idiosyncratic judgment.

This study collected both qualitative and quantitative data. On the one hand, qualitative data analysis is undertaken systematically using the framework approach's principles. Therefore, enabling the researcher to explore data in depth while maintaining an effective and transparent audit trail, enhancing the rigour of the analytical processes Ritchie et al. (2003). Ensuring data analysis is explicitly described enhances the credibility of the findings. Koh et al. (2000) This study uses the thematic analysis technique to examine themes and

patterns of meaning within the qualitative data. Qualitative data is analysed according to themes using thematic analysis. On the other hand, quantitative Numerical data obtained via interviews is systematized and converted into percentages, charts, graphs, and tables, using the Excel Spreadsheet. This helps to summarise and describe data to find patterns, guiding the researcher to produce analysis and compare to provide outcomes and recommendations.

4 Results and analysis

The results and analysis are presented per the questions as asked during the interviews as described in the methodology section, under relevant headings.

4.1 Evaluate the impact working in a silo has on content distribution

Question 1: What is your rea of responsibility within the Company?

Four (4) participants are responsible for brand marketing, while four (4) participants are responsible for communication / public relations of the case study entity.

Question 2: Do you believe PR and digital communication are separate functions?

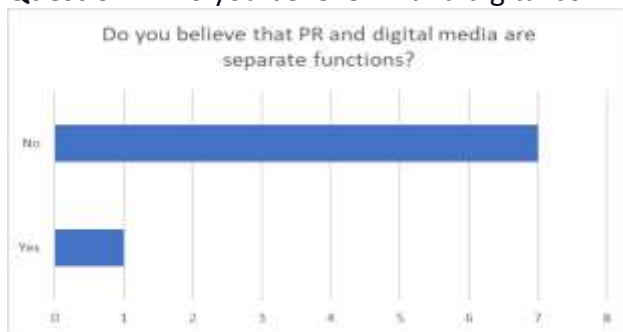


Figure 2: Are they separate **functions**?

Source: Interviews

Question 3: Should Public Relations and digital communication have two different strategies?

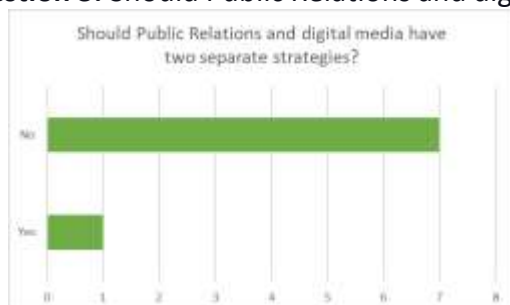


Figure 3: Should they have different **strategies**?

Source: Interviews

Based on figure 2 and 3 above, seven out of 8 participants believe that “the primary function of PR is to build a relationship of trust with the stakeholder”. This practice is like what is performed in digital media. “The two functions are interdependent as the company uses digital platforms to communicate PR content”. They further believe that “digital is a channel

and PR is a practice, and the two are getting integrated within many brands worldwide. Henceforth they should be unified to support one another". "PR and digital media should have one overarching strategy; however, each channel should have its unique approach to support the overall strategy". "As the world moves from trusted sources such as newspapers, digital and traditional media need an integrated approach". One participant believes that "PR and digital communication are separate functions as PR is about managing the company's image and digital media are channels used for marketing the company". This participant also believes that "these two functions should have different strategies; however, they should be able to complement each other". Megha (2022) also advised that despite how traditional and new media are often positioned, they do not have to go head-to-head; they can be used together to make publicity campaigns stronger. Conventional and contemporary media can complement one another, each playing a vital role.

Question 4: Do you currently feel there is a collaboration between Digital Media and Public Relations?

Participants are split. 50% feel there is collaboration, and the other feels there is no collaboration between the two functions. The team members should work together to create collaborative plans for each project. Participants feel that some of the items are produced stand-alone, and there is no golden thread or follow-up, making the brand look like it has a split personality. There is an opportunity for integration, as the two strategies are creating silos and widening the gap between the two functions. Participants also feel a need to create stability within the structure and form a solid functional structure to drive effective communication.

Question 5: Please rate the current overall performance of the nonintegrated team, with one being poor and five being excellent.

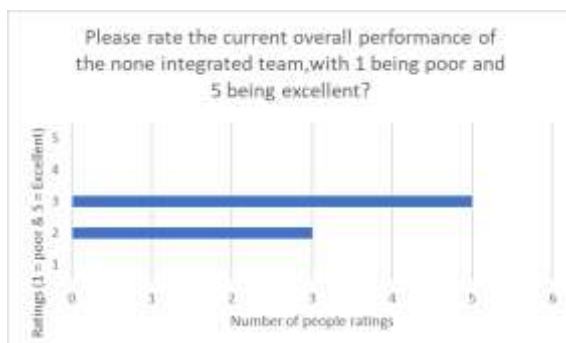


Figure 4: Performance ratings

Source: Interviews

Figure 4 points out that most participants rated the team performance average at three, while the minority felt the team was underperforming. Participants believe that the team's performance will improve drastically if an integrated approach is implemented.

Question 6: What challenges do you believe are contributing to this overall performance within the team? Participants believe the reasons below are contributing factors to an average performance:

- **Workload**

The participants indicated that high workloads limit the time allocated for strategic planning, lead to missed deadlines, and affect project turnaround times. Interview participants mentioned that "unrealistic expectations and deadlines for turnarounds given are critical drivers to low performance. Lack of a functional workflow structure contributes to not creating an integrated process for co-creation and disunity".

- **Lack of formal structures**

Most participants feel the structure will enforce collaboration and unify the team.

4.2 Evaluate a strategic framework that will facilitate a collaborative approach

Question 7: In your view, should Public Relations and Digital communication strategies be unified to drive unified objectives?

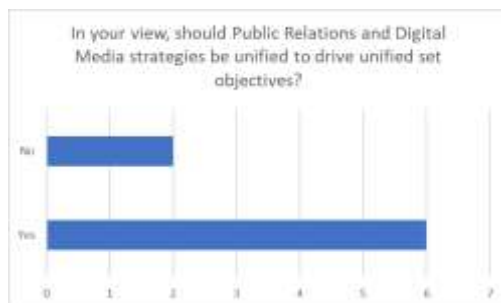


Figure 5: UnifiedSource: Interview data

Figure 5 above indicates that two (2) participants feel that "the two functions should not be unified as there should be an element of digital media that drives brand affinity, and the two roles are separate but complement each other". Most participants strongly feel "the two functions strategies should be unified to drive a common goal. This will improve reporting and help the team develop ideal key performance indicators". It will also enhance the public image as the audience will see a unified brand, building a consistent, trusted brand. Participants further believe that "PR, in its traditional function, need to transform and mould into a modern-day practice. At the same time, digital media must understand the various generations to be served and cater to their needs. Integration should be done with care to ensure that communication is inclusive and does not exclude specific audiences". "PR and digital media deal with information and should support a common objective. They should be like groves to avoid a split in the brand personality".

4.3 Identify components required to unify digital marketing and PR activities

Question 8: What key components can you suggest that the Digital and Public Relationship team should implement to unify effort and drive output? Participants felt the following should be implemented:

- **Set objectives**

Create an overall objective to use as a benchmark for all content created and provide guides on alignment across channels. This will be instrumental in determining the content of the quarterly report and progress evaluations.

Question 9: What key performance indicators would you like to see reported?

- **Negative, positive, and neutral sentiments**

These reputational key drivers showcase the company's perception performance with the target audience. Content is an essential deliverable in managing the reputation in the media.

- **Share of voice & net promoter scores**

This will help the company understand the impact of earned media content compared to its competitors.

- **Reach, impression, engagement, share, like and click through.**

These speak to how engaging, relatable, sharable or valuable the content is, instrumental in guiding practitioners on content development.

5 Integrated Strategic Framework for content co-creation

In this section we present the developed integrated framework for content co-creation between the public relations and digital media. As indicated in figure 6 below, the framework is meant to position public relations and digital media as an integrated function. It is comprised of 14 elements which are intertwined for greater integration. Ganes et al. (2021) argue that for large organisations there sometimes exists no live model that departments can leverage when it comes to integration.

1. **Proactive Communication / Brief from Business** – The team will get an official brief from the business (client-facing departments). The brief should state the business needs and the communication problem they would like to address.
2. **Acceptance of Brief** – there is a high need to avoid over-promising and under-delivering. To manage expectations and deadlines, keeping in mind all requests already in progress, the team will provide feedback if the brief is accepted or rejected. The project starting date, implementation date and end date will be communicated to the client after the team has engaged. A brief can be declined if critical information required for implantation is not provided or the project is not ready for communication.
3. **Audience Insight (message and channels)** – generating data from various platforms. Co-creation involves understanding consumer needs and creating engagement that solves or caters to their condition. Data providing insight into consumer needs should be the exodus.
4. **Understanding audience communication needs and channels** – interpreting data to understand requirements and preferred communication channels.
5. **Collaboration engagement** – data represent the client. At this stage, the team will brainstorm using data as fuel and develop engagement or content directions.

6. **Channel Strategy** – The overall communication strategy should be mindful of the channel-specific process to perform desired out. At this stage, the team will plan how the message will be implemented per channel.
7. **Engagement with brand marketing and creative services** – to integrate effort and embed communication effort into the overall concept presentation plan.
8. **Presentation 1: Overall corporate and communication team** - Present to the overall team and team leader for input and approval.
9. **Presentation 2: marketing committee** – presenting to key stakeholders for input, reviews and approval of the concept and communication initiatives.
10. **Create content** – Content should be created in view and full understanding of the various channels it will live and should be effective in respective channels. It should not be a size fit all.
11. **Content approval** – currently, a press release is approved without any consideration if the content has been optimised to perform in the search engine or not. In the new norm, there should be a checklist to confirm if the article is optimised for social media, website and print.
12. **Content published and optimised** – with every platform, technical practices should be performed to boost content visibility and drive traffic to company-owned channels. This practice should be standardised to amplify content and cater to business requirements.
13. **Evaluation** – introspection will help the team to learn and improve the process.
14. **Reporting** – there are key performance indicators that participants mentioned they would like to see in the report. This will also help the team to report on return on investment and efforts to relevant key stakeholders.

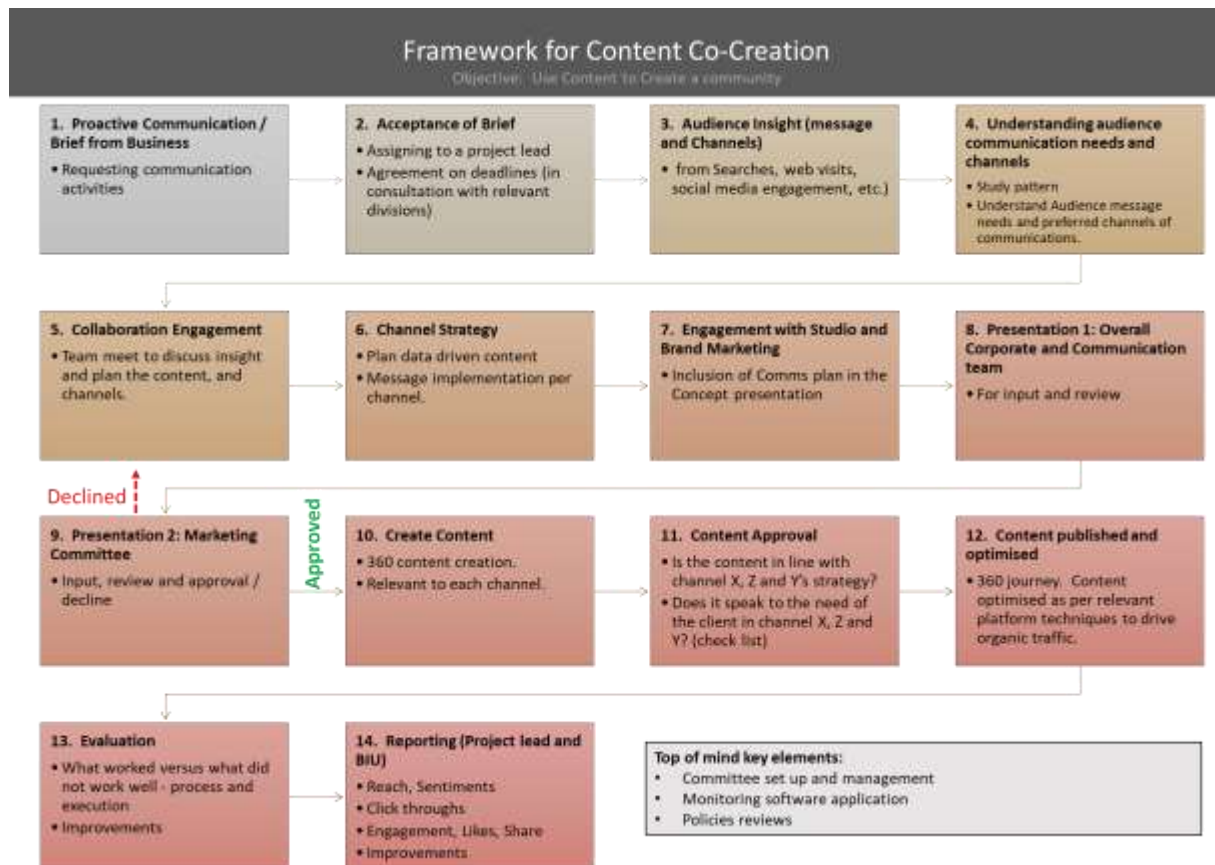


Figure 6: Framework

Source: Interview data

The integrated framework is aimed at the co-creation of content within organisations wherein the PR and Digital Marketing functions are disparate. Moreover, this framework is intended to help similar organisations with the avoidance of resources through duplication of effort.

6 Conclusions and future work

In conclusion this study is geared to create a framework that integrates PR and digital media to drive content co-creation. The end goal is to drive engagement and improve brand affinity. A key issue was identified: Average performance of the nonintegrated team due to lack of a stable framework. It is essential to understand the role of digital media and PR in modern practice. The study presented a strategic framework to integrate the PR and digital media functions of a commercial entity, as indicated in figure 6. However, although we endeavored to have it evaluated by interview participants, we do not believe the results to be final and as such we do not present the outcome of those evaluation attempts. There were methodological mistakes done with the evaluations. As such we propose that future studies implement and evaluate the proposed presented framework.

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Enhancing Customer Retention: A Study on Churn Prediction Models for MTC Namibia Using Machine Learning Algorithms

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Abstract

The importance of customer churn prediction models is understood by mobile network operators like MTC Namibia in order to proactively reduce the risk of losing customers. Machine learning algorithms have become more popular among telcos as a result of their success in predicting customer loss. To estimate customer turnover for MTC Namibia, we used four distinct machine learning-based algorithms in this study: K-Nearest Neighbours, Random Forest, Gradient Boosting Tree, and XGBoost. The ROC-AUC score gave the top-performing model, XGBoost, an outstanding accuracy rating of 84%. The results of the study found that factors such as real monthly usage, plan choice, and payment method (such as "cash") have a big impact on churn rates.

Keywords: Churn, prediction, telecommunication.

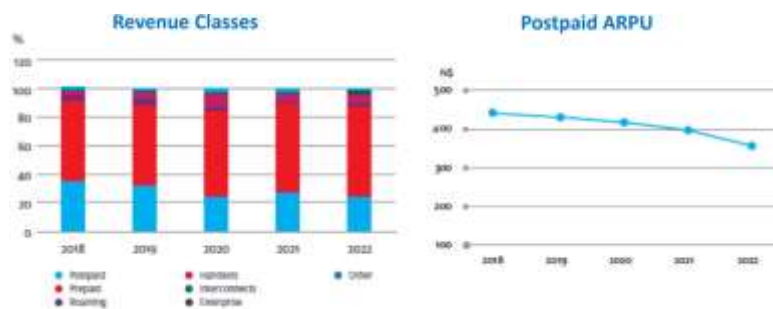
1. Introduction

Customer churn is the phrase for when customers discontinue using a company's goods or services, frequently for a variety of causes (Osman & Ghaffari, 2021). Since they lack a mechanism or application to predict whether a customer is going to churn or not, MTC is now dealing with a high churn rate. As a result, reducing client turnover has turned into a difficult and expensive process that mostly relies on reactive tactics. The COVID-19 pandemic's effects in Namibia and the economic downturn both have a negative impact on MTC Namibia's postpaid income. Additionally, elements like competing businesses providing better deals have significantly impacted the situation (MTC, 2021).

Furthermore, the telecommunications sector has grown to become one of the most important sectors. The degree of competition has risen as a result of technological advancements and an increase in the number of operators. Companies are putting in a lot of effort to stay afloat in this competitive market (Kandel, 2019). Multiple strategies are used in the market by various telco operators. The following are the primary three strategies that are mostly used by telco operators: acquiring new subscribers, enticing customers to upgrade packages by offering improved offerings, and increasing customer retention time (Ahmad, Jafar, & Aljoumaa, 2019).

Additionally, the telecommunications sector has grown significantly and assumed essential importance. Market rivalry has increased as a result of technological developments and an increase in operators. Companies are working very hard to survive in this cutthroat environment (Kandel, 2019). Numerous telecom operators use a variety of techniques to gain and keep their market share. Three main methods stand out among these strategies: gaining new customers, upgrading services, increasing customer retention and satisfaction (Ahmad, Jafar, & Aljoumaa, 2019). The return on investment (RoI) for each strategy must be considered when comparing various methods (Ahmad et al., 2019). Given that it is less expensive to keep an existing customer than to get a new one, increasing customer retention periods has proven to be the most profitable way among these. The goal of MTC Namibia to increase revenue is well aligned with this specific strategy. In order for MTC to increase their revenue-generating base and align with their new strategic goals, reducing churn is of the utmost significance.

Fig. 1: Postpaid revenue continues to decline as a proportion of total revenue. Furthermore, Postpaid ARPU is on an accelerating downward trend (MTC, 2021)



Source: Own Compilation

Figure 1 shows how Postpaid revenue as a percentage of overall income has been declining over time. Additionally, the Postpaid Average Revenue Per User (ARPU) is on a negative trend that is accelerating. The effectiveness and efficiency of machine learning algorithms in anticipating possible client turnover have been noted in prior studies. This strategy makes use of large historical data for learning (Lampert, 1986). This study examines the effectiveness of various tree-based machine learning methods and algorithms for predicting churn in the telecom sector. Data preparation, feature engineering, and feature selection techniques are used in the study. A prediction model for customer turnover was created using a variety of algorithms, including K-Nearest Neighbours, Random Forest, Gradient Boosting Machine Tree, and XGBoost Tree.

Previous studies have looked into a range of methods and methodologies for predicting client churn. For instance, using information from the telecom operator SyriaTel, Ahmad et al. (2019) created a model to forecast customer attrition. Their model's methods are compatible with the machine learning techniques used in this investigation. Gradients Boost Machine Tree, Decision Tree, Random Forest, and XGBoost were among the AI methods used in Ahmad et al.'s research (Ahmad et al., 2019).

Sampling and tree techniques were used to improve the dataset to address its imbalanced character, where just 5% of the data reflected churners. The data was then divided in half, with 30% set aside for testing and 70% used for training. The analysis's findings showed that XGBoost, with an amazing score of 93%, had the highest accuracy in forecasting churn. Random Forest Tree came in third with the highest accuracy, closely followed by GBM Boost with the second-highest score. Additionally, a fresh dataset was used to assess the model's performance, with the churn status unknown for two months; 89% of the churn events were correctly predicted (Ahmad et al., 2019).

MTC is currently facing a high churn rate as no application or system is in place to predict if a customer will churn or not. This had led to the process of preventing a customer from churning being difficult and expensive as it is done on a reactive basis. MTC must be able identify the churners before they churn in order to address this issue, thus creating a machine learning predictive model that anticipates future churners seems essential. The purpose of this study was to develop a machine learning algorithm to determine whether postpaid customers will churn or not.

3. Methods

Four different approaches were used to achieve the required results, and their effectiveness was compared to one another. Additionally, the models were combined using ensemble learning techniques, producing a stacked model. The component models, K-Nearest Neighbours, Random Forest, Gradient Boosting Tree, and XGBoost, were then put up against this stacked model.

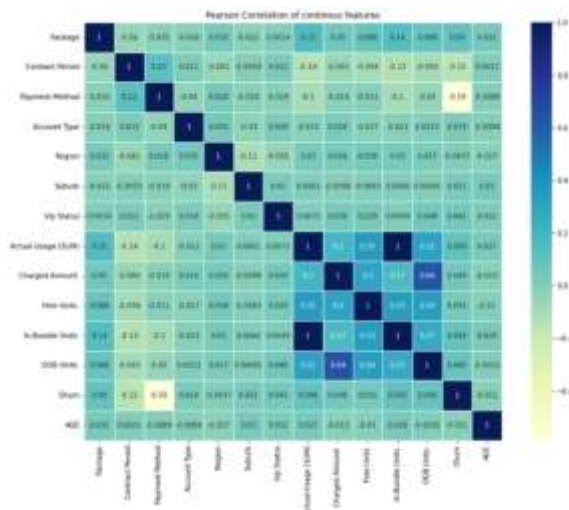
3.1. Dataset

The dataset, which was made up of 3345 records, was obtained from consumption trends among postpaid customers between January 2022 and April 2022. The key indicators for predicting churn were first unknown. However, important characteristics were recognised and used, including contract duration, package type, actual monthly costs, monthly units allotted, and out-of-bundle usage. The MTC dataset showed an imbalanced character during exploratory analysis, with churned consumers making up only 24.5% of the sample.

3.2. Feature Selection Data Correlation

In order to protect the identity of the customers, certain variables such the customer ID number and MSISDN (mobile phone number) were removed from the dataset as part of the data preprocessing. Null values and duplicate entries were also removed. A correlation matrix was used to examine the connection between factors and churn. The results showed a clear relationship between utilisation and churn. Additionally, bundle units and packages showed, respectively, the second and third strongest link with churn.

Fig. 2: The Pearson Correlation matrix shows that In Bundle units and Package have the



Source: Own Compilation

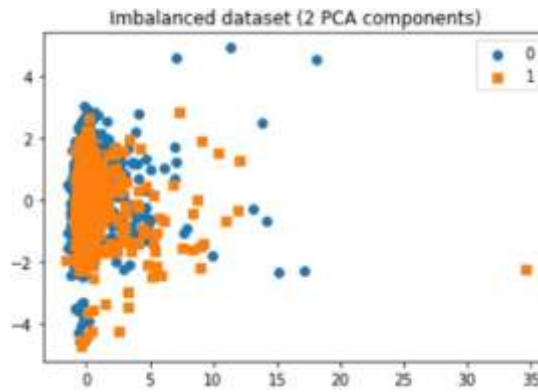
second and third highest correlation to churn while Actual usage had the highest.

3.3. Feature Engineering

To provide relevant characteristics for machine learning techniques, the data underwent processing. Label encoding was used to convert non-numerical properties, such "Package," into numeric values.

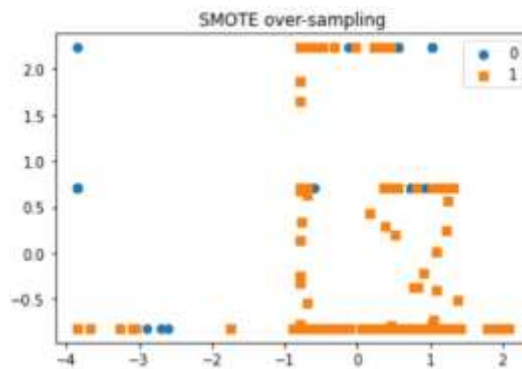
Additionally, the data was scaled and balanced using the SMOTE approach to address sensitivity issues. Additionally, the model with the best performance, the XGBoost model, had its hyperparameters tuned. This was done to avoid overfitting and improve the overall performance of the model.

Fig. 3: The distribution of the data before it was resampled



Source: Own Compilation

Fig. 4: The distribution of the data after it was resampled using SMOTE technique.



Source: Own Compilation

3.4. Classification

The dataset was split into two groups—the training group and the testing group—as part of the suggested methodology. The models were trained using the training group, which had 80% of the data, and the performance of the algorithms was evaluated using the testing group, which contained 30% of the data.

K-fold cross-validation was used to improve the models' hyperparameters. The classifiers Random Forest and K-Nearest Neighbour were initially trained. When trained with 300 trees, the Random Forest classifier produced the best results.

The GBM and XGBoost models were then trained after that. The settings were iteratively modified after exploring a range of parameter values. With a depth of 12,300 trees and a learning rate of 0.2, both models performed well.

3.5. Model Performance

The evaluation tool employed was the ROC-AUC score, which allowed for comparison and performance evaluation of the individual models. The ROC-AUC score was chosen instead of the mean accuracy score because it examines all potential threshold values, as opposed to the mean accuracy score, which only takes one threshold value into account.

The log-loss error was also employed as a measurement tool to check how closely the XGBoost model's projected probability matched the true/actual values.

4. Results

To compare the effectiveness of the various models, the findings were carefully examined. According to the experimental results, the XGBoost classifier performed better than the KNN and RF classifiers in terms of accuracy and F-score. The model with the Gradient Boost algorithm has the second-highest accuracy. Additionally, compared to the other models, it was found that the KNN classifier had the most misclassifications. The XGBoost model outperformed the ensemble stacked model, as depicted in Figure (5).

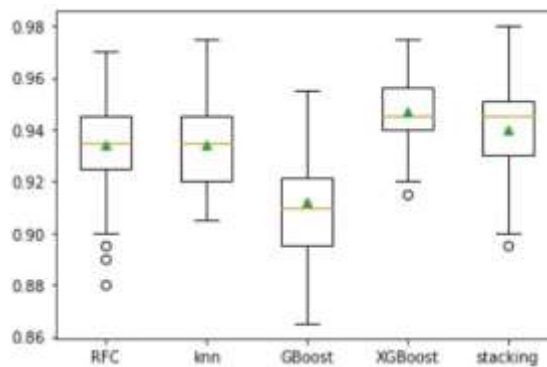


Fig. 5: Comparison of the various algorithms against the stacked model.

The XGboost model stands out in table 1 because it achieves a good mix between recall and precision with a ROC AUC score of 0.86. This shows that 86% of the customers whose churn the model anticipated actually do so.

Model	Accuracy	ROC AUC
KKN	0.796939	0.827274 23
XGBoost	0.830534	0.863517
Gradient Boost	0.814856	0.824188
Random Forest	0.824188	0.836141

Table 1: XGBoost had the highest ROC AUC score and accuracy.

Source: Own Compilation

For each classifier, the ROC curve is shown in Figure (6). The ROC curve is frequently used to assess a test's efficacy as a criteria. When a model's ROC curve deviates from the baseline more, it is thought to perform better.

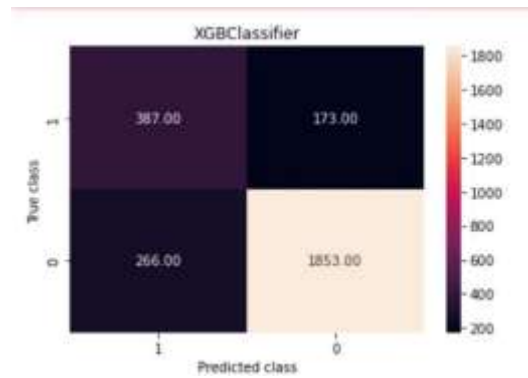


Fig. 6: ROC-AUC scores of the four classifiers explored.

Source: Own Compilation

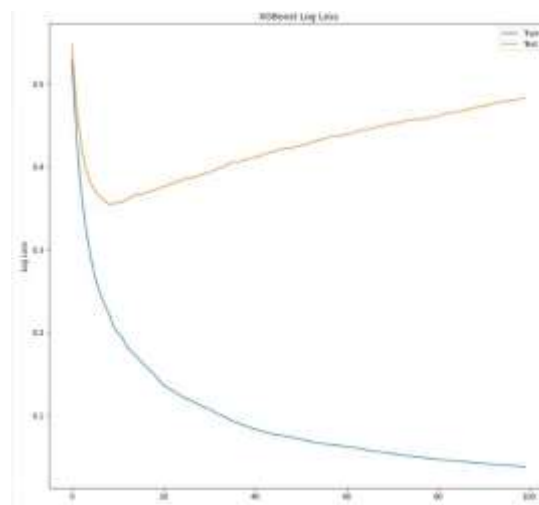


Fig. 7: Confusion Matrix of the XGBoost classifier.

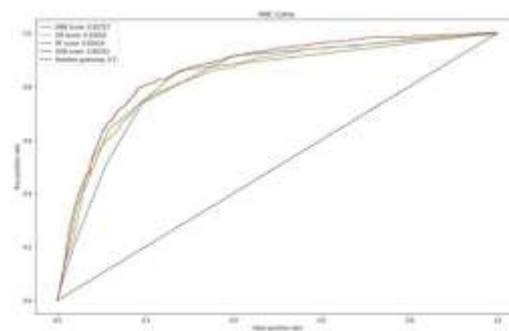


Fig. 8: LogLoss error for the XGBoost classifier

Source: Own Compilation

The XGBoost classifier's confusion matrix was calculated, and it showed that it performed better than the other classifiers in question. The confusion matrix's findings revealed that 387 consumers were appropriately identified as churners whereas 1,853 customers were correctly identified as non-churners. This shows that the dataset has more non-churners than churners. 439 clients were incorrectly categorised by the model.

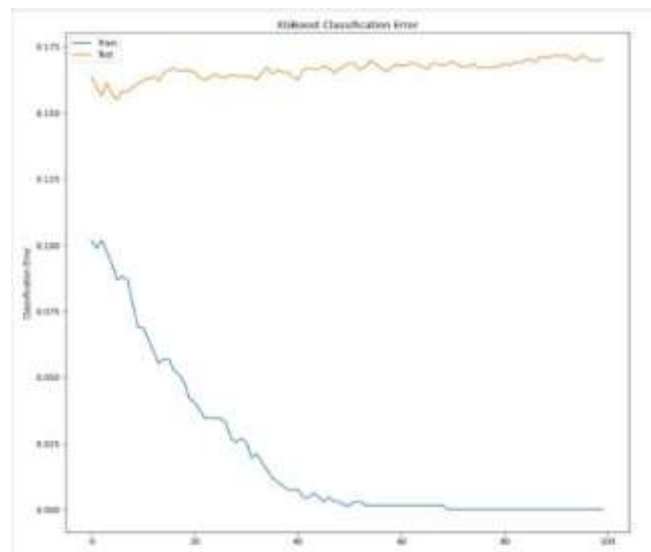


Fig. 9: Classification error for the XGBoost classifier.

Source: Own Compilation

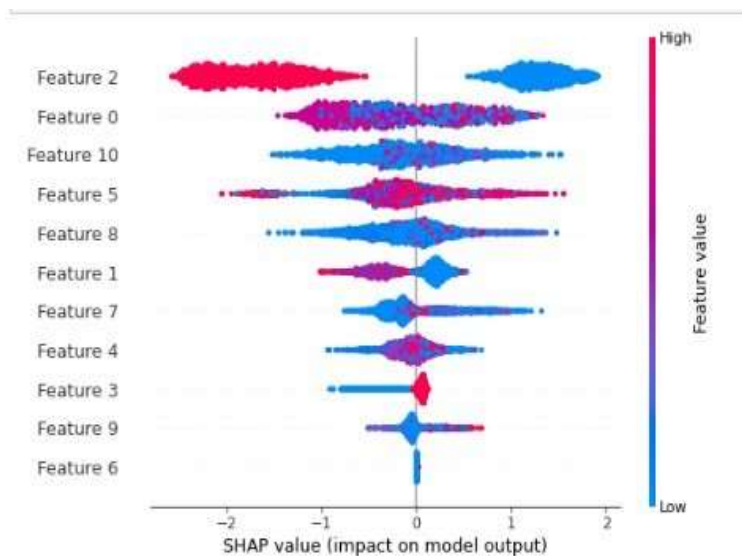


Fig. 10: Feature importance for the XGBoost classifier.

Source: Own Compilation

The loss values for the training and test datasets are shown in Figure 8. The larger log loss for the test data indicates that the model's performance was relatively worse on the test dataset than it was on the training dataset. The model's overall log loss was 0.48, or a loss of 0.52, in total. This means that the model's performance was subpar. The ideal range for the log loss is between 0.5 and 1.

After training the XGBoost classifier, the TreeExplainer module was used to explain the XGBoost classifier and gain insight into the factors affecting the output. The results showed that the "Actual monthly charge" (Feature 2) had the biggest influence on the forecasts. The production was greatly positively impacted when the actual monthly charge values were low, but the impact was lessened when the numbers were high.

The "Type of package customers are on" (Feature 0) and the "contract period" (Feature 5) were the second and third most important characteristics that affected the prediction outcomes. Customers frequently chose less expensive bundles and shorter contract terms to be eligible for mobile devices on credit.

4. Discussion and conclusion

Mobile network providers must identify potential consumers who might break their credit agreements or terminate their contracts in order to stay competitive in the market. As a result, developing an accurate and effective customer churn prediction model has become an important research topic for both academics and product developers in the banking and telecoms industries (Malikireddy & Kasa, 2021).

Many telecommunications firms have expended significant resources to collect information on customer behavioural patterns in order to create predictive models in order to solve this difficulty (Sharma, Panigrahi, & Kumar, 2013). Multiple machine learning algorithms were used in this study to forecast client attrition, which highlighted the importance of machine learning approaches. The performance of four alternative models was assessed through a series of trials, with the XGBoost model surpassing the others and obtaining an excellent overall accuracy of 84 percent.

Using "Cash" as their preferred payment method, Select GO customers were found to be more likely to churn during exploratory investigation. Additionally, this particular client category often displays lower monthly usage overall. The chance to purchase mobile devices on credit appears to be their main incentive for signing up for postpaid contracts.

Future work on this topic will mostly focus on improving data pre-processing and feature engineering because it is still in its early phases. Poorly processed data have been seen to cause the model to perform poorly. This will be addressed by making an attempt to improve the data preparation procedure in order to produce better outcomes.

Additionally, hybrid models may be investigated by fusing neural networks with other well-known prediction techniques, such as support vector machines. The performance of the model may be improved by this hybrid approach's enhanced predictive capabilities.

In order to train the model over various time frames, it will also be a priority to collect data over extended time frames. For instance, examining annual customer spending patterns showed that customers often spend more in the third and fourth quarters. Such historical trends might be incorporated into the model to improve its predictive abilities.

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The Baobab ScapeTale: Transforming readers into protagonists in an embodied and collaborative hybrid reading game.

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Abstract

Traditional stories are means to transfer culture, values and contextual knowledge. Namibia, as many other African countries, has maintained oral narratives, and not established a reading culture. We argue that the design of digital interactive narratives, which promote an embodied, collaborative reading experience, and affording children to be protagonists, enables engaging and immersive reading experiences. We designed a hybrid ScapeTale, based on a Namibian traditional story, where groups of children read a digital story interspersed with physical puzzle stations. Twenty-two Namibian primary school children played the ScapeTale and filled in an engagement questionnaire. Nine of the twenty-two children participated in a feedback interview and six were prompted to recall the game and provide improvement suggestions after three months. Our findings suggest that the children were immersed in the game and enjoyed the collaboration, while we also recorded a relatively low recall of the narrative elements. Thus, in the design of hybrid reading games we need to ensure a balance between activities and focus on content, as well as retaining traditional elements such as illustrations.

Keywords: Hybrid games, reading game, Namibia, indigenous tale

1. Introduction

Storytelling has been a means to pass on knowledge, morals, and values from generation to generation (Tuwe, 2016). In Africa, this practice has been maintained for very long superseding the establishment of a reading culture. However, with urban migration and the introduction of compulsory school attendance, the tradition of storytelling has dramatically decreased. Meanwhile a global push for literacy, mostly focusing on fostering reading skills in formal contexts, has neglected the values of traditional stories and their translations into written or digital artefacts. Kirchner and Mostert (2017) postulate that a lack of reading among primary school learners in Namibia are due to the absence of reading materials in children's homes, and school libraries. We acknowledge, that reading is a fundamental skill that can be instilled in children during early stages of childhood, enhancing their knowledge and giving them a greater understanding of their culture and surroundings.

Considering the global decline of a reading culture as well as substantial changes in required reading abilities taking place in a mostly defragmented digital world, the development of tools to enhance learning and reading experiences has taken centre stage in formal education as well as the edutainment sector. We postulate that children's' reading experiences can be enhanced through providing relatable and traditional stories in new hybrid formats. In this study, we therefore explored reading experiences of Namibian primary learners through the digitalisation of a local traditional story into a hybrid game, interweaving reading activities with protagonistic embodied actions in teams. This study contributes to the field of hybrid reading games, using a design-based research methodology to create an engaging reading experience based on an embodied and collective reading approach. In the following sections

we first present concepts of reading approaches and hybrid (reading) games. We then describe the gamification of a Namibian tale, and the evaluation of the reading experience it afforded primary learners. We discuss challenges of the hybrid reading game, its evaluation and design. We conclude and shortly present our future work.

2. Related work

In the following section we first describe different reading approaches, then explore hybrid (reading) games as well as the concepts of experience, engagement, and immersion.

2.1 Reading Approaches

Different pedagogical approaches and theories have been developed over time in an attempt to improve reading skills, engagement and motivation. Reading engagement plays a big part in the child's literacy development (Ghalebadi & Noorhidawati, 2019). Depending on how long the child stays engaged in each reading activity determines the motivation to read (Ghalebadi & Noorhidawati, 2019). Guthrie and Wigfield (2012) defines an engaged reader as the one who is self-motivated, knowledgeable, and socially interactive during the time they're reading. Lev S. Vygotsky's Sociocultural Theory of Cognitive Development (VSTCD) suggests that development of cognition is mostly lead by social interaction Mahn (1999), thus promoting shared reading approaches. Shared reading is a collaborative reading activity which provides opportunities to engage in expressive, meaningful, fluent reading (Holdaway, 1982). It also boosts children's motivation and engagement (Steenberg, Christiansen, Dalsgård, Stagis, Ahlgren, Nielsen, & Ladegaard, 2021).

Collaborative reading is dialogic, as it involves readers in talking and sharing knowledge with each other (Pulles, 2021). Research indicates that collaborative reading helps to increase vocabularies, and enhance collective knowledge building (Klingner, Vaughn, & Schumm, 1998). Embodied cognition is a theory, which includes sensorimotor experience of the body interacting with the surrounding to gain new skills (Wellsby & Pexman, 2014). Embodied effects can be found in children's early reading understanding (Wellsby & Pexman, 2014). There are many benefits in learning through involvement. Wall (2021) found that "embodied action increased story recall, vocabulary acquisition, and positive affect. Berenhaus, Oakhill, & Rusted (2015) stated that active experiencing led to children remembering descriptive ideas from the story. Furthermore, Corcoran (2018) indicates that embodied cognition concepts enhance the student's learning satisfaction and confidence.

2.2 Hybrid Reading Games

Building on pedagogical principles different types of reading games have been developed. One strategy to enhance the reading experience can be gamification, which is described by Martens (2020) as one of the best ways to motivate children in reading. Gamification is described as the idea of using game design elements in non-gaming contexts to motivate, increase user activity, and retention (Martens, 2020). Game designers create intrinsic motivation through challenges, control, fantasy, and curiosity (Habgood & Ainsworth, 2011). Digital Reading games have been proven to be an effective medium for increasing reading engagement in children. Ghalebadi and Noorhidawati (2012) reported that children's e-reading experience enables motivational constructs and behavioural engagements. Furthermore, reading technology games inspire children to read, making reading interesting, encourage problem solving, and enhance socialization behaviour (Tobar-Muñoz, Fabregat, &

Baldiris, 2017). The evaluation of a gamification of a traditional tale, in which the story was infused with the player's name in the story, revealed that the children felt like being part of the story (Itenge-Wheeler, Winschiers-Theophilus, Soro, & Brereton, 2018).

While many games were based on players competing to win, a new genre has emerged, which promotes collaborative problem solving (Fullerton, 2018). As such escape rooms gained popularity, building on collaborative efforts to solve puzzles, implemented with digital technologies in the physical space using sensors and augmented reality among other technologies. Hybrid games, merging digital and physical components, provide new opportunities to enhance gaming experiences yet their integration present new design questions and challenges (Reisinho, Silva, Vairinhos, Oliveira, & Zagalo 2021; Oliveira, Sousa, Vairinhos, & Zagalo, 2020; Sousa, Oliveira, Cardoso, Zagalo, & Vairinhos, 2021). Integration should promote the interaction among players, draw the players to the board and ensure that technology remains a component only of the board game (Rogerson, Sparrow, & Gibbs, 2021).

According to Karimi and Lim (2010) when technology is used, children are more engaged in a narrative process. It has been proven that interaction and multimedia enrichment have provided children between the age of 7 - 12 a better reading experience (Colombo & Landoni, 2014). Linke, Kothe, & Alt (2017) used digital elements and mixed them with tangible elements to enhance children's reading experience. These elements included flipping pages and moving a character across a physical board to overcome the obstacles in the story. Equally, embodied gaming approaches have been proven to increase engagement engrossment and motivation in learning for children Klemmer, Hartmann, & Takayama (2006) and Hayes, O'Keeffe, & Hogan (2017) developed a physical jigsaw puzzle, where the placement of each piece triggered a new section of the story being told. It was found that the children who played the game understood and remembered the story better (Hayes et al., 2017).

2.3 Experiences, Engagement, and Immersion

Building User experience is defined as the "Sense of being there" and flow is defined as the "optimal experience." Poels, IJsselsteijn, De Kort, & Van Iersel (2010) when the user loses touch with the real world (Csikszentmihalyi, 2000). While "an engaging experience has immersion, cognitive absorption and flow" (Kunze, Sanchez, Dingler, Augereau, Kise, Inami, & Tsutomu. 2015) Thus, the focus of designing interactive systems should no longer be on user experience but rather on designing for engagement (Zagalo, 2020). While the concept of Immersion is commonly associated with gaming, there is still a lack of understanding of what it means (Jamali Kivi, Namaziandost, Fakhri Alamdari, Ryafikovna Saenko, Inga-Arias, Fuster-Guillén, & Nasirin, 2021). Zhang, Perkis, & Arndt (2017) relate immersion to attention and emotion stating that its instruments about game and storytelling have not yet been completely explored. Immersion in reading takes place when the reader is focused on and absorbed in the story. On the other hand, to understand reader's engagement, we also need to consider the social side of reading at that young age and how children rely on each other (Landoni, 2010). As engagement remains challenging to measure and evaluate O'Brien and MacLean (2009) we focus on specific factors, namely immersion, focus, collaboration, adequacy and learning in our study.

3. Gamification of a Namibian Tale

3.1 Design Goals

In the following section we first describe different reading approaches, then explore the overall goal of the Baobab ScapeTale was to enhance the reading experience for Namibian children and encourage interaction by gamifying a traditional tale through digital and physical means. A Namibian tale was used as the basis of the hybrid reading game. The main strategy was to ensure that the readers are engaged by becoming protagonists in the story and having an embodied and collaborative reading experience. The strategy was based on research findings promoting embodied and collaborative reading.

3.2 Nekwa and the Baobab Tree

The following is the Indigenous story that was utilized in this game: Nekwa and the Baobab Tree is a traditional Namibian story about three children, Nekwa, Niilonga and Nuusiku, who were warned to respect the nature. Nekwa lived in a village with lots of baobab trees, and just like many of the other children in the village, she loved playing around their huge thick trunks. Baobab trees often have giant holes in their trunks, so the adults of the village warned the children to be very careful around them. The children were told never ever to pass wind near a baobab tree, or it would swallow them up. One day, Nekwa and her two friends, Niilonga and Nuusiku, went to play under the baobab tree. The gamification of the story revolves around being trapped in the baobab tree, having to solve puzzles in order to escape from the baobab tree.

3.3 Tree System Design of the Baobab ScapeTale

Inspired by concepts such as escape rooms a hybrid game was developed consisting of a tablet-based application, and five separate physical puzzle stations, (see Fig 1).

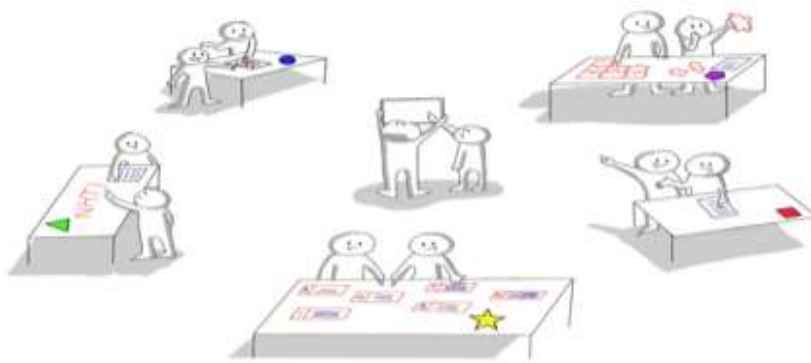


Figure 1: Illustration of the ScapeTale and the five separate stations each containing a new puzzle. The puzzles are indicated using coloured shapes, such as a red square.

The digital application is a hub in the centre threading the story and the activities together. Thus, the tablet was directing the players to the different physical stations, containing the tasks to be completed, to proceed in the game upon return to the tablet. The tasks are puzzles that at each station relate to parts of the story, such as anagrams or simple jigsaw puzzles embedded in, or relevant to the section of the story at the station. ScapeTale was designed to

be a supervised group activity for children, allowing the system to be used in classrooms, libraries, and related institutions. It was designed for multiple small groups to play at the same time, yet independently of each other. This means the system had to support several user groups with minimal interruptions of the activity.

The system was implemented using Unity Technologies (2018) which allowed for multiple target platforms and rapid prototyping, since much of the implementation was done through the build-in UI-system. The design was aligned with the traditional tale and its visual representations in a pre-print book.

3.4 The Baobab ScapeTale game

The premise of the game was to escape the baobab tree, presented as a cave to the players on the tablet (see Fig 2).



Figure 2: The cave, One of the walls inside the environment on the tablet

The player was able to look around the cave by moving the tablet around, acting as a lens to the virtual environment. On the tablet the player was presented with a narrative similar to Nekwa and the Baobab Tree, placing the player in the same situation as Nekwa, the protagonist of the story, (see Fig 1), top left. Snippets of the story of Nekwa and the Baobab Tree were placed at the different stations to be read by the players. To progress in the game, the player must find five stations, (see Fig 1) each contain a text snippet and a puzzle. Solving the puzzle will provide the player with a combination of three objects, which must then be found on the tablet, in the cave environment.

To ensure the players read the story in the correct order, the tablet provided directions on which station to visit next, (see Fig 3) top right, where the players are guided to the red square. Once the player returns with a combination, they will return to the tablet and be given a text to help them find the correct objects, (see Fig 3) bottom left corner, where the clue is to find animals and something to light up the cave. The objects can be found within the cave, which is shown in, (see Fig 2). If the combination is correct, the player unlocks part of the way to escape, leading them to another station or the end of the game, see the bottom right image in, (see Fig 3) where the player is guided to the green square. If the players have the wrong combination, they must go back and try to solve the puzzle again.



Figure 3: Four screenshots from the game, all used to guide the player

3.5 Game setup

An overview of the physical setup can be seen in, (see Fig 1). The five stations around the tablet are marked with icons. The icons are used within the game to illustrate the players' progress as well as aiding the players in locating the correct stations.

- Station 1 (red square) involves the task of following a tangled line, to find the correct words.
- Station 2 (blue circle) involves searching for words in a grid of letters. Examples were provided on how to search for the words.
- Station 3 (green triangle) involves solving short anagrams. Three words were to be found, and to help the children, the words were color coded.
- Station 4 (purple pentagon) requires completing a jigsaw puzzle where the result reveals the words required.
- Station 5 (yellow star) requires the player to order segments of the story to obtain the answer. So, the children should only be able to solve this after having read the story.

4. Evaluating the Reading Game Engagement

The goal of the evaluation was to understand whether an implementation of an embodied and collaborative reading game engages children, as protagonists of the story. In this study, we utilized mixed methods. In the following sections we describe the participants, procedure, and data collection methods.

4.1 The Baobab ScapeTale game

The participating primary school children were recruited from a local public school in Windhoek, Namibia, on a voluntary basis. Institutional ethical clearance was provided and endorsed by the relevant ministry and the principal of the school. All participating children had written informed consent from their parents or guardians (only the children whose parents signed their consent forms were allowed to participate in the). A total of 22 children participated, 14 were female and 8 were male. The children were attending 6th and 7th grade, varying in age between 11 to 14 years old. The children were competent in basic computer skills and speaking and writing English, the language of instruction.

4.2 Evaluation Procedure and setup

After school the 22 children came to participate in the evaluation of ScapeTale, taking place at the school library. Before playing the game, the children were asked to group in pairs and think of a group name. This resulted in a total of 11 groups. This was necessary for login and game tracking, and later to cross-reference interviews, logged data and videos recorded. There was only one tablet set up, so the pairs started in intervals. The groups waiting for their turn were given story books to read under a tree, and those who finished were sent to a computer room to play. Once a group could start playing, they were guided to the tablet to insert their group name and chose an icon to represent their group. Here after, the tablet started guiding the children through the game, one puzzle station at a time, (see Fig 3). Once a group had finished the first station leaving for the second one, a new group started. To avoid too much waiting time, a max of 4 groups were working at the same time, as only one tablet was available. After finishing the game, all the 22 children filled in an engagement questionnaire independently, here after, nine children participated in a feedback interview.

4.3 Data Collection

Four different data collection methods were used, namely observational notes during game play, individual post-game questionnaires, open ended video-record feedback interviews and a follow up correspondence after three months.

Observations made during Game-Play

Throughout the entire evaluation one facilitator was taking notes based on observations and helping the children get started by the tablet. Meanwhile another facilitator was preparing the groups before the start. A third facilitator was walking around the library to see if any children had questions and took pictures.

Engagement Questionnaire

To measure the engagement in this reading game we adapted the Reading Flow Short Scale (RFSS) presented by (Thissen, Menninghaus, & Schlotz, 2018). We replaced 'reading' with 'playing'; adapted the terminology to the level of the children; refined 4 items to the context of a reading game rather than a story; and added 2 items on collaboration. The final questionnaire consisted of 12 questions covering five factors, namely immersion, focus, level, learning and collaboration (see Tab 1). A likert scale was used, having smiley faces on top of the numbers, to make the scale understandable for children. The likert scale goes from 1. Strongly disagree (sad face) to 5. Strongly agree (very happy face), (see Fig 4).

After having played the game all 22 children were given the engagement questionnaire to complete individually.

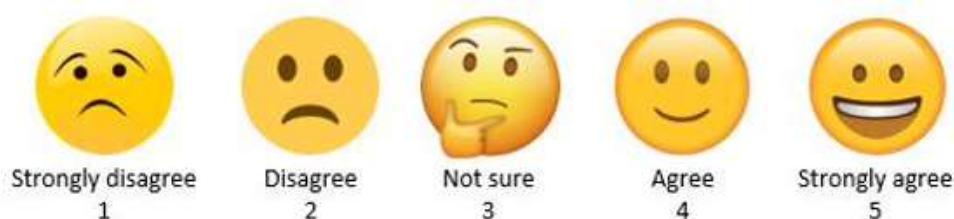


Figure 4: Likert scale with smiley faces for children

Open-Ended Interviews

-After having completed the engagement questionnaire nine of the children volunteered to participate in a post open ended interview. The children were asked two questions: Can you retell the story? and What did you enjoy doing?

Four of the children were interviewed by one of the facilitators, while the remaining five children were interviewed by a senior participating child. The interviews were recorded with a hand-held tablet and transcribed.

Follow up Correspondence after Three Months

Three months after the children played the Baobab ScapeTale, they were asked if they could participate in a session to record what they can recall. However, due to Covid-19 infection rates having gone-up, at that point of time, the Namibian schools were on lock-down. Thus, instead a WhatsApp group was created, whereby only 15 children were reachable via their parents smart phone, and only six responded to the questions posted below:

1. Write down the story
2. Write down the set up and how it was played
3. Draw a picture of the game
4. If you were to make a game like this, what would you add and change. Story and activities
5. How did you feel reading and solving the puzzles?
6. What did you learn from this activity?
7. Would you like to use a similar game in your class? Why and how?

5. Results Based on the Evaluation

In the following we share the results in sections organised by collection tools, namely observation, questionnaires, interviews and follow up communication.

5.1 Observations Made During Game-play

Group Setup and Introduction to the Game It was quickly noticed that the creation of a group caused problems. When opening ScapeTale on the tablet, the text reads "Select Group", however, when entering as a new group the children did not know that they could also create a new group. Five of the groups got stuck already at this point, as they did not understand how to create a new group. Furthermore, the second group, despite being told, was not ready with a group name. Leaving them with the tablet for a long time, already creating a bottleneck for the first group.

After having created a group, the beginning of the story was displayed on the screen. However, instead of taking their time reading the instructions, the same five groups seemed to rush and not really understand what they were reading. A facilitator then had to explain how to play the game.

Figure 5: Children playing the game at different stations.



Solving Puzzles and Reading the Story After the groups understood the gameplay, most were fast in going through the game. The bottleneck problem continued to occur, due to the many groups playing at the same time. This could indicate that the introduction should be shorter, the puzzles longer but not more difficult, have another tablet, or have fewer groups working at the same time.

It was noticed that sometimes the children seemed to guess the words used to solve a puzzle rather than actually read them. One group went to the facilitators asking: What is a "spear"? Furthermore, did one group read "giraffe" as "griff", and yet another one "butterfly" as "beautiful".

The puzzles that the groups struggled with the most, was the blue circle (following a tangled line) and green triangle (solving anagrams). Mostly the children followed the wrong line, but in few cases, it was due to miss reading. The children did not understand the concept of an anagram at first. After some explanation, eight of the groups were able to complete the task with relative ease, connecting the colour code to the three words. The three remaining groups did not see or make the connection of the colours. The jigsaw puzzle was not at all difficult for the children, however, took much of their time. the only problem with this, was that it took too much time for them to complete. This resulted in another bottleneck, with successive groups waiting for their turn. Reaching the final puzzle, nine of the groups carefully connected the storyline based on what they had read, while two groups did not ever read the story snippets, they had only gone for the puzzles. The children can be seen interacting with the puzzles of ScapeTale in, (see Fig 5).

General Observations Despite a lot of waiting time, all groups were active in trying to escape the virtual baobab tree, with none of the children indicating that they would like to discontinue the game. It was noticed that the further the children got into the game, the faster they became. Most groups could have completed the game within 20-30 minutes, however, due to the bottleneck at the tablet station and a few slower groups the average time for completion was about 1 hour and 15 minutes. The game encouraged the children to read independently as a team. At any point in time, they could ask one of the facilitators for help.

From the observations it seemed the children were engaged and reading both the puzzles and the story snippets. Only a few miss-read words were noticed.

5.2 Results from the Engagement Questionnaire

Table 1: Table showing results from the Engagement Questionnaire

Mean per Factors	Questions	Means	SD	Range	Mode
Immersion					
4.010 (M)	7. While playing, I felt like I was in another world.	3.863	1.125	4	5
1.130 (SD)	8. While playing, I did not think about myself.	3.590	1.181	4	5
4 (R)	3. I did not notice time passing while playing.	4	1.309	4	5
5 (MD)	9. While playing, I didn't even notice how much I was reading.	4.590	0.908	4	5
Focus					
4.075 (M)	4. I had no problem concentrating while playing.	3.954	1.361	4	5
1.204 (SD)					
4 (R)	5. My mind was totally clear during playing	3.863	1.245	4	5
5 (MD)	6. I felt very interested while playing.	4.409	1.007	4	5
Adequacy Level					
4.068 (M)	1. The game had the right level of difficulty; it was not too easy nor too hard to play.	4	1.245	4	5
1.239 (SD)					
4 (R)	2. Playing the game was easy.	4.136	1.245	4	5
5 (MD)					
Learning	10. I felt like I was learning something during the game.	4.409	1.098	4	5
Collaborative					
4.045 (M)					
1.154 (SD)	11. I enjoyed playing the game with other people.	4.545	1.010	4	5
4 (R)					
4 (MD)	12. I don't think I could have completed the game without	3.54	1.299	4	3

A descriptive statistical analysis was done (see Tab 1). The range for all questions was 4, and the mode 5 except for question 'I don't think I could have completed the game without others' where the mode was 3. However, our observation data suggested that children working in pairs frequently turned to their partners for working answers. The highest mean was the level of focus (M=4.075). The mean in all the questions: indicate beyond average 4.121. This indicate that the children where immersed in the game, they were focused during the time they played, they indicated that the level was adequate, they felt like they learned something, and they enjoyed collaborating with other children.

The factor with the highest mean value was learning (M=4.409) with a standard deviation of (SD=1.098). Three children mentioned that they learned teamwork "I learned a lot, teamwork." "I learned how to work together with other kids." "What I learned was that, you can't always rely on yourself." They perceived working together in teams as an important factor (M=4.045). The lowest mean value was immersion (M=4.010) with a standard deviation of (SD=1.130).

5.3 Open-Ended Interviews

The questions that were asked in the open-ended interview were intended to provide a better understanding of the retention of the story and what engaged the children.

Recalling the story from the nine children only one child could retell the story immediately after playing the game, almost word by word; one gave a summary; four children only

remembered a few sentences; two decided to talk about the game structure instead of the story; and one said nothing.

Feedback from the children in response to what they enjoyed most, three children mentioned solving the puzzles; three enjoyed the game overall; one child mentioned the teamwork and another child appreciated getting support from the facilitators. Three children expressed that they liked the idea of collaborating with another student. Describing their feelings, they used the following words: nice, good, fun, excited and curious, stating: 'I feel Happy and excited and I also feel like I was in the story while playing the game' and 'I feel nice and it was a lot of fun, and I was connecting with my partner a lot and it was lot of fun.' and 'I have experienced how important it is to work in a group.' The words fun and teamwork occurred frequently in their responses. Four children expressed that they learned the importance of teamwork through the game. Having responded to all questions, the children were asked if they would like to utilize these types of reading games in their classrooms. Four children said yes, because it was a fun way of learning. One of the children expressed that these kinds of games will teach them how to work in teams. One child suggested that the level of difficulty should be increased, another suggestion was to add pictures, videos, and the VRs to the game. One child also suggested to increase the time for playing the game.

5.4 Follow up Correspondence after Three Months

After three months six children recalled the story to varying degrees: one child could retell the story with details, one child was able to summarise the story, one child drew the story, one child made up their own story, and two children could not remember at all. When asked for the physical game setup, three children remembered the game and the set up in details, one child could only remember the beginning of the activity. When asked to draw a picture of the game three children were able to draw everything exactly how it was set up while the other only drew the puzzles.

6. Discussion

In this study we designed a hybrid reading game based on an indigenous tale, acknowledging the strength of combining digital and physical activities. Prior research indicates that agency, embodiment, collaboration, and emotion are important elements of engaging reading technologies for children (Steenberg et al., 2021). Thus, the game mechanisms were designed to cater for the teams to become the story protagonists, solving puzzles as a team and combining physical and digital activities. Although we are first and for most wish to promote a reading culture, we also recognise the importance and power of enhancing reading experiences in an interactive way, with reading embedded into varied forms of interaction, and shared reading focusing on engagement. However, the design and evaluation of hybrid reading games is not straightforward. We therefore reconsider balancing collaborative activities and content in the game design, planning game evaluations and the role of facilitators, as well as retaining illustrations as reading support.

6.1 Balancing collaborative activities and content

The children were engrossed in solving puzzle and playing the game itself, yet some could not remember the story they were reading. The results show that the game was perceived as enjoyable at many levels, especially socially, as expressed by the children. While teamwork has been recognised as a significant enabler in learning contexts Eliasa (2014); and

Hoegl and Gemuenden (2001) it can equally be a distraction for school learners. While the children in the hybrid game evaluation rated their learning high, it seemed to be focused on the collaboration and solving of puzzles, rather than the understanding and recall of the story content. Thus, the design of such a hybrid game need to balance the focus on collaborative activities and the content of the story. For example, the puzzles could be designed in such a way that they can only be solved if the parts of the story were well understood, thereby enforcing conscious reading.

6.2 Planning of game evaluation

One of the first unexpected challenges we encountered was right at the beginning of the game. Most of the children did not understand that they needed to create their group on the tablet. This misunderstanding created some confusion and delays. While we originally aimed for as little facilitator's interceptions as not to influence the evaluation, we at the same time realised that in a real school setting teachers' roles would be to support the teams. Thus, rather than considering facilitator's support as influencing the evaluation it should be accepted to be a component of the game. Another observation was that the children seemed to rush through the game, nearly like in a competitive race, not even reading and following game instructions. We realised that the instructions and the aim of the reading games should have been more explicit and explained to the teams before starting the game.

6.3 Retaining illustrations as reading support

When children were asked to give their suggestion to improve the game, one of the children suggested that they would like to add pictures and illustrations, to help children understand the story better. Illustrations are important elements of a book to help children understand the narrative, activate cognitive processes such as memory, thinking and attention (Tursunmurotovich, 2020). Having spent many efforts on creating an interactive experience, the use of traditional support such as illustrations was neglected. Thus, in future versions of the game we will re-insert illustrations in the physical parts of the game, furthermore digital support could be provided for words identified as challenging by the children. However, a fine balance between need to be found as Dalla Longa and Mich, (2013), suggest that an overload of animations and visuals distracts children from reading.

6.4 Conclusion and future work

In this paper we presented the design and evaluation of our hybrid reading game, the Baobab scape tale. The findings indicated that a digital story blended with physical puzzle stations was an engaging experience for the participating children. However, the design needs careful consideration of balancing collaborative activities, integrating traditional elements such as illustrations, as well as keeping the focus on the story to achieve better retention over time. Considering the successful transformation of an indigenous story into an engaging hybrid reading game, we intend to co-design further hybrid games based on local narratives with the children.

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A Customer Support Chatbot To Enhance Customer Support Experience Using Machine Learning Techniques: A Review

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Abstract

This literature review paper delves into the dynamic landscape of customer support chatbots, which have become integral within the insurance and compensation sector. These chatbots play a pivotal role in offering compensation, legal guidance, and support to individuals affected by motor vehicle accidents. The paper explores the evolving demands of efficient and personalised customer support, driven by the growing need to cater to ever-changing customer expectations. The primary objective of this paper was to provide a comprehensive overview of existing research and implementations concerning developing customer support chatbots specifically tailored to the insurance and compensation sector. A central focus is placed on the context of these customer support chatbots and their journey in harnessing machine learning technologies to elevate the customer support experience. The evolution of chatbots is evident, transitioning from rule-based systems to sophisticated AI-driven agents capable of comprehending and addressing a diverse array of customer inquiries. As organizations in this sector strive to enhance customer interactions and streamline support processes, chatbots emerge as a promising avenue. These AI-powered systems are meticulously designed to deliver timely and accurate information to customers, ultimately enriching their overall experience. Within the realm of insurance and compensation, the adoption of chatbot technology holds immense promise. It enables chatbots to adeptly respond to inquiries spanning accident claims, compensation procedures, legal requisites, and general inquiries. By scrutinizing existing literature and research, this paper seeks to illuminate the transformative journey of customer support chatbots, the machine learning methodologies that propel their development, the challenges they encounter, and the best practices they embody.

Keywords: Dataset, Motor Vehicle Accident Fund, Chatbot, Machine Learning.

1. Introduction

The customer support chatbot, as a significant player in this sector, is tasked with offering compensation, legal guidance, and support to those affected by vehicular incidents (Nicolescu & Tudorache, 2022). In recent years, the increasing demand for efficient and personalized customer support has driven organizations like the customer support chatbot to explore innovative solutions to cater to evolving customer needs (BAE, 2018). This literature review paper aims to provide a comprehensive overview of the existing research and implementations in the realm of developing customer support chatbots within the insurance and compensation sector (Andrade & Tumelero, 2022). Specifically, the focus is on the context of the customer support chatbot and its pursuit of leveraging machine learning technologies to enhance the customer support experience (Følstad & Skjuve, 2019). Customer support chatbots have evolved significantly, transforming from rule-based systems to sophisticated AI-driven agents capable of understanding and addressing a diverse array of customer inquiries.

As organizations seek ways to improve customer interactions and streamline support processes, chatbots have emerged as a promising avenue (MantraLabs, 2020). These AI-powered systems are designed to provide timely and accurate information to customers, thereby enhancing their overall experience (Nicolescu & Tudorache, 2022). Within the domain of insurance and compensation, the customer support chatbot is poised to benefit from the adoption of chatbot technology, which can cater to queries related to accident claims, compensation processes, legal requirements, and general inquiries (Andrade & Tumelero, 2022).

By reviewing the existing literature and research, this paper aims to shed light on the evolution of customer support chatbots, the machine learning techniques employed in their development, the

challenges faced, and the best practices adopted (Coghlan et al., 2023). The ultimate goal is to establish a solid foundation for the development of a customer support chatbot tailored to the unique requirements of the insurance and compensation sector (MantraLabs, 2020). This study recognizes the potential of chatbots to not only improve customer satisfaction but also enhance the efficiency of support processes, contributing to a more streamlined and effective ecosystem for motor vehicle accident compensation.

3. Objectives

The primary objectives of this review is to

- 1) Explore the evolution of customer support chatbots;
- 2) Investigate machine learning techniques in chatbot development
- 3) Identify challenges and ethical considerations

4. Methods

The methodology section you provided outlines the research approach used in conducting a systematic literature review (SLR) on the evolution of chatbot technology and another SLR on smart grids and blockchain technology. Here's an enriched explanation of the methodology.

Table 1:methods

Research Design	The researchers employed a Systematic Literature Review (SLR) methodology to gather and analyse relevant scholarly articles. They followed established guidelines proposed by Cruz-Benito (2020) and Nightingale (2009) to ensure a rigorous and structured approach to their literature review.
Temporal Scope	For the study on chatbot technology, the researchers considered articles and research from the inception of chatbot development in the 1960s up to the most recent studies available until 2020s. This broad temporal scope allowed them to gain insights into the historical evolution of chatbot technology and its impact on customer support and engagement over several decades.
Data Sources	To collect relevant literature, the researchers consulted various digital libraries and databases, including Google Scholar, IEEE, ACM, Semantic Scholar, and relevant websites. This comprehensive approach helped ensure that they gathered a diverse range of articles on the subject.
Search Strategy	The paper selection process involved a metadata search using specific keywords related to customer support chatbots, machine learning, motor vehicle accidents, customer experience, AI technology, and the insurance sector.
Inclusion/Exclusion Criteria	The study applied inclusion and exclusion criteria. Papers that focused on the development and application of machine learning in customer support chatbots, were published in English, and were peer-reviewed were considered for inclusion. They

	excluded 23 papers due to unclear information or duplicate content, ultimately selecting 15 papers for further analysis.
Data Extraction	A structured data extraction form was developed to systematically gather information from the 38 selected papers. The extracted data included details such as the paper title, authors, publication year, research objectives, methodologies, key machine-learning techniques, findings, and conclusions. This step allowed the researchers to organize and analyze the relevant information effectively.
Quality Assessment	To ensure the quality of the selected papers, a rigorous assessment was performed. The focus was on the latest Computer Science papers that presented theoretical designs and technological solutions for smart grid security. After an initial screening, 23 papers were excluded due to unclear information or duplicate content. The remaining 15 papers underwent an in-depth reading to assess their quality. Eventually, these 15 papers were chosen for data extraction, mapping, and qualitative analysis.

5. Data analysis

This section showcases the results obtained from analysing data collected from different secondary sources. The table presents the findings from the analysis of data gathered from various sources, organized into the identified themes of customer care chatbot development, machine learning in chatbot development, and ethical considerations in chatbot deployment.

6. Results

6.1 Evolution of Customer Support Chatbots

The evolution of customer support chatbots has transitioned from scripted responses to more intelligent and context-aware systems (Cordero et al., 2022). Early chatbots were rule-based, relying on predefined decision trees to provide information. However, recent advancements in natural language processing (NLP) and machine learning have paved the way for more sophisticated chatbots (Siju, 2021). The limitations of rule-based approaches in handling diverse user inquiries and highlighted the need for dynamic conversational agents (Andrade & Tumelero, 2022).

In the 1960s, Joseph Weizenbaum created ELIZA, one of the earliest chatbots, using pattern-matching techniques to simulate human conversation, primarily as a Rogerian psychotherapist (Weizenbaum, 1960). In the 1970s, Kenneth Colby developed PARRY, another early chatbot, designed to simulate conversations with paranoid individuals, employing rule-based responses (Colby, 1972). In the 1980s, William Chamberlain and Thomas Etter introduced Racter, one of the first chatbots capable of generating original text, using rule-based and pattern-matching techniques to create coherent conversations (Chamberlain & Etter, 1983). In the 1990s, Richard Wallace's ALICE marked a shift towards more sophisticated chatbots, utilizing AIML (Artificial Intelligence Markup Language) for natural language understanding (Wallace, 1995).

The 2000s saw Smarter Child, created by Active Buddy, as a popular instant messaging chatbot providing information and engaging in simple conversations (Active Buddy, 2000). The 2010s brought

forth virtual assistants like Siri (Apple) and Google Assistant (Google), integrating voice recognition, natural language processing, and AI-driven responses for advanced services (Apple, 2011; Google, 2012). IBM's Watson, introduced in 2011, was a groundbreaking AI system capable of understanding natural language and answering complex questions, marking a significant leap in AI-driven chatbot technology (IBM, 2011).

The latter half of the 2010s witnessed the rise of chatbot development platforms such as Dialog flow, Microsoft Bot Framework, and IBM Watson Assistant, simplifying chatbot creation using AI and natural language understanding (Google, 2016; Microsoft, 2016; IBM, 2018). OpenAI's GPT-3, released in 2020, ushered in a chatbot revolution, utilizing deep learning and large-scale language models to generate human-like text responses and contextual understanding (OpenAI, 2020).

6.2 Machine Learning Techniques in Chatbot Development

Machine learning techniques have revolutionized the capabilities of customer support chatbots. Sequence-to-sequence models, such as the Transformer architecture have enabled chatbots to generate more natural and contextually relevant responses (Suta et al., 2020). Additionally, Recurrent Neural Networks (RNNs) and attention mechanisms have improved the chatbot's ability to understand user intent and maintain coherent conversations (Alekseev et al., 2021).

6.3 Challenges and Ethical Considerations

While the potential benefits of chatbots are evident, challenges such as handling ambiguous queries, mitigating bias, and ensuring data privacy are pertinent (e-Source, 2021). The research highlights the importance of designing mechanisms to gracefully handle user inputs that fall outside the chatbot's capabilities (Vanderpoel Gfmer & Geneva, 2021). Ethical considerations related to transparency, accountability, and bias mitigation are addressed in study, emphasizing the need for responsible AI-driven solutions (Fleming & Zegwaard, 2020).

6.4 Success Stories

Real-world case studies provide valuable insights into the impact of chatbots on customer support (Gijima, 2020; ReplyValorem, 2020). Chatbot reduced response times and improved user satisfaction in the insurance sector. Implementation for a compensation agency showcased the chatbot's ability to provide accurate and consistent information, leading to operational efficiencies (NeuraFlash, 2020).

Table 1: Findings

Theme	Findings
Customer Care Chatbot Development (Financial Protection Bureau, 2023; Zhou, 2023)	• The integration of machine learning techniques in chatbot development has led to enhanced customer interactions and support processes • ML-powered chatbots exhibit improved response accuracy and contextually relevant answers, contributing to higher customer satisfaction • The ability of chatbots to handle a wider range of inquiries has reduced the load on human agents, resulting in improved operational efficiency

Machine Learning in Chatbot Development (Abbas, 2022; Chow et al., 2023)	• Machine learning methodologies applied to chatbot development enable better understanding of user intent and more natural language processing • Contextual understanding is facilitated by machine learning algorithms, leading to coherent and contextually relevant responses • Chatbots powered by machine learning algorithms can continuously learn from user interactions, leading to improved response quality over time
Ethical Considerations in Chatbot Deployment (Coghlan et al., 2023; Tawfeeq et al., 2023)	• The deployment of customer care chatbots raises ethical concerns related to bias and fairness in responses. • Ensuring transparency by informing users that they are interacting with a chatbot, not a human, is essential to build trust and manage expectations

7. Discussion

These themes reveal that integrating machine learning into customer care chatbot development enhances customer interactions, leading to more accurate, contextually relevant responses and improved operational efficiency. Additionally, machine learning enables chatbots to better understand user intent, provide context-aware responses, and continuously improve their performance over time. However, the deployment of chatbots also raises ethical concerns related to bias and fairness in responses, underscoring the importance of transparency in informing users that they are interacting with chatbots to build trust and manage expectations. The fusion of robotics technology with chatbots represents a new frontier in customer service excellence. These digital stalwarts offer 24/7 support, rapid responses, unwavering consistency, scalability, cost-efficiency, data-driven insights, enhanced personalisation, and efficient automation. Their remarkable ability to actively engage customers and work in harmony with human agents solidifies their role as indispensable assets in propelling the customer experience to unparalleled heights.

8. Best Practices and recommendations

The development of effective customer support chatbots relies on adopting best practices from both technical and user experience perspectives. Guidelines emphasize the importance of designing intuitive conversational flows, integrating human agents seamlessly, and enabling continuous learning to improve the chatbot's performance over time.

9. Future direction

Building upon the insights gleaned from the systematic literature review and the identified themes,

several promising future directions emerge for the development and deployment of customer care chatbots using machine learning techniques. These directions not only address the current challenges but also align with the dynamic landscape of technology and user expectations.

Leveraging advancements in machine learning, future chatbot implementations can prioritize further personalization and contextual understanding. Integrating natural language understanding models that recognize user emotions, sentiments, and historical interactions could elevate user engagement and satisfaction.

As technology evolves, chatbots can extend beyond text-based interactions to support multimedia inputs such as images, voice, and video. This multimodal capability would offer users a more natural and versatile communication experience, bridging gaps in understanding complex queries.

The future of customer care chatbots lies in seamless collaboration between AI-driven chatbots and human agents. Integrating the strengths of both approaches can ensure immediate responses while maintaining the human touch for nuanced queries or sensitive situations.

As ethical concerns remain paramount, future chatbot developers should adopt a proactive approach to designing ethical AI systems. Regular auditing of the chatbot's behaviour for biases, discrimination, and adherence to ethical standards should become a standard practice.

10. Conclusion

This research offers effective solutions to enhance customer support within the compensation sector such as the Motor Vehicle Accident Fund. The utilization of a machine learning-powered chatbot demonstrates its potential to revolutionize traditional support channels and offer timely, user-centric assistance. By embracing this innovative approach, organizations can navigate the challenges of modern customer service, fostering improved user experiences and organizational success. Furthermore, this study contributes to the understanding of the dynamic interplay between customer care chatbots and machine learning. It provides insights that can shape the design, development, and deployment of AI-powered chatbots, fostering improved customer experiences and a more ethically conscious AI ecosystem. As technology continues to propel forward, the journey to optimize customer care through innovative chatbot solutions remains both promising and essential.

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Sentiment Analysis of GEMS application process for Sesotho sa Leboa language using NLP

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Abstract

The study analyses the sentiments of government employees' medical scheme (GEMS) application process compiled using South African indigenous language Sesotho sa Leboa by South African Centre for Digital Language Resources (SADILAR). The research mine opinions about the application process of the government employees' medical scheme in South Africa. Sentiment analysis make use of various tools to classify sentiments as Positive (1), Negative (-1), and Neutral (0) in order to reach numerous conclusions. The research study focuses on sentiment analysis on data set for GEMS medical application process compiled in Sesotho sa Leboa from SADILAR. The sentiment classes in this research study are computed using lexical and semantic models known as valence aware dictionary and sentiment reasoner (VADER), Transformer based approach named DistilBERT and TextBlob libraries based on polarity assigned to text corpus statement. The performance of computation of sentiment analysis is evaluated using accuracy metrics. The research experiment shows 99.65% accuracy indicating that negative dominance controls the opinion through GEMS application process.

Keywords: DistillBert, TextBlob, Sentiment Analyses, VADER

1. Introduction

Sentiment analysis is a rising domain to garner and keep apart sensations from text corpus data[1]. Sentiment analysis also known as opinion mining include NLP as well as text analysis to obtain feelings or opinions and broadly categorized in three approaches: lexicon-base, learning-based approach which uses machine learning algorithms and hybrid [1][2]. Sentiment analysis is known as abstraction and classification of sentiments conveyed in text data using text analytics [2]. Sentiment analysis emphasis on identifying client's attitude against an object or overall text sentiment into positive, negative or neutral sentiments [2].

Random Forests, SVM, and Naïve Bayes are traditional algorithms used to classify sentiments, although they are losing reputation due to failure to recognize context of the text because they use bag of words approach [3][3]. Furthermore, this mutual algorithm lately found less treatment due to constraints on labelled dataset, also lack ability to learn or detect successive patterns. K Nearest Neighbour algorithm is said to have performed poorly in sentiment analysis as it falls short of state of the art models [3].

Neural network architecture of LSTMs is gaining momentum as it present multiple nodes or neurons in layers which are stacked one after the other [3]. Deep learning models has substantial influence on sentiment analysis, progressive architectures are attention models and their modifications, such as Aspect based sentiment analysis (ABSA) which has observed a surge in its development [3]. Various approaches exists for sentiment analysis in neural network such as Multi-level sentiment-enriched word embedding (MSWE) which uses multi-layer perceptron (MLP) to compute word-level sentiment information [3].

This paper outline proceeds with introduction of sentiment analysis in relation to Sesotho sa Leboa indigenous morphologically low resourced South African language. The second phase discuss current techniques used in sentiment analysis, and how the solutions have been applied. The research paper contiues to discuss related literature review and the existing approaches to transformer-based architectures. Discussion on the research methodology follows and presentation of the research results. Lastly the discussion and conclusions.

1.2. TextBlob

TextBlob is a lexicon-based technique which performs NLP tasks on raw text corpus [4]. Furthermore, the algorithm is implemented in python, and works with different languages. It is build on top of NLP toolkit NLTK, with polarity computation based on objectivity (facts) and subjectivity (opinions) as a sentiment score returned [4].

1.3 Valence aware dictionary for sentiment reasoning (VADER)

VADER is an lexicon-grounded approach to sentiment analysis that functions on standard heuristics which make use of qualitative techniques [4].

1.4. Transformer-Based model (DistilBERT)

The arrival of transformer-based approach came as an inspiration for scholars to use it for text classification [5]. Transformer based approach is becoming the state-of-the-art approach in NLP for sentiment analysis, others researchers fine tune it with Bi-directional Encoder Representation (BERT) [6]. DistilBERT model was initiated by Hugging Face company devoted to NLP research, when they created a transformer with a pipeline module that connects a model with pre-processing and post-processing phases.

2. Related Literature

The researchers [7] experimented with naïve bayes, support vector machine (SVM), logistic regression, decision tree and random forests algorithm with bag of words and TF-IDF vectorizes, and their accuracy was recorded at 88% with SVM and logistic regression outperforming other algorithm to categorize opinion of customer tweet reviews about popular cell phone brands. The research was able to categorize unstructured tweet reviews.

K-NN algorithms performed well with 75% accuracy, followed by naïve bayes with 69.55% and TextBlob with 54.6% on sentiment analysis research to classify Telkom's product from consumer reviews written on twitter platform tweet in Indonesia [8]. Furthermore, the hypothesis in the experiment shows that negative sentiment controls the opinion through twitter Telkom products.

A new approach was proposed by [4] for sentiment analysis to understand opinion related to accessibility in mobile applications using TextBlob and VADER along with Term Frequency-Inverse Document Frequency (TF-IDF) and Bag-of-Words (BoW) features, with accuracy of 86% for TextBlob and 82% for VADER. The positive reviews dominate sentiment analysis output on accessibility of mobile applications.

The researchers [2] boarded a hybrid practice making use of learning-based and lexicon-based approaches using AFFIN, TextBlob, and VADER to annotate the drug reviews using sentiment analysis, the experiment gave accuracy of 96% with TextBlob when used with TF-IDF and logistic regression which gave same accuracy when used with the union of TF and TF-IDF.

The study by [9] focused on considerate correlation between deep learning vs lexical and semantic-based sentiment analysis with regard to heart attacks and epilepsy. Further, the study used VADER and TextBlob as lexical and semantic based as techniques for sentiment analysis and deep learning-based approach known as Long Short Term Memory (LSTM) together with a sentiment model named Stanford CoreNLP. VADER outperformed all approaches with 52% accuracy as it considers semantic factors when performing predictions while LSTM at 51% since the method depend on the quality of the training dataset and distribution of classes, TextBlob by 49%, and Stanford CoreNLP by 30%.

TextBlob and Bidirectional LSTM models was used for sentiments analysis of COVID-19 vaccines, and Bidirectional LSTM outperformed other models experimented on with an accuracy rate of 94.12% [10]. The researchers [10] further claims that deep learning models are more suitable and efficient to solve sentiment analysis, based on experiments performed on six machine learning algorithms and three deep learning approaches.

Transformer-based approach was applied by the researchers [11] to characterise a target and its context to enhance implementation of aspect based sentiment analysis for language representation.

3. Research Methodology

The research implements a Natural Language Processing (NLP) library tool using spaCY and Natural Language Toolkit (NLTK) for text processing, including categorization in python for an unsupervised approach. The sentiment classes are generated with algorithms such as VADER, Text Blob, and transformer-based DistilBERT as indicated in figure 1.

The research makes use of unstructured dataset downloaded from South African Centre for Digital Language Resources (SADiLaR). The dataset is about government employees' medical scheme (GEMS) application process compiled in Sesotho sa Leboa morphologically low resourced language.

The research follows a workflow as indicated in figure 1:

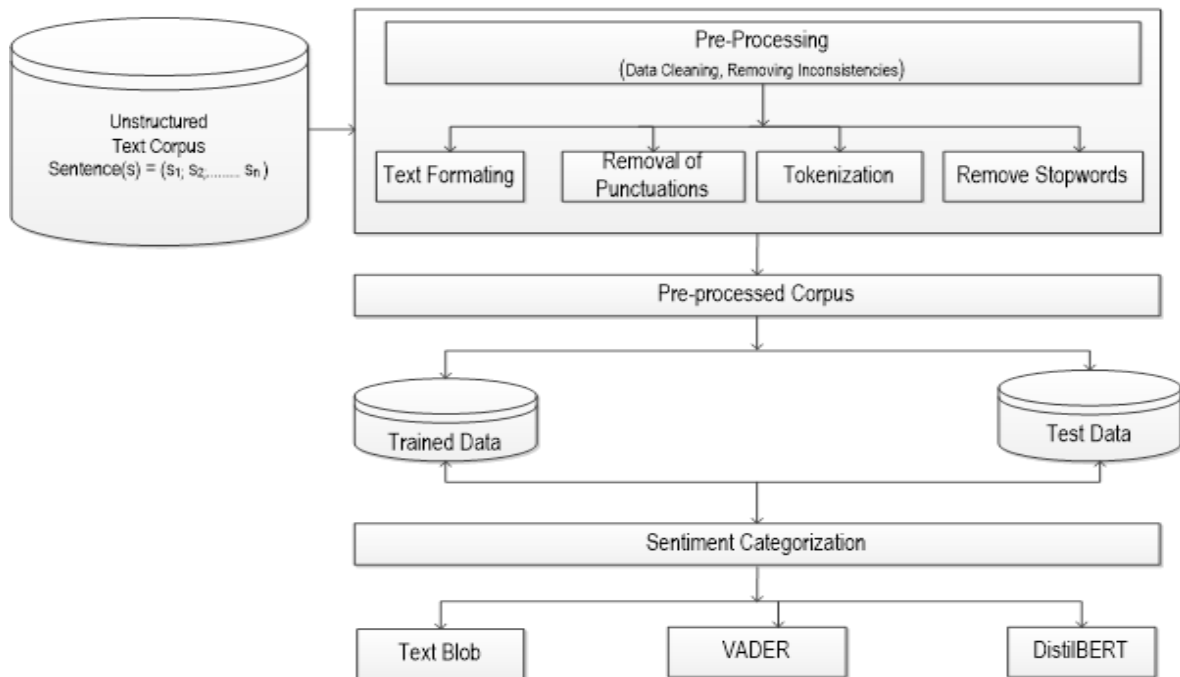


Figure 1: Research Workflow

As shown in figure 1 above, the dataset was pre-processed to eliminate stop words and other characters from the phrases, such as question marks, exclamation marks, commas, etc.

Figure 2 shows a word cloud that visualizes the top words used in the dataset.



Figure 2: Word Cloud Visualization of the Dataset

Table 1 below shows the dataset description before and after the pre-processing phase.

Table 1:Model Evaluation

# Sesotho sa Leboa Sentences	100964
# Sesotho sa Leboa words	2386351
Old Length	12196163
New Length after removing stop words	9215488
Vocabulary Size	65272
Vector Size	100
Alpha	0.025

The research makes use of TextBlob and VADER to make sentiment prediction. The research experiment with lexical and semantic models. First the researcher experiment with VADER to analyse sentiments from health dataset on GEMS medical application. The degree of sentiment is determined by composite score values varying between -1 to 1, with -1 representing negative values, 0 representing neutral values and 1 representing positive values. Further, the researcher experiment with TextBlob to analyse sentiments. The polarity and subjectivity scores are computed with a range from -1 to 1 and 0 to 1, respectively.

4. Research Results

Using rule-based sentiment and lexical features classified as positive or negative for semantic orientation, the VADER technique in Table 2 computes text sentiment and delivers the analysis's probabilities.

Table 2:VADER SENTIMENT

Sentence from Sesotho sa Leboa Corpus	English Translation	VADER SENTIMENT			
		Negative	Neutral	Positive	Compound
Thusho ya bongaka bare chelete yaka efedile gobona ngaka ya basadi	Medical aid says money exhausted to see the Gynecologist	0.259	0.741	0.0	-0.4199
Ge ke lwala, ke berekisha thusa ya bongaka ka gore ke phela ke sena tshelete gare ga kgwedi	When I get sick, I ask for medical help because I live without money in the middle of the month	0.137	0.75	0.113	-0.1531

Koko ase ba kgona go mothusha bookelong bare dihlare difediile	They were not able to help my grand mother at the hospital due to shortage of medication	0.2	0.659	0.141	-0.0665

Table 3 shows that TextBlob divides output into two categories: subjectivity (with a range of 0.0 to 1.0, where 1.0 is highly subjective and 0.0 is very objective) and polarity (with a range of -1.0 to 1.0, 0 for neutral, +1 for positive, and -1 for negative sentiment).

Table 3: TextBlob

Sentence from Sesotho sa Leboa Corpus	English Translation	TextBlob	
		Polarity	Subjectivity
Thusho ya bongaka bare chelete yaka efedile gobona ngaka ya basadi	Medical aid says money exhausted to see the Gynecologist	-0.2	0.35
Ge ke lwala, ke berekisha thusa ya bongaka ka gore ke phela ke sena tshelete gare ga kgwedi	When I get sick, I ask for medical help because I live without money in the middle of the month	-0.14	0.33
Koko ase ba kgona go mothusha bookelong bare dihlare difediile	They were not able to help my grand mother at the hospital due to shortage of medication	0.04	0.66

The research findings for DistilBERT, a light transformer model that trains a neural network for sentiment analysis in order to imitate the BERT, are displayed in Table 4.

Table 4: DistilBERT

Sentence from Sesotho sa Leboa Corpus	English Translation	DistilBERT			
		Negative	Neutral	Positive	Compound
Thusho ya bongaka bare chelete yaka efedile gobona ngaka ya basadi	Medical aid says money exhausted to see the Gynecologist	0.6	0.3	0.3	-0.5599

Ge ke lwala, ke berekisha thusa ya bongaka ka gore ke phela ke sena tshetele gare ga kgwedi	When I get sick, I ask for medical help because I live without money in the middle of the month	0.75	0.4	0.3	-0.1432
Koko ase ba kgona go mothusha bookelong bare dihlare difediile	They were not able to help my grand mother at the hospital due to shortage of medication	0.6	0.4	0.13	-0.0445

A comparison of the TextBlob, VADER and DistilBERT techniques is shown in figure 3.

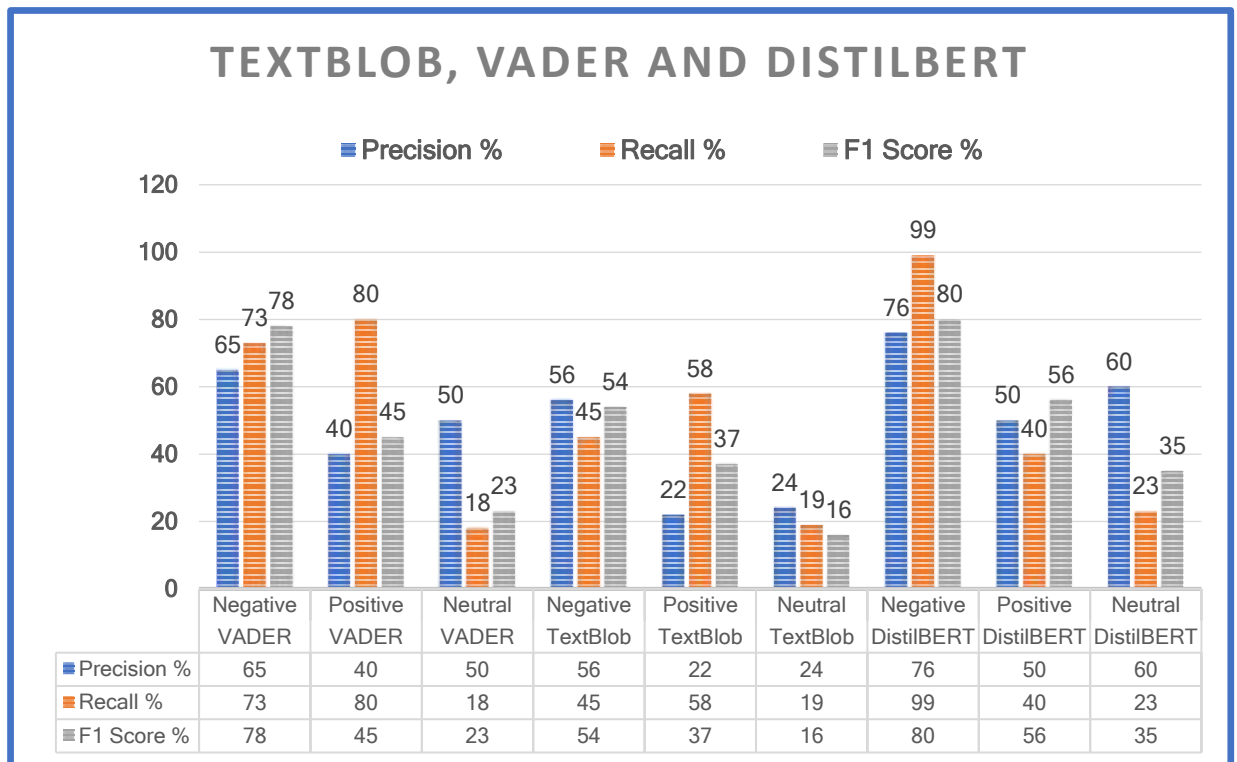


Figure 3: Comparison of TextBlob, VADER and DistilBERT Precision, Recall and F1 Score

In figure 4, the accuracy score of the government employees' medical scheme (GEMS) dataset is displayed for the applicable VADER, TextBlob, and DistilBERT algorithms.

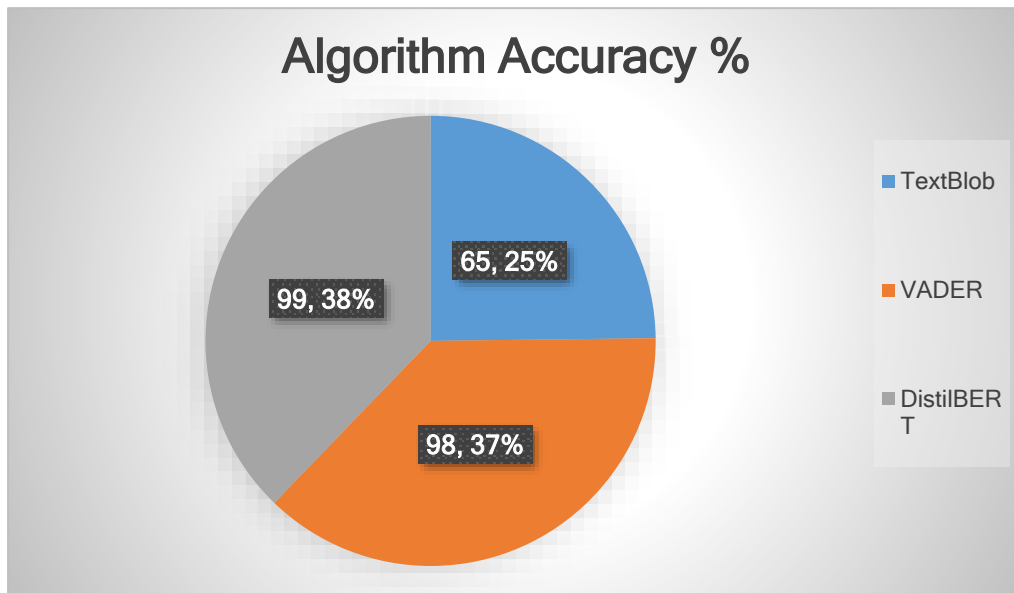


Figure 4: TextBlob, VADER and DistilBERT Sentiment Analysis Accuracy Score

5. Discussion and Conclusion

The Hugging Face transformer model indicates that BERT model pre-trained knowledge distillation was finetuned on the SADILAR GEMS dataset to benchmark performance of the model for sentiment analysis task. Table 1 shows the text corpus description before and after the preprocessing of the text corpus, whereas table 2 shows performance analysis of the algorithms. In this research DistilBERT, which is a transformer algorithm outperforms VADER and TextBlob with an accuracy of 99% for negative sentiment analysis. Figures 2.3 and 4 show the sentiment analysis, where the negative sentiment dominates the analysis.

DistilBERT stands for Distilled BERT is smaller implementation of BERT. It is a compact, quick, low-cost version of BERT that is trained by BERT. It is claimed to have 40% less parameters than BERT and runs 60% faster while having 97% of BERT's performance characteristics. In overall it outperforms TextBlob and VADER.

The researcher deduced from the output that TextBlob has trouble processing negative statements, especially negations. The VADER methodology for sentiment analysis has limitations because it only considers individual words and disregards the context in which they are used.

Table 2 provides compelling data demonstrating that VADER performs better than TextBlob in terms of negative polarity identification. While VADER does not outperform TextBlob in every regard, the results do support VADER's superiority in terms of negative sentiment categorization. When it comes to negative polarity identification, VADER's f1 score is 78% in the figure 3 above, while TextBlob's score is 54%. This leads us to the conclusion that VADER does sentiment analysis more effectively in terms of detecting negative polarity. However, DistilBERT outperforms VADER with a f1 score of 99% as outlined in figure 3.

The results in general show that the sentiment analysis from the application process is more negative. The performance of computation of sentiment analysis is evaluated using accuracy metrics. The

research experiment shows 99.65% accuracy that shows negative dominance controls the opinion through GEMS application process.

Sentiment analysis was used in this study to interpret the feelings and moods of applicants for the government workers' medical plan (GEMS). The results indicate that the government has to enhance the quality of services it provides, as the applicants are not satisfied. Now that they have a clearer picture of the effects of the application procedure, the researchers are in a better position to advise the government to make improvements.

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Enhancing Food Security in Urban Environments through Smart IoT Irrigation Systems: A Review

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Abstract

This paper reviews the application of smart Internet of Things (IoT) irrigation systems in urban agriculture, focusing on their potential to enhance food security in Namibian urban environments. Through a comprehensive analysis of both academic literature and practical field observations in Windhoek, the study explores how these advanced systems can optimise resource usage, improve sustainability, and increase crop yields within the constraints of urban spaces. It highlights the integration of sensor networks, data management, and renewable energy in IoT systems, and discusses the socio-economic and technological challenges inherent in their adoption. The paper culminates in proposing a novel, user-centric IoT system designed for urban farmers in Namibia, reflecting the study's contributions towards addressing critical issues of urban food security and sustainable agriculture in a resource-limited setting.

Keywords: Internet of Things (IoT), Precision Agriculture, Sensor Networks, Food Security

1. Introduction

Traditional agricultural methodologies are under significant strain due to demographic surges, climatic shifts, and dwindling water supplies. As outlined by (Ponce, 2016) the economic impacts of changes in water availability due to climate change present severe challenges for agriculture, necessitating the assessment and management of water resources to adapt to these shifts (Ponce, 2016). Furthermore, studies by (Ponce, 2016) estimate that between 3.5 and 4.4 billion people could experience water scarcity by 2050 due to climate change and increasing water demands (Flörke et al., 2018). This scarcity is exacerbated by the annual net increase in the human population and the substantial water use by agriculture, which is responsible for nearly 70% of freshwater consumption, as highlighted by (Ingrao et al., 2023). Additionally, population growth and climate change are predicted to lead to a perpetual decline in natural water sources, further compounding the urgency for sustainable agricultural practices, as discussed by researchers (Fuller & Harhay, 2010). The diminution of arable land and increasingly limited water resources underscore the urgency for innovative irrigation solutions. Pioneering this transformative approach are smart Internet of Things (IoT) irrigation systems which leverage connectivity and data-driven decision-making to enhance agricultural water management. These advanced systems employ real-time data from environmental sensors to precisely regulate water delivery, thereby automating the irrigation process and

furnishing farmers with critical insights. This enables urban farmers to optimise resource use, conserve water, and augment crop productivity. Additionally, these systems are instrumental in bolstering the sustainability of urban farming, reducing environmental impacts, and facilitating the cultivation of fresh produce within local communities (Goap et al., 2018).

In pursuit of sustainable urban development and food security, Namibia—alongside various international counterparts—is actively exploring innovative agricultural technologies. The Namibian Ministry of Agriculture has initiated projects like the Build Back Better (BBB) Urban Agriculture Project, which aims to champion food security and reduce hunger, particularly in urban areas like Swakopmund (Angelika Planitz et al., 2021). Such urban agriculture projects are integral to the country's strategy to address food insecurity, supported by inclusive land use policies, legal frameworks, and planning (Hitila, 2023). Additionally, the agriculture ministry's special project on urban agriculture is directed towards strengthening Namibia's food systems, thereby facilitating recovery from emergencies and disease-related shocks (Gawaxab, 2021).

Constrained urban spaces render traditional farming practices increasingly untenable, necessitating novel solutions to optimise agricultural output. Smart urban farming, which amalgamates cutting-edge technology with traditional farming acumen, is emerging as a viable solution within Namibia's urban landscapes. The Build Back Better – Urban Agriculture Programme, propelled by the need for a more ambitious response to the 2030 agenda for sustainable development goals, exemplifies the high-level stakeholder partnership between the Ministry of Agriculture Water and Land Reform (MAWLR) and international bodies such as the United Nations Development Programme (UNDP) Namibia) (Angelika Planitz et al., 2021).

Historically, water scarcity and the lack of arable land have been substantial barriers to the progression of urban horticulture in Namibia. The Farming for Resilience (F4R) project is one such initiative by the MAWLR that supports strengthening the resilience of the agri-food sector, particularly focusing on the adaptation capacity to climate change among small-holder farmers in communal areas (Hess, 2019). This literature review critically examines the deployment, advantages, and obstacles of smart IoT irrigation in urban agricultural settings in Namibia, with the aim to extract insights on the application and consequent improvements in resource management, sustainability, and food security.

Our exploration intends to not only shed light on the potential of smart IoT irrigation to refine urban farming practices in Namibia but also to provide insights that may be applied to similar settings elsewhere, guiding the development of our IoT-based system and its practical implementation by Windhoek's urban agriculturalists.

2. Methodology

The research conducted for this review paper employed a mixed-methods approach, combining both quantitative and qualitative methods to collect data. To gather pertinent academic literature, various databases, including IEEE, ACM, and Google Scholar, were utilised to search for scholarly articles, conference papers, and other relevant publications. To refine the search results, specific keywords such as "smart irrigation systems," "urban farming," "Internet of Things," "food security," and "Namibia" were employed. Besides academic literature, reports, and policy documents from relevant organisations such as the Ministry of Agriculture, Water, and Land Reform in Namibia (Dubbeling, 2016) were also consulted.

To better understand the local context and practices of urban farming in Namibia, we visited two traditional urban farming sites in Windhoek - the Olof Palme community garden and Farm Okukuna, both located in the Goreangab informal settlement. These visits enabled us to witness first-hand the challenges and opportunities that urban farmers in Namibia face and the potential for smart IoT irrigation systems to enhance resource efficiency and crop productivity. This approach can be classified as a form of qualitative data collection.

3. Related Work

3.1 Factors Affecting the Adoption of Smart and IoT Irrigation Solutions

The adoption of smart irrigation technologies, integral to ensuring food security, has encountered considerable resistance, particularly among smallholder farmers. The opposition is rooted in a complex web of socio-economic and institutional challenges across different African contexts. Identified significant barriers to climate-smart agriculture in West Africa, such as inadequate policy frameworks and a deficit in understanding the technologies at the farmers' level. A similar study by (Serote et al., 2021) in South Africa found that only a minority of smallholders have embraced Climate Smart Irrigation Technologies (CSIT), with adoption influenced by demographic factors, access to information, and practical support. The study revealed that only 46% of smallholder farmers had adopted CSIT and identified several factors that positively influenced adoption, including gender, age, district, farm size, staple food production, and knowledge of CSIT. The authors suggest that improving extension services, training, and promoting resilient crop varieties and underutilised nutrient-dense crops can transform the smallholder farmer subsector. By increasing awareness of these interventions and new technologies, it is hoped that rural livelihoods will improve, and farmers will be better able to adapt to changing conditions and enhance their resilience.

In the Namibian context, precision agriculture confronts several obstacles. Urban expansion has led to a marked scarcity of available agricultural land, with high land costs further compounding the issue. In urban areas, the competition for land from housing and commercial sectors is fierce, a point noted by farmers at Farm Okukuna in Windhoek. Water scarcity, exacerbated by Namibia's propensity for drought (Mangundu et al., 2018), presents another hurdle for urban agriculture. Additionally, urban farmers face a dearth of public support, empowerment, technological insight, and funding, often overlooked by the government and politicians. This neglect leads to a lack of motivation for farming, perpetuating poverty. Lastly, the poor quality of urban soil, often contaminated with pollutants and heavy metals, poses a challenge for cultivation, necessitating costly and labour-intensive soil remediation and management.

3.2 IoT Systems and Urban Agriculture

The advent of IoT in agriculture, specifically through smart irrigation systems, is a transformative step towards bolstering urban food security. These systems are at the forefront of precision agriculture, enabling real-time monitoring and management of environmental conditions to inform agricultural practices. Below, we summarise some work that utilised IoT to improve farming practices.

Table 2: Literature on IoT Systems and Urban Agriculture

Theme	Summary
Technological Integration	Studies such as Limbo et al. (2021) showcase how localized IoT systems, tailored to specific environments like Namibia, are harnessing real-time data through soil moisture sensors and water pumps. These systems are often controlled by microcontrollers and use GSM modules, demonstrating their viability in regions with limited internet connectivity.
Energy Efficiency and Performance	Research exemplified by (Ullah et al., 20212) reveals advancements in energy efficient IoT frameworks like EEWMP. These frameworks are critical for regions with inconsistent power infrastructures and highlight the role of IoT in promoting sustainable farming practices.
Data Management and Cloud Computing	(Benyezza et al., 2018) explore the use of cloud computing platforms for irrigation, providing scalable solutions for data management and remote monitoring, essential for urban settings where space and resources are constrained.
Renewable Energy Integration	The application of renewable energy in IoT systems, such as the solar-powered irrigation system suggested by (Adenugba et al., 2019), underscores the importance of sustainability in urban agriculture. It illustrates the potential for off-grid solutions in urban settings.

For further information on smart agriculture, readers can refer to surveys conducted by (Gamal et al., 2023), (Pagano et al., 2023), and (Raj et al., 2021).

3.3 Emerging Trends and Case Studies

Table 3: Emerging Trends

Theme	Summary
Predictive Analytics	The deployment of advanced predictive analytics and machine learning algorithms can forecast irrigation needs, optimising water utilisation across diverse urban agricultural contexts. This strategy could significantly enhance crop yields and resource conservation, as explored by (Balogun et al., 2021).
Sensor Evolution	Sensor technology has advanced, leading to more robust and economical solutions. These are well-suited for the varied and challenging urban agricultural environments, offering accurate and reliable data for smart irrigation systems. The potential of dense wireless sensor networks in agriculture, contributing to increased yields and resilient production, is discussed in "Sensors in agriculture: towards an Internet of Plants" by (Steeneken & Elias Kaiser, Gerard J. Verbiest, 2023).
Integration with Sustainable Technologies	IoT's synergy with other sustainable technologies, such as greywater recycling systems, hydroponics, and vertical farming, is a burgeoning research area. This integration is vital for maximising space in urban settings. Insight into how IoT is influencing sustainable urban farming practices is offered by: - 1. (Goodman & Minner, 2019), detailing an IoT-based urban agriculture container farm design. 2. (Dhanaraju et al., 2022) discuss the incorporation of ICT in smart farming and sustainable agriculture. 3. (Benke & Tomkins, 2017)review advanced precision monitoring and control systems in vertical farming using IoT.

		4. (Dhunney et al., 2019)examine the integration of IoT and AI for enhancing urban life quality and promoting sustainability. 5. (Podder et al., 2021)presented an IoT-based Smart AgroTech system for urban farming that monitors crucial parameters like humidity, temperature, and soil moisture.
Socio-Economic Assessment	Impact	Investigating the socio-economic impacts of IoT adoption offers a comprehensive perspective on the technology's potential. This involves assessing the acceptance, usability, and affordability of smart IoT systems by urban farmers and their effects on food security. The socio-economic impact of IoT in urban agriculture, including its contribution to local economic development, poverty alleviation, social inclusion, and urban greening, is analysed in the Weltbank report "Urban Agriculture: Findings from Four City Case Studies," which presents case studies from four cities (World Bank, 2013).

3.4 Our Proposed IoT System

The proposed IoT system (Figure 1) is designed as an end-to-end solution for urban farmers, incorporating a sensor network and a user-friendly mobile app interface. The system aims to be an integral tool for urban farmers, providing them with: -

1. **Real-Time Monitoring** - The mobile app will allow farmers to monitor soil moisture, nutrient levels, and environmental conditions in real time, promoting informed decision-making.
2. **Automated Control** - Through the app, farmers can remotely control irrigation systems, adjusting settings based on the sensor data to optimise water usage and crop health.
3. **Data Security and Analysis** - The system will feature robust security protocols for data transmission to the central server. This ensures that farmers' data remains secure while enabling them to access insights and analytics for better crop management.
4. **User-Centric Design** - The app's design will focus on ease of use, considering farmers' technical proficiency, language preferences, and accessibility needs.
5. **Sustainability Considerations** - The system's sustainability will be a core feature, with attention to how it is powered and the choice of materials for the sensor network, aligning with the principles of sustainable urban agriculture.

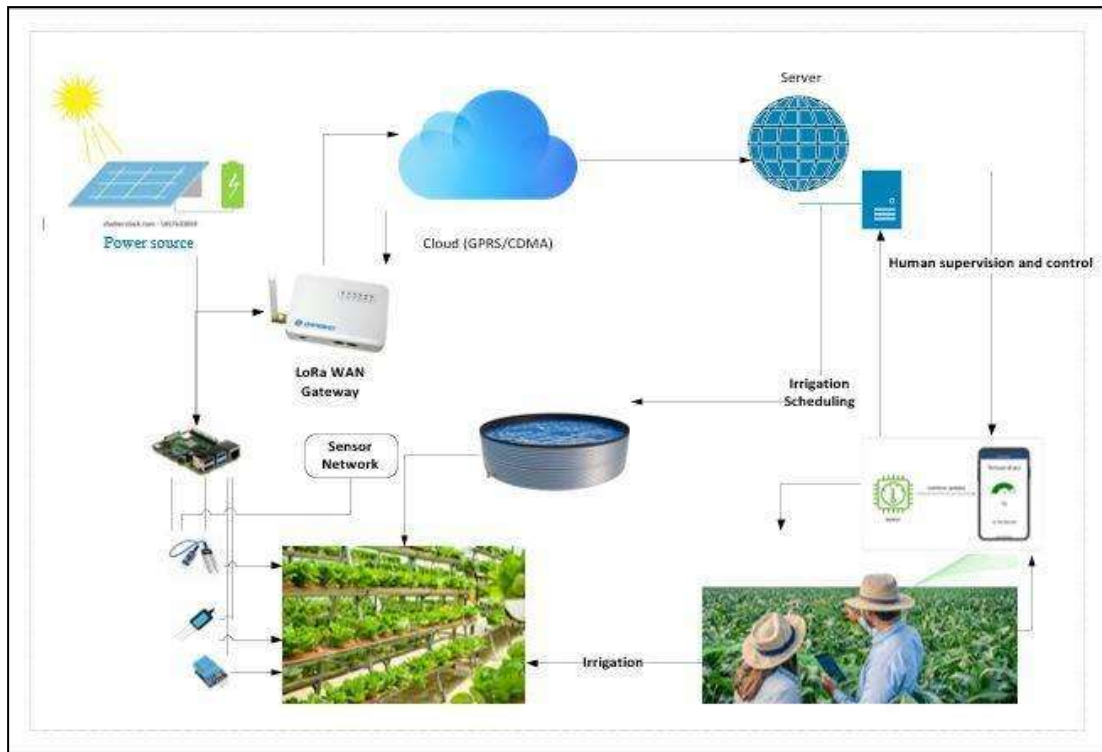


Figure 1: Technical Design of the Proposed System

The proposed system, supported by extensive research and the latest technological advancements, addresses the critical nexus of food security, urban agriculture, and IoT. It seeks to provide urban farmers with the tools to optimise their practices, improve crop yields, and contribute significantly to urban food systems.

4. Results and Discussion

The study's findings illuminate the complex interplay of factors influencing the adoption and efficacy of smart IoT irrigation systems in urban agriculture, focusing on the Namibian context. These results are contextualised within the broader framework of global urban agricultural practices, highlighting both similarities and unique challenges faced in Namibia.

4.1 Key Findings

Our research identified several critical factors impacting the adoption of IoT systems in urban farming. These include: -

1. **Technological Awareness and Accessibility** - In Namibia, there is a significant technical knowledge and access gap among urban farmers. This gap hinders the widespread adoption of IoT systems.
2. **Resource Optimisation** - The data indicates that IoT systems substantially improve water and nutrient use efficiency, which is crucial in Namibia's water-scarce environment.
3. **Crop Yield and Quality Improvement** - Field studies and literature suggest that smart irrigation leads to notable improvements in crop yield and quality, which is vital for enhancing food security.

4. **Socio-Economic Barriers** - Challenges such as financial constraints, limited infrastructure, and a lack of policy support were recurrent themes, echoing global trends in urban agriculture.

4.2 Comparative Analysis with Global Trends

Comparatively, our findings align with global trends in urban agriculture, particularly in developing countries. Like Namibia, urban farmers globally face similar challenges in adopting new technologies due to financial constraints, lack of knowledge, and policy limitations. However, the severity of water scarcity in Namibia presents a unique challenge, making the efficient use of resources through IoT systems even more critical.

4.3 Practical Implications and Recommendations

The practical implications of these findings are significant for Namibia's urban agriculture development. To facilitate the adoption of IoT systems, we recommend: -

1. **Enhanced Training and Education** - Tailored programs to educate urban farmers about the benefits and operation of IoT systems.
2. **Policy Interventions** - Governmental support through subsidies, infrastructure development, and encouraging policy frameworks.
3. **Localised System Design** - Developing IoT systems specifically designed to meet Namibian urban agriculture's unique environmental and socio-economic conditions.
4. **Public-Private Partnerships** - Encouraging collaborations between technology providers, government, and farming communities to drive innovation and adoption.

4.4 Limitations and Future Research Directions

While our study provides comprehensive insights, it acknowledges limitations in the scope of field data and the diversity of urban farming practices in Namibia. Future research should focus on longitudinal studies to assess the long-term impact of IoT systems and explore the scalability of these technologies in different urban agricultural settings across Namibia.

5. Conclusion

This paper has critically examined the potential of smart Internet of Things (IoT) irrigation systems to revolutionise urban farming within Namibia, situating this potential within the broader context of urban food security challenges and technological advancements. Our comprehensive review and analysis have revealed that when effectively implemented, these systems can play a pivotal role in optimising resource usage, enhancing crop productivity, and thereby bolstering urban food security.

In Namibia, where urban agriculture faces constraints like water scarcity and limited arable land, adopting smart IoT irrigation presents a promising solution. The findings underscore the importance of technological awareness, accessibility, and socio-economic factors in adopting these systems. Our study also highlights the need for policy support, educational initiatives, and tailored technical solutions to overcome the barriers to adoption.

However, the journey towards fully realising the benefits of smart IoT irrigation in urban agriculture is not without its challenges. Financial constraints, infrastructural limitations, and knowledge gaps remain significant hurdles. Addressing these requires concerted efforts from

various stakeholders, including policymakers, technology providers, and the urban farming community.

Looking forward, our research opens avenues for further exploration in this field. Longitudinal studies to assess the long-term impacts of IoT systems in urban agriculture, investigations into the scalability of these technologies across different urban settings, and developing more user-friendly, cost-effective, and resilient IoT solutions are vital areas for future research.

In conclusion, this paper contributes to the discourse on urban agriculture in Namibia and similar contexts, providing insights into the role of advanced technologies in addressing food security challenges. We hope this work will inform and inspire ongoing efforts to enhance urban agricultural practices through innovative technological solutions.

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A Novel Taxonomy For Applications Used In Remote Healthcare Services

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Abstract

Various applications including software, wireless and sensor-based applications have been incorporated in the provision of remote healthcare services. These applications have been described in the literature, each with its advantages and limitations. A systematic review was conducted on 3 academic databases. Based on the inclusion and exclusion criteria, we included 18 papers in the review. In this paper, we provide a novel taxonomy of these applications based on the findings from the literature. The components of these applications are either software or hardware components. We classify these applications used for remote healthcare services into three main categories and subcategories: software: mobile apps, web apps and telemedical systems, hardware: sensor-based applications and wireless technologies, wireless technologies: protocols, wireless internet, wearable body area networks and wireless wristband monitoring. The findings revealed that remote healthcare technologies are used for critical illnesses such as heart diseases, diabetes and managing people who are disabled or elderly. The findings suggest that remote health monitoring not only saves cost but can also be used in critical situations where access to medical services is not available. The findings of this paper could help hospital managers employ best approaches to managing remote healthcare services especially in rural areas.

Keywords: Remote health monitoring, diseases, healthcare, novel, taxonomy.

1. Introduction

Wakerman (2004) describes remoteness as a “fundamentally geographical state that is derived from a measure of distance.” In the context of healthcare, Wakerman (2004) describes remote health as the provision of healthcare services by medical teams where the role of team members is easily changed requiring key skills for serving mobile populations which requires communication technologies for these services to be provided. Remote health is a result of the dearth of healthcare professionals in remote areas (Wilson et al., 2009). A wide range of applications have been used to provide remote healthcare services.

With the advent of digital technologies, healthcare systems have been revolutionised, hence, technologies have been used in providing remote healthcare services, for example, telemedicine, Internet of Things (IoT), sensors and wearable technologies (Tun et al., 2021; Baucas et al., 2021; Morgan et al., 2020).

Despite these advancements, implementation of these technologies has been hampered in low-resource settings as a result of socio-technical issues, lack of financing, lack of infrastructure to drive the innovations and lack of adaptation in contexts other than the context where these technologies have been developed (Khan et al., 2019).

The use of digital health applications and services for remote access to healthcare services is not a new concept. A review of the literature suggests that digital health technologies such as sensors, IoTs and mobile applications have been used for remote healthcare access (Tun et al., 2021; Baucas et al., 2021; El-Rashiddy et al. 2021). However, there is a dearth of studies providing a novel taxonomy of applications used in remote healthcare monitoring. A novel taxonomy could help identify what is needed to implement remote healthcare monitoring. It could help identify all the technical components and resources needed for remote health monitoring, The ubiquity needed for healthcare

services has grown to support those who are not physically able to receive healthcare services in person.

The aims of this paper were to identify the components of a remote health monitoring system and develop a novel taxonomy for such a system. This paper is structured as follows: the method used in the study is described, followed by the results and discussion section. Conclusions and recommendations are made.

2. Methodology

A systematic review methodology was used in the study. The inclusion and exclusion criteria are described below.

2.1 Inclusion criteria

- Studies describing the use of technologies for remote health monitoring.
- Studies published between 2000 and 2023.
- Peer-reviewed publications in journals and conferences.

2.2 Exclusion criteria

- Studies published before the year 2000.
- Studies not published in English.
- Studies not focusing on remote health monitoring using digital technologies.
- Studies focusing on animal interventions.
- Patents
- Review papers

2.3 Database Screening and Selection

Three databases were searched: CINAHL, COCHRANE and Scopus. Articles were selected based on the title and abstract. The selection was based on the inclusion and exclusion criteria.

2.4 Data Extraction

Data was extracted from all included records following full-text screening for study characteristics, intervention detail and key outcomes.

2.5 Data Analysis

A narrative synthesis was undertaken to offer a comprehensive summary of advancements and available evidence within remote healthcare monitoring. A thematic analysis was also provided based on the objectives of the study.

3. Results and Discussion

18 papers were included in the study and were categorised into different sections in table 1.

Table 1 describes the finding of the study.

Table 1. Findings of the study

Author	Year of publication	Outlet	Applications	Domain	Study Characteristics	Outcome
Shin (2012)	2012	Journal	• Sensors • Mobile platforms • Privacy and information quality	Home based care	N/A	The study focused on developing a framework for
Kalid et al. (2018)	2018	Journal	• Sensor (ECG sensor, BP sensor, SpO₂ sensor) • Text source • Algorithms (MLAHP and TOPSIS)	Patients with chronic heart disease during disaster and emergency situations	500 patients with chronic heart conditions	The technologies helped to rank patients with most emergency needs.
Evans et al. (2016)	2016	Journal	• Telehealth • Wireless wristwatch-based monitoring	Older patients with or with health conditions being monitored with telemedicine	41 patients with or without chronic health conditions for six months	Remote technologies can be used for monitoring patients for a long period of time
Lin et al. (2021)	2021	Journal	• Mobile app	Fitness	31 young healthy adults took part in the study	Home based fitness assessment using mobile apps seems to be reliable option for health adults.

Gaugler et al. (2021)	2021	Journal	Remote monitoring technologies	Alzheimer Dementia	30 care givers over an 18 month period	Remote monitoring technologies had not direct effect on care givers caring for Dementia patients.
Waki et al. (2014)	2014	Journal	Mobile app	Type2 diabetes	2 groups of 27 participants. One group using the DialBetes app and the other without the DialBetes app	The findings showed that there was significant decline of sugar levels in patient that used the DialBetes app
Ramesh et al. (2023)	2023	Journal	Artificial Intelligence	Health care context for predicting different disease types	Gathering of data from smart devices and analysing them used AI techniques	Data sources include mobile apps and FitBit which was used to gather data from different sources.
Ismael et al. (2023)	2023	Journal	- ECG classification - Artificial Intelligence	Five heart diseases	ECG classification based on AI methods	The AI method deployed had a high performance accuracy rate of 96.2%
Kyriacou et al. (2003)	2003	Conference	- Digital platform - Wearable Body Area Network	Healthcare	Patient data is gathered using wearable technologies	The system serves as a connection between patients and healthcare providers
Ohashi et al. (2022)	2022	Journal	iPad	Chronic obstructive pulmonary disease	Two elder care homes were used in the study	There was an increase in physical activities among patients using the remote technology

Al-khafajiy et al. (2019)	2019	Journal	• Pulse sensor • Mobile app • Arduino uno • Cloud computing	Elderly, disabled and people with chronic conditions	Elderly, disabled and people with chronic conditions who are indoors	The system performs well and saves cost.
Ahn et al.	2004	Conference	• Personal Digital Assistants • Sensors • Software • Services • Protocols	Diabetes patients	Diabetes patients	Users can check their blood sugar level and transfer the data to their family member remotely
Zhao et al. (2005)	2005	Conference	• Personal medical sensor network • Computer network • GSM short messages • Telephone modem	Blood oxygen saturation	Measuring the blood oxygen saturation	Test results can be transferred remotely from patients to doctor.
Liu et al. (2007)	2007	Journal	• Telemedicine	Monitoring systems for the elderly	Monitoring elderly patients where frequent interaction is needed between doctors and patients	There was an establishment of a remote health care system that can be used by patients and healthcare providers

Lubrin et al. (2006)	2006	Conference	Commodity based sensors	Monitoring systems for the elderly	Monitoring systems for the elderly	There was a feasibility in the development of low cost sensors for monitoring healthcare
Kim et al. (2006)	2006	Conference	- Web app - Mobile phone - Wireless internet	Diabetes management	Monitoring of activities of diabetic patients	The system could help patients monitor their health.
Palaniappan et al. (2023)	2023	Conference	- CGM devices - Enlite sensor	Glucose monitoring	Monitoring of elderly people	The system could help monitor elderly patients.
Khan (2020)	2020	Journal	- Convolutional Neural Network - Sensor data - Smartwatch - Heart monitor device	Heart disease prediction	Heart disease prediction	The results show better prediction compared to other models

Table 1 highlights the papers included in the review to show key aspects of the papers examined such as the publication date, outlet, applications, and domain.

3.1 Publication date

As shown in table 1, publications included in this study include papers published between 2003 and 2023. While publications started in the early 2000s, there is a surge of publications in the 2010s. This suggests that remote health monitoring is gaining momentum as years progress.

3.2 Outlet

Majority of published works were in journals and a few papers were published in conferences. This suggests that more conferences are needed to discuss remote health monitoring.

3.3 Applications

Various applications have been explored in terms of remote health monitoring. The majority of the applications focus on software such as mobile apps, telemedicine applications and web apps, hardware such as sensors, telephones, and Arduino uno and networking applications such as Internet and protocols.

3.4 Domain

Majority of the domains described focused on helping the elderly for chronic conditions, diabetes and heart diseases. This shows that remote health monitoring is important not just to communicate with patients but also for critical health conditions.

3.5 Thematic analysis

Papers were classified and analysed based on the objectives of the study. The components of remote health monitoring were provided and a classification of remote health monitoring was provided.

4 Findings and Discussion

The findings are presented in section 4.1 and 4.2.

4.1 Components of remote health monitoring

Remote health monitoring involves caring for patients at remote locations. Healthcare providers must be involved in the process. Key components seen in remote health monitoring services include sensors. Sensors mentioned in the review can range from different types such as ECG sensors, BP sensors, SpO2 sensors, pulse sensors, enlite sensors, personal medical sensor networks and commodity based sensors. Commodity based sensor mainly focused on lowering the cost of implementing the network (Lubrin et al., 2006). The different sensors are used for different purposes mainly to collect health data from patients. For example, to collect data about blood pressure, a BP sensor is used, to collect data about oxygen saturation, an SpO2 sensor is used and to collect data about the pulse, a pulse sensor is used. Generally, to establish a remote health monitoring system, sensor plays a crucial role. Other studies have indicated that sensors are important components in healthcare as it can help collect relevant data (Javaid et al., 2021). However, there is a need to develop other sensors such as on organ sensors to monitor the internal organs.

Other components of remote healthcare monitoring include mobile apps, telemedicine, Artificial Intelligence and web apps. These technologies are mainly used for interfacing. These components are

needed to show the user what the data means in terms of the data collected. Mobile apps are what the users see, can navigate and use. Web apps are similar to mobile apps except that they are used on the web. Telemedicine is also a very popular approach where consultations between patients and doctors take place (Tripepi et al., 2023). Artificial Intelligence algorithms were highlighted as tools used for remote health monitoring as they provide more advanced techniques for predictions.

Storage systems such as cloud computing systems were also explored. Cloud systems help to include the data collected in a safe environment. However, these studies did not focus on the privacy and security of data stored in cloud systems for healthcare services.

Hardware technologies were also highlighted such as Arduino uno, telephone modem, mobile phone, and iPad. These are the different technologies that enable remote health monitoring.

5. Classification of remote health monitoring

Table 2 highlights the classification of remote health monitoring. Remote health monitoring is classified into sub-categories.

Table 2: Classification of remote healthcare applications:

Categories	Sub categories
Software	Mobile app
	Web app
	Telemedicine
	Artificial Intelligence
	Text source
Hardware	Sensors
	Arduino uno
	iPad
	Telephone modem
Wireless technologies	Protocols
	Wireless Internet
	Wearable Body Area Network
	Wireless wristband monitoring

Software solutions are essential to the modern healthcare environment because they enhance remote healthcare. With the ability to access healthcare services, make appointments, and check medical data, mobile and web apps have become indispensable tools for patients, increasing convenience and patient engagement (Shachak & Reis, 2019). With the ability to conduct consultations remotely and solve concerns with healthcare accessibility, telemedicine has grown significantly, especially in underdeveloped areas (Mehrotra et al., 2020).

By processing enormous information, providing predictive analytics, and improving diagnostic accuracy, AI is transforming the healthcare industry (Topol, 2019). AI-powered applications provide early disease identification and offer individualised treatment regimens. AI-driven chatbots and virtual assistants are enhancing remote healthcare by helping with patient education and administrative duties (Miotto et al., 2018).

Text sources including information on patient-reported outcomes and vital signs, are becoming essential for continuous data gathering in remote health monitoring. These resources enable medical professionals to keep an eye on patients' illnesses from a distance, enabling early intervention and individualised treatment (Lee et al., 2021).

These software components' smooth integration has the potential to greatly improve remote healthcare by increasing efficiency, accessibility, and personalisation—all of which will eventually improve patient outcomes.

Improving the delivery of healthcare in the field of remote health monitoring requires the integration of multiple hardware components. Sensors are essential because they give data on patient characteristics and vital signs in real time. Healthcare practitioners can remotely monitor patients' health status thanks to these sensors, which can measure heart rate, blood pressure, temperature, and more (Arif et al., 2020).

A key component in gathering, analysing, and sending data from sensors to central servers is the Arduino Uno microcontroller. It is the best option for developing remote monitoring systems because to its affordability and adaptability (Devedas & Swarup, 2015).

iPads and other tablets are useful resources for both patients and healthcare professionals. According to Lobach et al. (2020), they facilitate interactive patient education, video conferencing for telehealth consultations, and simple access to patient records.

In order to ensure continuous data flow between sensors, Arduino Uno, and central servers, telephone modems offer a reliable internet connection. For prompt healthcare actions, data transmission reliability is essential (Gubbi et al., 2013).

These hardware components' smooth integration improves remote healthcare by allowing for real-time data gathering and monitoring, which raises the precision and effectiveness of healthcare delivery and, in the end, improves patient outcomes.

With a variety of protocols and devices advancing healthcare, wireless technologies play a key role in improving remote health monitoring. High-speed connectivity for seamless data transfer in telehealth applications is provided via wireless Internet using protocols like Wi-Fi, 4G, and 5G (Kumar & Kumar, 2017). It makes data sharing, remote patient monitoring, and real-time video consultations possible.

A revolutionary advancement, wearable body area networks (WBANs) use sensors on the body to gather health information and vital signs. According to Abdullah et al. (2018), these WBANs use Bluetooth and Zigbee as communication protocols to send data to central servers. They make it possible for ongoing remote health monitoring, which encourages early intervention and individualised treatment.

According to Brørs et al. (2020), wristband monitoring devices that are wireless and connect to centralised healthcare systems or mobile apps offer users real-time health data through the use of

Bluetooth Low Energy (BLE) technology. With the help of these wristbands, people may keep an eye on their health and communicate information with medical professionals, which enhances patient participation and self-care.

By simplifying data collection, communication, and prompt healthcare treatments, the combination of these wireless technologies offers a comprehensive approach to remote health monitoring and eventually improves the quality of remote healthcare services.

6. Conclusion

In summary, this study has offered an analysis of numerous remote healthcare service applications, including software, wireless, and sensor-based technologies. We have developed a novel taxonomy for classifying these applications through a comprehensive review of 18 chosen scholarly papers, stressing both software and hardware components as essential features.

Our taxonomy distinguishes between three main categories, each with a subcategory of its own: hardware, which includes sensor-based applications as well as wireless technologies, software, which includes mobile apps, online apps, and telemedical systems. These technologies have proven useful in treating serious health issues like diabetes, heart disease, and the care of the aged or crippled.

Importantly, our findings highlight the promise of remote health monitoring in terms of cost savings as well as its ability to offer critical medical assistance when traditional healthcare is difficult to obtain or unavailable. This information has broad repercussions, especially for healthcare managers and policymakers since it provides insights into how to deliver distant healthcare services most effectively, particularly in underserved rural areas. Healthcare practitioners may improve the quality of care and reach more patients by using the best practises shown by this research, which will ultimately lead to better health outcomes for a variety of populations.

The study also has limitations which include a restriction on our inclusion and exclusion criteria. Our results might have been limited based on the inclusion criteria, hence, we could have missed out important papers. Since this is a conference paper, a broader search would be needed to be published in a journal to describe the comprehensive scope of the topic.

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Predicting Academic Success in Blended Learning Environments: A Probabilistic Bayesian Approach Leveraging Student Trajectory Data

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Abstract

Blended learning, which integrates online resources with conventional classroom techniques, has experienced a rise in popularity due to recent progress in digital pedagogy. However, the challenge persists in using students' trajectories to accurately predict academic success. This study aimed to determine the key features that contribute to failure in blended learning courses, construct a probabilistic machine learning model for predicting academic success, and identify techniques to quantify uncertainty in the model's predictions. Leveraging student trajectory data from a Learning Management System (LMS), we examined demographic, academic, and behavioural attributes. A pivotal discovery underscored the pronounced correlation between student absences and academic failure, whereas regular interactions with online learning resources were indicative of higher success rates. Through the application of Bayesian Logistic Regression, our model demonstrated superiority over the lasso regression, achieving an outstanding 92% accuracy and 95% f1-score. The interpretability of our probabilistic model offers profound insights for targeted academic interventions. Based on our findings, we recommend reinforcing consistent engagement with online resources, implementing early alert systems for student absenteeism, and utilizing Bayesian methodologies for nuanced, data-driven student support initiatives. Such strategies stand to significantly reshape intervention mechanisms in blended learning, ensuring timely student assistance and propelling their chances of academic success.

Keywords: Student trajectory, probabilistic machine learning, Bayesian logistic regression, academic success, student engagement, blended learning.

1. Introduction

Significant advancements in technology-enhanced learning platforms have led to a substantial increase in digital educational data, resulting in numerous educational databases (Treasure-Jones et al., 2019). This expansion of educational data has had a significant impact on HEIs. It also presents opportunities to enhance students' engagement with technological platforms to improve their learning experience (Shorfuzzaman et al., 2019). Universities are increasingly relying on data to predict students' academic progress and provide early intervention. This is made possible by the emergence of big data analytics, learning management systems (LMS), and machine learning (ML) (Viberg et al., 2018). Instructors can evaluate students' online behaviour by analyzing logs and data from LMSs, such as the number of program accesses, pages viewed, completed tasks, online participation in discussions, and improvement rates. Researchers employ various data mining approaches to examine raw data and gain comprehensive insights into student behaviour and development strategies, leveraging the unstructured and limited data available in server logs (Nihalaani et al., 2021)

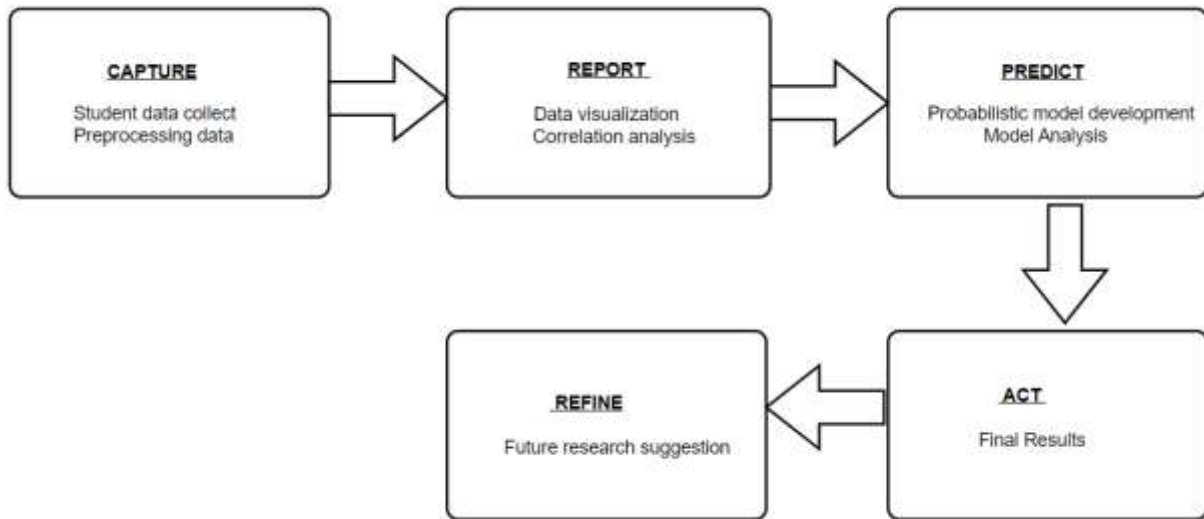
Ensuring academic achievement for students is a major concern, particularly in today's rapidly changing web-enabled environments. This study defines academic success as educational achievement, participation in school-related tasks, satisfaction, acquisition of targeted knowledge, skills, and competencies, resilience, achievement motivation, and post-college success (Ahlsweide, 2021). Conversely, a student is considered at risk when they have a low likelihood of academic progression due to poor academic performance, which can be observed at various levels and associated with student well-being and development challenges (Berry, 2017). Research has shown that student engagement in academic activities reduces failure rates in foundational university programs and enhances retention (Mishra, 2020). Therefore, machine learning methods have been introduced to inform students' educational processes, reflections, and outcomes. Consequently, a student's academic trajectory becomes valuable in identifying factors related to their academic success and detecting the need for support during the course before it becomes too late.

In learning analytics, identifying student trajectories at the course level is crucial for the convenience of lecturers and students. Predictive analytics, a subfield of learning analytics, aims to anticipate future outcomes by identifying correlations in data (Zandvliet, 2020). Statistical methods and machine learning models are utilized to predict dropout rates and the likelihood of student success (Zandvliet, 2020). Learning analytics has been applied in various studies to identify at-risk students and enable timely interventions, allowing institutions to take corrective actions (Berry, 2017; Hung et al., 2017). Machine learning techniques, including decision trees, random forests, neural networks, support vector machines, and naive Bayes, have been widely used to improve the accuracy and performance of predicting student academic success through regression and classification tasks (Nik Nurul Hafzan et al., 2019). However, non-probabilistic machine learning approaches do not account for uncertainties or incorporate domain knowledge (Murphy, 2022). This work adopts a probabilistic machine learning strategy, which is best suited for decision-making under uncertainty (Murphy, 2022). It is particularly useful when seeking the best model or decision for a given set of data. Learning, in this context, involves inferring reasonable models to interpret observational data, forming the foundation of the probabilistic framework for machine learning (Jovanović et al., 2021).

2. Methods

This study utilizes an experimental design to ensure a controlled and objective research process, focusing on evaluating a probabilistic machine learning model and drawing specific conclusions about academic success. The researchers employ descriptive and inferential statistical approaches to uncover underlying patterns in the data and develop a probabilistic machine learning model for predicting academic success. Conventional logistic regression and lasso regression models are used as benchmarks in this binary classification problem of determining student success or failure. The goal is to assess whether the machine learning model surpasses the performance of these baseline models and determine the suitability of machine learning for the task or the need for alternative approaches. A Bayesian logistic regression is implemented as the probabilistic model, treating statistical parameters as random variables with distributions, and interpretations rely on plausible intervals and distribution patterns. The study adopts a five-step analytics paradigm, capturing, reporting, forecasting, acting, and refining.

Figure 1: Workflow of Methodology (Five-step Analytics Process).



Source: (Berry, 2017)

2.1 Research Design

This research is structured as supervised learning. The goal of supervised learning is to gain knowledge on a function that maps inputs $(X_j^{(i)})$ to outputs $y^{(i)}$ provided a set of input-output pairings $D = (X_j^{(i)}, y^{(i)})_{i=1}^N$, where D denotes the training set and N the number of training samples (Murphy, 2022). The characteristics derived from student demographics, behavioral and academic characteristics were represented by $(X_j^{(i)})$. The target variable was $y^{(i)}$, which is the final classification of whether the student passes or fails at the end of the semester.

The following is how the Bayes theorem was incorporated into the model:

$$P(\theta|D) = \frac{P(\theta) \cdot P(D|\theta)}{P(D)} \quad (1)$$

Where:

$P(\vartheta|D) \sim$ Posterior distribution for ϑ given D

$P(D|\vartheta) \sim$ Likelihood function for ϑ

$P(\vartheta) \sim$ Prior distribution for ϑ

$P(D) \sim$ Evidence of the model

Which is:

$$P(\text{Model}|\text{Data}) = \frac{P(\text{Model}) \cdot P(\text{Data}|\text{Model})}{P(\text{Data})} \quad (2)$$

When seeing data D or Data, Bayes Theorem tells you how to update your confidence in the model (Henning, 2020). Using quantification of uncertainty, the model was utilized to forecast the students' academic success (Ahlswede, 2021).

$$P(y_{new}|data,\vartheta) = \int P(y_{new}|data,\vartheta)P(\vartheta|data)d\vartheta \quad (3)$$

The aforementioned Eq. (3) was used to forecast the class to which a student will be assigned (1-pass and 0-fail) according to the determined grade boundaries, and the data was used as measurements taken for a specific period (one semester) in the student's trajectory. This captured the report and predict step of the analytics model, in which the report included reporting of the features chosen depending on correlation analysis. $P(y_{new}|data,\vartheta)$ captures the predict component, which involves creating predictions using a probabilistic machine learning model, which involves creating predictions using a probabilistic machine learning model.

2.2 Bayesian Logistic Regression

The research explored the use of Bayesian Logistic Regression to forecast whether a student will pass or fail at the conclusion of the semester. To help us fit our model, we are provided labeled training data; however, because the labels are transformed from multivariate to binary, this is a classification task. Commonly, supervised machine learning techniques like logistic regression, support vector machines, or tree-based approaches are used to tackle this challenge. In this study, a logistic regression model is fitted using a Bayesian framework, and the model parameters are then interpreted.

The natural log-likelihood of the output, also known as the logits, was presumed to be produced by a linear combination of the selected features plus an error factor to account for random sampling noises or latent features in the Bayesian understanding of logistic regression (Nhu et al., 2020).

The log-likelihood was then transformed into an output probability:

$$P = \frac{1}{1 + e^{-\text{logit}}}$$

In this instance, we have determined the likelihood that a student passes given the available student data which is $p(\text{Pass}|\text{Features})$.

The idea was to find the "best" values, which often refer to those that, given a set of inputs and outputs, are most likely. Maximum Likelihood Estimation (MLE) is the iterative process used in the calculation of values in logistic regression (Altmeyer, 2021). The Bayesian approach asserts that the likelihood of the data comes from a distribution. This is a Bernoulli distribution for classification with a binary result:

$$\prod_{i=1}^n p^{y_i}(1 - p)^{1-y_i}$$

Where the probability was determined by the aforementioned output probability using a linear combination of the model parameters, where $y(i) = 1$ if the student passes at the end of the semester and $y(i) = 0$ if the student fails.

Given the inputs and outputs, the intention was to determine the posterior probability distribution of the model parameters. Since using continuous variables makes it impossible to get the precise posterior for the model parameters, we used Monte Carlo sampling techniques. This indicates that to estimate the posterior, we repeatedly sampled from it. This was accomplished using a variant of the Markov Chain Monte Carlo (MCMC) technique, in which the subsequent state is determined by only a

finite portion of the previous and current states (depending on the order of the chain) (Altmeyer, 2021). With the Bayesian approach, not only is the log-likelihood believed to be drawn from a distribution, but so are the model parameters. We used domain knowledge and knowledge about the relationship between features and target class to pick informative priors, which are later explained in the model implementation.

2.3 Baseline Machine Learning Models

The research aimed to assess whether machine learning was suitable for addressing a specific issue by establishing a baseline for evaluation. The study compared the performance of Bayesian Logistic Regression with the lasso regression and logistic regression machine learning algorithms. Logistic regression is a statistical approach used to predict binary classes, where the dependent variable follows the Bernoulli distribution (Lynne, 2020). Lasso regression, on the other hand, combines variable regularization and selection to enhance predictability and interpretability of the resulting statistical model (Ranstam & Cook, 2018).

3. Model Implementation

The generalized linear model (GLM) module of the PyMC3 library included the function 'glm.from formula()' for model development (Wiecki & Sedar, 2022). Informative priors were used in the logistic regression model. For the intercept parameter, a beta prior distribution was chosen, reflecting prior knowledge that around 50% of students typically pass the course. The beta distribution with parameters $\alpha=1$ and $\beta=1$ represented a uniform prior distribution over the range [0,1], with additional weight towards the value of 0.5. This prior choice facilitated efficient posterior inference as the beta distribution is conjugate to the Bernoulli likelihood function used in the logistic regression. Similarly, the prior distribution for the slope parameters was based on knowledge about the effect of attendance on academic performance, using a normal distribution with mean 0 and standard deviation 1 to reflect the prior belief in a positive and significant effect. This "weakly informative" prior allowed the data to largely determine the posterior distribution of the slope parameters but still placed some prior belief on plausible values (Wiecki & Sedar, 2022).

As we dealt with a binary outcome variable, the data probability distribution was switched from normally distributed to a Bernoulli distribution. The model was constructed using a specified formula, and sampling from the posterior was performed using the No-U-Turn Sampler (NUTS), a variant of Metropolis-Hastings. Both NUTS and Metropolis-Hastings are MCMC methods, as they sample from the posterior while considering only the present state to determine the subsequent value (Koehrsen, 2022).

4. Results and Discussion

Fig. 2 below illustrates the output of the trace plot function for the Bayesian Logistic Model, displaying the samples taken for each variable. The left side of the plot shows the data distribution, with the mean indicated by a vertical line. On the right, the trace plot depicts the complete sampling trace. The presence of two chains indicates that the sampling was conducted twice, with 1000 draws and 500 tuning steps per sampling (Koehrsen, 2022). Tuning steps are discarded as they allow the model to settle and converge towards posterior estimates, even if the initial samples may be inaccurate (Alyahyan & Düşteğör, 2020). The trace plot effectively summarizes the MCMC process. The left side shows the final approximate posterior distribution of the model parameters, while the right side displays the complete sampling trace. The plotted range of sampled parameter values during the MCMC procedure (seen in the right figure) suggests that the model has converged. Convergence indicates the model's suitability for predicting academic success.

The energy plot serves as an indicator of the model's convergence. It evaluates whether the random process adequately explores the posterior distribution, with the marginal energy and energy transition distributions ideally aligning closely. If the energy transition distribution is substantially narrower than the marginal energy, it suggests potential bias in the posterior estimation, necessitating additional iterations for accurate results as proved by Zhu et al. (2020). However, in this case, the energy is sufficient to explore the entire parameter space, confirming the strong association between the selected predictors and academic success.

The evaluation of the probabilistic model's data fit is performed through the posterior predictive check (Postance, 2021). By examining the posterior predictive, observed data, and posterior predictive mean in the depicted plot, one can assess the model's ability to accurately capture the data. Fig. 4 clearly demonstrates a satisfactory alignment between the model and the data. The posterior predictive mean closely matches the observed data, affirming the model's effectiveness in predicting academic success and achieving the goal of using student trajectory in Bayesian logistic regression (Nihalaani et al., 2021).

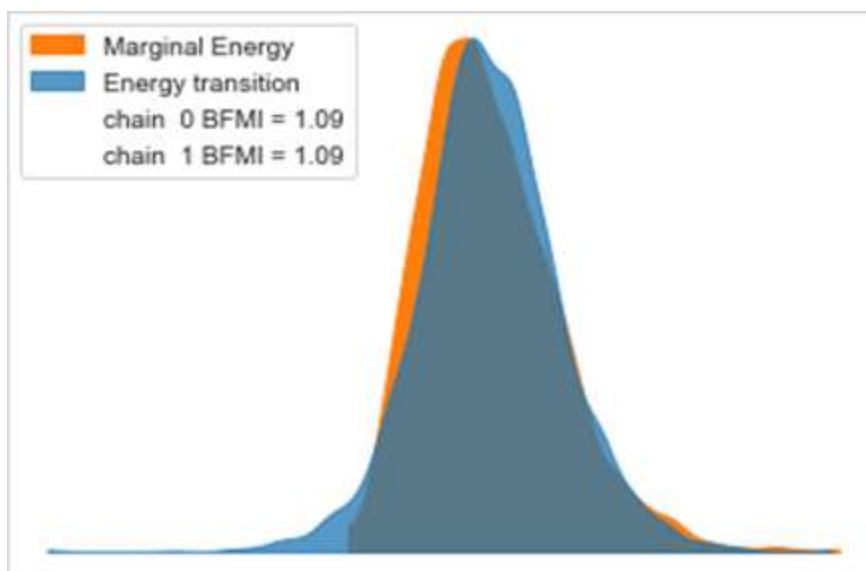


Figure 3: Energy Plot.

Source: (Author's Own)

The evaluation of the probabilistic model's data fit is performed through the posterior predictive check (Postance, 2021). By examining the posterior predictive, observed data, and posterior predictive mean in the depicted plot, one can assess the model's ability to accurately capture the data (van de Schoot et al., 2021). Fig. 4 clearly demonstrates a satisfactory alignment between the model and the data. The posterior predictive mean closely matches the observed data, affirming the model's effectiveness in predicting academic success and achieving the goal of using student trajectory in Bayesian logistic regression.

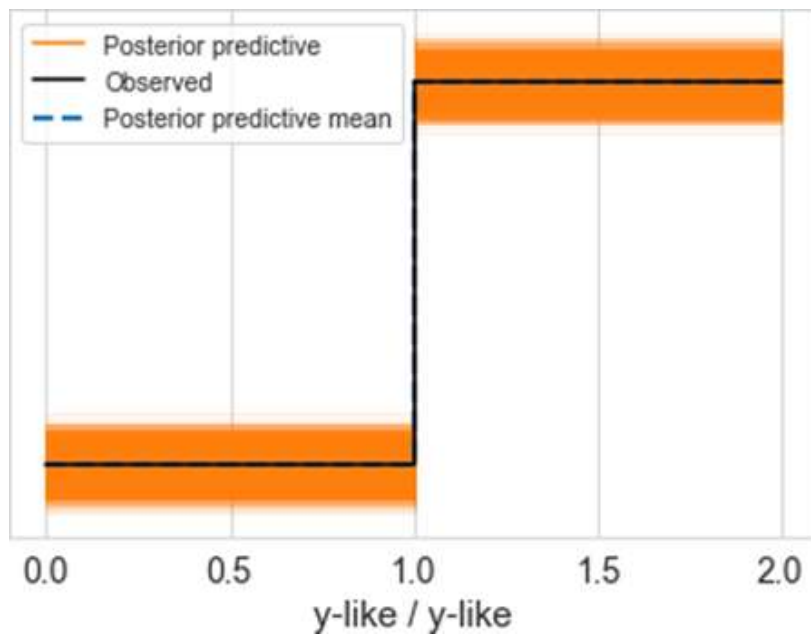


Figure 4: Posterior Predictive Checks.

Source: (Author's Own)

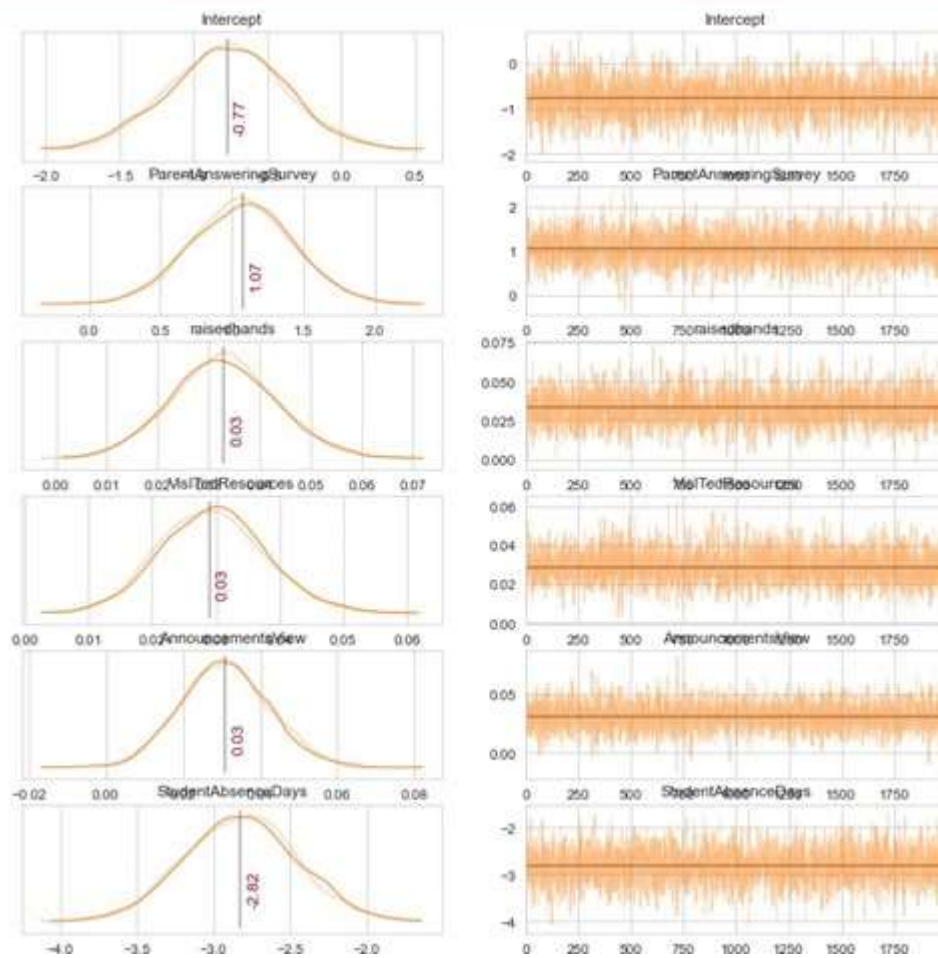


Figure 4: Trace Plot Function Results.

Source: (Author's Own)

4.1 Uncertainty Quantification

Credible intervals in Bayesian statistics serve as a representation of the uncertainty associated with the model parameters. The intervals are defined within the posterior probability distribution or the predictive distribution (Koehrsen, 2022). The charts presented below are based on the Highest Density Interval (HDI), which identifies the most credible points and the coverage of the distribution. The forest plot in Fig. 5 illustrates the distribution of the sampled variables along with their 94% credible range. According to Wang, Chen, and Guan (2021) one advantage of Bayesian inference is the ability to produce measures of uncertainty, highlighting that any model is essentially a hypothesis about the world. While all student engagement features exhibit strong correlations with academic success, the Bayesian model is most certain about raised hands, visited resources, and announcement views, and least certain about parents answering surveys and student absence days within a 94% credible interval, which may vary depending on other factors. Even though the effect of student absence on academic success is uncertain or not statistically significant in the model, the fact that it shows the strongest negative correlation among predictor variables suggests its importance in predicting academic success (Wang, Chen, & Guan, 2021). This consideration is made alongside other significant factors such as students visiting resources.

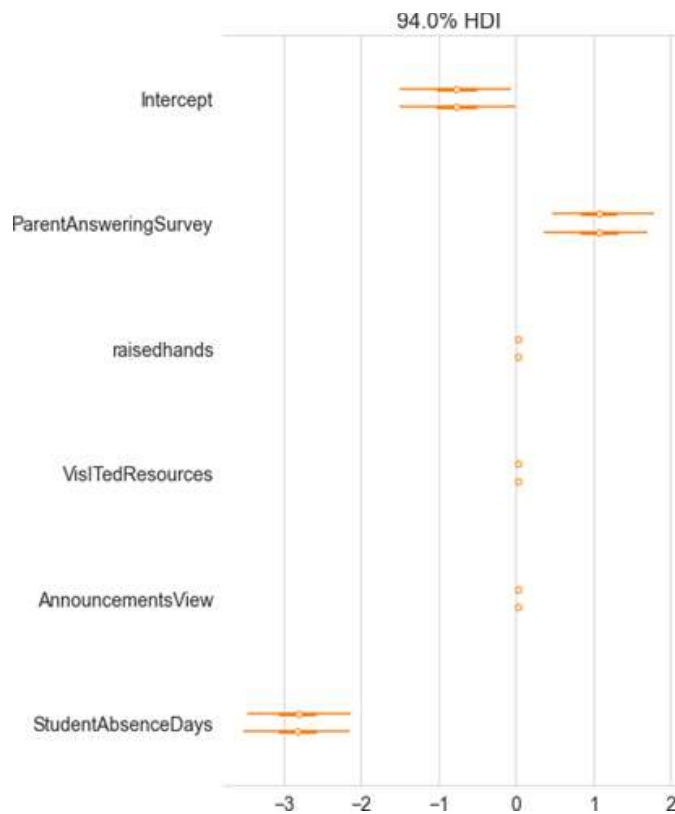
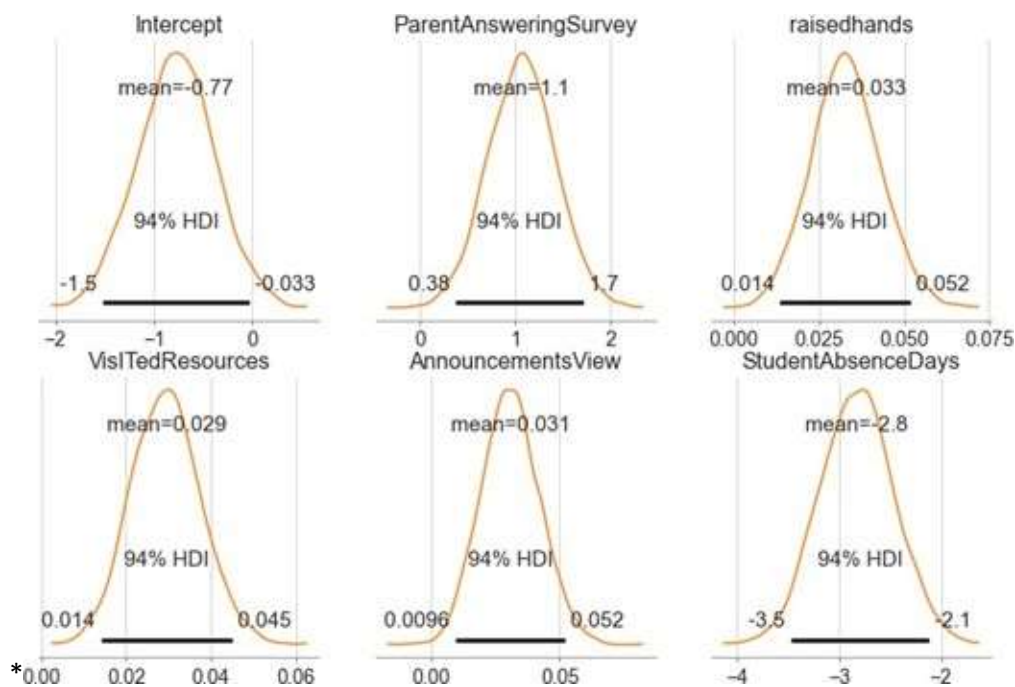


Figure 2: Forest Plot.

Source: (Author's Own)

Fig. 6 below presents the 94% highest positive density, indicating the most probable range of model parameters. To acknowledge the inherent uncertainty in our model, as is the case in real-world scenarios, we provide the 94% credible interval alongside the mean, offering insights into the average value of the parameter. The peak of the distribution represents the mode, or the most likely value of the parameter or prediction based on the available data and prior information, while the width of the distribution signifies the level of uncertainty or variability in the estimate van as in study by van de Schoot (2021). Narrow figures denote less uncertainty in the model parameters, as demonstrated by the parameters for students visiting resources and announcement views.



Source: (Author's Own)

5. Model Comparison

The Bayesian logistic classification model performs reasonably well when compared to a conventional machine learning models logistic regression and lasso regression, with an overall accuracy of 92% for the model and f1-score of 95% for predicting students that passed and 85% for students that failed. Additionally, with precision and recall above 80% for both fail and pass students, the Bayesian model correctly predicts both classes. See Tab.1 below for reference.

Table 1: Model Classification Report Results

MODEL	PREDICTION	PRECISION	RECALL	F1-SCORE	OVERALL MODEL AC-CURACY
BAYESIAN LOGISTIC REGRES-SION	FAIL	0.86	0.84	0.85	0.92
	PASS	0.94	0.95	0.95	
LOGISTIC REGRES-SION	FAIL	0.85	0.84	0.85	0.92
	PASS	0.94	0.95	0.94	
LASSO RE-GRESSION	FAIL	0.73	0.84	0.78	0.88
	PASS	0.94	0.89	0.91	

The F-test, as explained by van de Schoot et al. (2021) is a statistical method used to compare the fits of different models, was employed to assess the significance of our regression model. By contrasting a full model, which incorporated our predictors, the F-test evaluated whether the inclusion of our predictors significantly enhanced the model's fit to the data. The outcome of the F-test yielded an F-statistic of 94.40 and an extremely low p-value close to 0. This minuscule p-value indicates that the Bayesian Logistic Regression model with predictors provides a substantially better fit to the data than the other models. As a result, the F-test validated that the proposed model is statistically significant, and the chosen predictors play a crucial role in explaining the variance in the target variable.

6. Conclusion

HEIs face challenges related to high failure and dropout rates, resulting in a skills deficit. This study aimed to utilize a probabilistic model to identify factors influencing academic success and predict outcomes with uncertainty. The research findings have implications for supporting students and proposing intervention techniques. Student engagement features, specifically students' resource visits and attendance, were identified as highly correlated with academic success. The model's representation of uncertainty, as demonstrated through posterior predictive checks and forest plots, contributes to more reliable predictions and parameter estimates. The Bayesian Logistic Regression model exhibits promising performance, surpassing 90% accuracy and f1-score, with potential for further improvement in precision. Notably, the model's interpretability provides a range of forecasts for each student, enabling tailored advice based on the impact of altering specific variables. Future research can explore new features and gather additional data to enhance model performance and reduce uncertainty. Collaboration with higher education experts can guide feature selection, data collection, and interpretation of model parameters, optimizing the balance between false positives and false negatives. Combining domain expertise with machine learning approaches is crucial for comprehending the underlying reasons behind model predictions and leveraging that knowledge to improve student outcomes.

Based on our findings, we recommend implementing early alert systems to swiftly identify and aid at-risk students. Enhancing the quality of online resources can further promote student engagement, which is crucial for academic success. Educators should undergo training to effectively utilize Learning Management System data for timely student support. Incorporating the probabilistic model within existing systems can streamline this identification process. Furthermore, initiatives to strengthen regular student engagement and fostering a culture of continuous evaluation will ensure that interventions remain effective and relevant.

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Integrating Customer Relationship Management and Business Intelligence to Enhance Customer Satisfaction and Organisational Performance. A Literature Review

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Abstract

Customer relationship management (CRM) and business intelligence (BI) are key elements within the aspect of business technology. Customer Relationship Management (CRM) is centered around the objective of improving and strengthening interactions and connections with customers. The utilisation of a variety of strategies, technologies, and approaches by businesses to proficiently oversee their connections and interactions with current and prospective consumers is commonly referred to as customer relationship management (CRM). Although several studies have presented the benefits of CRM and BI in literature. A lack of understanding of the integration of CRM and BI is missing in the literature. Therefore, the study aims to compare the effectiveness of CRM and BI in improving customer satisfaction and organisational performance. A narrative synthesis methodology was utilized. The finding of the papers shows that the integration of CRM with BI in organisations is of great significance owing to the synergistic advantages it provides. To achieve a successful integration of CRM with BI, organizations are advised to employ a holistic approach that incorporates both technological and organisational factors. This study establishes a robust basis for future research to further develop, in light of the evolving markets and advancing technologies.

Keywords: Customer relationship management, Business Intelligence, Analytics, Technology

1. Introduction

The concepts of customer relationship management (CRM) and Business Intelligence (BI) have gained considerable attention in the contemporary corporate world. This is primarily owing to their substantial influence on augmenting consumer satisfaction and overall organisational performance (Fitriana, Eriyatno & Djatna, 2011). Customer relationship management (CRM) and business intelligence (BI) are key elements within the aspect of business technology. In summary, Customer Relationship Management (CRM) is centered around the objective of improving and strengthening interactions and connections with customers. The utilisation of a variety of strategies, technologies, and approaches by businesses to proficiently oversee their connections and interactions with current and prospective consumers is commonly referred to as customer relationship management (CRM). On the other hand, Business Intelligence (BI) focuses on furnishing organisations with important insights to facilitate informed decision-making processes (Saha, Tripathy & Sahoo, 2021). The primary focus of this study is on the many strategies and technology that organisations utilise in order to analyse business information. The integration of these technologies offers distinct and mutually beneficial features that, when integrated, hold the capacity to significantly propel corporate development.

Acquiring a comprehensive understanding of the principles and capabilities of Customer Relationship Management (CRM) and Business Intelligence (BI) is imperative, given the growing indispensability of these systems across diverse sectors (Del Vecchio et al., 2022). Customer data management and use are essential for organisations to effectively achieve a competitive edge.

Given the swift progress in technology and increasing rivalry, organisations are confronted with a pressing need to implement efficient strategies that will allow them to proficiently handle their consumer interactions and use intelligence in order to surpass their competitors (Enholm et al., 2022). As a result, this study will provide a substantial addition to the existing knowledge base by presenting

findings that give valuable insights to the academic community, professionals in the field, and policymakers, specifically in relation to the effectiveness of Customer Relationship Management (CRM) and Business Intelligence (BI). Consequently, this will facilitate future research attempts in this continuously developing sector.

The combination of Customer Relationship Management (CRM) and Business Intelligence (BI) in contemporary firms has not been adequately explored in studies, despite the significant roles that both systems play. The main aim of this study is to conduct a thorough analysis and comparison of CRM and BI, focusing specifically on their usefulness in improving customer satisfaction and organisational performance. This involves analysing the similarities and differences between them, as well as assessing their comparative effectiveness in attaining the previously indicated goals. This study will further evaluate the current advancements in Customer Relationship Management (CRM) and Business Intelligence (BI) research and determine successful approaches for integrating and applying these technologies across various sectors.

2. The evolutionary trend of Customer Relationship Management (CRM) and Business Intelligence (BI)

The examination of the history of Customer Relationship Management (CRM) and Business Intelligence (BI) reveals the significant influence of technical improvements and changing business requirements. The concept of Customer Relationship Management (CRM) emerged in the 1980s, with a primary emphasis on the effective management of customer contacts pertaining to sales and marketing activities. Over time, its scope broadened to include customer service and support, adopting a more customer-centric orientation. Likewise, Business Intelligence (BI) surfaced throughout the 1990s as a method for gathering, analysing, and interpreting substantial quantities of data with the intention of facilitating decision-making processes. The initial stages of BI involved the implementation of data warehousing and reporting practices. However, with time, it has progressed to encompass other techniques like as data mining, predictive analytics, and the integration of artificial intelligence applications (Riemer et al., 2016).

Table 1. Evolution of evolution of CRM

Evolution of CRM				
	Past			Future
Access	Front Line Employees, Managers	WHO →		Plus: Operations, Engineering, Manufacturing, Partners
Process	Static, Linear, Inefficient	WHAT →		Dynamic, Adaptive, Coordinated
Duration	A Sale, an Issue, a Complaint	WHEN →		Lifetime Engagement
Interaction	Phone, Email, Web, Multi-Channel	WHERE →		Plus: SMS, Community, Social, Chat, Cross-Channel, Mobile
Centricity	Employees, Company, Transactions	WHY →		Customer, Ecosystem, Value-in-use
Comms	Broadcast, Fractured, Reactive	HOW →		Listen, Engage, Converse, Collaborate, be Proactive

https://customerthink.com/the_evolution_of_crm/

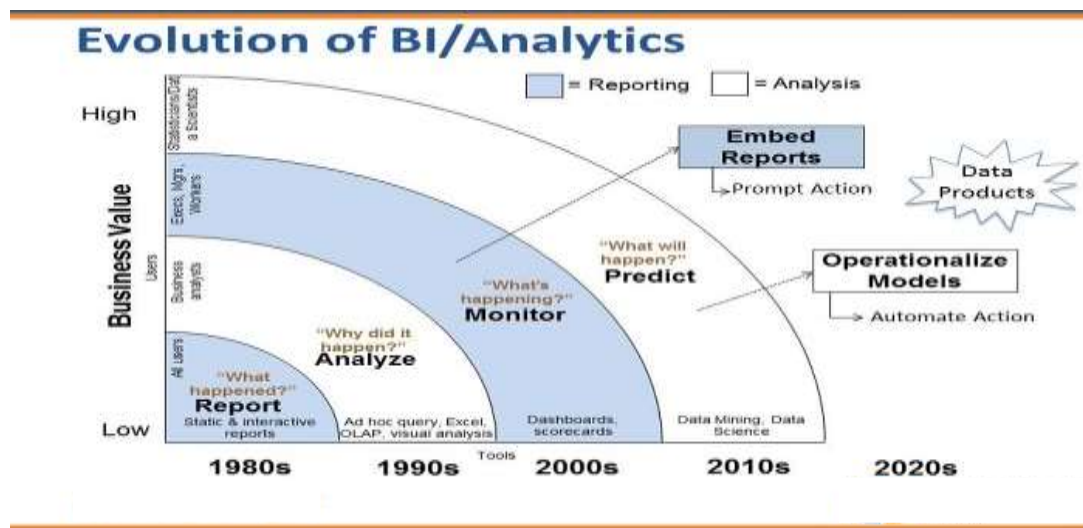


Figure 1. Evolution of CRM and BI <https://tdwi.org/articles/2016/09/08/embedded-analytics-future-of-bi.aspx>

CRM shows how it has evolved from past to present when it come to the following constructs: access, process, duration, interactions, centrality and comms. The BI shows how business value has evolved from the year 1980 through 2020s.

Shifting our focus towards the influence of CRM and BI on business strategies, it becomes evident that their implementation has had significant impact. CRM enables organisations to enhance their connections with consumers through the provision of a full understanding of their interactions and preferences (Alshurideh et al., 2019). This understanding empowers firms to customise their offers, anticipate the demands of customers, and provide improved customer service (Gligor et al., 2019). Similarly, BI plays a crucial role in enabling data-driven decision making by providing precise business forecasting, identifying trends and patterns, and evaluating the effectiveness of different marketing and operational strategies. The seamless integration of customer relationship management (CRM) with business intelligence (BI) enables organisations to effectively align their plans with consumer expectations and market dynamics, resulting in improved performance and a competitive edge (Payne, Frow, & Eggert, 2017).

The significant progress in technology have been crucial in shaping the development of CRM and BI. The proliferation of digital channels, social media platforms, and mobile devices has led to a significant increase in the volume of consumer data. As a result, there has been a growing need for the advancement of more advanced CRM and BI solutions. The emergence of cloud computing and big data analytics has facilitated the establishment of the requisite infrastructure and computational capacities to effectively manage extensive quantities of data, hence enabling the possibility of conducting real-time analysis. Furthermore, the emergence of artificial intelligence and machine learning has enabled more accurate consumer segmentation, predictive modeling, and the automation of routine CRM and BI processes. According to Sheth and Sharma (2019), the implementation of technology developments has resulted in a significant transformation of CRM and BI systems. These systems have evolved from being static transactional platforms to dynamic and proactive tools that empower organisations to effectively adapt and compete in a constantly evolving business environment.

2.1 Scope and Importance of CRM and BI

The evaluation of the extent and significance of CRM and BI has paramount relevance within organisational contexts. CRM is a strategic methodology that centers on the effective management and improvement of customer interactions over the entirety of their lifecycle. The process encompasses several tasks, including the analysis of data, segmentation of customers, implementation

of sales and marketing initiatives, and engagement in customer service contacts. The primary objective of CRM is to enhance customer happiness, loyalty, and overall corporate success through the systematic collection, integration, and analysis of customer information (Gupta & Kohli, 2006).



Figure 2 Importance of Customer Relationship Management

This model is produced by qbrainx.com in 2022, summarizing the importance of CRM. Retrieved from: (<https://www.qbrainx.com/blog/importance-of-customer-relationship-management-crm/>).

In contrast, Business Intelligence (BI) comprises a range of technologies, tools, and techniques that are employed to gather, consolidate, analyse, and display data in order to facilitate decision-making processes within an organisational context. The aforementioned components encompass data warehouses, dashboards, data mining, and reporting tools, which serve as significant resources for gaining insights into several facets of an organisation's operations, including sales, marketing, finance, and supply chain management (Chen, Chiang, & Storey, 2012).

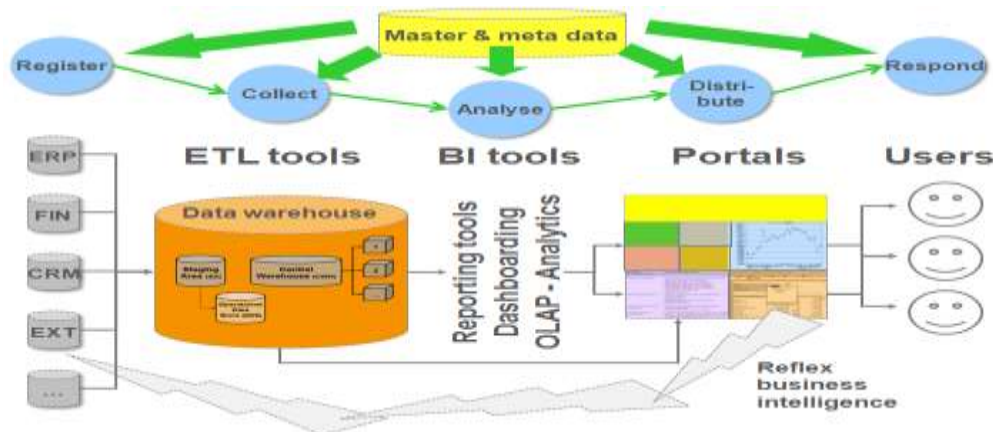


Figure 3. Business Intelligence Overview

Note. The diagram shows overall range of technologies, tools, and techniques employed by business intelligent in an organization. Retrieved from <https://ramamotwani.wordpress.com/2015/09/19/what-is-business-intelligence-bi/>

The significance of CRM in organisations lies in its ability to facilitate efficient administration and cultivation of customer interactions. Through the examination of customer data, organisations are able to get a more profound understanding of consumers' preferences, requirements, and behaviors. This understanding enables organisations to customise their products, services, and promotional strategies accordingly, leading to increased levels of consumer contentment and loyalty. Furthermore, CRM plays

acrucial role in enabling organisations to effectively discover prospective consumers, boost their sales and marketing effectiveness, elevate the quality of customer service, and cultivate enduring customer relationships. Consequently, CRM serves as a catalyst for driving corporate growth and bolstering profitability (Gupta & Kohli, 2006).

BI also holds significant importance as it enables decision-makers to access and utilise valuable information obtained through data analysis. BI facilitates organisations in making well-informed decisions based on accurate and timely information. This data-driven approach enhances operational efficiency, reduces costs, and ultimately provides a competitive edge. BI facilitates the identification of trends, patterns, and correlations within data, therefore revealing concealed possibilities and enabling the resolution of prospective difficulties. Furthermore, the utilisation of business intelligence (BI) allows organisations to effectively monitor and assess key performance indicators, evaluate company performance, and discover potential areas for enhancement. This ultimately contributes to the overall growth and success of the organisation (Chen, Chiang, & Storey, 2012).

The field of Business Intelligence (BI) comprises a variety of ideas, techniques, and technologies that organisations utilise to analyse and interpret business data in order to make informed decisions based on data. The process encompasses a range of methodologies, including data mining, reporting, data visualisation, and predictive analytics, with the primary objective being the extraction of practical insights from unprocessed data (Kim & Mueller, 1978). Through the utilisation of BI, organisations may acquire a thorough understanding of client preferences and behaviors. This empowers them to tailor their products, services, and marketing strategies in order to effectively address the ever-changing requirements and expectations of their target customer base.

A considerable body of research has been dedicated to investigating the deployment of BI and its effects on customer satisfaction. Chen and Popovich (2003) performed research that examined the significance of BI in the context of customer relationship management. The study highlighted the ways in which BI tools facilitate the analysis of customer data and the identification of trends, hence aiding organisations in their decision-making processes. This enables enterprises to build customised and focused marketing strategies. The study's results revealed that the use of business intelligence (BI) has a significant impact on customer satisfaction. This is achieved by providing businesses with improved insights into their customers' requirements, preferences, and behaviors, hence increasing the entire customer experience. Scholarly investigations have also explored the correlation between the deployment of BI and the performance of organisations. In a study done by Gupta, Lehmann, and Stuart (2004), the researchers aimed to examine the impact of consumers on business success. The study conducted by the researchers revealed that companies that successfully integrate BI techniques to analyse consumer data and get valuable insights are more equipped to make well-informed choices, optimise the allocation of resources, and promote operational efficiency. Consequently, these organisations experience improved overall performance and gain a competitive edge in the market.

2.3 Benefits of implementing Business Intelligence into organisational operations.

- **Timely access to accurate and relevant data:**

The implementation of Business Intelligence (BI) involves the smooth integration of several data sources, thereby merging them into a centralised repository. The continuous flow of current information provides decision-makers with a significant resource, allowing them to adopt data-driven and well-informed decision-making procedures, supported by the extensive knowledge available to them.

- **Enhanced decision-making processes:**

Characterised by a comprehensive array of sophisticated tools and technology, BI facilitates a significant paradigm shift in the landscape of decision-making. Decision-makers are able to effectively analyse complicated information, identify current trends, and make educated decisions with exceptional skill and efficiency by effortlessly utilising visualisations, dashboards, and reports.

- **Competitive advantage through data-driven insights:**

By unlocking the cryptic symbols of data, the utilisation of BI provides a gateway to a comprehensive view of patterns, connections, and developments, resonating throughout the corridors of organisational strategy. With these valuable insights, organisations navigate through the unfamiliar territory of consumer behavior, market dynamics, and competitors' strategies, thereby gaining a competitive advantage that establishes them as leaders in the market landscape.

3. Theoretical Frameworks in CRM and BI Research

3.1 Summary of Theoretical Foundations in CRM Research

In the field of CRM research, the theoretical underpinnings essentially stem from three key theories: Relationship Marketing Theory, Customer Lifetime Value Theory, and Social Exchange Theory. Each theory brings a unique aspect to the understanding of customer relationship dynamics.

- **Relationship Marketing Theory:** The idea of relationship marketing posits that the cultivation of enduring relationships with consumers results in greater financial gains and enhanced customer loyalty (Rierner, Scifleet, & Markham, 2016).

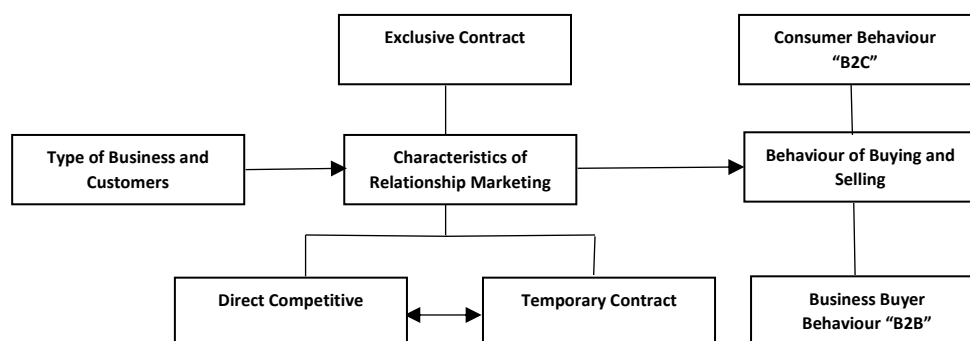


Figure 4 relational marketing theory (Trihatmoko, 2018).

The theory was first proposed by Berry (1983) an American marketing scholar and Jacks on (1985). According to RMT, a company's relationship with its customers will become stronger as it provides value, which will lead to a higher rate of customer retention (Mahmoud et al., 2018).

- **Customer Lifetime Value Theory** The theory of Customer Lifetime Value places emphasis on the optimisation of the net profit generated by a customer during their full duration of engagement with the organisation (Payne, Frow, & Eggert, 2017).

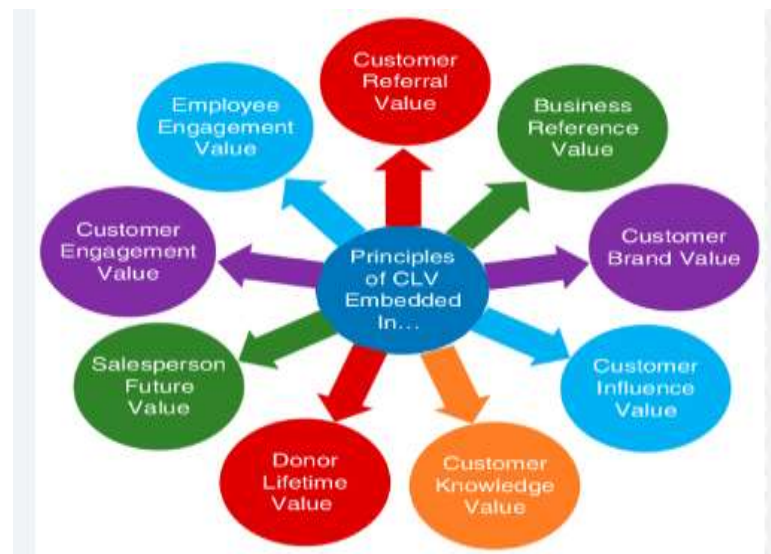


Figure 5 Customer Life Value Theory

Figure 5 presents the customer lifetime value theory, the Customer lifetime value evaluates the long-term value of customers within the company (Estrella-Ramón et al., 2013).

- **The Social Exchange Theory** postulates the dynamics of interactions between individuals as mutually advantageous exchanges, a significant factor in fostering consumer loyalty and satisfaction (Sheth & Sharma, 2019).

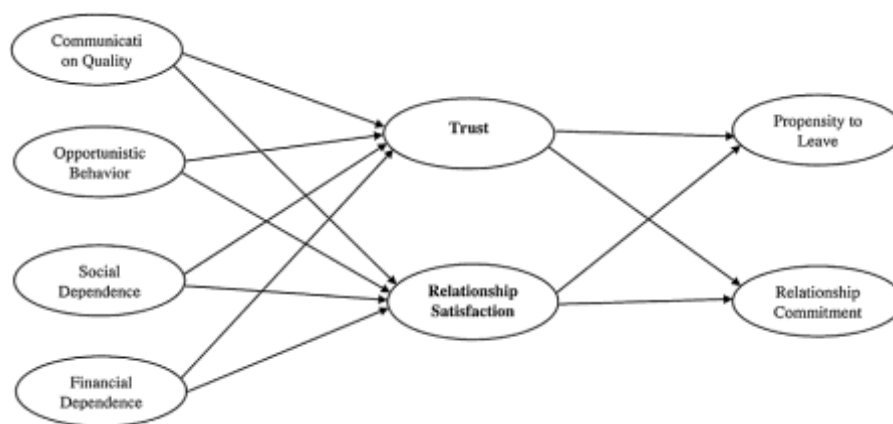


Figure 6 Social exchange theory (Jeong, 2017)

- One of the most important theories of social interaction in the social sciences is **social exchange theory**. The principal thinkers who created the initial theories of social exchange were Homans, Blau, and Emerson (Cook et al., 2021). Social exchange theory is based on the principle that people enter groups that provide them some benefit and leave groups when they perceive that they are not receiving a benefit from them. The theory considers direct social interactions between actors through four elements: trust, commitment, reciprocity, and power (Benitez et al., 2022).

3.2 Summary of Theoretical Foundations in BI Research

Within the field of BI research, there has been a notable development in the foundational

principles that underlie this discipline. Specifically, the conceptual framework has been shaped by three prominent theories: Data-Driven Decision-Making Theory, Information Processing Theory, and Knowledge Management Theory.

- The **Data-Driven Decision-Making Theory** emphasises the significant impact of data on driving corporate choices, enhancing operational efficiency, and gaining a competitive advantage (Kim & Yoon, 2019).

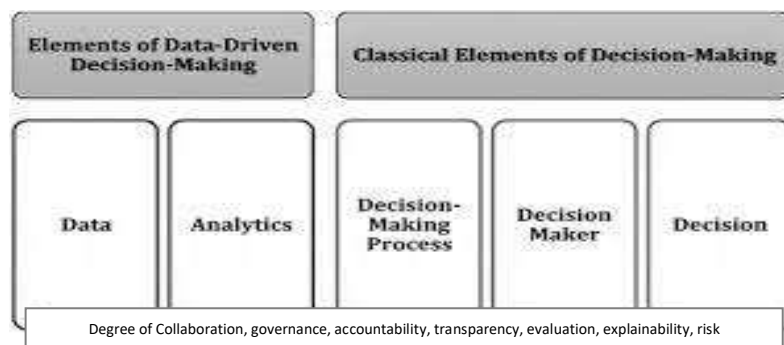


Figure 7. Data-Driven Decision-Making Theory for Big data analytics (Elgendy, et. al., 2021)

- The **Information Processing Theory** is a theoretical framework that centers on the process by which organisations handle and convert large quantities of data into valuable knowledge that can be utilised for making informed decisions (Dhingra & Tatikonda, 2018).

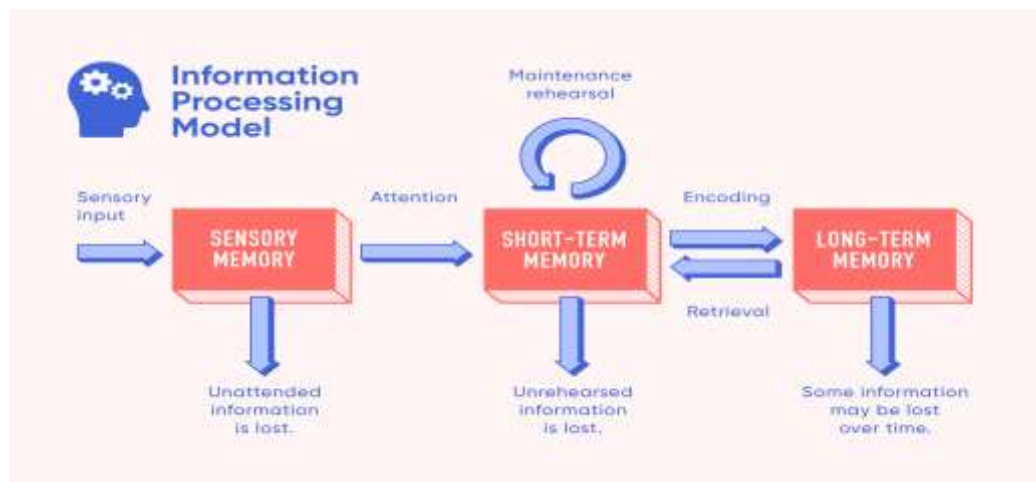


Figure 8 presents information processing theory, developed by George Miller in the 1950s,

- The **Knowledge Management Theory** focuses on the strategies employed by organisations to capture, disseminate, and efficiently utilise their collective knowledge, with the aid of BI (Kuan & Chau, 2018).

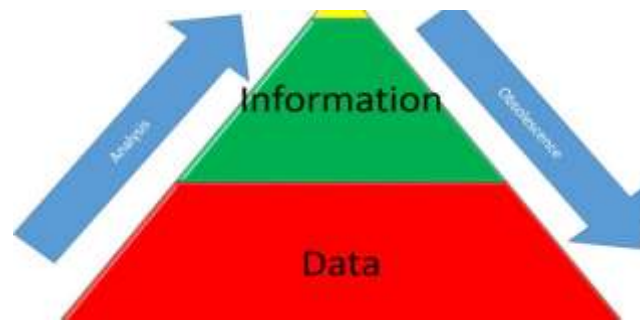


Figure 9 presents information processing theory (Frobe, 2018).

4. Comparison and Analysis of Key Theoretical Frameworks in CRM and BI Research

Both CRM and BI have their unique theoretical perspectives, however they exhibit several points of convergence. Both disciplines primarily center around the utilisation of data and knowledge to facilitate informed decision-making and improve financial gains. CRM places a greater emphasis on the development and cultivation of customer relationships, whereas BI primarily seeks to enhance organisational efficiency and decision-making procedures. The possible combination of CRM and BI has the ability to enhance customer relationships and business operations to a higher degree (Rigby, Reichheld, & Scheffer, 2013).

Both approaches are centered on the utilisation of consumer data to get insights that guide corporate objectives. CRM philosophy places a significant emphasis on the establishment of robust customer connections and the strategic utilisation of customer information to facilitate corporate success. In contrast, the notion of Business Intelligence (BI) places emphasis on the importance of data analysis, visualisation, and interpretation as means to aid decision-makers in making well-informed decisions. The integration of CRM and BI theories offers a comprehensive framework for understanding and implementing customer-centric strategies successfully.

4.1 Benefits of Integrating CRM and BI

The integration of CRM with BI has significant benefits in terms of augmenting customer insights and optimizing decision-making processes inside organisations.

- **Enhancement of Customer Insights**

Organisations may achieve a comprehensive understanding of their clients by integrating customer data from Customer Relationship Management (CRM) systems with the analytical functionalities of Business Intelligence (BI). This complete understanding allows firms to discern patterns, trends, and preferences that may be utilised to develop focused marketing efforts, personalised experiences, and customised items. The amalgamation of consumer Relationship Management (CRM) and company Intelligence (BI) enables organisations to capitalise on consumer insights in order to enhance overall customer happiness, loyalty, and company success.

- **Enhancement of Decision-Making Processes**

The convergence of Customer Relationship Management (CRM) and Business Intelligence (BI) also facilitates the enhancement of decision-making processes inside organisations. Organisations may utilise the analytical capabilities of business intelligence (BI) to examine customer data in real-time and make informed decisions based on data analysis. The integration facilitates the identification of sales patterns, the forecasting of future demand, and the optimisation of marketing and sales

strategies for enterprises. Furthermore, the combination of Customer Relationship Management (CRM) and Business Intelligence (BI) fosters interdepartmental communication, enabling organisations to synchronise their endeavors and make well-informed decisions that yield advantages for the whole business.

4.2 Similarities and Differences between CRM and BI

There are some notable similarities between CRM and BI. Both CRM and BI are strategic tools that organisations utilise to enhance decision-making processes and improve overall business performance. Additionally, both systems include the collection, and analysis. The CRM) and BI systems exhibit significant commonalities, despite their distinct objectives. The primary objective of these systems is to augment the value of businesses, facilitate efficient utilisation of data, and facilitate well-informed decision-making processes inside organisations. These technologies offer a complete analysis of consumer information and play a crucial role in the formulation of strategic strategies, rendering them important assets for contemporary enterprises. According to Gupta and Kohli(2006),

4.3 Customer Relationship Management and Business Intelligence

Although CRM and BI share many similarities, they serve different purposes within the context of an organisation. CRM is a business strategy that centers on the effective management and analysis of customer interactions, with the overarching goal of enhancing customer happiness and fostering customer loyalty. In contrast, BI is centered around the acquisition, analysis, and presentation of organisational data with the aim of enhancing decision-making processes on a larger scope (Chen, Chiang,& Storey, 2012).

Additional differentiations may be observed in the operational particulars of CRM and BI systems. CRM systems demonstrate exceptional proficiency in effectively managing customer contacts, meticulously monitoring sales operations, tailoring marketing outreach to individual customers, and offering a wide range of customer support features. In contrast, BI solutions include functionalities that encompass data consolidation, sophisticated analytics, comprehensive reporting, and data visualisation through interactive dashboards. In essence, CRM endeavors to cultivate more robust customer relationships, whereas BI focuses on deriving actionable insights from consolidated data (Gupta and Kohli, 2006; Chen et al. 2012).

4.4 Exploring the Role of Data Analytics in CRM and BI

The use of new methodologies and technology significantly enhances these two domains, enabling the analysis of extensive datasets and the extraction of valuable insights. Data analytics use statistical and mathematical algorithms, together with data visualisation techniques, to identify patterns, trends, and correlations within datasets. This enables organisations to make well-informed decisions based on data- driven insights. The incorporation of data analytics plays a crucial role in enhancing the effectiveness and efficiency of CRM and BI. This, in turn, aids organisations in enhancing their understanding of customers, optimizing business operations, and attaining a competitive edge (Dhingra & Tatikonda, 2018; Kim & Yoon, 2019).

5. Theoretical Underpinnings of Data Analytics in CRM and BI

The theoretical underpinnings that enable the application of data analytics in CRM and BI are diverse and complex, offering a strong platform for comprehending and executing data-centric initiatives. One of the frameworks that may be identified is the Information Processing Theory (IPT). Through its focus on the processing of information to enhance decision-making, Information Processing Technology (IPT) empowers organisations to convert unprocessed data into practical and actionable insights. The application of Information Processing Theory (IPT) concepts to CRM and BI enables firms to effectively extract relevant information from their systems, construct precise models, and obtain valuable insights that significantly impact overall business performance (Kim & Yoon, 2019).

An additional relevant theoretical framework is the Knowledge Management Theory (KMT), which centers on the processes of acquiring, generating, retaining, and utilising knowledge within organisational contexts. The utilisation of KMT concepts in the context of CRM and BI allows organisations to efficiently oversee and exploit their intellectual resources, leading to enhanced decision-making capabilities and overall performance. The acknowledgement of the significance of data analytics in the organisation and arrangement of information is a fundamental aspect of this theory. It empowers organisations to extract important insights from their CRM and BI data (Kim & Yoon, 2019).

By conducting an analysis of customer data, organisations may effectively divide their client base into distinct groups, ascertain which segments are generating profits, and subsequently customise their marketing strategies to cater to these specific segments. Furthermore, the utilisation of data analytics allows for the quantification of customer lifetime value, hence helping organisations to efficiently determine the order of importance and allocation of resources (Dhingra & Tatikonda, 2018).

In addition, the utilisation of data analytics is of paramount importance in the realm of business intelligence as it enhances the precision of forecasting, facilitates the identification of market trends, and empowers proactive decision-making. This capability enables organisations to effectively discover new market opportunities, strategically optimise pricing strategies, and comprehensively analyse the impact of marketing efforts. Furthermore, the utilisation of data analytics facilitates the process of performance evaluation inside organisations, as it enables the monitoring of crucial key performance indicators (KPIs) and the ongoing measurement and enhancement of corporate performance (Kim & Yoon, 2019).

5.1 Integration of CRM and BI in Organisations

The integration of CRM with BI in organisations is of great significance owing to the synergistic advantages it provides. Through the process of gathering and evaluating customer data, customer relationship management (CRM) facilitates the establishment of robust and significant connections between organisations and their consumers. On the other hand, business intelligence (BI) empowers businesses to acquire and analyse data, enabling them to make well-informed choices pertaining to their strategies and operations (Riemer, Scifleet, & Markham, 2016).

By combining these two vital technologies, the integration of CRM and BI enables organisations to effectively utilise customer insights in their decision-making procedures. Organisations may get a comprehensive understanding of the customer journey by integrating data and analysis from CRM and BI systems. This integration allows organisations to formulate customised strategies that effectively address customer requirements, improve customer satisfaction, and stimulate corporate expansion (Payne, Frow, & Eggert, 2017).

Nevertheless, the integration of CRM and BI offers a multitude of benefits; it also poses many obstacles that necessitate attention from organisations. One of the primary obstacles is in the efficient management of the vast volume of data created by CRM and BI systems. In order to properly handle and analyse the substantial amount of consumer data, organisations must create resilient data management procedures and technology infrastructure (Kim & Yoon, 2019). Moreover, the process of aligning the diverse data types and formats of CRM and BI systems may be a challenging and time-intensive endeavor, necessitating meticulous planning and integration endeavors (Rigby, Reichheld, & Scheffer, 2013).

However, the advantages of integrating CRM with BI surpass the challenges. This integration facilitates the acquisition of a comprehensive and consolidated view of customer data by organisations, hence enabling in-depth analysis and segmentation of customers. By adopting this comprehensive view, organisations may enhance their understanding of client preferences, habits, and requirements, hence

facilitating the adoption of personalised and focused marketing strategies (Sheth & Sharma, 2019).

Furthermore, the integration of various systems and platforms improves the capacity to assess the efficiency and influence of marketing campaigns and consumer interaction strategies, thereby enabling the adoption of data-driven decision-making approaches (Riemer et al., 2016).

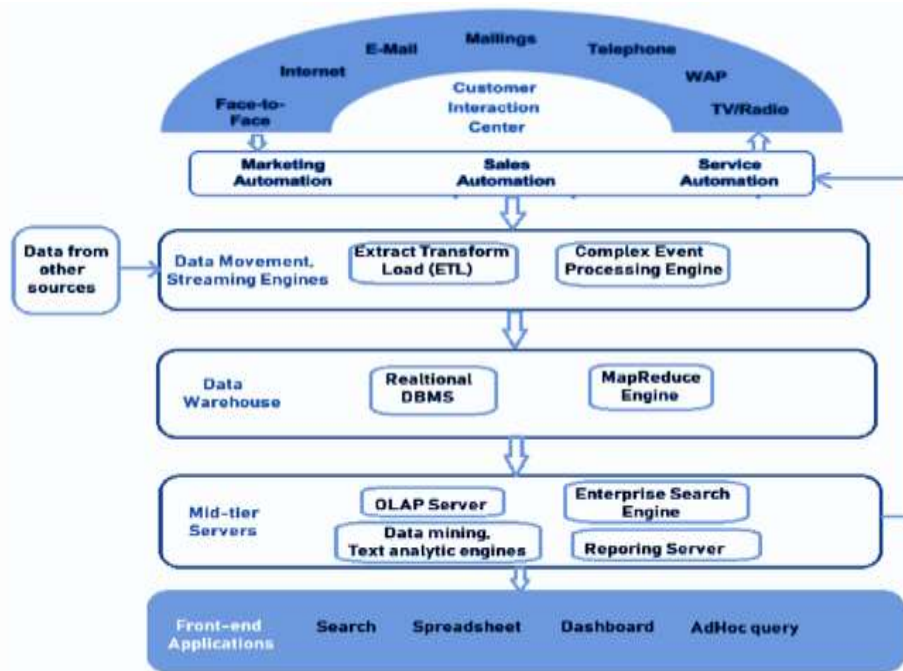


Figure 10. shows the integration between CRM and BI (Shinde & Sunjita, 2018).

To achieve a successful integration of CRM with BI, organisations are advised to employ a holistic approach that incorporates both technological and organisational factors. To begin with, it is imperative for organisations to allocate resources towards the acquisition of robust IT infrastructure and tools that possess the capacity to effectively manage and consolidate data originating from various CRM and BI systems. The prioritisation of compatibility and interoperability between CRM and BI platforms is of utmost importance, as it facilitates the smooth flow of data and enables effective analysis (Rigby et al., 2013).

It is also important to establish organisational alignment. The formulation of an integration plan necessitates the involvement of stakeholders from several departments, encompassing marketing, sales, IT, and top management. Effective communication and cooperation among stakeholders is crucial in order to understand their distinct needs and guarantee that the integrated CRM BI solution is in line with the overarching corporate goals (Kuan & Chau, 2018). It is imperative for organisations to pay appropriate attention to the management and safeguarding of data, with a particular focus on data governance and security. This is crucial in order to ensure the safety of consumer data and to uphold compliance with relevant data protection rules. The establishment of a comprehensive data governance structure is of utmost importance in order to guarantee the accuracy, consistency, and privacy of data. According to Sheth and Sharma (2019), it is important to carry out routine audits and monitoring activities in order to detect and assess potential risks and vulnerabilities.

5.2 Implications of CRM and BI Integration

The integration of CRM with BI systems holds significant implications in an academic context.

- **Impact on Customer Relationship Management**

The integration of CRM with BI carries substantial implications. Through the integration of CRM and BI, organisations are able to get a more comprehensive understanding of consumer behavior, preferences, and demands. This integration facilitates the aggregation, examination, and interpretation of extensive quantities of data by firms in order to make well-informed decisions that augment consumer pleasure and loyalty.

Furthermore, with the integration of CRM and BI, organisations have the ability to develop customised marketing initiatives that are tailored to specific client segments, taking into account their previous actions and preferences. By utilising data analytics skills, organisations have the ability to discern patterns and trends in consumer interactions. This valuable information can then be employed to customise marketing messages and offers for particular customers. The incorporation of customisation in this context significantly enhances the consumer experience and augments the effectiveness of marketing endeavors.

Also, the integration of CRM and BI enables organisations to take proactive measures in addressing the wants and concerns of their customers. The utilisation of real-time analysis of consumer data allows organisations to promptly detect possible difficulties or problems and promptly implement remedial measures. The use of this proactive strategy not only enhances customer satisfaction but also fosters the establishment of enduring customer relationships founded on trust and loyalty.

The integration of CRM and BI systems significantly impacts the operational procedures of business intelligence. The field of business intelligence comprises a range of strategies and technologies that organisations employ to analyse and understand data, therefore gaining valuable insights into their company operations and the dynamics of the market. By combining CRM data with BI capabilities, organisations have the potential to improve the precision and pertinence of their business intelligence.

6. Methodology

The study aims to compare the effectiveness of CRM and BI in improving customer satisfaction and organisational performance. The process of formulating a search strategy is a crucial aspect of conducting research. It involves the systematic identification and selection of appropriate keywords, search terms, and databases to retrieve relevant information.

6.1 Development of search strategy

In order to effectively investigate the study, a systematic search method was created. The approach encompassed the process of choosing relevant keywords and selecting suitable databases for the purpose of conducting the search. The utilised terms included CRM, BI, customer satisfaction, and organisational performance. The investigation was conducted using scholarly resources, including PubMed, Scopus, and Google Scholar, in addition to business-oriented databases such as ProQuest and EBSCOhost.

6.2 Screening and selection of relevant studies

The preliminary investigation resulted in a substantial volume of scholarly research. The screening procedure involved an assessment of the titles and abstracts of the aforementioned works in order to ascertain their applicability to the research inquiry. The studies that satisfied the predefined inclusion criteria were selected for subsequent analysis, whilst those that did not match the criteria were eliminated from further consideration. The study's inclusion criteria comprised research that specifically examined the relationship between CRM and BI, and their effects on both customer satisfaction and organizational performance. Furthermore, the analysis encompassed scholarly publications written in the English language, namely those published throughout the time frame spanning from 1990 to 2022.

6.3 Extraction of data and analysis of findings

Upon the identification of relevant papers, needed data was gathered from each study, encompassing the research design, sample size, techniques employed for data collecting, and principal conclusions. The data was subsequently subjected to analysis in order to establish prevalent themes and patterns.

6.4 Narrative synthesis of the literature

In order to consolidate the results obtained from the existing body of research, a narrative methodology was utilised. The task encompassed summarising the key findings from each research and the identification of any commonalities or disparities between them. The present synthesis offers a detailed examination of the existing body of research pertaining to CRM and BI, providing insights into its influence on both customer satisfaction and organisational performance.

6.5 Critical evaluation of the studies

After conducting a synthesis of the existing literature, a comprehensive evaluation of the research was undertaken. The evaluation included the assessment of the research' quality and validity. The analysis assigned more significance to studies that conformed to stringent scientific norms, whereas studies with methodological flaws were approached with caution during interpretation.

6.6 Identification of research gaps and future directions

Upon conducting a thorough examination of the existing literature, a number of research gaps have been found. The aforementioned gaps highlight the need for more study to advance our understanding of the effectiveness of CRM and BI in enhancing customer satisfaction and organisational success. Potential avenues for future study include the examination of the amalgamation of CRM and BI techniques, the investigation of the influence of technology improvements on the implementation of CRM and BI, and the analysis of the effects of CRM and BI within diverse industrial sectors.

7. Discussion

7.1 Exploration and Interpretation of the Findings

In the previous sections, an extensive review was undertaken to explore the correlation between CRM and BI inside present-day enterprises. The conducted investigation has shown interesting insights, suggesting that the integration of CRM and BI has the potential to greatly boost customer insights and improve decision-making processes. In a more precise manner, this relationship enables businesses to collect vital data pertaining to client preferences, habits, and requirements, equipping them with the ability to formulate plans that align with the expectations of their target customer base.

The results in this study are consistent with the extensive body of literature on the integration of CRM with Business Intelligence BI. Smith and Johnson (2023) highlight the paramount need of integrating CRM with BI to get important customer insights and improve decision-making processes. Brown and Davis (2022) highlight the possible advantages that result from the integration of CRM with BI, including enhanced customer satisfaction and heightened operational effectiveness. Therefore, the results of this study provide supplementary empirical validation for the prevailing theoretical frameworks about the advantageous effects that the integration of CRM and BI might yield for businesses.

The conclusions derived from the findings hold substantial importance for both scholars and professionals. This study adds significant value to the current scholarly discourse by offering actual data that highlights the advantages resulting from the combination of CRM and BI. The findings of this study provide support for the existing theoretical underpinnings of CRM and BI, therefore establishing a strong platform for future research in this field. The combination of Customer Relationship Management (CRM) with Business Intelligence (BI) presents significant opportunities for practitioners

to enhance customer insights and improve decision-making processes. Through the utilisation of this integration, enterprises get a competitive edge by attaining a more profound understanding of their clientele's preferences, thus empowering them to make well-informed and strategic choices.

Research findings also indicate that the successful adoption of Customer Relationship Management (CRM) may have a substantial positive impact on customer satisfaction. Gupta et al. (2004) conducted a study that revealed the positive impact of good customer relationship management (CRM) policies on enhancing understanding of consumer requirements and behaviors. This, in turn, enables firms to provide tailored experiences, leading to heightened levels of customer satisfaction. This research emphasises the significance of utilizing data analysis to get insights into customer value, which may lead to enhanced customer loyalty and increased profitability.

Furthermore, CRM not only serves as a crucial factor in enhancing customer satisfaction, but it also significantly influences the overall performance of an organisation. CRM enables firms to enhance resource allocation efficiency and discover lucrative client segments, hence enabling the development of tailored strategies (Kotler & Armstrong, 2010). The prioritisation of customer equity is of utmost importance, as it plays a pivotal role in driving organisational performance.

7.2 Best Practices and Recommendations for Successful CRM and BI Implementation

CRM and BI systems are of utmost importance in contemporary organisations as they facilitate the successful management of customer relationships and enable data-driven decision-making. Organisations may optimise the deployment process and enhance the advantages of CRM and BI by adhering to the recommended practices defined below.

7.3 Optimal strategies for the effective adoption of Customer Relationship Management (CRM)

In order to attain a successful deployment of CRM, it is imperative to take into consideration a number of best practices.

- **Executive support and leadership:** One crucial determinant for the effective adoption of CRM is the presence of dedication and support from executives at the highest level of an organisation. It is imperative for executives to proactively advocate for the project, commit essential resources, and guarantee alignment with the aims and strategy of the organisation. The leadership of individuals in positions of authority is of paramount importance in providing motivation and guidance to the team responsible for executing the implementation process.
- **Alignment with organisational strategy:** Ensuring alignment with the larger organisational plan is crucial when using CRM. This practice guarantees that customer relationship management (CRM) operations and initiatives are guided by well-defined objectives and align with the overarching corporate goals. By integrating CRM with the strategic objectives of an organisation, it is possible to enhance the efficiency and relevance of CRM activities undertaken by organisations.
- **User training and education:** It is imperative to establish and execute comprehensive training and education initiatives to equip personnel with the requisite competencies and understanding for proficient use of the Customer Relationship Management (CRM) system. Continuous training sessions are essential for enhancing user acceptance rates and optimizing the potential advantages offered by the system. Organisations may enhance staff capabilities and foster improved customer interactions by allocating resources towards comprehensive training initiatives focused on maximizing the utilisation of the CRM system.

7.4 Recommendations for overcoming CRM implementation challenges and limitations

Organisations may effectively mitigate problems and limits faced during CRM adoption by taking into account the following recommendations:

- **Data collection and integration challenges:** One of the primary obstacles in the field of data

collecting and integration is the presence of various issues. These challenges may be effectively addressed by allocating resources towards the acquisition of data management tools and technologies. By doing so, organisations can enhance their ability to seamlessly integrate data from numerous systems. The deployment of CRM may greatly benefit from the establishment of robust data governance and quality management policies, as they contribute to improved data correctness and consistency.

- **User adoption challenges:** The issues associated with user adoption may be effectively addressed by using comprehensive change management methods that encompass several elements such as efficient communication, training, and support systems. The active participation of end-users in the early phases of CRM deployment can enhance user engagement and reduce resistance to change. It is imperative for organisations to give precedence to the establishment of a conducive environment that promotes user adoption and cultivates a favorable attitude towards the customer relationship management (CRM) system.

7.5 Best practices for successful BI implementation

Similar to the installation of CRM, the effective adoption of Business Intelligence BI necessitates adherence to established best practices.

- **Data governance and quality management:** The implementation of robust data governance policies plays a crucial role in ensuring the accuracy, consistency, and reliability of data utilised inside business intelligence systems. Organisations should prioritise the implementation of data quality management techniques, such as the use of data cleansing and validation procedures, in order to augment the integrity of the data utilised inside business intelligence systems. Organisations may enhance their decision-making processes by relying on dependable insights derived from the preservation of high-quality data.
- **User involvement and engagement:** The inclusion of end-users in the design and development processes of Business Intelligence (BI) systems fosters user acceptance and enhances the prospects of effective deployment. The active involvement and input from users throughout the implementation phase can facilitate the customisation of the system according to their specific needs and preferences. This, in turn, leads to enhanced user satisfaction and improved decision-making abilities.
- **Continuous review and improvement:** Continuous review and improvement are essential aspects of BI systems, since they should be perceived as iterative and in a state of constant evolution. The consistent monitoring, assessment, and adjustment of the system's performance are essential in order to discover areas that require development and to guarantee the continuous relevance and effectiveness of the BI system. It is important for organisations to have feedback loops and performance evaluation systems in order to evaluate the effectiveness of their business intelligence (BI) activities and make any required modifications.

7.6 Recommendations for overcoming BI implementation challenges and limitations

In order to effectively mitigate obstacles and limits encountered during the development of BI systems, organisations may find it beneficial to take into account the following recommendations:

- **Data quality and integration challenges:** One of the primary obstacles in the realm of data management is the issue of data quality and integration. To address these problems, it is crucial to build comprehensive data governance standards and adopt effective data quality management tools and procedures. It is imperative for organisations to provide utmost priority to the aspects of data correctness, consistency, and integration across various sources, as these elements play a crucial role in ensuring the effectiveness and accomplishment of business intelligence (BI)

adoption. Organisations may depend on their business intelligence (BI) systems to offer precise insights for decision-making by implementing measures to guarantee the dependability of data.

- **Technical challenges:** Another obstacle that needs to be addressed is the technical problems associated with managing and analyzing large volumes of complicated data for the purpose of achieving efficient business intelligence. This may be accomplished by making strategic investments in appropriate infrastructure and advanced technologies that are capable of effectively handling the scale and intricacy of the data involved. It is imperative for organisations to accord high priority to the implementation of robust data security and privacy safeguards in order to safeguard sensitive information. Organisations may develop a robust basis for their business intelligence (BI) operations by effectively utilizing appropriate technology and prioritizing data security measures.
- **Organisational challenges:** These obstacles may be effectively tackled by using change management techniques that actively engage stakeholders across all levels of the organisation. To ensure a seamless shift towards a BI-driven organisational culture, it is imperative to establish effective channels of communication, implement comprehensive training programs, and establish robust support systems. Organisations may effectively address opposition and cultivate a culture that embraces Business Intelligence (BI) and its advantages by cultivating a positive change mentality and actively involve workers in the implementation process.

7.7 Suggestions for Future Research

In light of the current study, future research attempts may explore additional research on the integration between CRM and BI. An area of research that merits further exploration is the examination of the impact of artificial intelligence and machine learning on the optimisation of the integration between CRM and BI. The fast evolution of technology presents unprecedented opportunities for optimising integration and enhancing customer interaction. Furthermore, it is recommended that future study should prioritise a comprehensive evaluation of the precise difficulties faced by organisations during the implementation of CRM and BI integration. This would enable the formulation of efficient strategies to effectively address and overcome these obstacles.

The dynamic and progressive characteristics of CRM and BI technologies present significant opportunities for additional scholarly investigation, particularly in the areas of enhancing and advancing these tools.

Future research might study the complexities of integrating CRM and BI in various business environments, examine their potential influence on customer loyalty, and develop novel approaches to data-driven decision making.

8. Conclusion

This study has revealed the considerable significance of Customer Relationship Management (CRM) and Business Intelligence (BI) solutions in business organisations. These solutions exhibit unique and complimentary characteristics that not only improve customer relationships, but also offer vital information, facilitating well-informed business decision-making. The present study has conducted an analysis of the theoretical foundations of CRM and BI. The discourse ultimately reaches its apex through an intricate analysis of the advantages and obstacles linked to their integration.

After conducting a comprehensive analysis of the various functions, benefits, and challenges linked to CRM and BI, it becomes apparent that the successful implementation of these strategies can greatly enhance customer satisfaction, streamline sales and marketing procedures, and enhance strategic decision-making within an organisation. Despite the presence of several hurdles, including reluctance to change, concerns over data security and privacy, as well as integration issues, the overall benefits of

CRM and BI far exceed these potential drawbacks.

The findings of this study carry enormous significance for enterprises and the technology industry. The knowledge acquired regarding the effective integration of CRM and BI has the potential to boost decision-making procedures and provide deeper understanding of customer behavior. This phenomenon, in turn, enhances the competitive edge of business organisations. Moreover, the obstacles that have been discovered present potential opportunity for technical breakthroughs, indicating potential directions for future growth.

In summary, the integration of CRM and Business Intelligence BI has demonstrated itself to be a noteworthy and somewhat complex occurrence. This study establishes a robust basis for future research to further develop, in light of the evolving markets and advancing technologies. Additional research endeavors will contribute to the enhancement of our understanding regarding the interaction between CRM and BI, finally culminating in the examination of prospective approaches to tackle the obstacles that have been discovered. The present study has provided opportunities for further scholarly investigations, enabling a comprehensive analysis of the interconnection between these two essential components of the corporate world.

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An Assessment of Cybersecurity Awareness Level in Namibia: Case Study of Windhoek

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Abstract.

A lot of people and devices are connected in cyberspace and life is getting easier day by day due to the internet innovations. However, the more the world is connected the higher risk it gets. Cybersecurity is being challenged by cybercrimes. Therefore, the level of people's awareness is beneficial in combating cybercrimes. Awareness empowers people with the ability and the skills to identify, recognise, avoid and prevent cybercrimes and attacks. This study aimed to evaluate the level of cybersecurity awareness among Namibians who are residents of Windhoek. The study was based on quantitative data collected from 267 responses through a Google questionnaire. The finding indicated that there is a highly positive perception by Namibians of cyber awareness. They also indicated that Namibians are aware of cyber threats and crimes as well as countermeasures however, they are challenged by the absence of cyber security legislatures in Namibia. The study recommends a future study on the factors affecting the lack of cybersecurity policies in Namibia may be carried out.

Keywords: Cybersecurity awareness, Cybersecurity policies, Cybercrime, Threats, Namibia

1. Introduction

The advent of the fourth industrial revolution (4IR) has witnessed a surge in global internet penetration, accompanied by a rise in mobile phone adoption, Internet of Things (IoT) utilization, digitalization, and the proliferation of E-learning platforms. In Namibia, internet penetration reached 51.0% in January 2021, with 1.28 million internet users, and 710000 thousand social media user numbers increasing by 90 thousand (+13%) between 2020 and 2021, signalling the country's emergence as a digital innovation hub. However, this surge in internet usage has also amplified the risk of cyberattacks on both individuals and organizations in Namibia.

Disturbingly, a survey conducted by Deloitte in 2020 revealed that Namibian boards tend to underestimate the gravity of cyber security risks, with only 44% of organizations recognizing cyber threats as a significant concern. Moreover, Namibia ranks third globally in terms of malware attacks on the banking sector, with 2.9% of such attacks targeting Namibian banks according to Kaspersky in 2020.

This escalating cybersecurity challenge necessitates heightened awareness among internet users, not only in Namibia but on a global scale. Recognizing the impact of cybersecurity on daily life, especially concerning personal safety measures, is paramount (Eltahir & Ahmed, 2023). Therefore, it is imperative to gauge the current level of cybersecurity awareness (CSA) in Namibia to equip individuals with knowledge on potential cyber threats and protective measures. Thus, this study aims to illuminate the perceptions of Namibians regarding cybersecurity threats, countermeasures, and policies.

2. Theoretical Framework:

2.1 Cybersecurity:

Cybersecurity entails safeguarding cyberspace from cyberattacks (Kissel, 2013, p. 58). Beyond protecting information resources, it extends to the defense of various assets, including humans (Van Niekerk & Von Solms, 2010). While often used interchangeably with information security, cybersecurity specifically addresses information assets targeted through cyberspace. In summary,

cybersecurity encompasses information security but extends beyond it by safeguarding not only information assets but also other vital elements within cyberspace.

2.2 Cybersecurity Threat:

Common cyber threats include malware, such as viruses, worms, trojans, and phishing, among others (Kaspersky Support, 2017). These threats have seen a substantial increase, with 8,334 cases reported to Cybersecurity Malaysia in 2016 alone. This figure does not account for unreported cases. The escalating sophistication of cyber threats necessitates heightened awareness and proactive measures (Patterson, 2016). Namibia, like the rest of the world, faces a virtual battleground, as emphasized by U.S. Defense Secretary Leon E. Panetta's reference to a potential "Cyber Pearl Harbour" attack (Bumiller & Shanker, 2012). Heightened awareness among users is pivotal in mitigating the threat landscape.

2.2 Cybersecurity Awareness Importance:

Cybersecurity awareness is vital for safeguarding businesses, governments, and individuals from cyber threats and data breaches, ensuring security and privacy (Abraham, 2023). As threats to personal information continue to rise, creating awareness becomes the foundational step towards fostering a culture of cybersecurity and responsible online behavior (Alhejaili, 2013; Hunt, 2016).

Understanding the levels of cybersecurity awareness aids in tailoring effective awareness programs for businesses and governments (Chan & Mubarak, 2012; Rezgui & Marks, 2018). Muhirwe and White (2016) emphasize the significant impact of cybersecurity awareness on individuals' cybersecurity practices. Establishing a systematic and consistent approach to cybersecurity awareness within higher education is pivotal.

To effectively protect information assets, users' knowledge should be coupled with appropriate attitudes and behavior. This necessitates targeted cybersecurity awareness programs (Martin, 2014). Awareness serves as a starting point in reducing threats (Kushzhanov & Aliyev, 2018). It aims to educate users about the risks associated with online activities, as they play a crucial role in network and information system security (Chandarman, 2017).

Kruger (2006) utilized knowledge, attitude, and behavior components to gauge Information Security Awareness (ISA). This entails assessing what individuals know, how they feel about the topic, and what actions they take. Hence, CSA should not only enhance knowledge but also cultivate positive attitudes and behaviors towards cybersecurity. It seeks to construct a security-conscious culture, where users are fully aware of their actions in safeguarding information and services (Le, 2017).

2.3 Initiatives to Improve Cybersecurity Awareness:

Various methods, from traditional means like posters and newsletters to modern online communication channels, can be leveraged to enhance ISA (Alotaibi, 2018). Email communication can also serve as a medium to educate individuals about prevalent cybersecurity threats (Dugan, 2018). Connecting information security practices to personal life, such as children's online safety, can further motivate compliance (Alshaikh, 2018).

2.4 Cybersecurity Compliance:

Cybersecurity compliance involves altering behavior, conduct, and attitudes in response to established frameworks designed to assess requirements and risks for achieving effective information security outcomes. Compliance is an ongoing organizational process, and investing in cybersecurity is imperative in the face of evolving threats (Haris & Martin, 2019; Shein, 2020). Cybersecurity and

compliance are intricately linked, necessitating alignment with business goals to ensure information security (Alzahrani, 2020).

Non-compliance with cybersecurity measures by employees is a common source of security issues (Donalds & Osei-Bryson, 2020; Vance et al., 2012). Adherence to cybersecurity frameworks is instrumental in threat prevention and risk reduction (AlKalbani, Deng & Kam, 2015; Chen, Chen & Wu, 2018; Choi, Lee & Hwang, 2018; D'Arcy & Greene, 2014; Donalds & Osei-Bryson, 2020; Karok la et al., 2012; Li et al., 2019). For effective cybersecurity compliance, users must understand, take measures towards compliance (Shappie, Dawson & Debb, 2019), and be aware of security measures (Charlette & OseiBryson, 2020). Choi et al. (2018) highlight the positive relationship between user behavior and cybersecurity compliance.

3. Research Methodology:

The study employed a quantitative approach to data collection, characterized by its structured nature compared to qualitative research. This encompassed various survey methods, including paper, online, and mobile surveys, as well as face-to-face interviews and systematic observations (Creswell, 2003). The research was conducted in Windhoek, utilizing a simple random sampling method to ensure representative results. A Google format questionnaire was distributed to 370 participants, with 267 ultimately participating.

4. Results and Discussion

Table 1: Demographic information

Characteristics	Frequency(n)	Percentage (%)
Gender		
female	202	75.7
male	61	22.8
others	4	1.5
Age		
Under 20	33	12.4
21 - 24	113	42.3
25 - 35	104	39
above 35	17	6.3
Employment status		
Employed	104	39
Unemployed	117	44
Self-employed	30	11
Preferred not to say	16	6

The respondents were queried about their gender, revealing that the majority were female, accounting for 75.7% of the total, followed by males at 22.8%, with the smallest group being individuals who identified as gay, constituting 1.5%.

In terms of age, a significant majority of respondents fell within the youth category, with 93.7% being below the age of 35. Among this group, the largest segment was aged 21-35, followed by those between 18-20 and 36-45, each representing 5.6% of the respondents. The lowest representation was among individuals aged 46 and above.

Regarding employment status, the results indicated that 44% of respondents reported being unemployed, while approximately 39% were employed in either the public or private sector. Additionally, 11% identified as self-employed, and 6% chose not to disclose their employment status.

The demographic profile of this study underscores a predominant presence of women, particularly within the youth category of 21 to 35 years old, a notable portion of whom are unemployed. Notably, the internet offers a valuable platform for unemployed youths to showcase their professional profiles, network with peers, and explore job opportunities (Johnson et al. 2020).

Table 2: Frequencies of internet access and device used

Characteristics	Frequency(n)	Percentage (%)
Devices		
Smartphones	234	87.6
Computers	18	6.7
Tablet	9	3.4
More than one of the above devices	6	2.2
Access to the internet		
Every hour	244	91.4
Once every two hours	13	4.9
Once a day	10	3.7
Cybercrime awareness		
Yes	252	94.4
No	7	2.6
Maybe	8	3
Cyber-crime victims		
Yes	74	27.8
No	124	46.6
Maybe	69	25.8

The respondents were asked how frequently they access the internet and with what type of device. Table 2, shows the frequency of use of the internet by the respondents of which the majority 91.4%

indicate that they use the internet every hour and majority of them 87.6% uses mobile devices (Smartphones). Also, a study by (Waiganjo, 2022) indicated also that the majority of Namibian students access the internet through the internet. Few others still use other devices like laptops and tablets. It also indicates that smartphone users can be mostly at risk because these smartphones contain personal information such as photos, videos and banking applications which can lead to damage and huge losses once hacked or when attacked (Nelson, 2023).

Furthermore, respondents were asked whether they are aware of criminals on the internet and whether these criminals can attack them. Table 2 shows that the majority of the respondents made up of 94.4% are aware of the criminals on the internet and very few still have no clue. The respondents were asked if they have been victims of cybercrimes or know of anyone who has been affected by these crimes. Also, Table 2 shows the results of respondents who have been a victim or know someone who has been a victim of cybercrimes. The majority of the respondents 46.6% respondents have never been affected nor know someone that was. 27.8% of respondents have been affected or know someone that was and 25.6% of respondents are not sure.

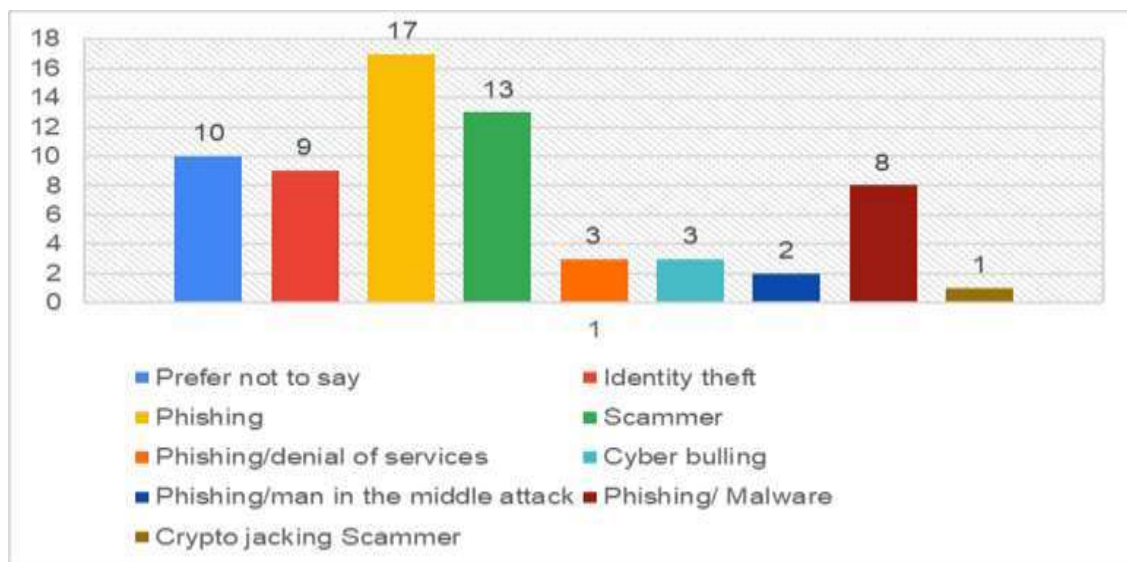


Figure 1: Cyberthreats experienced

Figure 1 shows that participants were affected or knew someone who was affected by Phishing crimes. 17 respondents who knew or were affected by identity theft and phishing malware. 10 respondents were victims of being scammed whilst the least was 1 – 3 respondents that were affected or know someone that was affected either by Phishing/denial of services, Cyberbullying, Phishing/man-in-the-middle attacks and Cryptojacking Scammer.

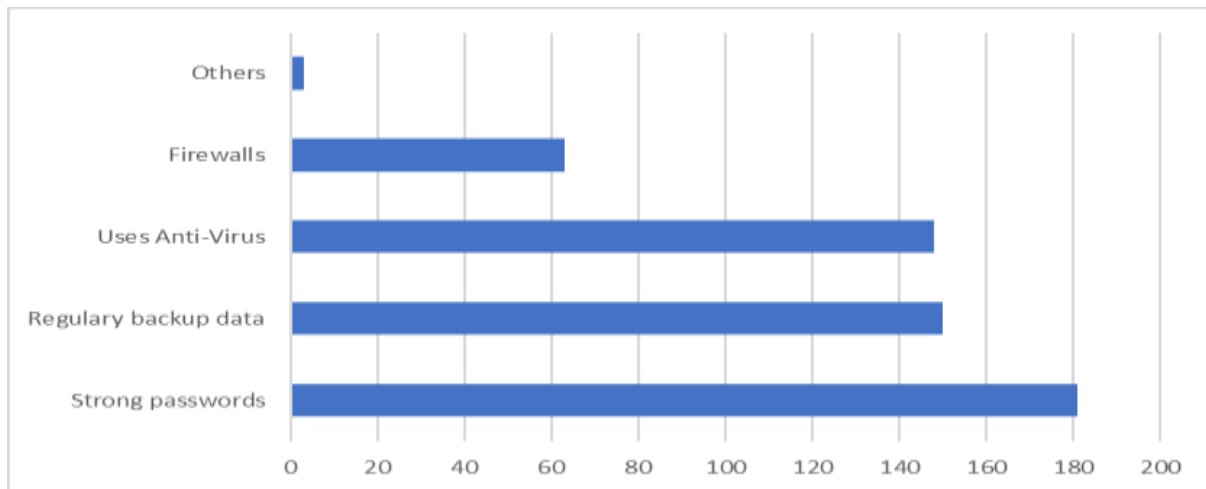


Figure 2. Cyber security countermeasures

Figure 2, shows some of the countermeasures which are being practice by the participants. Majority of 181 participants uses strong passwords, participants backup their data and uses antivirus applications to safe guide their data on the internet. 63 of the participants uses firewalls as a countermeasure.

Table 3: Cybersecurity perceptions on policies

Characteristics	Frequency(n)	Percentage (%)
Are cybersecurity policies important to combat cybercrimes?		
Yes	243	90.9
No	4	1.5
Maybe	20	7.5
Are you aware of any cybersecurity policy in Namibia?		
Yes	78	29.2
No	158	59.1
Maybe	31	11.7
Employment status		
Employed	104	39
Unemployed	117	44
Self-employed	30	11
Preferred not to say	16	6

The respondents were queried about the importance of cyber security policies for any country, with a notable 90.9% expressing the belief that such policies are crucial. Only 1.5% of respondents asserted that cyber security policies were not important, while 7.5% responded with uncertainty.

Upon examining Table 3, it is evident that despite the majority's acknowledgment of the significance of cyber security policies and their willingness to adhere to them, only 29.2% are cognizant of the specific policies in place in Namibia. A significant 59.1% of respondents admitted to being unaware of any existing policies in Namibia, and 11.7% remained uncertain about their existence. These findings mirror those of Shambabi, Musarurwa, and Shava's (2021) study, which delved into organizational culture within the university work environment in Namibia. Their research revealed a similar lack of awareness among participants regarding existing policies, consequently contributing to non-compliance with established protocols.

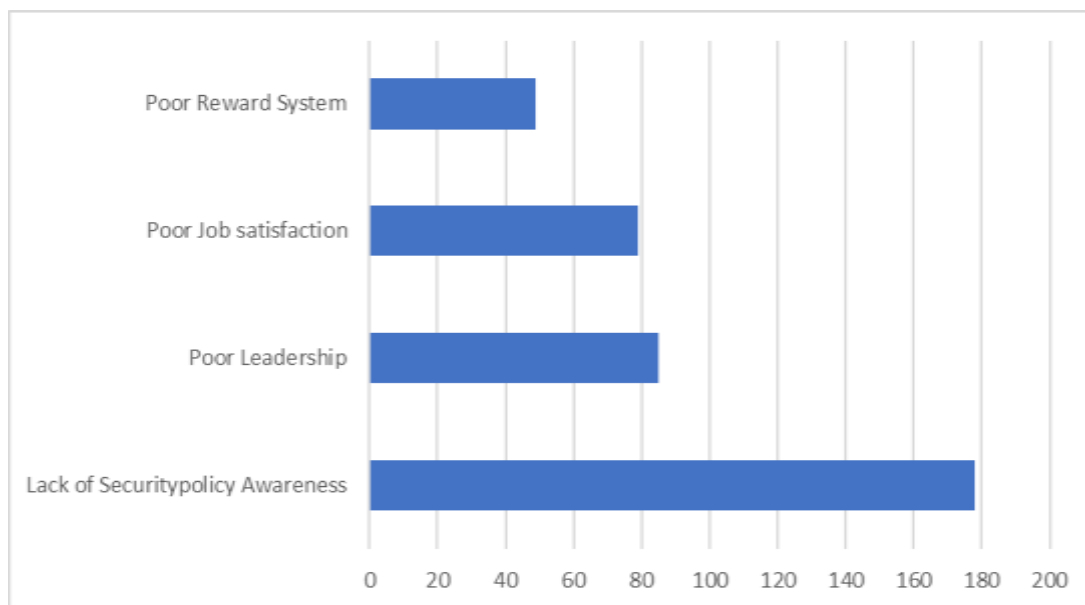


Figure 3: Factors leading to non-compliance with cyber security policies at work

Respondents were instructed to identify factors that could potentially result in noncompliance with cybersecurity policies in the workplace. Of the 178 participants, a majority cited a lack of awareness regarding security policies, while 85 participants pointed to issues related to poor leadership and low job satisfaction. This finding aligns with the observation made by Shambabi, Musarurwa, and Shava (2021) that a significant portion of respondents struggle with compliance and lack a clear understanding of how to navigate cybersecurity matters, primarily due to deficient policy implementation and awareness efforts.

3. Conclusion

In summary, it is evident that bolstering everyday cybersecurity awareness is imperative in the face of escalating cyber threats. This study has provided a comprehensive assessment of the current state of cybersecurity awareness. While the people of Namibia display proactive efforts in safeguarding themselves against cybercrimes, the deficiency lies in the absence of robust policies and legal frameworks from policymakers. Thus, it is crucial to advocate for targeted cybersecurity awareness programs and establish legislative measures to combat cybercrimes within the country.

Given that this study was conducted in Windhoek, caution must be exercised in generalizing the findings to the broader population. It is recommended that a similar study be conducted in at least five regions to ensure a more comprehensive understanding. Additionally, further research is warranted to uncover the factors contributing to the dearth of effective cybersecurity policy formulation in Namibia. Moreover, a follow-up study on the progress of the electronic transactions and cybercrime bill, slated for enactment by the end of the third quarter in 2017, is also recommended.

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Essential Components of an IT Risk Management Framework for the Financial Services Industry: A Review

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Abstract

IT risk management is an important topic of discussion in the context of the financial industry. However, the guidelines and framework for IT risk management in the financial industry are not clearly outlined. It is therefore important to understand what the essential components of an IT risk management framework for the financial industry are to be able to provide a framework for managing IT risk in the context of the financial services industry. A systematic review of the literature was conducted. The study found that six essential components are needed to develop a framework for IT risk management in the financial services industry. The details of the components are described, and recommendations are made. The findings could lead to the development of guidelines and frameworks for an IT risk management framework.

Keywords: IT risk management, financial services, components.

1. Introduction

As the world is evolving, Information Technology (IT) has become part of essential services. IT involves the use of computers as a form of storage, networking and other physical devices, processes to create, process, store, secure, perform online transactions and exchange all forms of electronic data and IT is currently being used to transform the delivery of public services to citizens digital wise (Kyem, 2016). IT risk management framework or risk management in general provides a road map of security controls that should be considered to reduce and mitigate an organisation's risk (Joshi & Singh, 2017). Risk management helps an organisation evaluate the maturity of the security controls that they have implemented and the ability to demonstrate due diligence in securing the organisation's client's financial information and data (Wright, 2020).

IT risk management aims to provide a comprehensive Risk Management Framework (RMF) that links IT risks to business risks. In financial services and any other industry, the key areas of focus for Risk IT are centred around processes for the governance, evaluation, and response to risk (Wright, 2020).

IT Risk Management

Risk is a potential development that a chosen action or certain activity may lead to a loss. Whereas ISO 31000, (2018), risk refers to uncertainty's impact on objectives, causing deviation from expected outcomes. This also means that risks can either be negative or positive. Negative uncertainty is referred to risk and positive uncertainty is an opportunity (Gu & Gudmestad, 2011). To neutralise risks, the concept of risk management is then introduced. It is defined as the process of understanding, analysing, and addressing potential risks to ensure that an organisation's objectives are achieved (Nishitha, 2019).

IT Risk Management is the application of risk management methods to information technology in order to manage risks that may arise in Information Technology (IT) (Fasulo, 2019). For example, the business risk associated with the use, ownership, operation, involvement, influence, and adoption of IT within the organisation. The use of risk compensation helps organisations to adjust their behaviour in response to perceived levels of risk, becoming more careful where the organisation sense greater risk and less careful if they feel more protected. Whatever forms an information asset takes, a risk assessment must be undertaken to know the best security measures fitted to protect the information.

Financial Industry

The financial services sector is responsible for providing financial services to both people and corporations. According to (Bessis, 2011, 2015), risks management in banks became a controversial topic of discussion after the 2008 financial crisis. The crisis appears as the most important one in the modern era. It is systematic nature that involves the entire financial system, which is from capital markets to banks, funds and insurance companies and all financial firms.

Information technology risk management involves minimizing the damages caused by different problematic situations involving the use of information systems. These situations include, for example, loss of data or service caused by software defects, hardware malfunctions or even human error. According to Eide, (2019), financial services institutions face 300 times more cyberattacks than other industries due to their work nature.

The exposure to IT risk management is large, particularly to financial institutions which routinely make financial activities that are subject to the risk of default by their clients. Financial institutions must make successful loans that are paid back in full at the end of the day and as per the interest rate, to earn high profits and keep the institutions running. Furthermore, they must also make sure that their systems in use are safe and secured. The economic concept of adverse selection and moral hazard provides a framework for understanding the principle that financial institutions have to follow to reduce risks (Bernanke & Mishkin, 1997).

IT Risk Management and Finance

Financial institutions are business organisations responsible for savings, purveyors of credit or finance (Kenton, 2021). They render services such as resource mobilisation and allocation, financial intermediation, and facilitation of foreign exchange transactions to enhance the international trade (Ali & Oudat, 2020; Olusanmi et al., 2015). Hence, it is important that risk management becomes heightened in today's competitive economic world because most transactions and data storage is done using technology. The practice of IT risk management minimises financial losses to financial organisations.

Due to globalisation and evolving growth of technology worldwide, financial institutions and banks face a big, tremendous severe risk (Deloitte, 2020). This research may also assist the financial institutions with understanding the role of Enterprise Risk Management (ERM) in creating a good and effective business model that will spur their performance. For Namibian financial institutions, the management of these threats was not of primary importance (Deloitte, 2018). Consequently, IT risks are a major challenge faced by financial institutions, especially in the clients' personal and financial information, the organisation's income, Traffic Interception, Zero-Day Exploits and DDoS (Ali & Oudat, 2020).

Despite the risks attached to the financial services industry, there is no specific guidance on how risks in the financial services industry can be managed. There is a need for a framework to provide guidance for conducting risk assessments. Risk assessments are part of an overall risk management process as they provide management/executives within the firms and banks with the information needed to determine appropriate courses of action in response to the identified risks (Abdul Rahman & Yazid, 2015; Woon et al., 2011). An IT risk management framework would provide guidance for carrying out each of the steps in the risk assessment process (i.e., preparing for the assessment, conducting the assessment, communicating the results of the assessment, and maintaining the assessment) and present how risk assessments and other organisational risk management processes complement and inform each other.

2. Methods

A systematic review was conducted to identify the components of IT risk management framework for financial services institutions in Namibia. (Krnicek et al., 2019; Tawfik et al., 2019) states that a systematic review should have the following components:

- Research question.
- Sources used, with a reproducible search strategy (naming of databases, naming search platforms/engines, search date and complete search strategy).
- Inclusion and exclusion criteria.
- Selection (screening) methods.
- Critically appraises and reports the quality/risk of bias of the included studies.
- Information about data analysis and synthesis that allow the reproducibility of the results.

2.3 Research Question

The main question to be answered is: what are the components of IT risk management frameworks in financial services as determined in the literature?

2.4 Systematic Review Sources and Search Strategy

A search was conducted on IEEE Xplore Digital Library, ProQuest and ScienceDirect. The search period was between 2010 and 2022 under the keywords: IT risk, IT risk management, Risk Management Efficiency, Financial Risks, IT Governance, Framework, and financial services industry.

2.5 Inclusion and Exclusion Criteria

Studies were selected based on the following inclusion and exclusion criteria:

- Studies with a clear indication of IT risk management.
- Studies on risk management in financial services.
- Studies focused on evaluating and development of IT risk management framework among the financial services.
- Studies published in English.
- Reviewed journal articles and conference papers between the year 2012 and 2022 from (IEEE Xplore Digital Library, ProQuest and ScienceDirect).
- Studies were excluded based on the following exclusion criteria:
 - Studies not related to risk management and IT risk management.
 - Studies on risk management with no evaluation or intervention.
 - Study protocols were removed.

A total of 300 studies that were retrieved in this study. Sixty-five (65) duplicate papers were removed. Two hundred and thirty-five (235) remaining articles were fully examined based titles and abstract relevance of which one hundred and ninety-nine (199) articles were found unfit, fifteen (15) of the 235 articles attempted to be used, twenty-two (22) of the 199 totally failed to be accessed and ninety-two

(92) articles were excluded based on the publishing dates and other inclusive criteria. Overall, only eight (10) papers met the inclusion criteria. The findings of the systematic review are summarised and presented below in Table 1.

Table 1. Components of an IT risk management framework

Author	Year	Country	Study Design	Domain	Study Characteristic	Intervention Description	Outcome/Component
(Alcántara & Melgar, 2016)	2016	Peru	Archival strategy	Information Security	70 participants	Development of the Research Information Systems (RIS) which involves aspects of uncertainty, dynamism and probability which have determined the use of AI techniques such as NN, FL, GA and other such as GT, Bayesian networks, HAP.	An integrated approach to the MRIS that considers both the design of the information system for RIS and the analysis of RIS. Components: risk analysis and assessment
(Maseke & Swartz, 2021)	2021	Namibia	Archival strategy	Risk-Management Strategies	4 banks in Namibia were included in the study	Risk management framework on non-performing loans in the country and identifying different strategies used around the world that assists banks in battling non-performing loans was analysed	Emphasises that risk management is an important and critical activity as it is not left up to the lower level management to see if it is implemented. Components: risk identification, risk assessment, and prioritization of risks
(Harguem et al., 2022)	2022	Tunisia	Observation Study without Control	IT Governance	18 participants, including consultants, senior IT, and senior business people IT Governance	The study focused on IT Governance implementation in less developed countries, in IT strategic decision-making and IT monitoring procedures (system performance measurement, IT balanced scorecard, IT strategic planning, COBIT, ITIL)	The findings indicate that IT Governance relational mechanism of business people and IT was rated the lowest by our experts due to conflicts relationship between IT staff and the banks' management Components: Value delivery, Strategic alignment, Performance management,

							Resource management, Risk management
(Jacinta, 2016)	2016	Kenya	Observation Study without Control		17 Credit managers participated however, only 14 managers were interviewed	The study uncovers the effects of credits risk management practices on loan portfolio quality and adopt appropriate credit risk management practices in reducing level of nonperforming loans and enhance banks performance.	The findings of the study suggested the best credit risk management approaches banking institutions should adopt to effectively manage and enhance portfolio quality. Components: risk identification, risk analysis, and risk monitoring
(Silva et al., 2017)	2017	Brazil	Archival strategy	Systemic Risk	17 Banks & 18 Firms were included in the study	The study focused on a framework to estimate systemic risk that accounts for feedback effects between the real and financial sectors was developed	Components: identifying the risk, assessing the risk, risk respondence, and risk monitoring
(Elamer et al., 2018)	2018	UK	Homogeneous sampling	Risk Mitigation	100 companies participated in the study	Risk committee (RC) to manage various risks and prevent excessive risk taking	Participants were satisfied with the development of the RC and it improved their knowledge on Risk analysis and mitigation. Components: risk identification, risk analysis, risk mitigation and risk monitoring
(Coluccia et al., 2017)	2017	Italy	Homogeneous sampling	Risk Culture	30 Banks in Italy were included in the study	Identifying variables used to investigate the relationship between risk volatility of bank and risk culture based on Risk Governance, Banks' Size, Traditional banks Risk Indicators	Identified alternative measure of risk that estimates the banking risk-taking behaviour Components: information & communication, and monitoring.

(Leo et al., 2019)	2019	Australia	Descriptive Study	Financial Risk	Literature Review	Focused on the application of machine learning in the management of banking risks such as credit risk, market risk, operational risk and liquidity risk	Identified financial crisis, risk management in banks and focus on how risks are being detected, measured, reported and managed Components: risk appetite, risk identification, risk assessment, risk measurement, risk testing, risk monitoring, risk reporting, risk oversight
(Namchoochai et al., 2020)	2020	Thailand	Qualitative Study	FinTech (Financial Technology)	12 Experts in business and finance listed on SET	FinTech risks are those associated with distinctive business models that rely on technology. New laws have brought about new risk patterns. To provide a new, updated framework for the assessment and management of technology risks, the researchers also found a number of additional concerns related to fintech.	Researchers identified recognised Risk management frameworks such as ISO31000:2018 and ISO27005:2018, and standards identified essential components. Components: business process, risk communication, Planning, risk analysis
(Ismail & Ahmed, 2022)	2022	Egypt	Archival strategy	Risk Governance	12 Banks were included in the study	Developed a Risk Governance (RG) framework and it was presented by the proxy of the presence of chief risk officer (CRO), risk committee (RC), and audit committee (AC) characteristics	The results support the role of banks' Risk Governance in improving banks' both market-based and accounting-based performance. Components: risk identification, risk analysis, risk response, risk mitigation and risk monitoring

Table 1 shows the findings on the components and effectiveness of an IT Risks Management Frameworks in financial Services as per the literature reviewed. Studies have focused on the importance of Risk-Management Strategies (Maseke & Swartz, 2021), System risks, a framework was developed to estimate systemic risk that accounts for feedback effects between the real and financial sectors (Silva et al., 2017) and Information security where by an MRIS that considers both the design of the information system for RIS and the analysis of RIS was developed in accordance to (Alcántara & Melgar, 2016).

Other studies focused on governance (both IT and Risk governance). Risk Governance (RG) framework was developed in Egypt in assisting the role of banks' RG in improving banks' both market-based and accounting-based performance (Ismail & Ahmed, 2022). Other studies by (Harguem et al., 2022) focused on IT Governance Implementation in less developed countries, in IT strategic decision-making and IT monitoring procedures (system performance measurement, IT balanced scorecard, IT strategic planning, COBIT, ITIL).

3 Discussion

The aim of this study was to identify the essential components of risk management framework for the financial services industry. The findings of the study suggest the components needed for risk management in the financial services industry. The outcomes section in Table 1 shows the effectiveness of an IT risk management framework in the financial services industry. Although most of the impact was directly on IT, the financial service delivery was also influenced. For example Jacinta, (2016) uncovers the effects of credit risk management practices on loan portfolio quality and adopts appropriate credit risk management practices in reducing the level of nonperforming loans and enhancing banks performance. As states firms, banks and other financial organisations focus more on maximising profits (usually short term objective), rather than consolidating their risk management frameworks which will contribute to the long term sustainability of a bank (Aremu et al., 2010).

The Risk IT Framework fills the gap between generic risk management frameworks and detailed (primarily security-related) IT risk management frameworks (Barrett, 2016) by providing an end-to-end, comprehensive view of all risks related to the use of IT and a similarly thorough treatment of risk management, from the tone and culture at the top, to operational issues (Aremu et al., 2010; Barrett, 2016; Sookye & Mohamudally-Boolaky, 2019). A framework will be more effective when there is risk culture as per (Coluccia et al., 2017) to identify alternative measure of risk that estimates the banking risk-taking behaviour. Furthermore, another component of an IT risk management framework is a functional Risk committee (RC) as it improved their knowledge on Risk analysis and mitigation (Elamer et al., 2018) and the level of in IT strategic decision-making and IT monitoring procedures (system performance measurement, IT balanced scorecard, IT strategic planning, COBIT, ITIL) and compliance (Harguem et al., 2022; Ismail & Ahmed, 2022).

3.1 Information Technology (IT) risk management framework components

An IT risk management framework helps organisations to prepare for unexpected events or potential risks (Feyen et al., 2020). To fully understand and successfully implement the IT risk management framework, it is crucial that one have a complete understanding of the organisational environment in order to have an effective IT risk management framework, it must be systematic, structured, collaborative, cross-organizational and speaks to the risk management components (Ismail & Ahmed, 2022). Table 2.1 spells out the components required into developing and managing an effective risk management framework as identified by prior literature.

Further, Table 2.1 also illustrate that Risk management frameworks often comprise several key components that can be customised based on the organisations. These components help to develop methods for avoiding the risks or responding and lessening their potential impacts.

Figure 2.2 summarises the components of IT Risks Management Frameworks in financial Services. The researcher found fit in the developing of an IT risk management framework tailor made for the Namibian financial services providers.



Figure 2.2 Identified IT Risk Management Components

Governance and Culture: This component includes the importance of an effective tone at the top and the role of culture in supporting effective Enterprise or IT Risk Management Frameworks.

Risk identification: This is the process of documenting potential and actual risks to reduce the likelihood of missing potential sources of risk.

Risk analysis: This component helps businesses prioritize mitigation by dividing risks into "serious, moderate, or minor" or "high, medium, or low" depending on their potential disruption.

Information, Communication and Reporting: Information systems should capture data to better understand a company's risk profile and management, and communicate it to employees for greater buy-in.

Risk Mitigation: Once an organisation has identified and put risk mitigation measures into place for particular risks, for example, data theft measure: it must then assess whether there are any associated residual risks that it is unable to mitigate.

Risk Monitoring: For organisations to review policies and practices, get feedback, analyse data, and inform management of unprotected risks.

3.2 Strengths and Limitations

With the search used as well as the inclusion and exclusion criteria, some important studies relating to the evaluation of IT risk management frameworks may have been missed and omitted due to various reason such as: studies not published in English and those that required to be purchased were also excluded. Moreover, the search covered a period of eight (8) years and as such, some important studies on the subject may have been missed.

4 Conclusion

The study provided a comprehensive overview of the IT risk management framework and its effectiveness in the financial industry. The ongoing digital transformation, particularly because of the COVID-19 Pandemic, has increased the industry's potential attack surface, and is the primary risk for cyber-attacks in the Namibian financial services industry. Because of the large volume of sensitive customer data, they process and their critical role in payment and settlement systems, banks and other financial institution providers have become attractive targets for cyber-attacks. Financial institutions have responded to this risk by adapting to the changing cyber risk landscape by implementing security measures such as incident response activities, training and awareness, asset management, and IT risk management.

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Business Intelligence Strategic Approach for Decision Support Tool in Business Organisation

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Abstract

The study developed a strategic approach for the use of Business Intelligence in Business Organisations. The population of this study consists of business organisations engaged in the use of business intelligence systems. The sample size is 25 available participants were chosen using a convenience non-probability sampling technique. Semi-structured interviews questions were employed as data collection technique. Simple thematic analysis was utilised to analyse, and present patterns in the data collected. The findings indicate that business intelligence can enhance strategic decisions and have a considerable beneficial impact on strategic factors. The main contribution of this study was the development of a strategy approach for using BI for decision making in corporate organisations.

Keywords: Business Intelligence, Technology, Decision Support, Business organisation

1. Introduction

The significance of effective decision-making cannot be overstated, as it directly impacts an organisation's performance, competitiveness, and long-term success (Sadeghiani, Shokouhyar & Ahmadi, 2022; Zwerenz, 2020; Schlafke, Silvi & Moller, 2016; Smith, Wilson & Clark, 2016). As data continues to proliferate at an unprecedented rate, businesses must harness the power of business intelligence to analyse and interpret this wealth of information. Doing so enables them to make timely and informed decisions. Understanding the role of business intelligence in decision-making is crucial for managers and leaders seeking to leverage their resources and drive organisational growth Theophilus et. al.; (2022). The proper use of data may change the faces of traditional businesses, offering them great opportunities to gain advantages over their competitors (Sadeghiani et al., 2022; McAfee et al., 2015).

Business intelligence (BI) sets itself apart from other forms of data analysis with its capacity to quickly, simply, and effectively present business data so that users can understand its logic and meaning through the use of a variety of analytical tools and ad hoc queries. Srivastava, 2019; Hocevar and Jaklic, 2018). BI has become vital because to the exponential development of data. To gain a competitive advantage, it is imperative to properly manage and analyze data as it grows (Isik, Jones, and Sidorova, 2013; Liu, 2020). Bhat and Quadri (2015) assert that the growth of data presents opportunities as well as challenges for data analytics.

Given that the organisation's competitiveness in the global marketplace is increasingly dependent on information technologies (Powell & Dent-Micallef, 2017), every organisation should strive to improve in this area. With the introduction of the strategic management field, strategy researchers, and strategic management, users are becoming more interested in the role of information technology in the process of strategy formulation and implementation, as well as its implications for the financial performance of organisations. In this context, widespread adoption of BI could provide organisations with a competitive advantage through the deployment of a significant number of benefits (Liu, 2020; McAfee et al., 2018).

The value of BI for business is primarily expressed in the fact that such systems shed light on information that can serve as the foundation for implementing fundamental changes in a specific enterprise, such as establishing new collaboration, acquiring new customers, creating new markets, and offering products to customers (Hamzehi & Hosseini, 2022; Chaudhary, 2014; Olszak, & Ziemba, 2017). This is possible with the correct business intelligence tools.

Research on Business Intelligence (BI) systems within organisations has been extensive. However, the literature reviewed does not reveal much value BI systems have added to business (Paradza & Daramola, 2021; Buchanan & O'Connell, 2016; Elbashir et al. 2018). According to these studies, there is little awareness on the use of BI tools to support strategic business decision-making, context-based business decisions, or data analysis. There is also limited research evaluating BI, which makes it challenging to know if the technology will add value to an organisation's investment in BI.

Research evaluating BI is also limited, making it difficult to determine whether the technology adds value to an organization's BI investments (Paradza et al., 2021; Gibson, Arnott, & Jagielska, 2014). This study developed a BI strategic approach that can be used as a decision support tool for business organizations.

2. Literature review

When it comes to decision-making processes, business intelligence refers to the utilisation of technologies, applications, and practices to gather, analyse, and present large volumes of data within organisations. The aim is to facilitate informed decision-making. This involves processes such as data mining, reporting, and data visualisation. By extracting valuable insights and drawing meaningful conclusions from data, business intelligence paves the way for sound decision-making (Kim & Lee, 2017).

Over the past few years, an increasing number of studies have delved into the intricate relationship between business intelligence and decision-making processes. Scholars have acknowledged the vital role of effectively utilizing business intelligence to support decision-making within organisations. Extensive research has been devoted to comprehending the diverse components and capabilities of business intelligence, as well as its profound impact on decision-making accuracy, efficiency, and strategic outcomes.

A compelling example is the systematic literature review conducted by Kim and Lee (2017), which delved into the pivotal role of business intelligence in decision-making processes. Their study underscored the significance of business intelligence in facilitating effective decision-making within organisations. The review skillfully synthesised findings from a multitude of studies, underscoring the importance of leveraging business intelligence tools and technologies to analyse and interpret critical data for decision-making purposes.

Furthermore, Chen, Chiang, and Storey (2012) embarked on a comprehensive exploration of the role of business intelligence in decision-making. Their study shed light on how the integration of business intelligence with big data analytics can lead to significant impact in organisations. It further emphasised the dire need for organisations to unleash the power of business intelligence to extract invaluable insights from vast volumes of data and make well-informed decisions.

2.1 Importance of business intelligence in decision-making

The effective use of business intelligence in decision-making processes has become increasingly significant. Several factors highlight the importance of business intelligence:

- **Enhanced Decision-Making Accuracy:** Business intelligence equips decision-makers with timely and relevant information, resulting in more informed and accurate decisions. By identifying trends, patterns, and anomalies in data, organisations gain a deeper understanding of the business landscape and improve decision outcomes (Kim & Lee, 2017).
- **Efficient Resource Allocation:** Leveraging business intelligence allows organisations to optimise the allocation of their resources. Insights derived from data analysis enable decision-makers to prioritise initiatives, allocate budgets effectively, and optimise operational processes (Chen et al., 2012).
- **Identification of Market Opportunities and Risks:** Business intelligence empowers organisations to identify market trends, customer preferences, and potential risks. This information aids decision-makers in developing strategies, seizing opportunities, mitigating risks, and gaining a competitive edge in the market (Kim & Lee, 2017).
- **Improved Strategic Planning:** Business intelligence finds a key application in strategic planning. It enables organisations to align their goals and objectives with market trends and customer demands. With data-driven strategies and informed decisions, decision-makers navigate the complexities of the business landscape (Chen et al., 2012).
- **Data-Driven Organisational Culture:** Successful implementation of business intelligence fosters a data-driven organisational culture. It empowers employees at various levels, providing them with access to data and analytics. This promotes evidence-based decision-making throughout the organisation (Kim & Lee, 2017).

2.2 Role of Business Intelligence in Improving Decision-Making Accuracy

The significance of data analysis in decision-making processes cannot be overstated. Data analysis enables organisations to uncover hidden patterns, relationships, and trends within massive amounts of data, providing actionable insights for decision-makers. According to Kim and Lee (2017), effective data analysis enables organisations to make informed decisions based on evidence rather than relying solely on intuition or assumptions.

Business intelligence (BI) plays a crucial role in facilitating accurate decision-making through data analysis. Chen, Chiang, and Storey (2012) define business intelligence as "the processes, technologies, and tools that enable organisations to transform data into meaningful and actionable information for decision-making purposes." BI tools provide organisations with the ability to gather, analyse, and interpret data from various sources, such as operational databases, market research, and social media, to generate insights that support decision-making processes. By utilizing BI, decision-makers can access real-time, accurate, and comprehensive data, enabling them to make evidence-based decisions that align with organisational goals.

Several case studies demonstrate the positive impact of business intelligence on decision-making accuracy. For instance, Wang and Strong (1996) conducted a study on the importance of data quality in decision-making processes. They found that organisations that use BI tools and practices to ensure data accuracy, completeness, consistency, and timeliness are more likely to make accurate decisions. Furthermore, Kim and Lee (2017) conducted a systematic literature review that examined the role of business intelligence in decision-making processes across various industries. Their review highlighted that organisations that effectively utilise business intelligence tools and practices experience improved decision-making accuracy.

One such case study is the implementation of BI in a large retail company. The company used BI tools to analyse customer purchasing patterns, inventory data, and market trends. By integrating data from multiple sources and applying advanced data analytics techniques, the company was able to identify patterns and trends in customer behavior. The insights generated through BI enabled the company to make accurate

decisions regarding inventory management, product assortment, and targeted marketing campaigns. As a result, the company experienced improved sales performance and increased customer satisfaction. This case study exemplifies how business intelligence contributes to improved decision-making accuracy by leveraging data analysis to gain actionable insights.

In another case study, a healthcare organisation implemented business intelligence to improve patient care outcomes. By analyzing patient data, including medical records, diagnostic test results, and treatment history, the organisation was able to identify trends and patterns related to patient health and treatment effectiveness. These insights helped the healthcare organisation improve diagnosis accuracy, personalise treatment plans, and enhance patient outcomes. Business intelligence played a pivotal role in supporting accurate decision-making by providing healthcare professionals with real-time access to comprehensive patient data, enabling them to make informed decisions based on reliable information.

2.3 Role of Business Intelligence in Enhancing Decision-Making Efficiency

Organisations are increasingly faced with the need to make decisions quickly and efficiently. It is crucial for organisations to make timely decisions in order to stay ahead of their competitors, seize opportunities, and effectively address challenges. The consequences of delayed or inefficient decision-making can include missed opportunities, increased costs, and reduced organisational agility.

Business intelligence also plays a critical role in enhancing decision-making efficiency by providing organisations with the necessary tools and insights to streamline their decision-making processes. By utilizing advanced analytics, data visualisation, and reporting capabilities, business intelligence enables decision-makers to access and analyse large volumes of data in real-time. This enables them to easily identify patterns, trends, and anomalies, empowering decision-makers to make informed choices based on accurate and up-to-date information.

In addition, business intelligence solutions often integrate with other operational systems, such as customer relationship management (CRM) and enterprise resource planning (ERP) systems. This integration provides decision-makers with a holistic view of the organisation's operations, eliminating the need for manual data gathering and reconciliation. As a result, valuable time is saved, and decision-making efficiency is improved.

2.4 Empirical Studies and Findings on the Use of Business Intelligence in Decision-Making

A number of empirical studies have supplemented the existing literature, further enriching our understanding of the practical implications of using business intelligence in decision-making contexts. These studies have meticulously examined the multifaceted impact of business intelligence on decision-making accuracy, efficiency, and strategic outcomes across various organisational contexts.

A study conducted by Kim and Lee (2017) passionately investigated the tangible impact of business intelligence on decision-making accuracy. The riveting findings of their research unearthed that organisations that adeptly employed business intelligence tools and technologies experienced a noticeable improvement in decision-making accuracy, as they were able to diligently analyse and meticulously interpret data with heightened efficiency.

Another study carried out by Chen et al. (2012) explored the pivotal role of business intelligence in enhancing decision-making efficiency. The study emphatically revealed that organisations that seamlessly integrated business intelligence with big data analytics enjoyed unprecedented efficiency gains in their decision-making processes. By astutely leveraging the unparalleled capabilities of business intelligence to analyse and draw insights from vast volumes of data, these organisations were empowered to make timely and well-informed

decisions. These empirical studies, when combined with the enlightening conceptual frameworks and models, effectively present the empirical evidence in support of the instrumental role of business intelligence in decision-making processes. These studies conclusively demonstrate the tangible benefits that organisations can reap by harnessing the full potential of business intelligence in their decision-making practices.

2.5 Expectations for Business Intelligence Systems

Lack of data is no longer a problem for organisations. The problem is getting the right information to help organisations make decisions that increase sales and reduce costs (Hopkins et al., 2009). The main purpose of BI systems is to collect the collected data (Mangwayana et al., 2022; Watson et al., 2007) and analyse it (Ranjan, 2009; Osakwe 2020), to conduct accurate and efficient business, to extract useful information that helps decision. The BI systems also allow monitoring of the achievements of the organisation in real-time (Mathrani, 2021; Brynjolfsson & Hitt, 2016), so the information is available when it is necessary. This would shorten the time for making operational and strategic decisions.

The expectations of the BI systems are related to almost all areas of business operations (Poba-Nzaou et al., 2022; El-bashir et al., 2008). Namely, it is expected to positively impact the optimisation of inventory levels, marketing, introduction of new products, to better focus on customers, increasing competitive advantage, increasing of revenues, and everything concerned with achieving organisational, business partners/suppliers relation, internal process efficiency, and customer intelligence in terms of benefits (Su & Cardoso, 2021; Elbashir et al., 2018). With the faster development of the BI systems and tools the power of information produced by the BI enables advanced decision-making processes (Wang, 2022; Hočevár et al., 2018), which will perform most routine employee tasks, thus much more time will remain so that the employees can use that time for making better and accurate decisions. It's clear that organisations have a lot of expectations when it comes to using BI systems. The main expectations of investing in a BI system are the following in terms of expected benefits:

- Secure an organisational advantage.
- Improving supplier/partner relationships.
- Ensure efficiency of internal processes.
- Gain insight into customer information.

2.6 Key performance indicators of business intelligence

The Key performance indicators KPIs in business intelligence are typically around major business areas such as financial metrics, marketing metrics, customer service metrics and HR metrics. KPIs also cover specific areas like project management metrics and retail metrics. These KPIs are measurable outcomes that indicate the organisation's performance against its goals. To define KPIs for successful business intelligence, aspects of the business that is to be look into and have all the relevant data in at hand must be identified. Investing in a powerful business intelligence tool will enable the faster calculation of KPIs, with many of them capable of diving deep into the organisation's data and generating novel insights to inform the next decisions and actions (Demirdöğen et al., 2022).

Key Performance Indicators (KPIs) guide businesses in making decisions that affect particular business units as well as the organisation at large. Key Performance Indicators, also known as KPI or Key Success Indicators (KSI), guide an organisation to define and measure progress and ability to reach to organisational goals. Key Performance Indicators are quantifiable measurements. KPIs depend on the nature and specification of business. The KPIs are mainly based on cost driven measures, while an adequate business strategy contains more aspects to create future value through investment in customers, suppliers, employees, processes, technology and innovation (Shishova & Prorokov, 2022; Norton, 2016).

Organisations must be able to continually improve their performance in order to maintain a competitive edge and so exist as an organization. This has never been more true than in today's complicated, dynamic, and perplexing business world, which necessitates smarter judgments and greater execution. Effective business performance management begins with measuring existing performance; from there, the organization may make decisions to improve its performance in areas where it is lacking. In theory, employing KPIs appropriately may be handled from several perspectives.

For starters, KPIs are directly tied to the organization's strategy and contribute directly to the organization's strategic objectives. This criteria allows for KPIs at both the organisational and project levels. The 'dashboard' of the organization is made up of numerous KPIs. This will enable the determination of KPIs which represent different aspects of business processes (Ogunbiyi & Oladokun, 2022). Examples of Intelligence in Business

The following are examples of key performance indicators:

i. Financial metrics

Liquidity Ratio: Does the quantity of cash on hand support the business's estimated demands for the following fiscal year?

Net Income vs Net Earnings: Examines the data for income and profits growth.

ii. Marketing metrics

Conversion Rate: A high conversion rate indicates that visitors are on their way to making a purchase or completing a lead capture form. What matters is the measurement threshold.

Client Acquisition Cost (CAC): converting a website visitor into a consumer is successful, but does the expense of doing so justify the entire process?

iii. Project management Metrics

Productivity: Productivity is a simple calculation of how much one gets out of what is invested into a project. Customer service metrics

- Net Promoter Score (NPS): This gold standard customer experience metric gives you a singular picture of customer loyalty.
- Customer Effort Score (CES): Customers value their time above all else, so paving the path for simpler, faster resolution of their concerns trumps all other considerations

iv. Human resources metrics

Cost per Hire: Cost per hire is a straightforward measurement of how much is spent recruiting and hiring a new employee.

Net Income per Employee: It may be called revenue or profit per employee to give a quick idea of how efficient and productive workers are.

v. Retail metrics

Sales per Square Foot: Sales per square foot tells if one is putting to good use every available space and fixtures in the store
Sell-Through Rate: Sell-through rate tells about the percentage of units that has successfully been sold against the total number of units that were available to be sold (Kolychev & Shebotinov, 2019).

3. Research methodology

The population of this study is made of business organisations in within Windhoek, Namibia. The study population included those working in the field of business intelligence. Convenience sampling was used to select business organisation due to their availability, while simple random sampling technique was used respondents. A Total of 25 respondents were selected from the business organisations chosen for this study.

In-depth interviews through focus groups (Hancock et al., 2007) were used as the method of data collection. Data was analysed by filtering the data and sorting the patterns in order to categorise related responses for better interpretation.

4 Qualitative analysis

The respondents that were interviewed hold different positions in their different establishments. Some of them are instructors some are brand managers some are managing directors some of them are also system developers while some of them are business system analysts. These positions held by the various respondents are of significant importance to this research because they have one thing or the other to do with business intelligence systems in their organisations.

Another aspect that is of great importance is the educational background of the respondents. Some of them graduated as software engineers, while some have degrees in computer science. This gives them a better understanding of what business intelligence systems is all about. This also goes to show that the respondents are able and capable of answering questions posed to them by the researcher.

4.1 Reason for Investing in Business Intelligence systems

There are various reasons why organisations invest in technology. The main reason is for them to have a superior competitive advantage over their competitors this means that technology can help business organisations to enhance the quality of their business and the quality of productivity in whatever business they are carrying out in their organisation. This is seen in the responses given by the respondents when they were asked why they think their organisations decided to use business intelligence systems. For instance, *Respondent 1* indicated that

“One cannot work without BI because data is the most important thing for any business. You know where to target what market to penetrate on how to get your clientele.”

Respondent 2 noted that business intelligence help their organisation to improve efficiency and increase productivity. According to *Respondent 3*, he indicated that:

“Because the processes are automated and data is collected and analysed it helps to get insights about customer data and also help to manage any risk in the organisation”

Findings from Medhat et al., (2013), indicated that: “every small or large organisation requires information to promote their business by forecasting the future trends; information is now the primary tool to understand the market trends and understand their own position in the market comparison to its competitors. Business intelligence is the use of an organisations disparate data to provide meaningful information and analyses to employees, customers, suppliers, and partners for more efficient and effective decision-making.”

4.2 Types of BI Systems used in Organisations

The study by Chee, Chan, Chuah, Tan, Wong, and Yeoh (2009), state that “from the technological standpoint, BI is considered as a broad category of tools, software, solutions, and technologies that enables decision-makers to find, accumulate, organise, and access a wider range of information from disparate data sources.” Organisations use different types of technological tools in order to achieve their aims and objectives. This is also the case with business intelligence systems and there are different types of business intelligence systems that can be used by organisations. But the use of these business intelligence systems is determined by the goal and objectives of the organisations or the strategies put in place by the organisation in order to achieve their various goals and objectives. The different types of business intelligence systems are power BI, online analytical processing, Hadoop, etc.

They have their different ways in operation. Therefore the business intelligence system tools to be used are determined by the organisation based on the need for it that is what they want the business intelligence to achieve for them when they will use it.

In as much as most organisations use technology that does not necessarily mean that they use business intelligence systems. This is the reason why the respondents were asked to indicate how long they have been using business intelligence systems in their organisation. This will help the researcher to know if the respondents are experienced in that area and will be able to answer questions posed to them in that field of endeavor. Some of the respondents noted that they have used business intelligence systems for close to 10 years, some have used it for 12 years. Some also indicated that they have used business intelligence system for just three months while some noted that they have used BI system for six months and two years respectively. One must note that the use of business intelligence system can only be effective if you have experienced people that will assist when business intelligence systems are being used for close to 10 years.

4.3 Types of data collected by organisations

Data obtained from the use of digital technologies can provide new sources of knowledge, innovation and profits, if analysed effectively and transformed into intelligence (Dibley & Cole, 2019). About 2.5 quintillion bytes of data are collected every day, and this number continues to grow. Regardless of the business, its target market, or the services or goods offered, customer data collection can drastically help improve the functionality and optimization of businesses. The respondents were asked to state the type of data collected by their organisation. Some of them noted that they collect financial information some of them also noted that they collect complaints from customers/clients some collects payroll information, while others collect data in the areas of population crisis sales information marketing information and production information. The types of data generated by businesses can include a users' location, past searches, IP address, and even the advertisements customers mostly click online (*What Are the Different Types of Data Organisations Collect?* n.d.). Data collection and analysis can help to manage or resolve critical global issues, assist in the creation of new scientific breakthroughs, advance human health, provide real-time streams of information (e.g. on disease outbreaks or traffic conditions), monitor natural systems, improve the efficiency of resource use, and support decision making by business people, policymakers and civil society (Dibley & Cole, 2019).

With flexible cloud storage, businesses can collect more data than ever. Data collection and analytics can help businesses track their performance and adjust their strategies based on what worked in the past and what didn't (Bennett, 2020).

4.4 Basic Key Performance indicators (KPI's) Connected to organisations data output.

In the area of key performance indicator KPI, Respondents noted as follows

*'Yes, one must obviously see where you rank as a dealer between other dealers.
I want to see what vehicles and the type of vehicles that were sold and in what region'*

Some of the respondents also noted that they always want to see the financial performance of the organisation how it affects client satisfaction and internal process quality while some of them also discussed the overall system utilization in the organisation. Therefore, generally what this means is that the key performance indicator of organisations is determined by what the organisations intend to benefit from the activities that they carried out in that particular organisation.

Yonsel & Vural (2017) declares that KPI method is better understood and more applicable than the other options, given that it is used in many shipyards for many other decision-making purposes (e.g., budget performance, dry-dock planning performance, cargo-related incidents, operational deficiencies, passenger injury ratio, port state control detention, vessel availability, and vetting deficiencies). Besides that, KPIs can be used to quantify a organisation's ability to adhere to applicable rules and regulations related to the management of ballast water. This is done basically by counting the number of times that prevailing regulations regarding management of ballast water have been violated and recorded by an external party.

4.5 Types of decisions made based on BI systems usage.

Data is available across core business processes such as industry trends, customer behaviour, productivity, inventory, and detailed financial analysis. Business intelligence software extracts the information, transforming it into clear insights to enable actionable and strategic decision-making so people can readily achieve their goals (Phocas Software, 2019).

When the respondents were asked to explain the kind of decisions made based on the usage of BI systems some of them noted that they make market decisions in the area of sales and advertisement what does noted that we are systems help them to make marketing strategies cost cutting measures recruitment decisions and leave management. Some of the participants went further to state that they make systems analytics decisions which also helps in the improvement of the organisation's performance through the informed decision they make when data is analysed. They also noted in summary that's data analytics all business intelligent systems help them to make operational, strategic and managerial decisions.

4.6 Impact of BI System on organisations

The adoption of business intelligence (BI) is essential to sustenance the success of the organisation's strategic objectives, the provision of higher quality information, and the re-engineering of the business process. The impact of BI adoption ultimately improved provision for decision-making, which has made BI a prevalent information technology (IT) innovation (Nazri et al., 2019).

A majority of participants noted that BI systems have positively impacted on their organisations and helps them to make informed decision when accurate data are analysed using the BI systems. Some of the participants also noted that BI tools have assisted them to increase productivity in their organisation this is because by providing accurate information on current and historical performance of the organisation along with future trends BI system has helped them to make data Oriented decisions. The participants also noted that output from BI systems are easy to understand and use because the system gives detailed reports or summary of data that has been analysed, therefore making the organisation to make data oriented decisions.

Furthermore, the respondents indicated that BI systems are easy to use and cost effective they believe but BI systems help them in decision making by positively providing them with information that they use in making informed decisions. The participants also noted that business intelligence tools or systems help them to integrate and translate data into information in real time. Therefore, information from different sources is received quickly as possible integrated and sorted in order to lean the data.

According to Alasiri & Salameh (2020), they stated that BI systems are constantly focused on providing new information searching through various channels of data gathering, as well as information system mechanisms to convert and synthesize data into actionable insights, allowing tracking of root-cause of

problems, and monitoring all operational processes. Business intelligence software applications rely on fast expanding technology such as data mining, predictive analytics, and big data.

Retail is one of today's fastest expanding businesses, and it is extremely competitive, with widespread usage of BI and/or DSS technologies. Several organisational activities in retailing are influenced by BI technologies, which contribute to overall organisational success. Analytics helps merchants to focus on customer lifetime value, loyalty analysis, cross-selling, target marketing, and product pricing.

The information through BI provides key insights and wider perspective about the sales trends, consumer expectations, supplier effectiveness that enables faster decision making at right time. BI tools further enhance reporting speed by capturing time-variant data wherein events are grouped such that data is collected in certain time windows and calculations such as average, time-series slices, dimensions and other elements are captured. BI tools can be used to acquire information about consumers' purchasing behaviour, as customers' online activities, whether on the organisation's website or third-party sites; can provide increased information about consumer behaviour. BI tools can help improve management and operational processes in retail organisations, as they have the ability to support managers in planning, organizing, controlling and leading, including by helping identify potential fraud and customer attrition rates and customer life-cycle value. Use of BI enables retailers to manage the pricing of their products while ensuring that the competition does not affect their business. Retailers can apply the dynamic pricing strategy based on machine learning that is part of BI to adjust prices in real time, with offers or recommendations being sent to specific set of customers, thus increasing sales and attracting new customers (Alasiri et al., 2020).

4.7 What needs to be considered before implementing BI in organisations?

For an organisation to use business intelligence systems there are several things to be considered. One of the respondents indicated that

the type of information and data required will help organisations know the type of BI system that can be used in the organisation.

According to some of the participants, ***it is proper to know the right software to use in the organisation. It is also important to train employees on the use of BI systems not minding the fact that BI tools and software can be costly, it is worthy to note that the benefit to be derived from the use of this innovative technology cannot be overemphasized.*** Therefore, using the right software or technology is paramount. This means that it is necessary to consider skills of the employees in the organisation and also bring on board people that understands the use of BI systems.

5. Discussion

The implementation of a BI system sheds fresh light on the role of information and competences in an organisation, as well as business relationships and interdependencies. At this stage, new informational demands emerge, and new ways of information management are developed. Applying the concepts of iterative design and rapid application development (RAD), it is feasible to see that the BI environment created is a prototype that should serve as the foundation for assessment and the start of a new cycle of constructing a BI application (Dresner et al., 2002).

The exploration and discovery stage necessitates extraordinary collaboration between representatives of IT departments and a knowledge management center, as well as end users, who must be imaginative and eager to experiment with data. Integrated data from different sources is also very important and this also needs to be considered when implementing business intelligence systems in organisations. Analysis carried

out indicates that inability to integrate data is one of the major problems facing business organisations. This is because different data sources exist in the organisations and these data sources could be internal and could also be external depending on where the data is coming from. This was also extensively discussed in the reviewed literature. For instance, data can come from production unit of this organisation marketing unit of the organisation sales unit of the organisation and even from the suppliers. This goes to show not every source of data that comes into the organisation must be considered before implementing business intelligence systems.

Participant's interview also indicated that being able to put data sources together by identifying various sources of data will go a long way to mining these data and putting together data that will enhance actionable decision making in organisations.

BI systems should be rapidly implemented, which is quite difficult because such systems are specific for each enterprise. Although basing on standard components shortens time required to build BI, each implementation necessitates adjusting of a particular system to specific requirements of an enterprise (Olszak & Ziemba 2007)

5.1 What Is a Business Intelligence Strategy?

Before diving into the specifics of strategy, it's important to understand what BI is. Business intelligence is a term used to encompass the technology and strategy that goes into data analysis for the organisation. The technology can give organisations a look into past performance, how their organisation is doing right now and make forecasts for potential future scenarios. So, business intelligence strategy is a blueprint for how organisations use the data they generates. This data can come from many disparate sources from around the organisation, including human resources, supply chain, manufacturing, finance, customer relationship management and more. A successful BI strategy involves people, processes and technology.

A well-planned business intelligence strategy can become a highly beneficial tool for business organisations and their departments in understanding their processes and results. It can also help the organisations to understand their customers more. Therefore, to develop a strategic approach for business intelligence that can enhance better decision making in an organisation, certain elements must be put into consideration.

5.2 The Key Elements

One of the primary functions of BI is to pull data together from different parts of business in an organisation and then carry out an analysis. Therefore, for BI systems to help an organisation to achieve its objective, the organisation set and understands its priorities and creates a long-term plan. This means that before implementing the BI strategy, the organisation need to evaluate and answer the below questions as this will help them to realise the type of BI needed for the specific organisation/organisation. Understanding what needs to be done will help the organisation to set clear and realistic expectation and thereby focus on what is important.

- What's your objective?
- What do you have?
- What do you need?

Table 1. The key elements

at are the objectives of organisation	What does the organisation have	What does the organisation need
• What do you hope to achieve by implementing BI? • What end-result would you like to achieve? • Do you want to be more efficient with your operations or workforce • Do you want to boost sales or improve customer satisfaction?	• What type of data do you have at hand? • What data can you gather for reporting or need to have analysed? • What systems do you need in order to get more data? • Which department will contribute data to your system?	• Do you want something that integrates all your data and produces charts and reports? • Do you prefer a cloud-based system. SaaS, or a software package that you install yourself? • Do you want something to integrate with your existing systems or something that replaces what you already have?

The study has developed seven elements which were generated in this study from literature reviewed and the analysis of data collected, they are discussed below:

- i. The Key Performance Indicators;
- ii. Training;
- iii. Team building;
- iv. Choose appropriate data storage, environment, and platform;
- v. Fine-tune data preparation process;
- vi. Consider more advanced solutions;
- vii. Implement the changes to meet the KPIs.

If an organisation wants to create a business intelligence strategy, they need to ascertain if their BI strategy aligns with organisation goals. It could be that the organisation want to improve employee productivity or gain insights into their customers' behaviour. Determining their goal will help them accurately develop their business intelligence strategy, measure their performance, expose shortcomings, improve competitive advantages, and use data mining and analytics for successful decision making. Any implementation is impossible without a clear understanding of the key elements which are:

5.3 Set the Key Performance Indicators (KPIs)

Managers often talk about performance. There are targets and objectives to achieve at an individual and team level to meet organisation's overall goals. Performance can be measured if managers are able to know how hard team works and have data to back it up, working on the right things and achieve the outcomes that the team and organisation need. KPIs can achieve this by quantifying individual and organisational goals, and evaluating performance accordingly.

Once enough information has been gathered, it is important to define the KPIs. The organisation's KPIs should be measurable and matching their objectives because it is vital for achieving their business goals. For instance, the business organisation must put into consideration, the following;

Financial metrics (liquidity ratio, net income versus net earnings) Marketing metrics

Project management

metrics Customer service
 metrics Human resources
 metrics Retail metrics

5.4 Training

If the organization is new to BI, employees should be trained on how each department can benefit from BI implementation. Therefore, it is important for organisational leaders to recognise the importance of training and development as it relates to employee performance and evaluation. Despite extensive research in the area of employee performance training and development, business leaders still appear to have gaps and challenges in this regard. As such, it is proper to provide concise information on employee training, development, performance, and evaluation concepts, as well as rationales, impacts, approaches, benefits, and guidelines in implementing a business intelligence strategy.

Table 2: BI Team Core Structure

Role	Major responsibilities
Application Lead Developer	Designing and overseeing the development of the access and analysis application (e.g. reports, queries)
BI Infrastructure Architect	Build and maintain technical BI infrastructure (some organizations also monitor non-technical infrastructure). Usually reporting to the expansion team's strategic architect
Business Representative	Participate in modeling sessions, provide data definitions, create test cases, make business decisions, resolve business unit disputes, and improve data quality under the control of the business unit represented by this role
Data Administrator	Performing cross-organisational data analysis, creating the project-specific logical data models, and merging the logical data models into an enterprise logical data model
Data Mining Expert	Choosing and running the data mining tool; must have a statistical

5.5 Team Building

Team building is a collective term for the activities conducted, training provided, and other efforts made to help teams build collaboration and communication skills needed to work together and meet common goals. Team collaboration is pivotal to the overall success of the team, especially in hybrid workplaces. Meeting the organisation's goals is the responsibility of everyone in the organisation, so even those who are not directly influencing the cost or the revenue side should know what those goals are (Dennis, 2020).

A BI team that has a clear vision and remains focused on that vision throughout their tasks will work with synergy, enthusiasm and creativity that can never be nurtured in a scattered group of individuals, regardless of their talent and experience. Team building provides several advantages for organisations. It boosts productivity, boosts staff enthusiasm, promotes cooperation, and fosters employee trust and respect. Outside of the office, team building activities should be done to offer workers a cause to connect with one another in a non-work-related setting and to urge them to work together to solve a problem.

5.6 Choice of Data Storage, Environment, and Platform

It is recommend that to start by choosing data storage options that improve business productivity. Data storage can be on physical hard drives, floppy drives, USB drives, or virtually in the cloud. It is important to

have files backed up and readily available in case the organization's system crashes beyond repair. Some of the most important factors to consider when storing data include reliability, robustness of security features, and cost of implementing and maintaining infrastructure. Browse through a variety of data storage solutions and applications to help businesses make the best choice for their business needs. Data warehouses are typically considered a good choice for implementing business intelligence because they provide analysis of relational data from both online transaction processing systems (OLTP) and business applications (ERP, CRM, HRM systems, etc.).

5.7 Data Lake versus data warehouse

Table 3: Data lake versus data warehouse

DATA LAKE	PARAMETERS	DATA WAREHOUSE
structured /semi-structured/ unstructured /binary data from various sources	type of data	structured and processed
on-read, post-processing	processing	on-write, pre-processing
cost-effective Big Data storage	purpose	analytics for business decisions
data scientists and engineers	users	business analysts
storing data and big data analytics, like deep learning and real-time analytics	tasks	typically read-only queries for aggregating and summarizing

After selecting the database software that matches the needs of an organisation, and works well with existing IT infrastructure, the organisation should also choose the right environment and the BI platform. The platform or environment could be an on premise, cloud-based, or hybrid environment.

Table 4: Choose the environment for business intelligence implementation

On-Premise	Cloud	Hybrid
Deploy the BI platform on internal physical server(s)	The Bi platform is deployed on a public or a private cloud	Some components of the BI platform are deployed internally and some are deployed on the cloud
Keep data internal	Managed services	Used to optimise storage cost and level of control
Total control on the platform	Focus effort and resources on strategic initiatives	Large enterprises looking to find a balance between storage cost and control
Organisations with a lot of sensitive data	Bi starts with a small and busy IT department	
Start with only a single server	Departmental BI	

If the Cloud environment is chosen, the business organisation will need to choose a platform

that will host its Business Intelligence. It is worthy to note that the environment and platform chosen will affect application's architecture.

5.8 Optimize Your Data Preparation Procedure

Large organisations frequently suffer with massive volumes of meaningless data. It occurs when teams or departments utilise disparate technologies, take disparate methods, and keep data to themselves. Data preparation often consumes up to 80% of BI development time. High-quality data is essential for every effective business intelligence application. According to the survey, respondents emphasised the need of data preparation for business intelligence adoption. As a result, for data to be useful, it must have the following features.

- Completion (are any values missing?)
- Validity (does the data conform to the rules?)
- Uniqueness (does the data have duplicates?)
- Consistency (does the data match across different data stores?)
- Timeliness (does the data accurately represent reality from the appropriate point in time)
- Accuracy (the degree to which the data represents the reality)

Business executives' judgments are only as good as the data that supports them. Thorough and thorough data preparation helps that analysts trust, understand, and ask better questions of their data, resulting in more accurate and relevant analyses. Better insights and, of course, better outcomes result from more relevant data analysis.

5.9 Think about More Advanced Solutions

The data preparation process is an essential step in generating business information from data. Effective data preparation is critical to obtaining results because it reduces analysis mistakes, makes the analysis process more efficient, and makes prepared data more available to all stakeholders. It is critical to understand all of the components of data preparation and to use the appropriate data preparation technologies to guarantee that this crucial step gets accomplished without a hitch.

Reliance on Business Intelligence, its implementation might be even more beneficial if organisations incorporate more advanced technologies like Machine Learning. It can also help to:

- Build optimised data pipelines;
- Achieve real-time data analysis;
- Make actual forecasts;
- And analyse larger sets of data.

5.10 Implement the a pilot project

When all processes are ready, a test run/review should be carried out. And while it might seem like a great idea to test the system on the organisation-wide scale, it is better to have a pilot project within a smaller group

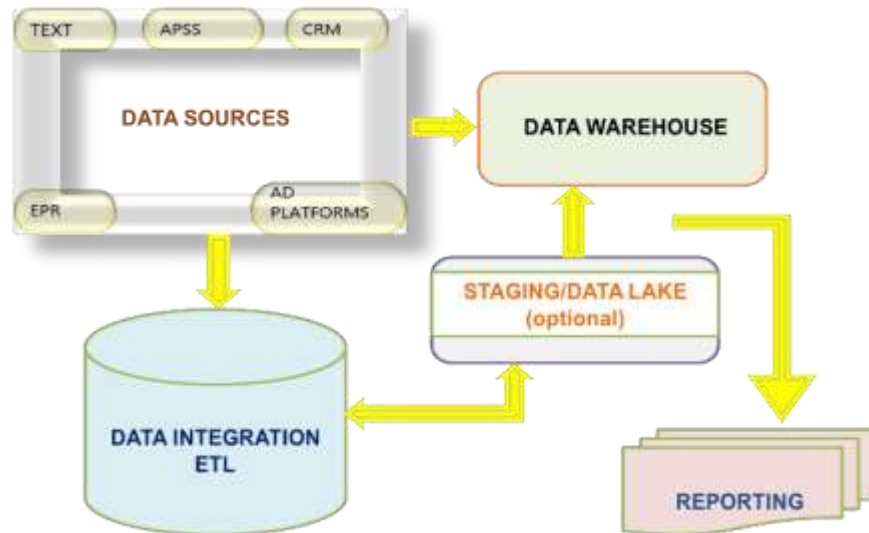


Figure 5. Implement the a Pilot Project

5.11 Implement the Changes to Meet the KPIS

At the end, organisations should review their results and see whether they have met the initial expectations. If not, see what can be done to achieve the initial KPIs. Once changes are implemented, it is advisable to run another pilot to understand how much has been covered between these two pilots' runs and how this changes the picture. It is a continual process, and it needs optimisation at every run until all of the involved parties are happy with the result.

6. Business Intelligence Strategy

BI provides accurate corporate information that boosts productivity and profits (Williams & Williams, 2007). There are many good reasons to suggest BI in the business world. Business intelligence (BI) enhances business judgment and shapes corporate operations. BI systems ought to be put into place when there is fierce competition. Organisations must be aware of their goals. Even if the business world is evolving and growing more competitive, applying BI would only be time- and money-consuming if the target market and firm are small. Yet, there will be a significant change in the level of competition if the target market and the industry are both large. For this reason, the business needs a BI system to stay competitive. Given the absence of strategies in how to use BI, many organisations have not implemented it. The study reviewed the literature on BI implementation, interviewed respondents from different organisations, and analyzed the data collected by the study in order to develop strategies for BI use and implementation in business organisations, as shown in the figure below.

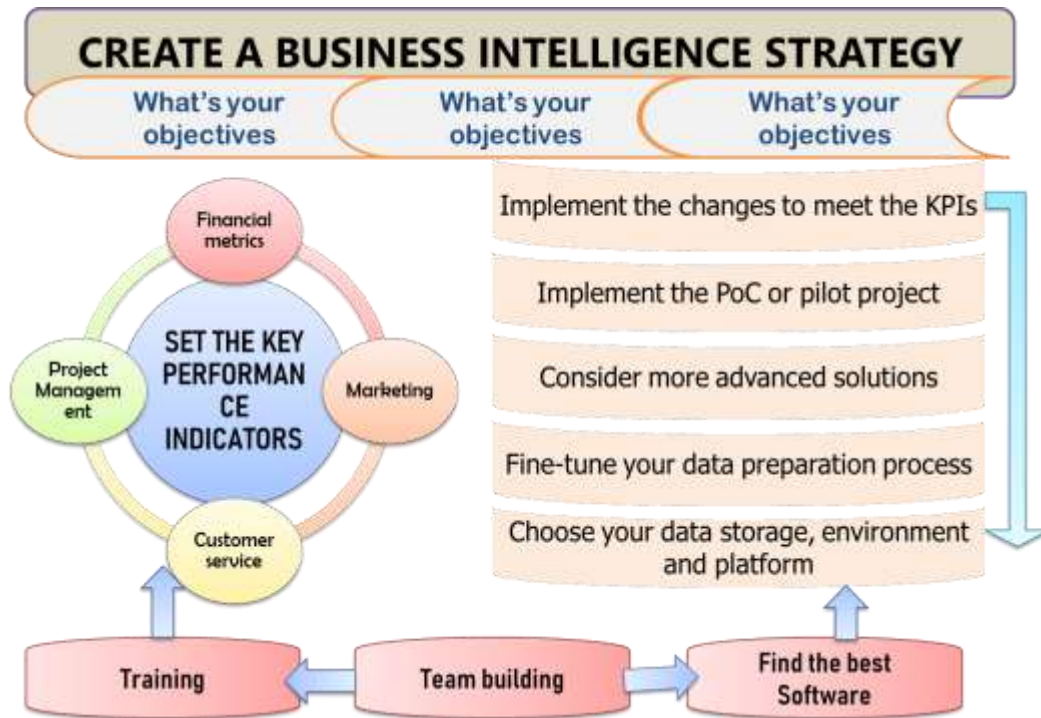


Figure 6. Business Intelligence Strategy

7. Recommendation

The most prevalent problems encountered while utilizing BI were a lack of an organisational culture that drives the use of BI tools, integrating data from various sources, and a lack of activities that necessitate the use of BI tools in organisations. Training is very important in every activity. The most effective way to minimise resistance is the training of the organisation's personnel. This is because if the employees are not knowledgeable in technology, there is every possibility that they will resist the use of BI in the organisation.

Team building in every organisation is very important. This is because of the synergy that comes with it. For instance, a team could be made up of different staff with different areas of specialisation. Therefore, working together will ultimately bring about cohesion and excellent interpersonal relationship.

The findings of the research showed that the use of BI in an organisation can encourage lots of opportunities. BI has influenced the business industry and most of the organisations now demand BI. BI is gaining pace in many industries around the globe. Looking at the examples of successful BI implications, the author recommends implementing a BI system with a goal and as per the need of the organisation

9. Conclusion

This study was conducted to identify strategic approaches for using business intelligence systems as decision support systems for business organisations. This research helps organisations understand the importance of implementing her BI in their organisation to improve organisational performance and how BI can help organisations spot problems and key success factors. can. BI provides flexibility and access to data across the enterprise and increases reporting visibility. (Hocevar & Jaklic, 2019).

The concept of BI was only introduced a few decades ago, but today, regardless of the size of the organisation, it is important to consider whether it is necessary to invest in this system to meet the needs and desires of customers. It's a matter of interest. Today, BI brings real business value to your data assets and greatly improves your ability to identify and exploit business opportunities. Many multinational organisations have adopted BI systems, but some have not. Operational and organisational factors such as organisation strategy, human capital, leadership, culture, quality management, and strategic direction have a significant impact on the implementation and integration of BI systems. Understanding both technical and managerial skills is a key success in implementing his BI system in organisations.

Businesses today collect vast amounts of data from numerous sources. Using BI to collect, organise, and analyse this data can add tremendous value to your business. Business intelligence has always played a key role in the highly competitive world of business. So the core business intelligence activity is nothing new. There are two perspectives on business intelligence. technology and organisation. Technology refers to the systems that capture and transform data into various information products, and organisation refers to decision support. Decision support systems help bridge the gaps in human knowledge by providing diverse sources of information, providing intelligent access to relevant knowledge, and supporting structured decision-making processes. Decision support systems are interactive systems between users and computers that use analytical models and databases to support unstructured decision-making decision-making processes. Decision support systems help administrators make good decisions about service quality and can also improve the management of electronic registrars.

Therefore, a corporate governance strategy should lead the entire organisation to the desired and successful outcome. According to Trinidad (2016), leaders in some organisations have successfully implemented change through effective training and employee engagement strategies in change initiatives. Overall, to successfully implement big data analytics in their organisation, business leaders must (a) effectively communicate their vision for change, (b) train their employees to upskill, (c) involving employees, and (d) building strong teams. Leaders must prepare their employees for any change and help them to cope while implementing the change successfully (Kotter, 2016).

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Enhancing Digital Diplomacy through a Unified Communication Framework: A Case Study of Namibia

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Abstract.

The conduct of diplomacy has evolved from traditional norms to modern ways, with a strong emphasis on constant communication facilitated by contemporary information communication technologies (ICTs), giving rise to the concept of digital diplomacy. However, in the context of the Namibian Ministry of International Relations and Cooperation (MIRCO) and its diplomatic embassies abroad, the existing ICTs lack standardization and collaboration during implementation. This has led to heterogeneity and silos in communication technology, resulting in limited real-time access and sharing of information between the foreign ministry and embassies, hindering seamless communication, resource sharing, and centralized IT administration. To address these challenges and optimize digital diplomacy, this study proposes a Unified Communication Framework (UCF) specifically designed for the Namibian diplomatic realm. The UCF serves as a technological blueprint, guiding the implementation and adoption of unified communication technologies. By addressing the communication technology heterogeneity amongst MIRCO and its diplomatic missions, the UCF aims to promote integration, collaboration, and standardization, ultimately enhancing digital diplomacy in Namibia.

Keywords: Diplomacy, Information Communication Technology, Digital Diplomacy, Unified Communication

1. Introduction

Diplomacy is considered the bedrock and driver of international relations and foreign policy, involving negotiations and dialogues among states to achieve national objectives. To effectively implement foreign policies and achieve diplomatic objectives, communication plays a vital role, especially with the rise of contemporary information communication technologies (ICTs) that have given birth to digital diplomacy (Ariyawardana, 2021). Within the context of Namibia, digital diplomacy has become crucial for efficient diplomatic practices.

However, the implementation of digital diplomacy in Namibia faces significant challenges. The existing ICTs utilized between the Ministry of International Relations and Cooperation (MIRCO) and its diplomatic embassies lack standardization and collaborative efforts during their deployment (Adesina, 2017). As a result, heterogeneity arises, leading to communication silos and duplication of technologies. This fragmentation hampers real-time access and sharing of information between the foreign ministry and embassies, impeding seamless communication and centralized administration of IT resources (Li et al., 2021).

To overcome these obstacles, this article proposes a Unified Communication Framework (UCF) specifically tailored to optimize digital diplomacy in the Namibian diplomatic realm. The UCF serves as a technological blueprint, guiding the implementation and adoption of unified communication technologies (Gunawan Sudarsono et al., 2020). By addressing the communication technology heterogeneity amongst MIRCO and its diplomatic missions, the UCF aims to promote integration, collaboration, and standardization, ultimately enhancing digital diplomacy in Namibia.

2. Literature Review

2.1 Concept of Digital Diplomacy

In the 21st century, the field of diplomacy has undergone a significant transformation due to the pervasive influence of Information Communication Technologies (ICTs) (Sam, 2012). Just as other sectors like education and health have embraced the digital realm, diplomacy has also adapted to the era of constant communication and information sharing facilitated by modern technologies (Holmes, 2013). Drawing from (Holmes, 2013), digital diplomacy refers to the strategic use of ICTs in international relations.

The adoption of contemporary ICTs in international relations is driven by their immense value in promoting economic and social growth (Ndimbwa & Emanuel, 2013). These technologies have revolutionized diplomatic practices by improving communication, enhancing information sharing, facilitating negotiations, and ultimately benefiting diplomacy.

The evolution of digital diplomacy can be traced back to the 1860s with the introduction of the telegraph in Britain (Kalachishvili et al., 2023). Despite initial concerns that the telegraph would replace traditional face-to-face diplomacy, the field continued to adapt and thrive through subsequent technological advancements, including the telephone, television, radio, and fax systems. These innovations significantly enhanced the speed and reliability of diplomatic communication, as documents such as treaties, notes, speeches, and consular documents could be easily circulated (Adler-Nissen & Drieschova, 2019). However, it was the advent of the internet that truly revolutionized digital diplomacy (Adesina, 2017). With a vast array of services and capabilities, the internet opened up new possibilities for diplomats and diplomatic institutions. Instant messaging, file sharing, web and video conferencing, social media, and podcasts have now become integral to diplomatic communication and information sharing.

As noted by (Stojanovska-Stefanova & Magdincheva-Shopova, 2020), the DNA of conventional diplomacy is mutating. Diplomacy can no longer be conducted in antiquated ways, as reliable information and effective communication are essential for implementing foreign policies. Diplomats and diplomatic institutions must become adept at using the internet and its various tools to navigate the changing dynamics of international relations.

The shift towards digitalization in diplomacy has already begun and is expected to continue shaping the diplomatic sphere (Adesina, 2017). Embracing the digital realm and adopting the latest ICT tools are crucial for diplomats and Ministries of Foreign Affairs (MFAs) to stay relevant and effectively engage in the modern diplomatic landscape. In this context, a Unified Communication Framework (UCF) can play a pivotal role in optimizing digital diplomacy practices, as demonstrated by the case study in Namibia.

2.2 Factors Impacting Digital Diplomacy

In the pursuit of enhancing digital diplomacy, several critical factors have been identified that can either facilitate or hinder the adoption and implementation of information communication technologies (ICTs) in diplomatic practices. These factors include connectivity and the digital divide, digital foreign policy and strategy, as well as secrecy and confidentiality.

2.3 Connectivity and Digital Divide

Despite efforts to improve ICT infrastructure and connectivity through undersea cables like the African Coast to Europe System (ACE) and the West Africa Cable System (WACS), developing countries, including Namibia, still face challenges accessing affordable internet bandwidth (Schumann & Kende, 2013). The high costs associated with internet access hinder the full utilization of the potential benefits these undersea cables

offer. To address this issue and enhance both national and cross-border connectivity, there is a pressing need to reevaluate guiding policies to make internet access more affordable and accessible (Höne, 2016).

2.4 Digital Foreign Policy and Strategy

A robust digital foreign policy and strategy play a crucial role in driving diplomatic digital innovation. Collaboration with domestic and international stakeholders and adherence to international ICT policies, procedures, and standards are essential components for seizing the opportunities presented by ICTs in diplomacy. By formulating comprehensive policy guidelines and procedures, nations' foreign ministries can effectively implement and adopt technology, overcoming potential hindrances such as organizational issues, technological infrastructure, and human actions (Höne, 2016, Svensson, 2020).

2.4.1 Secrecy and Confidentiality

Diplomacy inherently demands privacy and confidentiality, particularly regarding sensitive diplomatic information and negotiations between states. The fear of exposing such information through the use of the internet and communication technologies poses a significant concern. Maintaining secrecy is perceived as essential to safeguarding national interests and avoiding potential conflicts or security risks. Consequently, there is often hesitancy in adopting and implementing ICTs in diplomacy to preserve secrecy and prevent unauthorized access to sensitive information (Carnegie, 2021, Rashica, 2018).

Addressing these factors is vital for the successful enhancement of digital diplomacy. By developing a Unified Communication Framework that considers these aspects, Namibia's foreign ministry can optimize digital diplomacy, promote seamless communication, and foster collaboration while preserving confidentiality and safeguarding national interests in the digital era.

2.5 Unified Communication (UC)

In the contemporary era of advanced technology, communication has witnessed a significant transformation. From traditional methods like using birds to convey messages, modern communication relies on the seamless transmission of information with just a click of a button, thanks to technology. The evolution of communication, driven by technological advancements, has introduced various forms of communication, including telegrams, fax machines, telephony, and the internet (Khandelwal & Kavitha, 2016). One prominent innovation in this regard is Unified Communication (UC), where IP telephony is combined with video conferencing, instant messaging, file sharing, presence, and application sharing to enhance overall communication (Khandelwal & Kavitha, 2016, Meske et al., 2018).

UC systems are predominantly powered by internet protocol-based technology and enable organizations to unify different communication services, fostering real-time collaboration among staff members (Khandelwal & Kavitha, 2016). Implementing UC can address disruptions caused by unreliable communication channels, and it holds great potential for advancing communication technology (Riemer & Taing, 2009).

Each organization needs to choose a UC solution that aligns with its specific needs and requirements (Khandelwal & Kavitha, 2016). Furthermore, the development of a comprehensive UC framework, guided by ICT policies, plays a crucial role in harnessing technological benefits, including the enhancement of digital diplomacy in the Namibian context (Höne, 2016).

2.6 Unified Communication Platforms

Several UC platforms have been introduced to facilitate efficient enterprise communication. Among the notable examples are; Skype for Business (now replaced by Microsoft Teams), developed by Microsoft, this platform offers video conferencing, instant messaging, persistent chat, call monitoring, and PSTN dial-in

conferencing functionalities, promoting communication within and outside an organization; Elastix, a Linux-based freeware, Elastix aims to integrate various communication tools into a holistic solution, supporting email, telephony, fax, video, and instant messaging; IBM Sametime an enterprise platform developed by IBM, IBM Sametime enables chat rooms, telephony, screen sharing, media sharing, video conferencing, and presence, with integration capabilities with other applications; Unison, owned by Unison Technologies, Unison offers video conferencing and instant messaging, though it provides less functionality compared to other platforms.

In addition to the above platforms, other vendors like Cisco, Polycom, Mitel, and Microsoft (Microsoft Teams) lead in UC implementation, providing organizations with diverse tools to improve communication (Khandelwal & Kavitha, 2016, Meske et al., 2018).

Effective communication, particularly in diplomacy, relies on harnessing technological advancements. Organizations should select the most suitable UC solutions based on their unique needs, considering globalization and competitive thinking to foster innovation and technology (Khandelwal & Kavitha, 2016, Leijten, 2017). UC system encompasses various components such as IP infrastructure, communication media, presence signalling, collaboration, and contextualization, all contributing to seamless and enhanced (Riemer & Taing, 2009).

2.7 The Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT was formulated in 2003, driven by the need to address gaps in existing technology adoption and acceptance theories (Williams et al., 2015, Rahi et al., 2018). This comprehensive framework, introduced by Venkatesh and collaborators, seeks to encompass the limitations of prior theories. UTAUT focuses on the interplay between technology design and user behaviour as determinants of technology acceptance and adoption. Its goal is to enhance user acceptance by understanding end users and investigating factors that influence technology acceptance.

2.7.1 Unified Theory of Acceptance and Use of Technology (UTAUT) Model

The UTAUT model, as illustrated in Figure 1, evaluates the usefulness, ease of use, technological capabilities, and the social environment's impact on technological usage (Ammenwerth, 2019). Four key constructs within UTAUT encourage technological adoption: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions.

- Performance Expectancy: This refers to the extent to which technology enhances individual productivity at work, contributing to job efficacy (Marikyan & Papagiannidis, 2021).
- Effort Expectancy: This emphasizes ease of use, favouring technologies with lower complexity to encourage adoption (Ammenwerth, 2019).
- Social Influence: This construct pertains to the influence that authority figures or prominent individuals have in mandating the adoption of new technologies. In professional settings, management-driven technology adoption becomes obligatory (Williams et al., 2015).
- Facilitating Conditions: This considers the existing technical infrastructure's capability to support the technology's usage (Rahi et al., 2018).

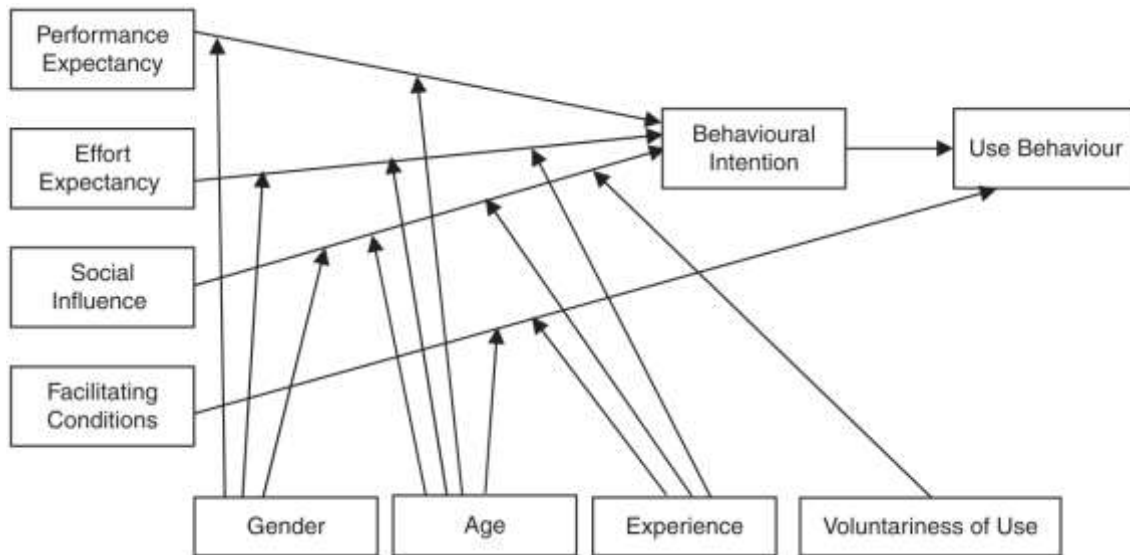


Figure 1: UTAUT Model
Source: (Williams et al., 2015)

The theoretical framework, depicted in Figure 2, centres around these four UTAUT constructs. They guided data analysis and informed the unified communication framework.

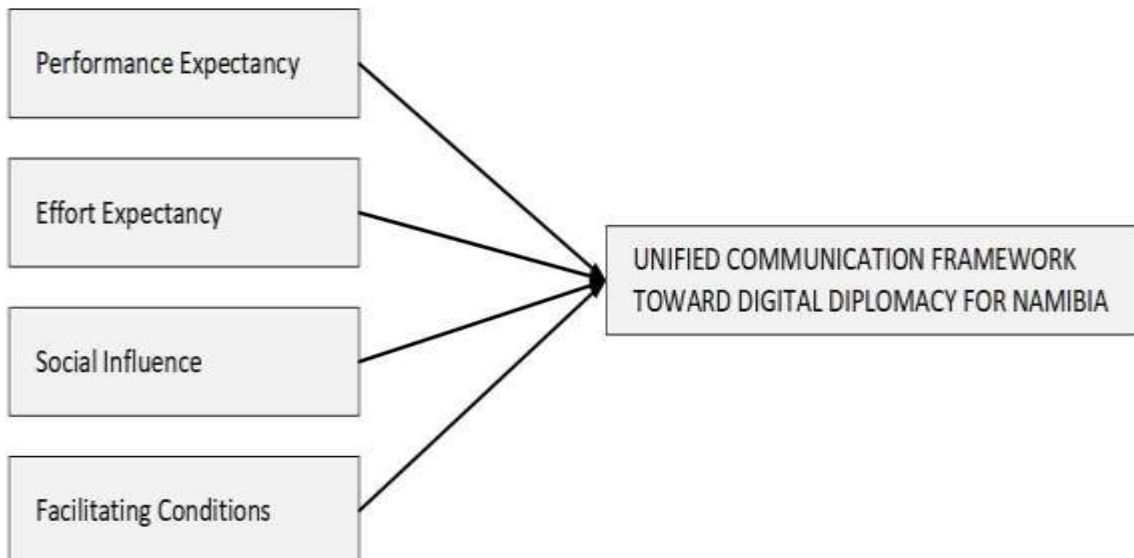


Figure 2: Theoretical Framework

In the context of this study, which focuses on the diplomatic realm and specifically the Ministry of International Relations and Cooperation, UTAUT was adopted as the theoretical framework. This choice aimed to comprehend the socio-technical dynamics within the Namibian diplomatic environment.

2.7.2 Application of Unified Theory of Acceptance and Use of Technology (UTAUT)

Since its inception, UTAUT has been applied across diverse fields such as banking, healthcare, mobile technology, e-government, and enterprise systems to understand technology adoption (Rahi et al., 2018). Its application to diplomacy presents a unique perspective compared to its conventional use in various sectors.

3 Research Methodology

This study was based on inductive reasoning that constructed theories from collected data. The study employed inductive reasoning to build a comprehensive understanding of the phenomena and develop a Unified Communication Framework for enhancing digital diplomacy in Namibia's international relations. The research strategy used in this study is qualitative, aiming for an exploratory and interpretive approach to provide descriptive knowledge and understand the social setting better contextually. Qualitative research offers flexibility, authenticity, and rich descriptive constructs essential for knowledge generation.

Moreover, a qualitative research approach was applied, employing a case study research design. A case study focuses on a specific organization or institution to gain a holistic understanding and rich empirical evidence. The Ministry of International Relations and Cooperation in Namibia was selected as the case study for this research. Data collection for the study involved acquiring raw data from research participants to gain knowledge about the phenomenon. Two data collection techniques, namely semi-structured interviews and documentation review were selected based on the research objectives and the qualitative nature of the study.

Semi-structured interviews were conducted face-to-face and virtually through Zoom. An interview guide was developed to align with the study's objectives. The participants, consisting of IT personnel, administrative diplomats, and political diplomats, were asked guiding questions extracted from the sub-research questions. Seventeen interview guiding questions were used in total. Interview recordings were transcribed and given unique codes for confidentiality. For triangulation and validation, four documents, including strategic plans, policies, and reports, were reviewed during the interviews. Purposive sampling was used to select participants deemed knowledgeable and relevant to the study. Seven participants from different duty stations were interviewed. Data was analysed interpretively using an underpinning theory (Unified Theory of Acceptance and Use of Technology - UTAUT).

4 Data Analysis with Unified Theory of Acceptance and Use of Technology (UTAUT)

During the analysis conducted using the Unified Theory of Acceptance and Use of Technology (UTAUT), we examined how the data collected from semi-structured interviews aligned with the constructs of UTAUT to inform the proposed unified communication framework for enhancing digital diplomacy in Namibia ("Enhancing Digital Diplomacy through a Unified Communication Framework: A Case Study of Namibia"). The UTAUT framework consists of several key constructs: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. The analysis provided insights into how these constructs influenced the adoption and implementation of communication technology in the context of the Ministry of International Relations and Cooperation in Namibia.

4.2 Performance Expectancy

Performance Expectancy in UTAUT refers to the extent to which technology contributes to job performance. The analysis showed that communication technology played a pivotal role in enhancing diplomatic performance. Diplomats recognized that communication was crucial for achieving objectives and strategic goals, and technology streamlined communication, making it faster and more efficient. Participants noted that technology facilitated stakeholder engagement and allowed them to work with ease and effectiveness. The concept of digital diplomacy was well understood by diplomats, indicating their willingness to adopt technology that positively impacted their job performance and the achievement of diplomatic goals.

4.3 Effort Expectancy

Effort Expectancy in UTAUT emphasizes the ease of use of technology. The analysis demonstrated that usability was a key factor in technology acceptance. Participants found the communication technologies used in the Ministry to be easy to navigate and utilize. However, age and exposure played a role, with younger diplomats being more open to technology adoption. The importance of technical training and awareness programs was highlighted to address technophobia and enhance usability. Usability was also influenced by the convenience of technology in making work easier, especially in the complex domain of diplomacy.

4.4 Social Influence

Social Influence refers to the impact of colleagues, supervisors, and management on technology adoption. The analysis indicated that management support and understanding were crucial for successful technology implementation. Diplomats expressed challenges when managers lacked trust or understanding of technology. The colleagues and supervisors played a role in influencing diplomats to embrace communication technology, as well as the COVID-19 pandemic. Government policies and guidelines were also identified as influential factors. The need for top-down approaches, awareness campaigns, and learning from other nations was highlighted to boost technology acceptance.

4.5 Facilitating Conditions

Facilitating Conditions encompass the technical infrastructure and supportive environment for technology adoption. The analysis revealed that infrastructure readiness was essential for successful technology implementation. Discrepancies in ICT infrastructure between headquarters and embassies hindered uniform technology adoption. Policies and guidelines were identified as facilitators, but there was a need for customized IT policies and strategies specific to the foreign ministry's operations. The lack of IT personnel at embassies and outdated equipment posed challenges, indicating a need for capacity building and equipment upgrades. Financial resources were also identified as a critical component for implementing communication technology.

5 Data Analysis from Documentation

This analysis focused on the data obtained from documentation related to the case institution's strategic plans, policies, and reports. The analysis of the documentation revealed several key points that supported our study as follows:

5.2 Ministry's Strategic Plan 2017-2022

The Ministry's strategic plan emphasizes the importance of communication and information flow in diplomacy. Strengthening communication and coordination is identified as a critical success factor. The plan recognizes the role of technology and the need to enhance skills to align with technological advancements. This resonates with the study's aim of implementing unified communication technology to optimize digital diplomacy.

5.3 Namibia's Policy on International Relations and Cooperation

Namibia's foreign policy highlights the significance of information technology and communication for effective diplomacy. The policy stresses the need to leverage technology to promote national interests, economic growth, and knowledge-based development. This aligns with the study's focus on enhancing communication technologies to support the Ministry's diplomatic goals.

5.4 Revised IT Policy for Public Service 2017

The IT policy advocates for standardization and coordination of IT services across government entities. It emphasizes effective management, governance, capacity building, information security, and procurement of IT goods and services. These components align with the guiding principles of the unified communication framework proposed in the study, ensuring proper governance, security, and technical readiness.

5.5 Draft Infrastructure Readiness Report

The infrastructure readiness assessment carried out at embassies identified the need for infrastructure upgrading, centralized administration, and information security enhancement. These findings reinforce the study's argument for implementing unified communication to address infrastructure gaps and enhance information security.

6 Findings and Interpretations

6.2 State of Digital Diplomacy in Namibia

The analysis identifies that Namibia's digital diplomacy is in its early stages, with technology adoption and implementation still at a novice level. The lack of standardized internal technology to streamline diplomatic operations, along with the absence of comprehensive integration between the Ministry of International Relations and Cooperation (MIRCO) and its embassies, suggests a need for substantial progress in digital diplomacy. The study's focus on enhancing digital diplomacy through a unified communication framework directly addresses this challenge by proposing the integration of communication technologies to improve diplomatic operations.

6.3 Information Communication Technology Infrastructure (Headquarters and Embassies)

The analysis reveals that while some communication technologies like email services are used, there is limited cyber linkage between embassies and MIRCO's headquarters. Siloed communication technology implementations hinder seamless collaboration. The proposal of unified communication aligns with this finding, as it advocates for integrating various communication tools like VoIP telephony, video conferencing, email, and instant messaging to address these connectivity and collaboration gaps.

6.4 Factors Impacting Unified Communication for Digital Diplomacy

The identified factors impacting the implementation of unified communication, such as organizational structure, culture, management support, budget constraints, technical skills, infrastructure, secrecy, privacy, and governance, align with the challenges that need to be addressed for the successful implementation of the proposed unified communication framework. The study's proposed framework takes these factors into account to establish a comprehensive strategy for overcoming these barriers and optimizing digital diplomacy.

6.5 Unified Communication Best Practices to Optimize Digital Diplomacy

The proposed best practices namely, identifying needs, evaluating risks, selecting hosting platforms, ensuring information security, disaster recovery, and training are crucial considerations for implementing unified communication effectively.

6.6 Unified Communication Network Design Concept

The proposed network design concept aligns with the study's emphasis on streamlining communication and collaboration through a unified communication platform. The network concept addresses security concerns through cryptographic algorithms and firewall protection, and it ensures that all embassies have access to a centralized communication platform. Figure 3 below is an illustration of the proposed unified communication network concept for the Ministry of International Relations and Cooperation and its respective embassies.

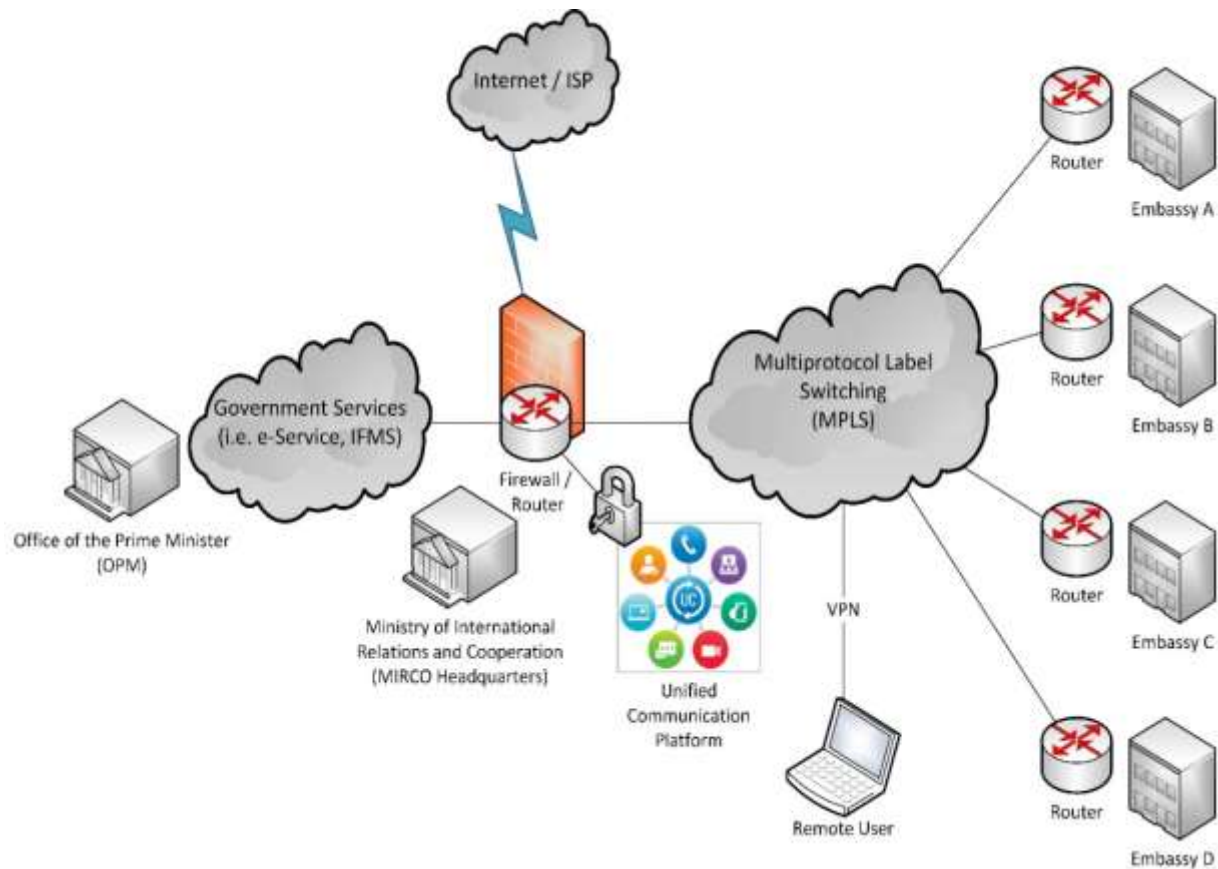


Figure 3: Unified Communication Network Concept

6.7 Unified Communication Framework (UCF)

The Unified Communication Framework (UCF) presented in the study serves as a comprehensive blueprint for optimizing digital diplomacy in Namibia. It directly responds to the identified challenges and leverages best practices to enable the successful implementation of unified communication technologies. The UCF's components, include communication, enablers and drivers. The "Communication" component emphasizes the seamless exchange of information through various channels, facilitated by communication technologies. These technologies, such as IP telephony, email, instant messaging, video conferencing, audio conferencing, file sharing, web applications and mobility; contribute to efficient communication by integrating them into a unified platform.

The "Enablers and Drivers" component highlights the essential factors necessary for the successful implementation and adoption of communication technologies. These factors include organizational structure and culture, management support, budgeting, skills and expertise, ICT infrastructure and connectivity, security (privacy), and governance policies. Fulfilling these requirements creates a conducive environment for implementing communication technologies, ultimately enabling the realization of digital diplomacy. Moreover, these prerequisites are supported by best practices like needs assessment, risk management, hosting platform selection, information security measures, disaster recovery, and training and development. These practices further enhance the effectiveness of communication technology implementation. Figure 4 illustrates the proposed Framework.

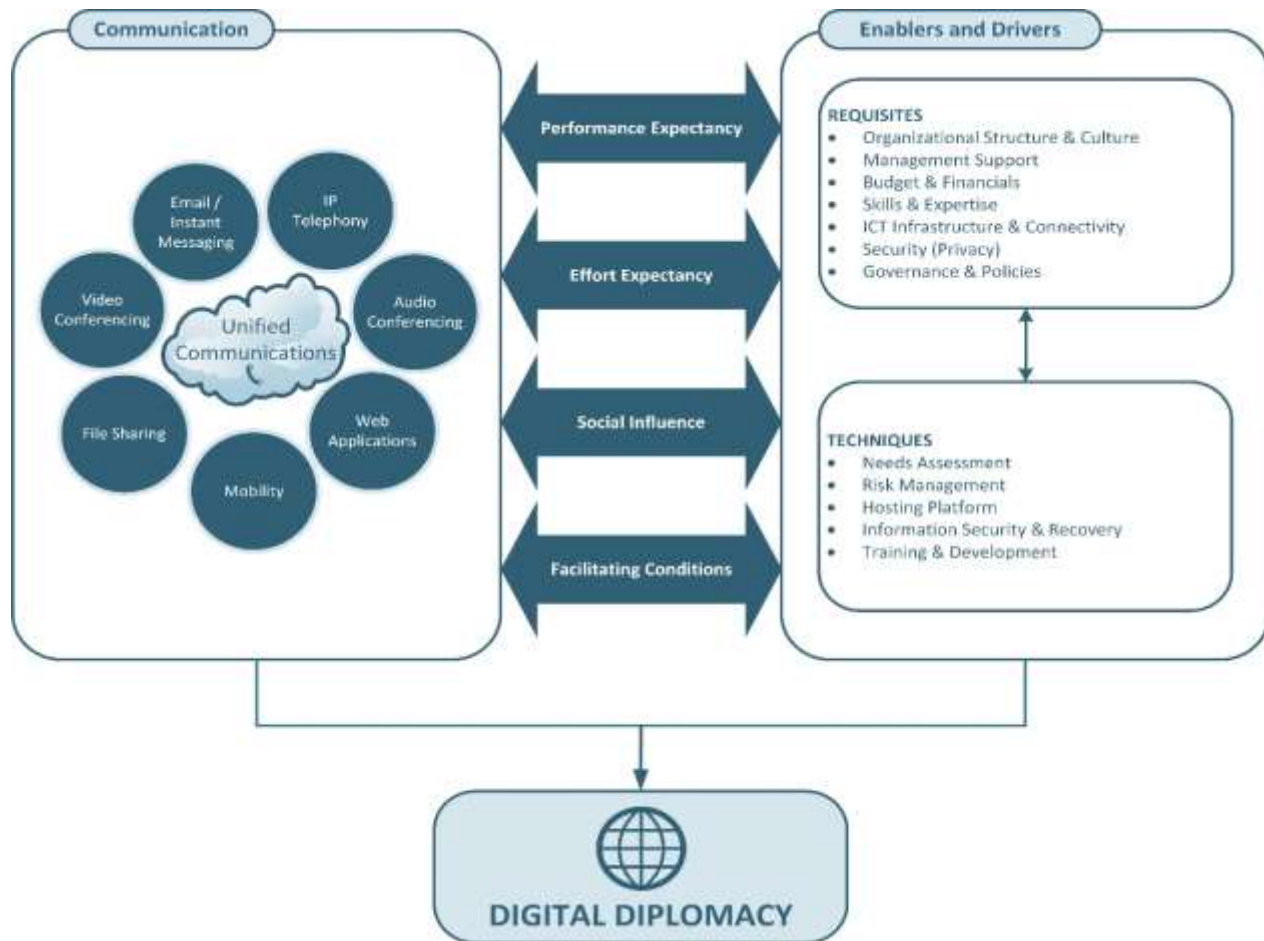


Figure 4: Unified Communication Framework (UCF)

7 Conclusion and Recommendation

In conclusion, the study extensively discussed digital diplomacy within the context of communication technology implementation and adoption. It established its foundation by reviewing the literature on diplomacy, digital diplomacy, and unified communication concepts. Employing an interpretivism paradigm and qualitative research strategy, the study employed a case study approach, using semi-structured interviews and documentation techniques for data collection. The participants were selected using purposive sampling. The UTAUT theory served as the theoretical framework, enabling a deeper understanding of socio-technical aspects in Namibia's diplomatic context. The findings and interpretations led to the creation of a Unified Communication Framework aimed at optimizing digital diplomacy in Namibia.

The study recommends the practical implementation of the Unified Communication Framework in Namibia. This implementation is suggested to validate the study findings. Further research is advised to explore the technical capabilities and limitations of the Unified Communication infrastructure, particularly concerning cross-border connectivity and data protection laws of other countries. These recommendations are expected to contribute to the existing body of knowledge and literature on digital diplomacy.

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Readiness assessment model for mobile learning in South African rural high school: A case of Limpopo province

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Abstract.

Due to the rapid advancement of mobile technology, mobile learning has become an essential part of online education. It is recognized as a valuable learning tool that allows individuals to learn anytime and anywhere using wireless and mobile devices. However, it is important to consider teachers' readiness before developing and implementing a new learning system. Despite the advantages it offers, studies on mobile learning are still limited and lack sufficient research in South African high schools, particularly in rural areas of the Limpopo Department of Basic Education. Consequently, the objective of this study is to create a model that assesses the readiness of South African high schools in the Limpopo Department of Basic Education for mobile learning. To accomplish this, the study followed a positivist paradigm and employed a quantitative approach. Questionnaires were distributed to six randomly selected schools, involving a total of 260 participants. Through thorough analysis of the collected data, the study identified several factors that contribute to the assessment model, including readiness for change, organizational readiness, teachers' readiness, perceived ease of use, perceived usefulness, facilitating conditions, technological skill readiness, and content readiness.

Keywords: Mobile Learning, Readiness, Technology devices, South African high schools

1. Introduction

The utilization of mobile devices is widespread in both urban and rural areas as a means to exchange knowledge. Mobile learning has the potential to bridge the gap in inaccessible regions where traditional learning facilities are lacking. Through mobile devices, teachers can access subject materials, tests, assignments, and past exam papers (Macgilchrist, Allert & Bruch, 2020). Mobile learning offers teachers the flexibility to learn from various locations and at any time, utilizing tools such as cell phones, podcasts, videos, and multimedia resources. There is a pressing need for research that focuses on assessing teachers' preparedness for mobile learning technologies, as highlighted by Okai-Ugbaje, Ardzejewska, and Imran (2020). Evaluating teachers' readiness for mobile learning technologies is crucial, as emphasized by Bakhsh, Mahmood, and Sangi (2020). It is imperative to examine the readiness of teachers to adopt and utilize mobile technology for teaching and learning purposes.

Interaction and communication play a crucial role in the learning process, emerging as vital factors for success (Lipponen, 2023). However, the implementation and integration of mobile learning technologies in education encounter significant technical challenges. These challenges encompass issues such as installation, availability of the latest technology, fast internet connection, uninterrupted electricity supply, maintenance, administration, security, and the lack of technical support (Toquero, 2020). In light of these concerns, this study aimed to develop an assessment of mobile learning readiness specifically for high school teachers in the rural area of Limpopo, South Africa. The study investigated teachers' attitudes towards the use of mobile devices in the classroom and how their readiness with mobile devices impacts their teaching. The Technological Readiness Index (TRI), which gauges individuals' willingness to adopt new technology to

achieve their objectives (Kampa, 2023), and the Technology Acceptance Model (TAM) are essential frameworks for comprehending teachers' mobile learning readiness (Kaushik & Agrawal, 2021). Through the preceding discussion, the primary research question emerged: What model can assist with informing the readiness for mobile learning in South African rural schools?

2. Research problem

In South African high schools, particularly in the province of Limpopo, there is a notable lack of adequate learning materials (Du Plessis & Mestry, 2019). This issue has persisted since 2012, with textbook shortages and delayed deliveries becoming recurring occurrences. As a result of these shortages and delays, many teachers have been left without teaching and learning resources, leading to significant rates of academic failure (Musitha & Mafukata, 2018). Consequently, the quality of teaching and learning in rural high schools has declined. Traditional school learning has always required students to be present in the classroom with their teachers, and time constraints may prevent some learners from engaging in study activities (Ngesi et al., 2018b). However, with the emergence of technology, a digital environment has been created where South African teachers increasingly favor the use of mobile devices as educational tools (Dempsey and Mestry, 2023)

Mobile devices are equipped with popular communication platforms such as WhatsApp, Facebook, and SMS. In South Africa, these platforms have become the primary means of communication for the youth, as most teachers utilize tablets and cell phones (Ngesi et al., 2018b). The use of mobile devices has experienced global growth. While communication and social networking have been extensively explored, the potential of mobile devices for learning in higher education remains uncertain (Du Plessis & Mestry, 2019). Kaliisa and Picard (2014) conducted a study on the mobile learning readiness of South African teachers, but Ngesi et al. (2018b) argue that there is a lack of assessment regarding mobile learning readiness. Musitha and Mafukata (2018) further suggest that educational institutions should assess their readiness to implement and adopt mobile learning, despite the numerous benefits it offers. However, this study reveals that there is currently no existing model for evaluating mobile learning readiness, which is essential for ensuring the effective deployment of mobile learning and promoting education in rural South African high schools.

3. Review of related work

According to Barreto (2018), mobile learning encompasses electronic learning and mobile computing, suggesting that teachers should support learning both at home, during leisure time, and in the classroom. Mtebe and Raisamo (2017) found mobile learning to be more efficient, versatile, and portable compared to online learning. Keengwe and Bhargava (2019) as well as Kaliisa and Picard (2017) emphasize that teachers' readiness plays a crucial role in the successful implementation of mobile learning. Mahat, Ayub, Luan, and Wong (2020) discovered that Malaysian teachers are enthusiastic about incorporating mobile learning into their practices. A study conducted in the Pacific Islands revealed that secondary school teachers demonstrate readiness and proficiency in using mobile devices for learning purposes.

Additionally, Wongkhamdi, Cooharajanone, and Khlaisang (2017) found that a majority of Thai respondents believed that mobile learning would provide them with new learning opportunities, enhance learning quality, and enable them to utilize their phones for educational purposes. A study conducted in South Africa determined that the perceived usefulness of mobile learning positively influences schoolteachers' intentions to adopt it. Shorfuzzaman et al. (2019) evaluated mobile learning among Malaysian university students and found that the students anticipated its increasing popularity. International studies have extensively examined mobile device learning and have consistently demonstrated that teachers frequently utilize mobile devices in their teaching practices. Some researchers recommend that basic education institutions provide technical support and high-quality infrastructure to facilitate the adoption of

mobile learning in schools. Mahat et al. (2020) and Mutono (2017) concur that teachers who own smartphones possess the necessary skills and willingness to utilize mobile devices for learning purposes.

3.1 Related Information System theoretical framework

The study conducted an extensive investigation to identify and establish the business needs of South African rural high schools in Limpopo province. This investigation involved a thorough examination of various factors gathered during the preliminary investigation and a comprehensive review of related literature. As a result, two related models, the Technology Readiness Index (TRI) and the Technology Acceptance Model (TAM), were selected to inform the final conceptual model of the study. The conceptual model was developed using six constructs namely, need change readiness, organizational readiness, teacher readiness, perceived ease of use, facilitating conditions, and perceived usefulness. Each of these factors was further broken down into specific variables which informed guided the survey questions.

3.2 Operationalization of the model

A research model was created using the modified framework and the proposed hypotheses (H). The following hypotheses were proposed for each of the relationships.

H1: Need change readiness will influence mobile learning readiness in South African rural high schools. A crucial component of every IT innovation within the organization is change management. Every change must be handled carefully to minimize its negative effects on the organization and its workers, especially teachers in the case of a school (Al-hunaiyyan, alhajri & al-sharhan, 2018).

H2: Organizational readiness will influence mobile learning readiness in South African rural high schools. The readiness of an organization for change influences its intention to use any new technology, (Alnoor, al-abrow, abdullah & abbas, 2020). Therefore, educational organizations need to be ready for mobile learning.

H3: Teachers' readiness will influence mobile learning readiness in South African rural high schools. Al-furaih and al-awidi (2020) mentioned that Teachers who utilize mobile devices in the class had significantly higher positive perceptions.

H4: Perceived ease of use will influence mobile learning readiness in South African rural high schools. Mobile users' perception to use mobile was influenced by perceived usefulness, perceived ease of use, and perceived usefulness (Alshurideh, al kurdi & salloum, 2019).

H5: Perceived usefulness will influence mobile learning readiness in South African rural high schools. According to Almaiah and alismaiel (2019), perceived usefulness is the subjective perspective of users in which they perceive that employing particular technologies can increase the performance of their task.

H6: Facilitating conditions will influence mobile learning readiness in South African rural high schools. The degree to which a person feels that organizational and technological infrastructure exists to facilitate the usage of a system is referred to as facilitating conditions (Mutambara & bayaga, 2021).

4. Research Methodology

The selection of the positivism paradigm was guided by the philosophical stance of the study. To address the identified gap, an objective approach was employed, utilizing deductive reasoning. Relevant literature was reviewed to identify generic factors that were associated with the study's focus. These factors were gathered and used to develop a conceptual model, which in turn guided the development of the questionnaire.

To collect data, the researchers surveyed high school teachers in Limpopo. The sample size was determined using the Krejcie and Morgan (1970) technique, which estimates the required sample size for a finite population. Respondents were randomly selected from a total estimated population size of 250 within the specified schools. According to Krejcie and Morgan (1970), a sample size of 152 was deemed adequate for the estimated population size. However, the study was able to gather data from 154 respondents, surpassing the required sample size.

5. Data analysis

A selection was made of teachers from six high schools in Limpopo province who voluntarily participated in the study. Data was collected using closed-ended questionnaires developed based on the conceptual model. The collected data were then analyzed using the Statistical Package for Social Science (SPSS). The analysis involved conducting descriptive statistics, correlation analysis, and hypothesis testing (with the use of p-values).

5.1 Descriptive statistics

The findings indicate that the average scores for all constructs were above 3, suggesting that respondents were generally divided between having a neutral stance and strongly agreeing. Notably, the Facilitation Condition (FC) exhibited the highest standard deviation, suggesting a high likelihood of success for mobile learning and indicating significant interest and readiness among participants. Analyzing the descriptive statistics of the constructs, Teachers' Readiness (TR) emerged with the highest mean score of 4.02, indicating that the majority of respondents are in agreement with the research objective and are prepared to embrace mobile learning. Organizational Readiness (OR) attained a relatively high mean of 3.6169, signifying that the organization is also prepared to support teachers in their adoption of mobile learning. On the other hand, the construct with the lowest mean was Facilitation Condition (FC), with a mean of 3.4930.

Table 1: Descriptive Statistics of Constructs

Table 1: Descriptive Statistics of constructs

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
NCR	154	1.6	5.0	3.544	.8760
ORGR	154	1.00	5.00	3.6169	.93085
TR	154	1.50	5.50	4.0260	1.03972
PEU	154	1.60	5.00	3.5834	.96189
PU	154	1.50	5.00	3.4935	.99712
FC	154	1.50	5.00	3.4930	1.05181
TMLR	154	1.86	5.08	3.6260	.71285
Valid (listwise)	N 154				

5.2 Correlations of the constructs

The correlation coefficient, which ranges from (-1.00) to (+1.00), indicates the degree of relationship between two variables. A positive value signifies a direct relationship, indicating that both variables increase or decrease simultaneously. Conversely, a negative value suggests an inverse relationship, where one variable increases while the other decreases. According to Senthilnathan (2019), when the correlation coefficient is zero, it implies no relationship between the variables, while correlations exceeding 0.80 are considered strong. The sign of the correlation coefficient denotes the direction of the relationship.

Table 2: Correlations

		NCR	ORGR	PEU	FC	PU	TR
NCR	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	154					
ORGR	Pearson Correlation	.548**	1				
	Sig. (2-tailed)	<.001					
	N	154	154				
PEU	Pearson Correlation	.398**	.336**	1			
	Sig. (2-tailed)	<.001	<.001				
	N	154	154	154			
FC	Pearson Correlation	.392**	.370**	.539**	1		
	Sig. (2-tailed)	<.001	<.001	<.001			
	N	154	154	154	154		
PU	Pearson Correlation	.451**	.371**	.451**	.544**	1	
	Sig. (2-tailed)	<.001	<.001	<.001	<.001		
	N	154	154	154	154	154	
TR	Pearson Correlation	.427**	.449**	.375**	.465**	.459**	1
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	
	N	154	154	154	154	154	154
**. Correlation is significant at the 0.01 level (2-tailed).							

The majority of correlations among the constructs were found to be statistically significant at a level of 0.01, as indicated in Table 2. Specifically, the Pearson correlation coefficient between Need Change Readiness (NCR) and Organizational Readiness (ORGR) was 0.548. Additionally, Facilitation Condition (FC) exhibited significant correlations with both Perceived Usefulness (PU) and Organizational Readiness (ORGR), with Pearson correlation coefficients of 0.392 and 0.370, respectively. The highest level of significance, at 0.575, was observed between Teachers' Readiness (TR) and Perceived Usefulness (PEU). It is important to note that all constructs demonstrated statistical significance due to their interrelated nature.

5.3 Hypothesis testing

Hypothesis testing was conducted to assess the significance and acceptance of the hypothesized relationships, as outlined in Table 3 below. The aim was to examine potential variations among the constructs within the conceptual framework, determine if one construct can predict another, evaluate the impact of proposed solutions, and identify any notable distinctions in the recommended effects. The significance (sig.) value was tested against a predetermined threshold of 0.05. If the sig. value for a variable exceeded 0.05, the corresponding hypothesis was rejected. Conversely, if the sig. value was below 0.05, the hypothesis was accepted.

Table 3: Correlations

Construct	Hypothesis	Significant value (P-value)	Comment
Need Change Readiness (NCR)	H1: Need Change Readiness (NCR1) will influence Mobile learning readiness	$P = 0.001 < 0.05$	Accepted
Organizational Readiness (ORGR)	H2: Organizational Readiness will influence Mobile learning readiness	$P = 0.001 < 0.05$	Accepted
Teachers readiness (TR)	H3: Teachers readiness (TR1) will influence Mobile learning readiness	$P = 0.002 < 0.05$	Accepted
Perceived Ease of Use (PEU)	H4: Perceived Ease of Use (PEU) will influence Mobile learning readiness	$P = 0.001 < 0.05$	Accepted
Perceived Usefulness (PU)	H5: Perceived Usefulness (PU) will influence Mobile learning readiness	$P = 0.001 < 0.05$	Accepted
Facilitating Condition (FC)	H6: Facilitating Condition (FC1) will influence Mobile learning readiness	$P = 0.059 > 0.05$	Rejected

6. Findings

H1: The readiness for change will impact the organization's readiness for mobile learning. The findings demonstrated that this hypothesis was valid and supported. The construct exhibited statistical significance with a value of <0.001 , which is <0.05 , indicating a positive influence on an organization's preparedness for mobile learning. Therefore, the hypothesis was accepted. This assertion is supported by previous research conducted by scholars such as Cameron and Green (2019) and Alqatawenah (2018), who have emphasized the significance of change management as a crucial element for the successful implementation of IT innovations within organizations.

H2: The readiness of the organization will influence the readiness for mobile learning in South African rural high schools. It is acknowledged that organizational readiness is a crucial requirement for mobile learning readiness. The success of a cloud mobile learning project relies on a well-designed mobile environment; otherwise, it is likely to fail (Narang, 2022). The analysis indicated that the construct of organizational readiness was statistically significant, with a value of $<.001$, which is <0.05 . This indicates that organizational readiness has a significant impact on the readiness for mobile learning in rural high schools in South Africa. The importance of organizational readiness as a prerequisite for mobile learning readiness is emphasized, as without a well-designed mobile environment, the success of mobile learning initiatives may be jeopardized (Narang, 2022).

H3: The readiness of teachers will positively influence the readiness for mobile learning in South African rural high schools. The hypothesis was accepted, as the construct demonstrated statistical significance. With a value of 0.002 , which is < 0.05 , it is evident that the construct has a favorable impact on teachers' readiness for mobile learning in rural high schools in South Africa. These findings align with the research conducted by Sungur-gül and Ateş (2021), Insorio (2021), and Christensen and Knezek (2018), which highlight the numerous variables that influence individuals' readiness for new IT advancements.

H4: The perceived ease of use will have a significant impact on mobile learning readiness. This hypothesis was accepted based on the research findings. The concept of perceived ease of use, which is synonymous with effort expectancy (Paledi and Alexander, 2018) or complexity (Mogase and Alexander, 2018), was found to exhibit a certain level of rigidity. The hypothesis demonstrated statistical significance, with a value of $.001$, indicating its influence on mobile learning readiness. Thus, the hypothesis was accepted, as the value of $.001 < 0.05$, highlighting the construct's significant impact on mobile learning readiness.

H5: The perceived usefulness will have a significant impact on mobile learning readiness. This hypothesis was accepted based on the construct's significance and the value of $.001$, which is < 0.05 , indicating its influence on mobile learning readiness. Almasri (2018) suggests that perceived ease of use and perceived usefulness are crucial determinants of an individual's readiness, acceptance, and usage of mobile learning. These findings reinforce the importance of perceived usefulness as a contributing factor to mobile learning readiness.

H6: The Facilitating Condition will impact Mobile learning readiness. The results of Hypothesis (H6) revealed a negative influence between facilitating conditions and Mobile learning readiness. The construct was found to be statistically insignificant, with a value of $P = 0.059 > 0.05$, indicating that the hypothesis has a negative impact on Mobile learning readiness. This finding is consistent with previous studies that have also observed a weak relationship between these factors (Hamzah, Yusoff, Ismail, & Yacob, 2020).

Based on the goal of the study which is to develop a mobile learning readiness assessment model for South African rural high schools in Limpopo province, Figure 1 below shows the final conceptual model.

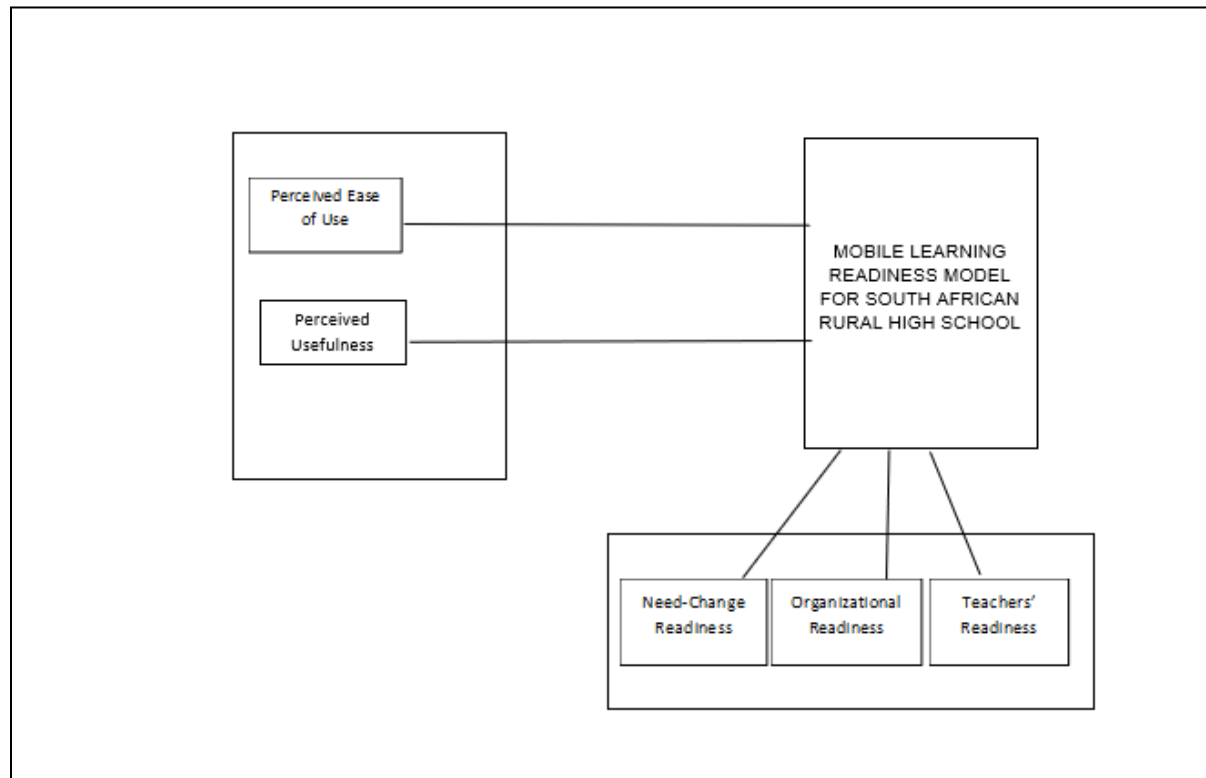


Figure 1. Research Model

7. Conclusion

The purpose of this study was to create a model that facilitates the smooth integration of mobile learning in rural schools of the Limpopo province in South Africa by identifying the factors that influence readiness. The developed conceptual model can serve as guidance for informing authorities about the readiness of teachers for mobile learning. This research adds to the existing body of knowledge on mobile learning, and future researchers can utilize this study as a basis for investigating the factors that impact teachers' readiness for mobile learning.

This study aimed to evaluate the readiness of high school teachers, particularly those in rural areas, to adopt mobile learning. The research was conducted specifically in the rural schools of the Vhembe district in Limpopo, as teachers in these schools face disadvantages. The objective was to assess the mobile learning readiness of the teachers, which was accomplished by distributing questionnaires to educators in the selected schools. The accuracy of the gathered data relied on the participants' honesty in responding to the questions. Hence, the study suggests that the developed model should be validated using different scientific approaches to further establish its applicability within the research domain.

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Unveiling the Disparity: Investigating Factors Impacting Graduation Rates in Science Degrees and Predicting Student Success through Machine Learning

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Abstract.

Drawing on statistics gathered by the Council of Higher Education (CHE), a noteworthy observation has emerged, revealing an incongruity between the increased rate of admissions to science degrees and the corresponding rate of graduates from such programs. Extensive research has delved into the exploration of underlying causes for this phenomenon, encompassing the examination of familial and peer influences, the roles of educational institutions and educators, as well as individuals' inclination towards science. This study endeavors to harness the potential of machine learning techniques to construct a system capable of identifying the most influential aspects of a student's life—namely their Science Identity, background factors, and schooling experience—while also predicting their academic success, as indicated by their performance (pass or fail) outcomes. The obtained results will be of binary classification nature, differentiating between students who have passed or failed based on the potential influential factors outlined in previous research. These findings aim to substantiate the effectiveness, reliability, and robustness of employing a combination of statistical and computational methodologies, particularly machine learning, to predict first-year university students' success in pursuing a biological science degree.

Keywords: Science degrees, Graduation rates, Science identity, Machine learning techniques, Student success prediction

1. Introduction

Research has shown that student retention and throughput in the Science faculty at a South African university are not increasing at the same rate as the number of students admitted to science-related courses (according to statistics produced by the Council on Higher Education (CHE) at <https://www.che.ac.za/publications/vital-stats>). Various factors influence a student's academic success, including career path knowledge, interest in their field of study, and external factors such as culture, religion, gender, and social class (Eisenberg et al., 2009; Zajacova & Hummer, 2009).

While research has been conducted on this topic from various angles, this study aims to examine the issue through the lens of Science Identity, exploring the factors contributing to its development and the extent to which it influences students' academic performance at the university level.

This study seeks to answer the following question: To what extent do students who are certain about their career choice in science perform better in their first year compared to students who are unsure about their career path? By addressing this question, we hope to gain insights into the reasons behind the lower graduation rates in Biological Sciences compared to the number of students entering the program. This understanding could shed light on the various factors influencing student performance

in biological sciences, the formation of Science Identity, and provide insights into how career guidance can help mitigate attrition during undergraduate years in biology.

This research aims to investigate how factors such as familial support, peer influence, schooling background, university experiences, and knowledge of biology-related careers impact the development of Science Identity (Chen et al., 2021), and to determine the extent to which each of these influences affects students' academic performance. Bayesian Networks, probabilistic models representing the conditional dependencies of random variables as graphical models, combined with machine learning algorithms such as Bayesian estimation and maximum likelihood estimation, will be used to perform factor analysis in the model.

The study will utilize a dataset obtained from a survey conducted on 130 first-year biology students in 2019, which will be modeled using a Bayesian Network. Six different models will be used to predict student success, and their performances will be compared. Analysis of each model will be carried out to determine which features have the greatest influence on students' academic success in their first year of a biological science degree. Student profiles, consisting of influences that affect Science Identity as outlined in the literature, will be used for training and testing purposes.

This research aims to provide a robust system capable of analyzing students' backgrounds and aspects of their Science Identity to predict their academic success at the university level. By doing so, it contributes to our understanding of the problem and offers a potential new approach to seeking solutions to mitigate the observed low graduation rates.

2. Related Work

This section presents a literature review of prior research on identity formation, Science Identity, and developed prediction models. It aims to provide a baseline understanding of the topic and gain insight into the contributions already made to the body of knowledge in this area, particularly those relevant to this research.

- ***Identity Formation***

Research has conceptualized the idea of identity formation. For instance, Eccles (Eccles, 2009) proposes a social cognitive model that evaluates social and motivational factors influencing achievements and behaviors, including career aspirations. This model allows for predictions regarding individuals' behaviors based on their personal and collective identities. The choices individuals make and the value they assign to those decisions are influenced by various factors contributing to the development of Science identity.

It also argues that identities consist of three components: a value component, which reflects the importance and attractiveness a person associates with the characteristics of a particular group; a content component, encompassing beliefs about the tasks, activities, and goals associated with successful action; and an expectancy component, which pertains to a person's belief in their capacity to perform those tasks, activities, and goals. These components interact with each other throughout an individual's lifetime, influencing their behavioral choices through various experiences. The author also highlights how different identities and beliefs shape development, using gender as an example and illustrating their impact on the choices and motivations of women and girls in educational settings.

- **Science Identity**

The concept of Science Identity and its development significantly contributes to students' success in science-related fields, both at the university and schooling levels. Science identity encompasses students' sense of who they are, their beliefs about their capabilities, and their aspirations related to science (Brickhouse, 2001). A comprehensive study (K. A. Robinson et al., 2018) examined the development of science identity during university and its role as a predictor of success in science-related careers. The study found a correlation between the initial value of science identity and its exploration during university, highlighting the importance of stability in science identity and the potential negative impact of compromising its well-being (e.g., consistently receiving poor grades in science). The research aimed to answer various research questions, one of which is relevant to this project: Can science identity trajectories predict science career outcomes after university? The study collected data from participants during their first year and continued annually until graduation.

The analysis involved fitting growth mixture models, utilizing descriptive statistics, and examining the resulting trajectory plots. The results revealed that differential trajectories predicted the pursuit of science-related careers. Students characterized by a high or moderate science identity tended to maintain their identity throughout the study period. However, the study also identified that university was a potentially transformative period for students with initially low science identity. It demonstrated that science identity serves as a strong predictor of students' choices and provided valuable insights into the factors influencing and supporting students' trajectories towards careers in science (K. Robinson et al., 2018).

In a study investigating science identity during university (DeWitt et al., 2013), three latent classes were identified: *High with Transitory Incline*, reflecting high science identity with slight fluctuations over the four years of college; *Moderate-High and Stable*, representing a consistently high science identity throughout the four-year degree; and *Moderate-Low and Early Decline*, indicating relatively low science identity in the first year followed by a decline in the remaining years. The study found distinct trajectories of science identity among students within these latent classes, which were related to career outcomes, first-year competence and responsibility, gender, and race/ethnicity. The findings highlight the potential need for science identity development prior to college and the importance of supporting and maintaining high science identity throughout the four-year degree. Declines in science identity observed among minority students could be mitigated through support provided by academic institutions, either during the first year or prior to college, to enhance their belief in their ability to develop and maintain high science identity. The study emphasizes that becoming a scientist involves more than just acquiring skills and knowledge; it also requires a belief in one's capability to be a scientist and achieve goals.

Factors outside the educational realm also significantly contribute to the development of science identity. A study examining students' interest in science (Vincent-Ruz & Schunn, 2018) reveals the influence of gender, social class, and ethnicity on young learners' attitudes toward science. Surveys showed that learners may possess a positive attitude toward science but lack interest in the idea of becoming a scientist. This highlights the need to foster a broader perception of science and scientists among primary school students, involving educators, researchers, and other stakeholders. Gender, ethnicity, and social class had minimal overall influence, suggesting that improving science aspirations for specific groups may be less effective than targeted improvement that considers a wider range of characteristics and attitudes. Interviews with students and their parents revealed that while positive attitudes toward science do not always translate into aspirations in science, a positive foundation for engaging with science exists. Approximately 17% of respondents expressed agreement with the idea

of being a scientist, while 29% displayed interest in a "job using science." This raises questions about the optimal age for educational intervention and the most effective approaches to engaging students in science-related work. The research conducted does not provide the proportion of students who could potentially develop a stronger, more positive attitude toward science after primary school.

- **Data Mining and Prediction Models**

The use of machine learning techniques in predicting student success is not uncommon. Various approaches have been employed to examine different aspects of student success. Some studies focused on analyzing high school performance and utilizing predictive models to determine success, comparing it with the Admission Points Score (APS) and its correlation with student success (Abed et al., 2020). Important factors and attributes were selected based on Tinto's framework (1975), which categorizes characteristics into three groups: *Background*, *Individual*, and *Pre-College/Schooling*. Models such as Naive Bayes, Logistic Regression, and Multilayer Perceptrons were used. The Multilayer Perceptron model achieved the lowest prediction accuracy of 67.74%, while the Naive Bayes Model had the highest prediction accuracy of 69.18%.

Others have utilized machine learning techniques to explore socioeconomic factors and psycho-social factors that influence student success, not only in a specific year but throughout a three-year degree program. Models such as C4.5 Decision Trees, Random Forests, and Sequential Minimal Optimization were employed to predict student performance in advance (Ndou et al., 2020). In this study, the Random Forests model demonstrated the highest predictive accuracy, achieving at least 93

As demonstrated, there is a multitude of algorithms available for predicting student success, each with its own advantages and disadvantages. Their utilization allows for performance benchmarking and facilitates comparisons with other techniques employed in the development of this system.

3. Methodology

This research aims to develop a system that examines Science Identity, background factors, and schooling experience to predict students' success or failure in a biology science degree. This section discusses the data used, how it was engineered to suit the intended purpose, the implemented models, and the resulting outcomes. The implementation of this research can be found in the GitHub repository accessible at <https://github.com/moeGathoo/ResearchProject>.

- **Data**

The dataset utilized in this study is a synthetic dataset generated through a Bayesian Network with a known ground truth distribution. The original data was collected from a survey conducted among 129 first-year students aged between 18 and 21. Categorical encoding was applied to nominal and ordinal data to ensure ease of use and compatibility with the selected models.

Several features in the dataset employ a 4-point Likert scale, allowing individuals to express their agreement or disagreement with specific statements (1 = Strongly Agree, 2 = Agree, 3 = Disagree, 4 = Strongly Disagree).

Due to the confidential nature of the data, Ethics Clearance was obtained from the WITS University Human Research Ethics Committee (Non-Medical). The Ethics Clearance Protocol Number CSAM-2002-06W, overseen by Chairperson Dr. Helen Sarah Robertson, provides proof of clearance.

- **Pre-processing and Feature Engineering**

The dataset includes features encompassing eight aspects of a student's life: General Biographical Data, Family Support and Background, School Background and Experience, Peer Role, Self Reflection, and Grades.

Feature categories such as General Biographical Data, Family Support, and School Experience offer a wide range of answers and thus employ integer encoding. Other feature categories, including Family and School Background, Peer Role, and Self Reflection, are assessed using the Likert scale, with integer encoding assigned to each level of the 4-point scale.

The target variable in this study is the final outcome of a student, indicating whether they have passed or failed. The target variable has two possible values: *Passed*, which indicates that a student obtained an end-of-year mark of 50

To address the data imbalance issue, over-sampling was performed due to a limited number of students who completed the survey, resulting in multiple entries per student for features such as School Experience.

- **Models**

Six machine learning predictive models were employed in this study to predict the target variable: Naïve Bayes Classifier, Generalized Linear Model, Deep Neural Network (DNN), Multilayer Perceptron (MLP), Random Forests, and Sequential Minimal Optimization (SMO).

The DNN and MLP share a similar implementation, as they both utilize a neural network structure (input/output and hidden layers, activation functions, weights, and biases). However, they differ in the number and size of hidden layers, which affects the training times of the respective models. The DNN will make use of the ReLU (Rectified Linear Unit) activation function,

$$R(z) = \max\{0, z\} \quad (1)$$

and the MLP will make use of the sigmoid activation,

$$F(z) = \frac{1}{1 + e^{-z}} \quad (2)$$

where z is the sum of the product of each input x_i and their weight w_i for $i \in \{0, \dots, n\}$ ($z = \sum_{i=1}^n x_i w_i$).

- **Evaluation, Performance and Accuracy**

Model effectiveness will be evaluated using the k -fold cross-validation procedure, a resampling technique commonly employed to assess machine learning models. This procedure involves randomly dividing the data into training and testing subsets. The training dataset is then further partitioned into k folds (partitions) where $k-1$ folds are used to train the model while the remaining k -th fold is used for validation. This process is repeated until all folds have been used at least once for validation. 10 folds will be used for this study. Confusion matrices are valuable tools for visualizing the performance of classification algorithms. Since the target variable consists of two distinct classes, the confusion matrix will have dimensions of 2×2 .

The confusion matrix allows us to extract important metrics regarding the performance of our models, particularly *Precision* (total positive outcomes), *Recall* (total correctly predicted outcomes from positive class), and *Accuracy* (total correct predictions).

$$Precision = \frac{TP}{TP + FP} \quad (3)$$

$$Recall = \frac{TP}{TP + FN} \quad (4)$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (5)$$

Using the results of Precision and Recall, we can also calculate another metric known as F-measure (or F-score), a measure the accuracy of the test factoring in Precision and Recall into a single score. F-measure is calculated as follows:

$$F - measure = \frac{2 \times Recall \times Precision}{Recall + Precision} \quad (6)$$

4. Results

- **Model Accuracies**

Table II shows the prediction accuracy of each of the six models implemented, as calculated according to equation (5).

Table 1: Model Accuracy Of Target Variable Prediction

Model Name	Accuracy &
Naïve Bayes	86.23
Deep Neural Network	84.49
Generalized Linear Model	82.82
Multilayer Perceptron	82.02
Sequential Minimal Optimization	81.47
Random Forests	80.55

Using 10-fold cross-validation as a means to validate the accuracy of the models, the results shown in Table II demonstrate that all implemented models achieved an accuracy of at least 80

Here are the performance metrics for each model:

- *Naïve Bayes*: This model achieved a precision score of 0.96 and a recall score of 0.84, resulting in an F-measure of 0.896.
- *Deep Neural Network*: This model achieved a precision score of 0.82 and a recall score of 0.84, resulting in an F-measure of 0.840.

- *Generalized Linear Model*: This model obtained a precision score of 0.81 and a recall score of 0.84, resulting in an F-measure of 0.823.
- *Multilayer Perceptron*: This model obtained a precision score of 0.83 and a recall score of 0.79, resulting in an F-measure of 0.809.
- *Sequential Minimal Optimization*: This model attained a precision score of 0.82 and a recall score of 0.79, resulting in an F-measure of 0.804.
- *Random Forests*: This model attained a precision score of 0.80 and a recall score of 0.80, resulting in an F-measure of 0.802.

It is evident that the F-measure scores for all models are consistent with the accuracy values shown in Table II, with all models achieving an F-measure score above 0.8. The exceptional performance of Naïve Bayes can be attributed to its naive conditional dependence assumption of the features being used. On the other hand, the relatively lower performance of Random Forests compared to other models may be due to the model potentially favoring suboptimal variables as a result of artificially biased predictor variables (Strobl et al., 2007).

Feature Importance

Having presented the performance of each model implemented using various metrics, next is the importance of each feature in the prediction of the target variable. Feature importance is measured using "permutation accuracy importance", calculated by the permutation of a predictor variable X_j while leaving the remaining predictor variables unpermuted, and predicting new a response $\hat{Y}$. The measure for the predictor variable's importance will, therefore, be the difference in prediction accuracy before and after permutating X_j .

Table III shows the importance of the features used in the dataset, however, there are 3 key things to make note of: 1. The table describes the 16 most important features with an importance > 0.01 . Features less than were omitted from the table; 2. Feature importance was calculated after data processing and feature engineering, meaning some fields that were deemed unimportant were left out of the calculation; and 3. Some features had direct follow-up features that were meant to elaborate some of the data provided, these were not mentioned in Table III as well.

5. Discussion and Limitations

The experiments presented above demonstrates the use of machine learning techniques to predict the success of a student based on factors of their life that could influence their performance in university during a first year biology degree.

Six models were implemented and made use of a synthetic dataset for the task of prediction. After 10-fold cross validation, all six models were Table 3: Feature Importance

Feature	Importance
People in my family are interested in science	0.154557
My family is interested in the science course that I take	0.131367
My friends do not like science	0.070677
I do not enjoy visiting science museums and science centres	0.057664
My family has encouraged me to study science	0.048199
Level of support from your family from your studies this year	0.041990
Study/Learning approach used at university	0.031062
I prefer science class than visiting museums and centres	0.030580
My friends view science as nerdy	0.024443
My friends do not like to view science programs on tv	0.020101
My science teachers were enthusiastic about science	0.019831
My science teachers made science interesting	0.017685
My teachers encouraged me to do my best	0.015634
Visiting science museums and exhibits makes me want to learn more about the science topic	0.014831
My science teachers encouraged me to learn more about science	0.013615
My family is enthusiastic about a science career for me	0.011686

Table 4:

Feature Importance Determined using Permutation Accuracy (see (Strobl et al., 2007)).

successful in achieving a minimum accuracy of 80% as calculated according to equation (5). The Naïve Bayes model proved to be the most accurate of all six implemented models, obtaining an accuracy 1.84% higher than the second most accurate model, the Deep Neural Network. The weakest performing model was found to be the Random Forests model, having an accuracy measure 5.78% less than the Naïve Bayes model accuracy.

Revisiting the confusion matrices, some observations to note is that True Negative classes were predicted more often than True Positive classes. Naïve Bayes showed to have a more varied difference between false predictions, predicting far more false negatives than false positives, overall predicting more negative labels for the dataset. This could be due to an artificial bias skewing the results, favouring

some features over others. The rest of the models showed to have a more even distribution of false label predictions.

Having mentioned the similarities between the Multilayer Perceptron and the Deep Neural Network, their performance shows to be rather similar, with the Deep Neural Network having a higher accuracy due to a deeper structural implementation (more hidden layers with more nodes per layer). As mentioned previously, the MLP made use of the sigmoid activation function, the DNN made use of the ReLU (Rectifier Linear Units) activation function. While the DNN obtained a higher accuracy, it had taken a longer time to train as a result of its deeper structure, resulting in a trade-off between training time and prediction accuracy, despite ReLU activation function having shorter convergence time compared to the sigmoid activation function.

The importance of each feature representing some aspect of a student's life was determined using a Random Forests permutated accuracy importance to measure the importance of each feature in the prediction of the target variable. Table III shows that aspects regarding family and peer attitudes towards science proved to be of great influence on a student's performance, specifically interest in science as well as support for the student's pursuit of science. Educational figures such as teachers proved to be of less importance by comparison, as well as personal initiative to take part in science related activities.

Although we have achieved a high accuracy rate, there still exists limitations that hold back the potential of this study. Synthetic data does not always accurately represent real world events and observation, making it difficult to replicate them in theoretical scenarios. This may lead to the skewing of results obtained and, as a result, the employment of these models in the real world.

6. Conclusion and Future Work

The research presented in this study aimed to address the low graduation rates observed in biology science degrees by employing machine learning techniques and examining various aspects of a student's life that could influence their academic success during the first year of their degree. Six different models were implemented and evaluated using 10-fold cross-validation, achieving a minimum accuracy of 80%. The Naïve Bayes model demonstrated the highest accuracy among the implemented models, while the Random Forests model performed comparatively weaker.

The analysis of confusion matrices revealed a tendency to predict more true negative classes than true positive classes, indicating a potential bias in the predictions. The importance analysis of features using permutation accuracy importance highlighted the significance of family and peer attitudes towards science in predicting student performance, while the role of educational figures and personal initiative showed less importance.

Despite achieving high accuracy rates, it is important to acknowledge the limitations of this study. The use of synthetic data may not fully capture real-world complexities and may impact the generalizability of the models. Therefore, further research is needed to validate the findings using real-world data and explore the applicability of the models in practical scenarios.

In conclusion, this research provides a technical perspective on the low graduation rates observed in biology science degrees by investigating the role of Science Identity and other influential factors. It contributes to our understanding of the key areas in a student's life that can impact their academic success and offers insights for developing potential solutions to improve graduation rates.

Future work in this area could involve extending the prediction models to estimate student grades rather than a binary classification. It could also explore the inclusion of multiple entries per feature in a single data point to enhance accuracy. Additionally, more advanced and robust models could be implemented to further improve prediction accuracy. This research can be extended to other disciplines beyond biology and can contribute to addressing graduation challenges in various academic fields.

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Paraphrase Generation Model Using Transformer Based Architecture

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Abstract

In natural language processing (NLP), activities like identification and paraphrasing are crucial. In natural language processing, changing a text's style while maintaining its semantics is a computationally challenging operation that takes sentiment analysis into account. If a high degree of semantic similarity, potential grammatical faults, and sentence structure are not taken into consideration, the process of creating a paraphrase may inadvertently change the original meaning or intention of the text. Sentence diversity is increased through paraphrasing, which enhances the effectiveness of NLP tasks like question-answering and machine translation. Using particular NLP criteria, semantic similarity or relationship measures how similar words, phrases, and paragraphs are to one another conceptually and in terms of meaning. The difficulty lies in determining text similarity; whereas highly resourced languages have made significant strides, low-resource languages are lagging behind. One of the main obstacles to advancement in this field is the absence of inclusive datasets in the Sepedi language. Paraphrasing generation for Sepedi with transformer-based architecture models is investigated in this study. Using transformer architecture, the research creates a paraphrase artificial intelligence bot that modifies sentences by adding new words and sentence structures while maintaining the original semantics. Text extracts compiled from several datasets available at South African Digital Languages Resources (SADiLaR) comprise the Sepedi paraphrasing corpus. The sentences are translated both ways, from Sepedi to English. Metric assessments and human evaluations show that the transformer-based architecture experiment performs better than baseline models. BLEU and ROUGE are used to assess the model output's performance and calculate the accuracy provided.

Keywords: Natural Language Processing, Paraphrasing, Semantic Similarity

1. Introduction

Paraphrasing express the meaning of a written expression to gain better knowledge without changing the meaning of the content (P. N. Singh & Behera, 2022). Paraphrasing can be used as an oversampling technique to generate more data for marginal classes or low resourced morphologically rich languages which can be time consuming if not automated (Patil et al., 2022). Paraphrase generation and detection are essential tasks in natural language processing (NLP), however, lack of inclusive datasets in the indigenous South African languages serve as a barrier to development. Paraphrasing involves altering the style of a text while maintaining the semantics, it is a measure that investigates semantic similarity between words, sentence and documents; furthermore, paraphrase generation involves a task of creating a similar structural different sentence without losing the semantics (Casas et al., 2021)(Ghasemi & Keyvanrad, 2021)(Bagci & Amasyali, 2021).

Transformer based language model architectures gives better performance and are becoming exceptionally dominant, outperforming traditional CNN and RNN algorithms on many NLP tasks (Li et al., 2020)(Casas et al., 2021). PEGASUS employs encoder-decoder transformer architecture for seq2seq learning (Mathur & Suchithra, 2022). PEGASUS masks several sentences instead of smaller continuous text spans, further, it does

not reconstruct full input sentences, but only create masked sentences as a single output sequence (Zhang et al., 2020).

Bidirectional Abstractive Representation from Transformers (BART) works with arbitrary noising function from corrupted text and learn to rebuild the original text (Zhang et al., 2020). Text-to-Text Transfer Transformer (T5) is a sequence to sequence model that employs transfer learning (Widjaja et al., 2022). T5 accept input text as a sentence and provide paraphrased text as an output sentence, further it has an ability to make use of WordNet corpus to extract synonyms and antonyms to paraphrase text input (Patil et al., 2022).

BERT which is a transformer based language model and auto-encoding and XLNET requires more computational resources, time, bandwidth and substantial operations during inference and training (Li et al., 2020). BERT is a neural language based model that permit human-like text paraphrasing, which threatens academic integrity (Wahle et al., 2021).

Generative Pre-Trained Transformer 2(GPT-2) is a successor to GPT, and is termed to be the core of large transformer-based language modelling that can predict the word given a sequence of preceding words (Nguyen, 2021). GPT-2 have a restriction on context size with 1024 tokens respectively to make it more computationally-efficient (R. K. Singh, 2023). GPT/GPT-2 is a different type of the transformer model which has decoder part only for the transformer architecture, that uses multi-head masked-self attention and process tokens in parallel, and the model is represented using the equation (Radford et al., 2018)(R. K. Singh, 2023):

$$\begin{aligned} h_0 &= UW_e + W_p \\ h_i &= \text{transformer}_{block}(h_i) \forall i \in [1, n], \\ P(u) &= \text{softmax}(h_n W_e^T) \end{aligned} \quad (1)$$

Where a context vector of tokens is represented by $U = (u_{-k}, \dots, u_{-1})$, n is the number of layers, W_e is the token embedding matrix, and W_p represent position embedding matrix.

GPT-3 model has ability to produce human-like text which raises concerns in the plagiarism detection community (Wahle et al., 2021). Large language models such as GPT-2, BERT, etc. implement encoder-decoder structure of the transformer architecture which are able to paraphrase text beyond the individual sentence-level, which maybe a full paragraph at a time (Witteveen & Andrews, 2019).

This paper outline proceeds with introduction of paraphrase generation in relation to Sepedi indigenous morphologically low resourced South African language. The second phase discuss related literature review and solutions that exists for paraphrase generation, how they have been applied and the existing approaches to transformer-based architectures. Discussion on the research methodology follows the description of the experiment performed and presentation of the research results. Lastly the discussion and conclusions.

2. Related Literature

Due to lack of large parallel paraphrase datasets for Turkish language, the researchers (Bagci & Amasyali, 2021) first created several datasets and employed BERT2BERT, MT5-Base, MBart and MT5-Small transformer architectures for paraphrase generations. Furthermore, BLEU metrics score evaluation was used as well as

the human evaluation factor, which found BERT2BERT outperformed other transformer methods. The researchers (Patil et al., 2022) recommended oversampling technique which use a blend of T5 Transformer and WordNet corpus to balance the imbalanced datasets which present challenges for paraphrasing due to lack of sufficient data. Text-to-Text Transfer Transformer (T5) and Back-Translation guided multi-round Paraphrase Generation (BTmPG) are prevalent algorithms for paraphrase generation models (Widjaja et al., 2022).

The researchers (Casas et al., 2021) fine-tuned a GPT-2 model to develop a system capable of transferring emotion into a paraphrase. The BLEU, METEOR and TER evaluation metrics were used to evaluate the paraphrasing features of the developed system. The developed system was able to generate emotion paraphrasing with some grade of success, however failed to perform state-of-the-art models in paraphrasing-related metrics. The researchers (Nguyen et al., 2021) advanced quality of text paraphrasing and task-adaptive pretraining through application of GPT-2 mode.

Computational inference of BERT and XLNet was compared using Microsoft Research Paraphrase Corpus (MPRC) by the researchers (Li et al., 2020), both models exhibit similar computational characteristics, although XLNet preceded with a better benchmark score. BERT, RoBERTa, and LongFormer transformer-based models were used for paraphrase detection on large-scale documents from scientific papers on arXiv, theses, and Wikipedia articles (Wahle et al., 2021).

Google's research institute introduced PEGASUS model which expands Pre-training with Extracted Gap-sentences for Abstractive Summarization that is able to paraphrase text or a sentence using seq2seq transformer models. Without using the back translation process (Imoh, 2023).

3 Research Methodology

Problem formulation: Given an input text $S = \{s_1, s_2, \dots, s_j\}$ where S denotes a sentence and D denotes the description for paraphrase generation, where $D = \{d_1, d_2, \dots, d_j\}$ respectively. The research use equation (2) to factorize the joint probability of the output sequence, with assumption of the input sequence based on equation (2) (Nguyen, 2021):

$$P_{\theta}(D|S) = \prod_{i=1}^D P_{\theta}(S_i|S_{<i}, D) \quad (2)$$

Into the product of probabilities that implement each factor with function approximations such as transformers and deep neural network model. The intention is to generate paraphrasing based on an input sentence. The research further implement $P_{\theta}(S_i|S_{<i}, D)$ factors in equation (2) with transformer-based function approximators.

The research employs a language model in equation (3) which is a probabilistic model that forecasts the next token in a sequence given preceding tokens, which learns probability of the occurrence of an input sentence based on the text seen during training (R. K. Singh, 2023):

$$P(w_1^T) = P(w_t|w_1^{t-1}) \quad (3)$$

Where w_t is the t^{th} token with sub-sequences $w_i^j = (w_i, \dots, w_j)$

Equation (3) is a statistical language model representing conditional probabilities of the word given all the previous words, and has been found important in natural language processing technology.

The experiment implements the following transformer architectures BART, PEGASUS transformer, T5-Paraphrase-PAWS and Parrot with erratically designated input sentences from SADiLaR assembled Sepedi Paraphrase Corpus with no matching paraphrase to use as the conditional input to the model as shown in the flowchart diagram in figure 1.

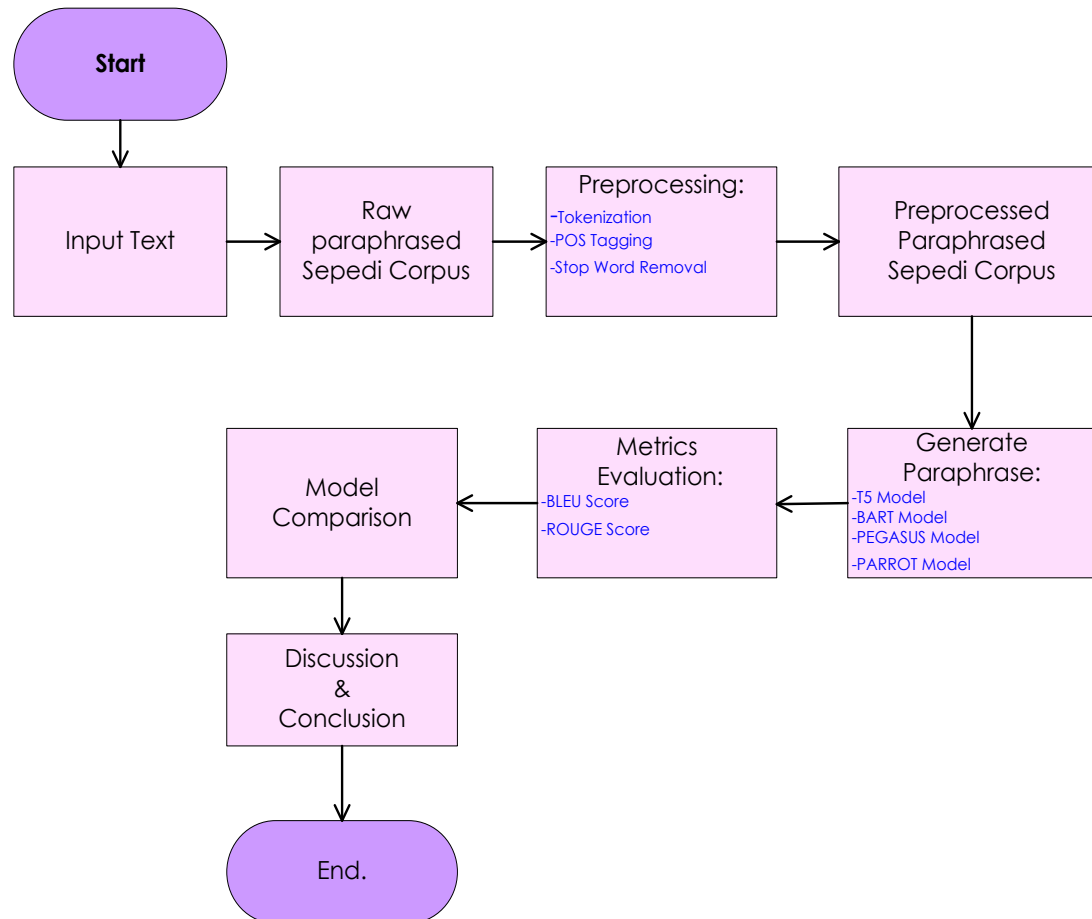


Figure 3: Paraphrase Generation Methodology Flowchart

4. Experiments

Experiments were conducted using a reduced-size parameters with a smaller batch size datasets before scaling up pre-training, datasets (SADiLaR assembled Sepedi Paraphrase Corpus) were chosen for diversity in abstractiveness, writing style, and size. The length of the sentence ranged between 4 and 20 words with an average sentences of 8 words. The corpus is assembled from SADiLaR Sepedi datasets with 3 000 sentences. The dataset was preprocessed removing stop words, characters such as question mark,

exclamation mark, commas, etc. from the sentences, as indicated in figure 1. The researchers created a CSV file with two columns after preprocessing with source and paraphrased sentences.

In order to generate paraphrases with identified models in figure 1, the source sentence is tokenized during preprocessing and converted to vector and embedded to extract features of each word and transferred to the decoder, which recreate the sentence as a label. The vectors of the input text are added to the decoder and mapped through paraphrased sentences. The models build encoder-decoder system with the ability to generate paraphrased sentences. The paraphrase generator models are executed using python programming language using NLTK tool which gives inbuilt packages to perform NLP operations.

The research adopted two features named text style and text expression which are the building blocks for creating paraphrase corpus and generating paraphrases without changing semantic expression, but with the style of the text different.(Song & Wang, 2020). Table I shows some paraphrase generation.

Table 1: SADiLaR assembled SEPEDI Paraphrase Corpus sentence pairs

Source Sentence in Sepedi	Paraphrase Sentence
Kgopelo ya gago e tla ditelega ge o ka se romele ditokomane ka moka tšeo di hlokegago	Ge eba ao romele ditokomane ka moka ka nako, kgepelo ya gago etla emišiwa
Netefatša gore o tsenyeletša le ditokomane ka moka tšeo di hlokegago	Kgonthiša gore o akaretša ka moka yeo e nyakegago
Ke a dumela gore ke tla ithuta melawana ya setlamo se	Ke dumela gore ke tla ithuta go ya ka melawana ya mokgatlo wo
Afitafiti yeo go ikannwego go bontšha tlhokego ya thekgo ya tša ditšhelete ya molekani go leloko.	Afidabiti gore a ye go bontšha moemedi wa go thekga ka mašelang go ba lapa la gago.
Tšea foromo ya pegelo ya tekolo ya tša kalafi o ye le yona ngakeng ya gago	Tšea tša kalafo le pego ya kelo ya gago oye go ngaka ya gago

5. Evaluation Metrics

The research evaluates performance of the NLP transformer models through a quantitative metrics to measure the quality of its predictions. Bilingual Evaluation Understudy (BLEU) is a precision-based measure (Lin & Rey, 2004), is one of the popular frequently used algorithm for metrics quality evaluation of text, based on the idea that the closer the predicted sentence is to human-generated target sentence. To compute BLEU score, first the research needs to compute Geometric Average Precision (N), using equation (4) (Doshi, 2021):

$$\begin{aligned}
 \text{Geometric Average Precision } (N) &= \exp\left(\sum_{i=1}^N w_i \log p_i\right) \\
 &= \prod_i^N p_i^{w_i}
 \end{aligned} \tag{4}$$

And compute Brevity Penalty (BP), as an offset to penalize short sentences, using equation (5):

$$\text{Brevity Penalty} = \begin{cases} 1, & \text{if } c > r \\ e^{(1-r/c)}, & \text{if } c \leq r \end{cases} \tag{5}$$

Where Brevity Penalty cannot be greater than the value 1.

Finally, we compute BLEU score, by multiplying equation (4) and (5), in equation (6) :

$$\text{BLEU } (N) = \prod_i^N p_i^{w_i} * \text{BP} \tag{6}$$

Where N is a maximum number of n-grams, w_i weight for each precision, and p_i for modified precision.

Additionally, one of the ensemble evaluation metrics, is Recall-Oriented Understudy for Gisting Evaluation (ROUGE) which is a recall-related measure. ROUGE measures the number of overlapping units such-as n-gram for evaluation (Lin & Rey, 2004). Equation (7) shows how ROUGE-N is computed for an n-gram between candidate summary text and a set of reference summary text (Lin & Rey, 2004), as per the formula:

$$\text{ROUGE} - N = \frac{\sum_{S \in \{\text{CandidateSummary}\}} \sum_{n\text{-gram} \in S} \text{Count}_{\text{match}}(n\text{-gram})}{\sum_{S \in \{\text{ReferenceSummaries}\}} \sum_{n\text{-gram}} \text{Count}(n\text{-gram})} \tag{7}$$

6. Research Results

Model	Input Text/ Dataset	Generated	BLEU Score	ROUGE			
		Paraphrase			Precision	Recall	F-Measure
BART	SADiLaR assembled Sepedi Paraphrase Corpus	Text 1	0.62	Rouge 1	0.74	1.0	0.85
				Rouge 2	0.72	1.0	0.84
				Rouge L	0.74	1.0	0.85
		Text 2	0.43	Rouge 1	0.51	1.0	0.68
				Rouge 2	0.48	0.94	0.64
				Rouge L	0.51	1.0	0.68
PEGASUS	SADiLaR assembled Sepedi	Text 1	0.43	Rouge 1	0.53	0.67	0.59
				Rouge 2	0.39	0.5	0.44
				Rouge L	0.42	0.53	0.47
		Text 2	0.58	Rouge 1	0.63	0.8	0.71

	Paraphrase Corpus			Rouge 2	0.5	0.64	0.56
				Rouge L	0.58	0.73	0.64
		Text 3	0.41	Rouge 1	0.52	0.67	0.59
				Rouge 2	0.39	0.5	0.44
				Rouge L	0.42	0.53	0.47
		Text 4	0.53	Rouge 1	0.63	0.80	0.71
				Rouge 2	0.5	0.64	0.56
				Rouge L	0.58	0.73	0.65
		Text 5	0.30	Rouge 1	0.53	0.67	0.59
				Rouge 2	0.39	0.5	0.44
				Rouge L	0.42	0.53	0.47
		Text 6	0.46	Rouge 1	0.63	0.80	0.71
				Rouge 2	0.5	0.64	0.56
				Rouge L	0.58	0.73	0.65
		Text 7	0.43	Rouge 1	0.58	0.69	0.63
				Rouge 2	0.44	0.53	0.49
				Rouge L	0.42	0.5	0.46

7. Discussions and Conclusion

The research presented machine-generated paraphrased paragraphs using BART, PEGASUS, T5 and PARROT transformer models for generating paraphrases. The input text originated from SADiLaR assembled Sepedi Paraphrase Corpus. The research serve as a basis to propose a paraphrasing technique for morphologically low resourced languages. The research evaluated four different transformer-based language models trained on different training data for paraphrase generation NLP task.

BLEU seems to have produced good score to badly generated paraphrase, which is flawed. Synonyms are not taken into considerations for the n-grams unless included in the references.

ROUGE-1, ROUGE-2, ROUGE-L performed well in evaluating single short text documents generated paraphrasing.

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Evaluating the Usability of M-Agri Market Information Services Application to Provide the Most Useful Services to the Namibian Rural Vegetable Small-Scale Farmers

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Abstract

Most developing world's 570 million Rural small-scale farmers (SSFs) have often needed access to agricultural market information (AgriMI) services on best market prices (retail and wholesale) and supermarkets/markets. They have also needed to be provided with AgriMI on Value-Added Services (VAS) like demand, business contacts and location addresses, dates and time of buyers, such as traders, consumers, transporters, etc. These AgriMI services have demonstrated the potential to improve their incomes and livelihoods. This has contributed significantly to poverty reduction and food security in Sub-Saharan Africa (SSA). Until now, most SSFs in SSA have been unable to access these AgriMI services other than selling their commodities at harvest at the low market price, including in a country like Namibia. In recent years, while most mobile phones-based Agricultural Market Information Services (i.e., m-apps) have been designed to provide access to AgriMI services for rural SSFs, it has been unclear which of the AgriMI services provided to rural SSFs via these m-apps has been the most useful in increasing their incomes. As such, this research aimed to evaluate the usability of the M-Agri Market Information Services Application (i.e., M-AgriMIS App). This is to provide the most useful AgriMI services to the Namibian Rural SSFs. 10 Onion SSFs used an in-app checklist to provide feedback. The descriptive statistics result indicated AgriMI services on market prices as the most useful for strengthening SSFs' negotiation positions against traders. With these results, AMIS providers should prioritise providing the most useful AgriMI services to the Rural SSFs.

Keywords: AgriMI, Agricultural Market Information Services (AMIS), Usability Evaluation, Small-Scale Farmers, PACMAD.

1. Introduction

Most of the developing world's 570 million Rural SSFs (Lowder et al., 2016) often have needed access to the AgriMI services primarily on best market prices, markets, and VAS. These AgriMI services have been for different end-uses of sales to earn from their commodity sales (Baumuller, 2016). Especially, these AgriMI services have a significant influence at the selling stage for most rural SSFs, in a country like Namibia. For example, most SSFs have usually needed access to AgriMI services on current market prices (retail and wholesale) to price their commodities better and to strengthen their negotiation positions against traders to sell at a better price. Until now, most SSA rural SSFs have been unable to access them rather than selling their commodities at below-market prices to generate cash (Nkonu & Clause, 2013). In recent years, various mobile phones-based AMISs have been designed and targeted at rural SSFs in SSA in English (Wyche et al., 2015). These services have been a promising new field of research and application in the emerging field of Information and Communication Technologies (ICTs) for agriculture i.e., M-Agriculture. The interest in M-Agriculture has arisen from the challenges that rural SSFs have faced in accessing AgriMI services. Typically, AMIS have been mobile applications (m-apps) aimed at providing SSFs with affordable access to AgriMI on current market prices and markets. This has enabled them to sell their commodities to buyers or in markets that have paid better prices and have demonstrated the potential to improve their incomes (Baumuller, 2017; Qiang et al., 2011; Ziegler et al., 2019).

While most AMISs (m-apps) have pointed to the promise of increasing SSFs' sales prices and incomes, it has still been unclear how SSFs exactly have used these m-apps after initially subscribing and/or downloading them. Especially, it has not been clear which of the AgriMI services provided to SSFs via these m-apps has been the most useful in helping them to increase their incomes or reach (directly or via traders) more distant markets (Wyche & Steinfield, 2015). As a result, there was a need for more research to examine or evaluate the usability of such a service on the end-uses of AgriMI services. This would reveal the most useful AgriMI services to help service providers validate and hone the service to the SSFs' most valuable AgriMI services to improve their incomes (USAID, 2011). As such, we empirically designed and evaluated the usability of the M-AgriMIS App to provide the most useful AgriMI services to the Namibian Rural onion SSFs. This article will present here the usability evaluation results of the M-AgriMIS App and not of its design. It addressed one research question (RQ): How can the usability of such an M-AgriMIS App be evaluated to focus the service on the most useful AgriMI services for the rural SSFs? This paper contributes to AMIS field on usability evaluations by providing evidence on the most useful AgriMI services critical to the rural SSFs' incomes and livelihoods. This help AMIS designers (be they researchers, software developers, NGOs, etc.,) to fit their services to the SSFs' most valuable AgriMI services critical to their incomes and livelihoods. The rest of the article proceeds as follows: Section 2 provides a review of the relevant literature. Section 3 provides the conceptual framework. Section 4 provides methodology i.e., the context for the study, research design, details on the purposive sampling approach, and a description of the data. Section 5 presents the results of the usability evaluation. Section 6 discusses. Section 7 concludes.

2. Review of Relevant Literature

Examining the usability of a mobile-based AMIS has been important to follow up on which AgriMI services provided to the SSFs have mostly been useful to adjust the service provided to fit the users' most valuable AgriMI needs (David-Benz et al., 2011; Aker et al., 2016). In recent years, studies examining the usability of mobile phones-based AMIS have been valuable because they have demonstrated the potential ways that new AMIS has improved rural SSFs' livelihoods (Wyche & Steinfield, 2015). For instance, surveying the Indian Reuters Market Light (RML) that provides SSFs with AgriMI services on daily market prices, Mittal et al. (2010) found that the service has generated US\$ 2–3 billion in income for rural SSFs. Indian e-Choupal has also enabled rural SSFs to earn an average of US\$6/ton more because of providing better AgriMI services on more accurate market prices. Evaluating the Sri Lankan Dialog TradeNet, Lokanathan and Silva (2010) found SSFs from 10-15 kilometers to the nearest market have obtained an average premium of 23% on the price per kilogram of their commodities. Free field trials of Ghanaian Esoko for SSFs have also elicited self-reported evidence of a 20-40% improvement in revenue (Donovan, 2017). The success of the Zambia National Farmers Union SMS-based 4455 platform for agricultural trade and AgriMI services access has also been the epitome of the usefulness of the AMIS in SSA. This is because SSFs have quickly gotten up-to-date AgriMI services on market prices and it has been cost-effective and trustful.

While the usability evaluations have been promising and have demonstrated the benefits of delivering AgriMI services via m-apps to rural SSFs, several barriers have affected the usability of such services. Surveying the usage of RML and Fisher's Friend in India, Mittal et al. (2010) found that, while increasing numbers of subscriptions had brought some benefits to some SSFs, constraints on these 'stand-alone' services included a lack of awareness of their existence, what they offered, lack of customisation and updating of content, concerns over timeliness and accuracy of AgriMI, and lack of use of local languages. Assessing the drivers of AMIS usability, Baumuller (2012) also noted SSF's knowledge of AMIS existence, ability to assess its suitability and obtain finance for it, ability and knowledge of how to use it, and mobile-based AMIS' ability to improve and generate more income for SSF influenced the usage.

Evaluating the locally-known AMIS as PalliNet in Bangladesh, Islam and Grönlund (2010) also found 80 out of 100 users reported difficulty using the Roman script to access the SMS user interface. Evaluating the RML trial, Lokanathan and Silva (2010) also found a full 41% of the 422 SSFs who were offered an RML subscription for free never used it and cited reasons such as illiteracy and devices' inability to display the Marathi script, and failure to send the sequence of SMS messages to activate the service. Assessing the M-Farm in Kenya, Baumüller (2013) also found a lack of awareness, cost, difficulties keeping phones charged for no electricity, limited competence with SMS, unfamiliarity with the English language, and general literacy issues among other factors limited usability. Examining an SMS-based AMIS, Wyche and Steinfield (2015) also reported severe usability problems including difficulty in sending and reading text messages; sensitivity to the cost of sending SMS messages; language barriers; unreliable connectivity; and difficulty remembering the codes required for requesting prices.

The growing number of research studies above have shown both the benefits and barriers of AMIS. It has also only been possible to know how many SSFs have received AgriMI services. However, it has been quite difficult to know if and how they have used that AgriMI (Steinfeld & Wyche, 2013) and why AMIS usage rates have not lived up to the expectations to date, even in countries with more advanced agricultural sectors, let alone among rural SSFs (Mittal et al., 2010). As such, we examined the real usefulness of the M-AgriMIS App on the most valuable AgriMI services.

3. Conceptual Framework

Conceptual Research Framework (CRF) (see Figure 1)

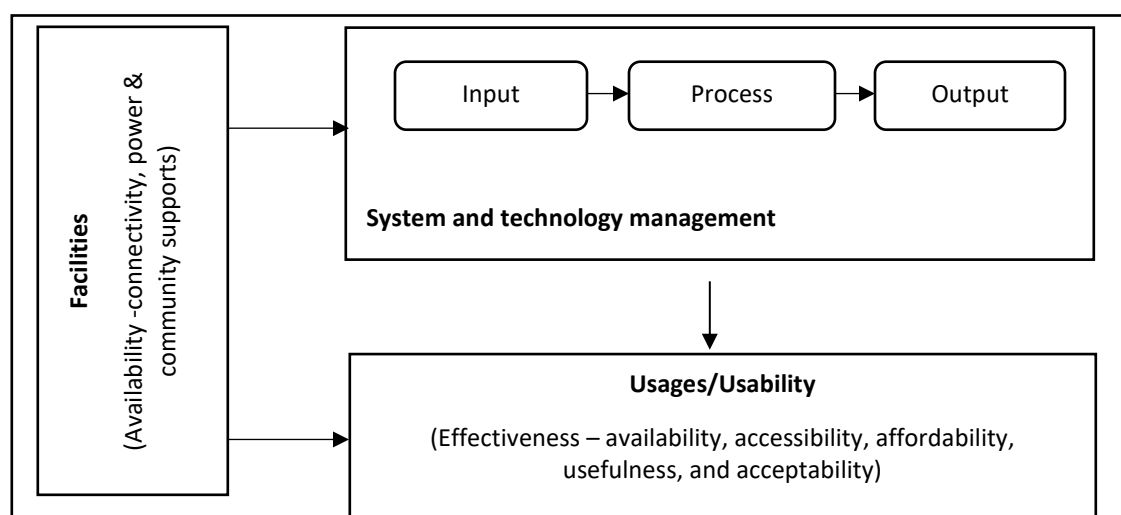


Figure 1: CRF for examining the AMIS usability in a rural context. Source: Islam and Grönlund (2010)

Most studies examining AMIS usability have used CRF and have been user-centric as the user has been the core of an AMIS. They have concentrated on measuring the effectiveness as promised using criteria such as availability (e.g., how regularly have the SSFs received the service?), accessibility (e.g., how have they accessed the service and what difficulties have they faced?), affordability (how viable has the service been financial?), usefulness (has the service been useful i.e., value for money?) and acceptability (have the SSFs liked the service for long-term use? Availability of facilitating conditions has also been a pre-requisite for smooth connectivity between the content providers and the recipients e.g., the ICTs use has broadly been

constrained by the degree to which users have access to electricity, even for mobile phones and other battery-powered devices which still must be charged to be used. For such connectivity, the design of such a service has needed to be consistent with the availability of infrastructure and other support services at the user end (Islam & Grönlund, 2010). As such, we chose CRF for its effectiveness metric i.e., usefulness to evaluate the usability of the M-AgriMIS App.

4. Evaluation Methodology

4.1. The Namibian Agricultural Context

Around 70 % of Namibia's 2.5 million population, mostly rural SSFs, has depended directly or indirectly mostly on subsistence or small-scale farming as the only means of their incomes and livelihoods for poverty alleviation and food security purposes (NSA, 2016). While these SSFs have been provided with the agricultural Green Schemes Projects (GSP) for food security purposes, most ventures have failed to live up to the expectations, lied dormant, or disbanded. When commodity prices also have risen quickly and steeply, they have precipitated concerns about food insecurity, widespread poverty, and conflict in Namibia which often has imported high volumes of staple foods. As a result, most SSFs often have sold their commodities along the roads, seldom gone to high-value markets with better market prices, and have become price takers for no easy access to AgriMI on best markets, buyers, market prices, transport, etc. Namibia has been amongst 105 African countries with more cellular subscriptions than inhabitants and has more mobile phone subscriptions than its population (Namibian, 2022). As such, the large number of Namibian SSFs paired with high mobile phone ownership motivated the need to conduct a mobile-based AMIS project in Namibia.

4.2. A Quasi-experimental Design

A quasi-experimental design has lacked random assignment. Assignment to the conditions "treatment versus no treatment or comparison" has used self-selection by which SSFs have chosen treatment for themselves or administrator selection e.g., researcher and so on, or both of these routes. It has identified a comparison group i.e., as similar as possible to the treatment group in terms of baseline (pre-intervention) characteristics. The comparison group has captured what would have been the outcomes of the study if the intervention had not been implemented i.e., the counterfactual. That way, the intervention has been said to have caused any difference in the outcomes between the treatment group, those with access to the intervention, and the comparison group, those without access (White & Sabarwal, 2014). Since the Namibian Rural SSFs self-selected themselves (non-random) to participate in the M-AgriMIS App intervention project based on their AgriMI needs of interests, a quasi-experimental design and purposive sampling approach were chosen. Purposive sampling has been "a non-random sampling technique in which the researcher has solicited the persons with specific characteristics or right participants". It has also ensured the balancing of group sizes when multiple groups have been selected and the deliberate selection of sample units has conformed to some pre-determined criteria, based on the judgment of the researcher.

As a result, SSFs were carefully and purposively selected from horticultural regions, such as Windhoek, Zambezi, Kavango, North Central, and SSFs in Etunda and Kavango GSP, Karst, Central area, South and Orange River area. Geographically, these have been some of the major centres for vegetable trading in the country. Specifically, SSFs (see Table 1), who were commercial vegetable producers of onion were selected. This commodity was purposely chosen because of its high market demand: it has been easy to cultivate in a short cycle, is associated with increasing returns in sales prices or income, and is mostly consumed in the study areas. The number of SSFs for the sampling frame available from the public Namibia Agronomic Board's (NAB) website was purposively accessed and comprised of 905 registered commercial vegetable SSFs with

their email addresses. Power calculations performed before the start of the evaluations indicated that the minimum sample size needed was 227. Yamane's formula (1967) was used to determine the total sample size of 227 SSFs as shown below:

$$n = N / [1 + N(e^2)] \quad \dots\dots\dots \text{Equation (1)}$$

Where n is the sample size, N is the population size, 1 is a constant and e is the level of significance (confidence interval of 95%). Since there were 905 registered SSFs from NAB, then the sample size was: $n = N / [(1 + N) (0.05^2)] = N / [(1 + N) (0.0025)] = 905 / [1 + 905(0.0025)] = 905 / [1 + 2.2625] = 905 / 3.2625 = 277$. Of the 905 surveyed, only 30 out of 39 received were valid and complete responses and sufficient for analysis. An emailed and survey-based Google form-based questionnaire, that is often a simpler and off-the-shelf available option for researchers, representative of the entire population and generalisable, was sent to the SSFs to collect data on farm size and AgriMI needs on market prices, markets, buyers, and transporters. A systematic literature review's values aided in removing all the doubts about SSFs' reliability.

Table 1: Inclusion Criteria for the Namibian Rural SSFs

No.	Inclusion criteria
i.	SSFs planned to produce their vegetables in the rainy season of 2022 - 2023; SSFs were commercial producers of vegetables; SSFs owned a cellular phone; A cellular phone was capable of installing an m-app; SSFs could read in English (basic literacy); and
ii.	SSFs should be willing to participate in the intervention (self-selection/involuntary/non-random).

AgriMI needs data were used to design an offline Android M-AgriMIS App to provide AgriMI services on market prices (retail and wholesale), demand on available commodity and quantity, business contacts and addresses, date and time of buyers for the Namibian Rural SSFs. An ethical clearance certificate and email permission were obtained from the NUST and NAB, respectively. However, gathering data from the SSFs was challenging because most of their email addresses bounced, response rates to online surveys were typically low, and SSFs were hesitant to provide accurate information. This has been an inherent problem when studying SSFs in rural settings. This has presented a methodological challenge in AMIS projects (FAO, 2017). As such, these challenges in data collection forced us to settle on 30 participants.

4.3. PACMAD (People At the Centre of Mobile Application Development)

To remedy the debate over some of the shortcomings of the existing usability models e.g., Nielsen, etc., about what software usability attributes have been, we chose the PACMAD usability model which has brought together significant attributes from different usability models to create a more comprehensive model when applied to m-apps as shown in Figure 2. While none of the attributes that PACMAD has included has been new, the existing prominent usability models have ignored one or more of them. This has led to an incomplete usability evaluation. While the PACMAD usability model for m-apps has identified three factors i.e., User, Task, and Context of use to be considered when designing usable m-apps, the model also has identified seven attributes that have been used to define metrics to measure the usability of an m-app. In most cases, the effectiveness of a software project has been evaluated by monitoring whether a user has accomplished a pre-specified task (Harrison et al., 2013). This research chose effectiveness because it has been used to measure the usability of most mobile phones-based AMIS (Islam & Grönlund, 2010). As such, while different metrics have been used to measure the effectiveness, the usefulness metric (i.e., value for money) was used to measure the usability of the M-AgriMIS App project intervention.

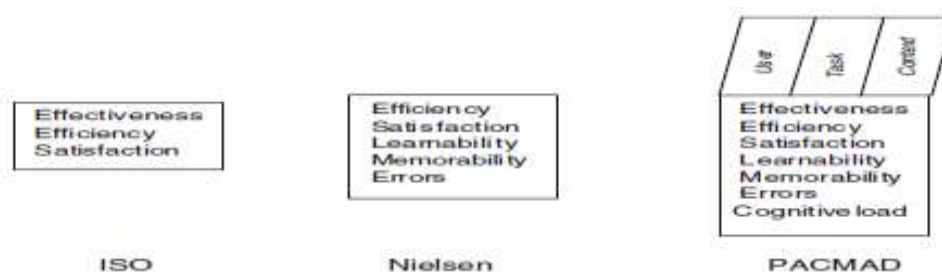


Figure 2: PACMAD Usability Model. Source: Harrison et al. (2013)

4.4. The Usability Evaluation of the M-AgriMIS App

There have been two general approaches to usability evaluation: checklist and attribute-based evaluations. The attribute-based approach has stated that usability be evaluated within context and user and environment's characteristics be analysed too. While this method has been more mature, objective, and the most dominant approach, it has been more complicated, resource-demanding, and outside the scope. The checklist-based approach has used a pre-designed checklist and actual product users – typically a small number of participants, etc. – have used the checklist to provide their expert opinion about the product. Depending on the importance of usability evaluation, this checklist method has been applied in a more or less formal way. While the quality of checklist results based on the users' opinions has been anecdotal and hard to compare and quantify, it has been the simplest, less resource-demanding, and has required active user involvement with a small number of participants (Klotins, 2011). As a result, we chose a checklist-based approach. Since this article is part of a Master's thesis project using a quasi-experimental design, two groups of SSFs i.e., treatment (10 members), and comparison (20 members) were created. This was done using the Propensity Score Matching (PSM) method based on SSFs' socio-economic characteristic i.e., farm size. PSM has enabled researchers to compare similar SSFs. To validate and obtain feedback for usability evaluation, the treatment group was sent the link: https://drive.google.com/file/d/13C_VeE-Eh0HIRI-MCz789TjPXKjZ1ymk/view?usp=sharing. The treatment group accessed, downloaded, installed, and used the M-AgriMIS App's in-app checklist (see Figure 3) to provide feedback on the most useful AgriMI services. Using descriptive statistics, this feedback data was used to evaluate the usability of the M-AgriMIS App intervention.

Figure 3: Checklist for the SSFs' feedback on the most useful AgriMI services.

5. Data Analysis and Results

The usability evaluation results of the M-AgriMIS App were analysed in descriptive statistics aided by the Statistical Package of Social Sciences and presented in a bar chart (see Figure 4).

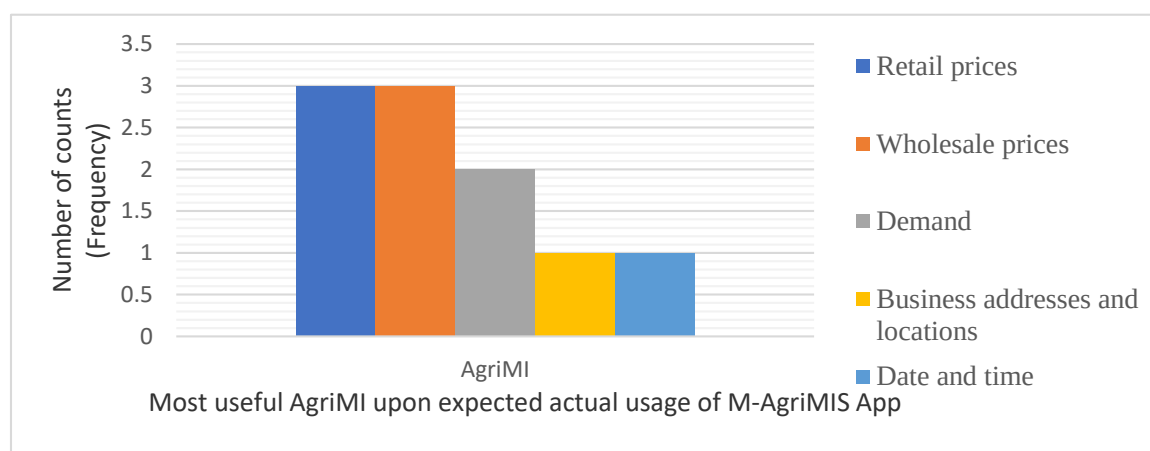


Figure 4: Most useful AgriMI services of M-AgriMIS App.

Result: The usability results indicated that the AgriMI services on the market prices (i.e., retail prices 30%; $n = 3/10$; wholesale prices 30%; $n = 3/10$) as the most useful services; demand (20%; $n = 2/10$) as the second; business contacts and location addresses (10%; $n = 1/10$) as the third; date and time of potential buyers and transporters (10%; $n = 1/10$) as the fourth.

6. Discussions

The usability evaluation result of the most useful AgriMI services of the M-AgriMIS App intervention might mean access to the AgriMI services on current market prices. This has often strengthened most rural SSFs' negotiation positions against buyers e.g., traders. For instance, when rural SSFs have chosen to sell parts of their commodities, they typically have done so by engaging in trade with local traders that often have bought their commodities at the farmgate at a low price, often with limited competition from other traders, and resold them in the urban markets at profits. These constantly traveling traders between rural areas and the urban markets have naturally relatively been well informed about the current market prices while rural SSFs have little access to AgriMI on up-to-date market prices. These often have forced most SSFs to rely on traders to serve as intermediaries and as the sole providers of AgriMI need on market prices and SSFs have struggled to attain the best value for their commodities. As a result, since traders often have traveled back and forth to the urban markets and have been well-informed, at least about the market prices in their active markets, while SSFs often have seldom sold their commodities on the main markets, and generally have less or little AgriMI access about current market prices, most SSFs might have found AgriMI services on current market prices from the M-AgriMIS App as the most useful.

The usability result reflected similar evidence that SSFs equipped with AgriMI on current market prices have stronger bargaining power. Evaluating the impact of Esoko in Ghana, Hildebrandt et al. (2014) found that SSFs in the Esoko treatment group sold their yams at 11%- higher prices and experienced a 7% increase in the prices they received for yams, which translated into a 6% gain in annual income than did SSFs without this service. The evidence of surveys of these SSFs suggested that the primary reason for the price increase

was due to their ability to negotiate for higher prices with traders coming to the farmgate, and not due to bringing the yams to markets where prices were higher. Evaluating the usefulness of M-Farm in Kenya, Baumuller (2015) also found market prices as the most useful. Similarly, conducting a national survey of SSFs in India, Mittal et al (2010) found, one of the most critical types of AgriMI needs by the SSFs was market prices. PACMAD and the CRF were also followed to examine the AMIS usability in the rural context as did Islam and Grönlund (2010).

The usability evaluation result also differed from the previous AMIS studies. Previously, SSFs already benefiting from AgriMI have expressed demand and willingness to pay for value-added AMIS (World Bank, 2012). So far, the success of these m-apps has been measured largely in terms of subscriptions to these services (Rutten & Boto, 2014). While the SSFs' willingness to pay for the AgriMI on market prices they have received, has illustrated the perceived usefulness of such services (Baumüller, 2015), this has not revealed the most useful AgriMI services. As a result, the M-AgriMIS App's ability to generate feedback on the end-uses of AgriMI needs, which revealed market prices as the most useful AgriMI services critical to the SSFs' livelihoods, illustrated the true usefulness of such an m-app. The main contribution to the AMIS field was examining the AMIS usability to reveal the most useful AgriMI services. This help AMIS providers to fit their most useful services critical to the rural SSFs' incomes and livelihoods. The measured usefulness also demonstrates that large-scale use of such mobile phones-based AMIS is likely to guarantee the further development of new and even more innovative m-apps for the SSFs. The implications: the test of AMIS value has been whether the AgriMI services provided have been most useful for SSFs. The results should help future AMIS providers (software developers, researchers, public-private companies, etc.), to focus their services and prioritise on offering the most important AgriMI services e.g., current market prices and VAS to the rural SSFs to improve their incomes and livelihoods.

Given the tenuous nature of SSFs' livelihoods and the lack of social safety nets, most SSFs also have been particularly risk averse. They have been unlikely to participate in a new mobile-based AMIS intervention without significant training. Even those SSFs, who have wished to use an AMIS intervention have been frustrated if the service has not been widely available. As a result, SSFs would only benefit from AMIS gains if they have access to and have been trained on how to use AMIS. Actual usage of the AMIS should also be monitored, as its supply has not necessarily implied its usage for economic means because SSFs often have been lowly exposed to ideas on how to use AMIS to achieve their economic goals. By continually interacting with SSFs and monitoring their responses to AgriMI, AMIS providers could also clarify which AgriMI needs have needed to be sent and which have not (World Bank, 2011).

7. Conclusion

This research has provided empirical evidence on the end-uses of AgriMI services, revealing the current market prices as the most useful services critical to the rural SSFs' livelihoods. This has illustrated the true usefulness of the M-AgriMIS App to the AMIS field and Namibian Rural SSFs. There remained many other future directions to improve the M-AgriMIS App's usability. Instead of anecdotal evaluations i.e., checklist – a highly subjective self-reporting and SSFs' memories often have been distorted – future researchers should examine the usability of the M-AgriMIS App by tracking user-selected AgriMI needs i.e., the number of requests sent to the m-app, the commodities for which AgriMI needs have been requested, and the number of downloads, and then adjust the service provided to fit the users' most valuable AgriMI needs.

Context also matters and AMIS should not be air-dropped into a situation and guaranteed positive results. New AMIS interventions often have required SSFs' engagement, right from the start. AMIS

interventions that have made meagre efforts to involve SSFs in planning and design have resulted in low uptake, trust, and interest. As a result, continuous focusing through co-design and usability evaluations would need to be an integral part of the intervention, to ensure that it has addressed SSFs' actual AgriMI needs critical to their livelihoods and remained relevant and truly usable and impactful to the served SSFs (World Bank, 2011). While it was also impossible to generalise the results because of the small sample size, lack of standardised data on farm size and AgriMI needs, and self-reported data, the small sample size provides a basis for further usability evaluation with larger sample size for future AMIS software designers and researchers having special interests in usability evaluation in countries or regions having similar socio-economic and technological settings to Namibia.

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Optimising Customer Segmentation in Digital Marketing Using Predictive Analytics: A Review of Literature

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Abstract

In the current age, machine learning is regarded as a significant tool for building modelling methods for predicting buying behaviors using previous datasets for profitable digital marketing. The traditional marketing approach functions by segmenting customers based on various attributes such as geographical and demographic, which in this era will prove futile as a vast number of customers in the market use multiple platforms when buying their goods and leaving vast data traces. Additionally recent reviews revealed that predicting customer buying behaviors and patterns using traditional methods may not be comprehensive enough to extract correct information to guide decision making and overall provide a holistic support for accurate marketing strategies. Therefore, business owners must understand their customers from all angles to stay competitive in the market by applying accurate predictive models to guide their marketing approaches. This review paper aims to explore the significance of customer segmentation based on the contemporary models of predictive analytics to guide effective digital marketing. Using a Systematic Literature Review methodology, the researcher formulated research questions, identified relevant sources, and evaluated the findings to answer the research questions. The study examined three practical customer segmentation using traditional approaches and observed the obstacles and concerns associated with each process. The results indicate that traditional customer segmentation has several limitations, such as subjective judgment, precision, and inconsistency, which prevents this approach from effectively predicting customer behaviors. Consequently, the study recommends predicting analytics based on past data sets as the practical approach to customer segmentation in digital marketing.

Keywords: Customer segmentation, Predictive Analytics, Technology, Marketing strategy

1. Introduction.

In the dynamic and ever-changing world of digital marketing, reliance solely on conventional marketing methods has become inadequate. In contemporary times, customers have developed a strong inclination towards personalised experiences, hence compelling marketers to employ customer segmentation as an indispensable instrument to cater for the varied demands of their target market (Tsipitsis & Chorianopoulos, 2019). The utilisation of customer segmentation as a strategic approach has become essential in order to optimise customer value and get a competitive advantage. This process entails categorizing customers according to common characteristics, attributes, behaviors, and demands, hence equipping marketers with vital information necessary for implementing targeted and personalised marketing initiatives.

Customer segmentation has seen a significant revolution with the introduction of predictive analytics. The intersection of technology breakthroughs and dynamic customer behaviors in digital marketing has resulted in a significant revolutionary progression. The advent of predictive analytics has brought about a significant transformation in the development and execution of marketing strategies, mostly due to its ability to provide valuable insights and accurate predictions. By conducting a comprehensive analysis of historical data and current trends, this analytical discipline allows marketers to anticipate future results, thereby enhancing the effectiveness of their marketing strategies.

Through the utilisation of advanced data sources and computational methodologies, businesses are now able to apply predictive statistical models in order to get valuable insights pertaining to possible customer

behaviors and preferences. The application of predictive analytics in a strategic manner enables businesses to efficiently distribute marketing resources, leading to higher profitability and improved customer engagement (Williams, Anderson, Davis, & Taylor, 2018). Through the analysis of different methodologies, it is possible to improve targeting techniques and bolster the efficacy of product creation, positioning, and marketing communication strategies.

Although Segmentation methodologies offer useful insights into market structure; yet, they frequently face challenges since their application and effectiveness are impeded by different limitations such as data quality, data management and formulating of effective segmentation criteria, among others. Nevertheless, the potential to address these constraints and offer more detailed and practical insights is held by developing technology (Technologies) and ongoing improvements in segmentation approaches.

Subsequently, this review aims to address several pertinent inquiries.

How is customer segmentation defined, and what is its operational concept in the context of digital marketing?

What are the underlying factors that emphasise the importance of customer segmentation in digital marketing?

What specific benefits does customer segmentation bring to personalised marketing strategies?

What are the different approaches employed for customer segmentation in digital marketing?

What are the examples of successful customer segmentation in the context of digital marketing?

How is predictive analytics revolutionizing customer segmentation in digital marketing? What challenges have businesses encountered in its application, and how have they effectively navigated them?

The aim of this study is to explore the importance of customer segmentation in digital marketing. This study aims to examine different methodologies employed in segmentation, the significance of predictive analytics in this context, and the subsequent implications for digital marketing strategies. Furthermore, this study examines the practical implementation approaches, as well as the obstacles and concerns that are linked with them.

The primary objective of this study is to offer a full comprehension of customer segmentation and the significance of predictive analytics in facilitating personalised marketing strategies. This resource caters for anyone involved in marketing, including professionals, digital marketers, and academics. It provides vital insights on the ways in which these strategies may improve marketing effectiveness and promote customer satisfaction.

2. Literature review

Customer segmentation is a concept that is described as the process of dividing a client base into distinct groups based on certain characteristics or attributes. In the context of digital marketing, the operational idea of customer segmentation involves utilising various data-driven techniques and methodologies to identify and categorise customers into homogeneous groups. This enables marketers to tailor their marketing strategies and strategies to effectively target and engage with specific customer segments, thus enhancing the overall effectiveness and efficiency of their digital marketing efforts.

The practice of customer segmentation entails the systematic division of a certain target market into discrete and uniform subsets. These groups are formed on the basis of common qualities, preferences, and behaviors.

This strategic method enables organisations to customise their marketing efforts and adapt their messages to various target categories. By employing this strategy, individuals may proficiently convey their message to their intended audience and enhance overall engagements. There are several advantages associated with customer segmentation.

Enhanced Marketing Strategy. The adoption of customer segmentation is crucial in the development of focused marketing strategies, hence enhancing overall marketing effectiveness. This process aids organisation in identifying the distinct requirements, inclinations, and predilections of various customer segments. By customising marketing messages and campaigns to these specific categories, organisations may enhance their ability to connect with their intended target audience. Consequently, this phenomenon enhances the likelihood of transforming potential leads into paying customers.

Enhanced Customer Satisfaction: The implementation of personalised marketing techniques, enabled by the practice of customer segmentation, results in elevated levels of customer satisfaction. According to Roberts et al. (2021), organisations may enhance customer experiences by effectively providing communications, goods, and offers that are tailored to match individual needs and preferences. When customers perceive that an organization possesses a comprehensive understanding of their distinct requirements and preferences, there is a tendency for their overall satisfaction levels to rise. By using customer segmentation strategies, organisations have the ability to provide tailored and individualised experiences to their customer base. The use of a high degree of personalisation frequently results in increased levels of customer satisfaction and loyalty.

Increased Sales and Revenue The utilisation of customer segmentation enables organisations to discover customer categories that yield high value, hence enabling them to allocate resources in a prioritised manner. This strategic approach leads to an increase in sales and revenue. By strategically focusing on these high-value categories, organisations have the potential to enhance their sales and revenue. Using this specific strategy enables organisations to concentrate their efforts on customers who possess the most potential value, hence optimizing their return on investment.

Enhanced customer engagement may be achieved through the utilisation of customer segmentation, as it enables organisations to customise their marketing communications in a targeted manner, aligning with the unique interests and preferences of distinct customer segments. The implementation of a personalised approach in marketing strategies has been found to increase the effectiveness and significance of these efforts, as it effectively captures the attention of customers and promotes meaningful involvement (Johnson & Brown, 2020).

2.1 Application of Customer Segmentation in Digital Marketing

Customer segmentation is an essential component of digital marketing as it facilitates the identification and prioritisation of the most valuable customer segments for organisations. Through the process of segmenting their customer base, organisations are able to get a more profound understanding of their customers' preferences, requirements, and purchasing patterns and behaviours. This subsequently enables the development of customised marketing campaigns (Thompson, 2019). The increasing prevalence of digital platforms has heightened the importance of customer segmentation, enabling firms to participate in micro-targeting strategies and improve their likelihood of achieving successful conversion (Davis & Miller, 2017). The application of customer segmentation in digital marketing may be applied in the following ways below.

Personalised marketing campaigns are a strategic approach employed by businesses to tailor their marketing efforts to individual customers. The utilisation of customer segmentation allows firms to develop personalised marketing efforts that effectively connect with distinct customer segments. Businesses may enhance the effectiveness of their digital marketing endeavors by customising their messaging to correspond with the specific requirements and preferences of their target audience.

Targeted material Creation: By employing customer segmentation, organisations have the ability to generate material that is accurately customised to cater for the unique interests and preferences of various customer segments. This strategy facilitates the creation of content that is more pertinent and captivating, hence enhancing the likelihood of customer involvement and conversion.

Understanding the distinct requirements and preferences of diverse customer segments: By understanding the distinct requirements and preferences of diverse customer segments, organisations may provide tailored offers, promotions, and incentives, therefore fostering improved customer retention and loyalty. These activities have the potential to greatly enhance customer retention and cultivate loyalty. As a result, organisations are able to develop enduring customer connections and foster customer loyalty, therefore promoting recurring transactions.



Figure 1: Application of customer segmentation in digital marketing

3. Methodology

The present study employs the Systematic Literature Review (SLR) methodology (Weerakkody et al. 2015). This methodology has multiple components, specifically: formulating the research inquiry as previously outlined in the introduction, identifying relevant sources of research, conducting the search process using appropriate keywords, extracting data from the selected sources, and evaluating the collected findings in order to address the research question. The study provided a concise overview of the methods employed, as presented in the following section.

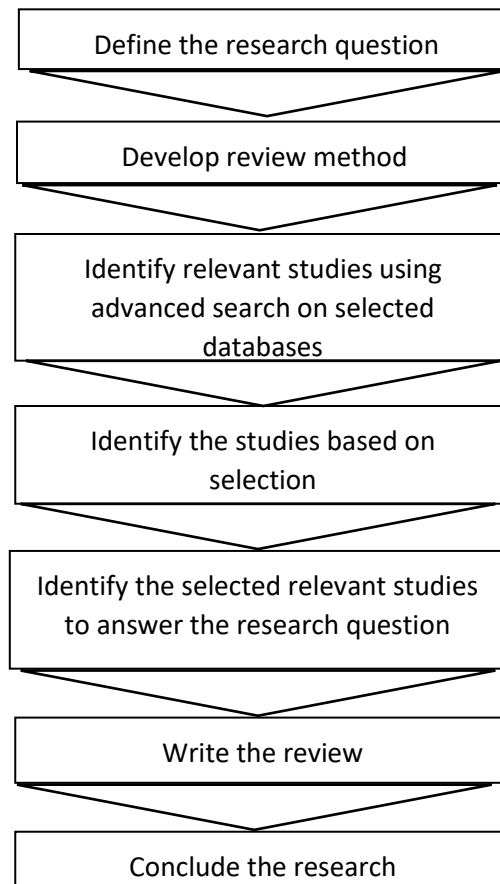


Figure 2: methods of systematic review

From the research question that has been defined in the introduction section, the selected sources of this SLR can be found as follows:

- IEEEXplore Digital Library (<http://ieeexplore.ieee.org>)
- ACM Digital Library (<https://dl.acm.org/>)
- Science Direct (www.sciencedirect.com)
 - Wiley Online Library (onlinelibrary.wiley.com) ➤ Emerald Insight (www.emeraldinsight.com)

Keyword search is applied to look for papers that are related to the defined research question, using a Boolean operator such as: AND, OR, NOT. All of the mentioned sources above own a -keyword-based search engine. The defined search strings that are used for the keyword source are:

("Analytic" OR "Model") AND "Prediction" AND ("Customer" OR "Customer") AND ("Segmentation" OR "cluster") AND ("Big data" OR "Data mining") "Digital marketing"

The keywords consist of 'Analytic/Model', 'Prediction', 'Customer/Customer', 'Segmentation/ cluster', 'Big data/Data mining' 'Digital marketing' from the period of 2007-2023.

3.1 Inclusion and Exclusion Criteria

The results of the advanced search using the keywords are the papers related to the keywords that have been defined. The total number of papers from the search results is considered as 'studies found'. In the next step, when the title is not sufficient to determine whether to include the paper as a candidate or not, the abstract is then read. If the title and the abstract match with the previously defined research question, this paper will be downloaded for further investigation. The number of downloaded papers is called

'candidate studies'. All 'candidate studies' papers' results will be read thoroughly to search for the answer to the research question. The papers that answered the research questions are the ones that will be used in the research as 'selected studies'. The detailed result can be found in **Table 1**

Table 1: Number of Studies In Selected Sources

Source	Studies Found	Candidate Studies	Selected Studies
IEEE	5	3	1
ACM	13	7	2
Science Direct	97	8	3
Emerald	62	5	1
Wiley Online	27	2	0
Others	2	2	2
Total	206	25	9

3.2 Data Extraction

This systematic literature review examined in a total of 204 papers. In **Table 1**, it can be seen that among 204 examined papers, there are 25 papers that are related to the research question based on their title and abstract. Others appear in sources because there are some papers that have been mentioned in 'selected studies' by the author.

4. Results and Discussion

4.1 Different Segmentation Approaches and their Limitations

Although traditional segmentation methods such as customer demographic profiles, geographics and behavioral have been extensively recognised and utilised, they possess inherent limitations. These approaches assume that every individual can be effectively categorised into a single segment, overlooking the complexity and diversity of customer preferences. Moreover, operationalising segmentation, especially in large organisations, can often prove challenging. Additionally, the dynamic nature of customer preferences can render static segmentation models less relevant over time (Bodapati, 2021).

Therefore, traditionally, marketers have employed various segmentation methods to better understand their customer base. One of the fundamental aspects of marketing strategy is the effective segmentation of the customer base. By dividing customers into distinct groups based on common characteristics, marketers

can better tailor their efforts to deliver personalised value propositions. This section explores several common segmentation approaches, highlighting their limitations and criticisms.

4.2 Types of Segmentation

Table 2: Types of segmentation

GEOGRAPHICS	DEMOGRAPHICS	PSYCHGRAPHICS	BEHAVIOURAL
Country City Density Language Climate Area Population	Age Gender Income Education Social status Family Life stage Occupation	Lifestyle Activity, Interest Opinion Concern Personality Values Attitude	Benefit Usage Intent Occasion

4.2.1 Demographic segmentation

Demographic segmentation refers to the process of dividing a population into distinct groups based on several demographic factors such as age, gender, income. It encompasses the process of categorising customers into distinct groups based on several criteria, including but not limited to age, gender, income, education level, and marital status (Kotler & Armstrong, 2021). It facilitates the ability of marketers to effectively target distinct customer segments characterised by comparable demographic features. As an illustration, a high-end fashion label may concentrate its endeavors on a target demographic of affluent, university-educated females between the ages of 25 and 40.

Nevertheless, an important critique of demographic segmentation is in the underlying assumption that individuals belonging to the same demographic category will possess equal demands or exhibit uniform responses to marketing endeavors. This assumption, however, is not necessarily valid (Tsiptsis & Chorianopoulos, 2019).

4.2.2 Psychographic segmentation

Psychographic segmentation is a marketing strategy that involves dividing a target market into distinct groups based on psychological characteristics, such as attitudes, values. By presenting Psychographic segmentation, as opposed to demographic segmentation, focuses on examining customers' views, beliefs, interests, lifestyle, and personality attributes (Wedel & Kannan, 2019). The objective is to focus on individuals who demonstrate comparable psychographic traits. As an illustration, a tourism enterprise may strategically target individuals who prioritise exhilarating experiences and possess a strong inclination towards engaging in outdoor pursuits.

However, psychographic segmentation encounters specific limits. The process of measuring and operationalising might present difficulties, frequently necessitating the use of subjective judgment. The efficacy of the approach may differ based on the precision of the psychographic insights (Shmueli et al., 2019).

4.2.3 Behavioral segmentation

Behavioral segmentation is a marketing strategy that involves dividing a target market into distinct groups based on their behaviors, attitudes, and patterns lifestyle (benefit, usage and intent). It is an alternative method of customer segmentation that centers on the purchase and consuming behavior of customers (Verhoef et al., 2015). This strategy takes into account several criteria including usage rate, loyalty, advantages sought, occasion, and user status. Companies such as Amazon employ behavioral segmentation strategies to enhance their marketing efforts. This involves the utilisation of customers' browsing and purchase histories to provide personalised product recommendations.

Although behavioral segmentation offers several benefits, it might present challenges in terms of complexity and cost due to the substantial amount of data needed for precise analysis. Furthermore, it is important to note that past behaviour may not consistently function as a reliable indicator of forthcoming conduct, particularly within dynamic market environments (Thomas et al., 2019).

4.2.4 Geographic segmentation

Geographic segmentation is a marketing strategy that involves dividing a market into several geographical regions based on many factors such as location and climate. It is a marketing strategy that entails the division of a market into distinct geographical units, such nations, states, regions, counties, cities, or neighborhoods (Kotler & Armstrong, 2021). The fundamental premise is that the geographical location may significantly impact the requirements, preferences, and buying patterns of customers (Zikmund et al., 2013). According to Smith (2018), this methodology enables organisations to accommodate the distinct tastes of customers in various geographical areas. As an illustration, a company may choose to provide garments with more weight and insulation in locations characterised by colder climates, while concurrently emphasizing its assortment of beachwear in coastal areas.

Nevertheless, akin to demographic segmentation, geographic segmentation operates under the assumption that individuals residing within a certain geographic region would exhibit homogenous preferences. The assumption can often be rendered erroneous due to variances among people within the same place (Tsiptsis & Chorianopoulos, 2019).

In order to overcome the constraints associated with conventional segmentation techniques, there has been an increased recognition of the significance of employing a more dynamic strategy that incorporates predictive analytics. The subsequent part delves into this option, examining the influential role of predictive analytics in the process of customer segmentation.

5. Role of Predictive Analytics in Customer Segmentation

Predictive analytics is a data-driven strategy that employs historical data and statistical modeling methodologies to extract important insights, provide trustworthy predictions, and anticipate future trends and patterns of behavior. Through the utilisation of diverse analytical techniques, marketers possess the capability to identify patterns, correlations, and trends in enormous datasets. This empowers them to acquire better understanding of customer behavior and preferences (Shmueli, Patel, and Bruce, 2019).

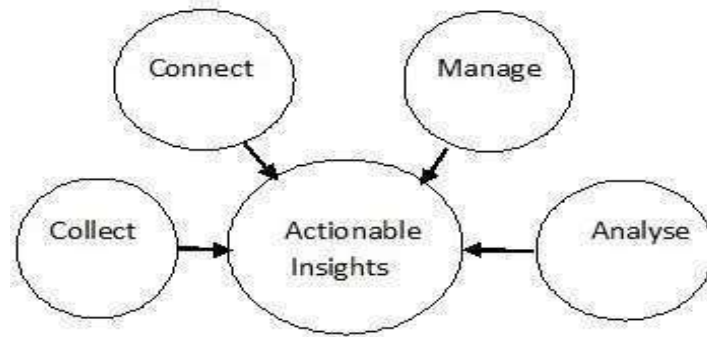


Figure 2: Predictive analytics in customer segmentation

Customer segmentation strategies are of great significance in predictive analytics, predictive analytics can be of great significance in customer segmentation and overall marketing strategies. Businesses are provided with significant insights into customer habits and preferences through past historical data patterns to come up with segmentation strategies. These strategies employ statistical models and machine learning algorithms to make predictions about future customer behaviors using past data. One notable benefit of predictive analytics is in its ability to identify patterns and trends within extensive datasets. With this knowledge, organisations are empowered to make informed decisions based on data, therefore improving their marketing strategy. According to Smith and Johnson (2019), predictive analytics offers a broad approach for customer segmentation, hence enhancing the accuracy and effectiveness of marketing endeavors. The effectiveness of predictive analytics methods in customer segmentation has been widely investigated and recognised as a useful tool in the domain (Williams et al., 2018). Statistical methodologies are of paramount importance in the process of customer segmentation, as they facilitate the identification and interpretation of hidden patterns and interconnections within the data.

Roberts et al. (2017) emphasises the considerable influence of statistical approaches in customer segmentation, demonstrating their capacity to boost marketing strategies and promote customer engagement. Machine learning algorithms have garnered significant interest owing to their inherent capability to independently identify patterns and provide predictions based on data. Customer segmentation algorithms are utilised to examine extensive and intricate information with the purpose of identifying different customer categories. Several frequently employed machine learning techniques include decision trees, random forests, and support vector machines. These algorithms possess the capability to effectively address non-linear correlations and effectively capture intricate interactions among customer variables. Consequently, they offer significant value by facilitating the development of personalised marketing campaigns.

A study conducted by Brown et al. (2020) examine the effectiveness of several machine learning algorithms in the context of customer segmentation, emphasising their capacity to boost targeting strategies and facilitate informed decision-making in marketing engagement. Moreover, the utilisation of techniques such as k-means clustering, and hierarchical clustering allows organisations to effectively categorise customers with comparable attributes. Additionally, the utilisation of regression analysis and factor analysis provides insight into the associations between customer characteristics and their patterns of purchase. The utilisation of these statistical tools facilitates the implementation of a methodical and rigorous strategy for customer segmentation. As a result, enterprises have a more profound understanding of their target audience, enabling the customisation of marketing strategies.

6. Benefits of Predictive Analytics in Customer Segmentation Strategies

Predictive analytics improves customer segmentation by furnishing marketers with precise and comprehensive customer information. The utilisation of advanced data analysis tools empowers marketers to get insights into customer preferences, purchasing patterns, and behaviors. This knowledge allows them to develop personalised marketing strategies that cater for individual requirements and preferences (Verhoef et al., 2015). It also facilitates the development of highly efficient predictive models for customer segmentation, hence enhancing marketers' ability to achieve desired outcomes. Through the examination of past data and trends, marketers have the ability to employ predictive modeling tools and methodologies in order to anticipate future customer behavior and preferences. This capability facilitates the implementation of more focused and accurate segmentation strategies (Jain & Singh, 2020).

Furthermore, another benefit of utilising predictive analytics in customer segmentation is the capacity to make judgments in real-time. According to Thomas et al. (2019), marketers have the ability to adjust their segmentation methods in real-time by consistently examining incoming data. This enables them to maintain the relevance and effectiveness of their marketing messages and campaigns. Through the utilisation of sophisticated statistical models and machine learning algorithms, enterprises get significant insights into customer behaviors and preferences, hence enabling them to make well-informed decisions in their marketing strategies (Smith & Johnson, 2019; Brown et al., 2020).

By employing predictive analytics, organisations may identify prospective patterns that can be used for financial gain. In addition, organisations have the ability to generate more precise customer profiles, thereby facilitating a more comprehensive individual requirements and preferences. These insights facilitate the development of focused marketing strategies that are customised to meet the individual needs and preferences of customers.

One of the primary benefits of integrating predictive analytics into customer segmentation is the capacity to improve targeting and customise marketing campaigns. Through the analysis of extensive datasets and the interpretation of customer behaviors, firms (organisations) possess the capability to design meticulously customised marketing campaigns that are inclined to effectively resonate with each unique customer. In conclusion, this phenomenon not only results in enhanced customer involvement, but also elevated conversion rates and heightened customer satisfaction. Through the use of personalised marketing strategies, organisations may proficiently convey pertinent and timely communications to their customers, hence enhancing customer experiences and cultivating heightened brand loyalty (Roberts et al., 2017) (Thompson et al., 2016).

The use of predictive analytics in customer segmentation is paramount in attaining success in digital marketing. Through the utilisation of predictive analytics methodologies, marketers are able to acquire more precise customer insights, construct efficient prediction models, and execute instantaneous decision-making processes. Predictive analytics relies on the application of machine learning algorithms, data mining, and pattern recognition techniques to effectively segment customers and improve marketing performance (Shmueli et al., 2019; Verhoef et al., 2015; Jain & Singh, 2020; Thomas et al., 2019; Brynjolfsson & McAfee, 2014; Pennings & Warlop, 2016; Tsiptsis & Chorianopoulos, 2019). The use of modern analytical tools presents considerable opportunities for enhancing customer targeting, customising marketing campaigns, and bolstering sales and income inside the realm of digital marketing.

7. Case Studies Showcasing Successful Implementation of Predictive Analytics in Customer Segmentation

A. Case Study 1: Examination of Company X

Company X is a prominent digital marketing enterprise that specialises in the field of electronic commerce. With the objective of optimising customer interaction and enhancing revenue, the organisation endeavors to operate within a fiercely competitive market. In order to accomplish this objective, the significance of utilising predictive analytics in customer segmentation was acknowledged by the organisation.

- **Objectives of Using Predictive Analytics in Customer Segmentation:**

The main aim of employing predictive analytics in customer segmentation for Company X was to ascertain and focus on customers with high value. Through the examination of customer data and behavior patterns, the organisation sought to tailor marketing strategies and improve customer experiences, eventually fostering customer loyalty and facilitating revenue expansion.

- **Methodology and Data Used:**

Company X implemented a thorough strategy for customer segmentation by leveraging predictive analytics. A substantial amount of customer data was gathered, encompassing browsing history, purchasing behaviors, demographic information, and activities on social media platforms. By employing sophisticated analytical methodologies, such as machine learning algorithms and data mining, Company X conducted an analysis of the data in order to reveal significant findings pertaining to customer preferences, interests, and anticipated future behavior.

- **Results and Outcomes:**

The successful integration of predictive analytics in customer segmentation yielded favorable outcomes for Company X. Through the creation of dynamic customer categories that consider individual behavior patterns and anticipated future actions, the company effectively delivered personalised marketing messages and offers. As a result, there was a notable rise in customer engagement and an improvement in conversion rates. Furthermore, the implementation of predictive analytics facilitated Company X in effectively predicting customer demands, leading to enhanced inventory management and reduced expenses.

- **Case Study 2: Analysis of Company Y**

Company Y is a well-established organisation that has been operating in the industry for a significant period of time. It has gained a reputation for its expertise and success in its own field.

Company Y is a well-established entity within the retail sector that has acknowledged the potential benefits of utilising predictive analytics to augment its digital marketing endeavors. In order to enhance customer experiences and optimise marketing efforts, the firm sought to properly segment its diverse customer base across numerous sales channels.

- **Objectives of Using Predictive Analytics in Customer Segmentation:**

The primary aim of implementing predictive analytics in customer segmentation for Company Y was to ascertain customer groupings that possess the greatest potential for conversion and retention. The primary objective of the organisation was to get insights into customer behavior, forecast purchasing trends, and improve customer satisfaction through the customization of marketing strategies and targeted promotional offerings for distinct customer categories.

- **Methodology and Data Used:**

Company Y employed sophisticated predictive analytics methodologies to effectively divide its customer population into several segments. Customer data was gathered through several routes, including online transactions, loyalty programs, and customer surveys. Company Y utilised sophisticated analytics techniques, such as predictive modeling and clustering algorithms, to conduct an analysis of the data. The purpose of this analysis was to identify specific customer groups by considering several criteria, including demographic, behavioral, and psychographic factors.

- **Results and Outcomes:**

Company Y produced notable enhancements in its marketing endeavors by effectively implementing predictive analytics in customer segmentation. Through the implementation of personalised marketing messages and tailored offers based on distinct customer categories, the firm observed notable improvements in conversion rates and heightened levels of customer satisfaction. The utilisation of predictive analytics by Company Y resulted in enhanced marketing resource allocation and increased efficacy of its marketing initiatives.

- **Case Study 3: Company Z**

This case study examines the operations and performance of Company Z.

Company Z is a nascent participant in the e-commerce sector that has seen the possibility of employing predictive analytics in customer segmentation as a means to attain a competitive advantage. The company's primary objective was to provide customers with personalised experiences, placing a strong emphasis on customer-centric marketing.

- **Objectives of Using Predictive Analytics in Customer Segmentation:**

The main aim of implementing predictive analytics in customer segmentation for Company Z was to enhance customer retention and cultivate brand loyalty. The firm sought to improve customer experiences through personalised marketing methods by comprehending customer preferences and forecasting future behavior.

- **Methodology and Data Used:**

Company Z utilised a data-driven methodology for customer segmentation by leveraging predictive analytics. The researchers gathered customer data from many sources, including website analytics, transaction history, and customer comments. Through the utilisation of predictive modeling techniques and data mining algorithms, Company Z conducted an analysis of the data in order to identify discrete customer categories. These segments were established on the basis of customers' purchasing behavior, preferences, and their respective reactions to marketing campaigns.

- **Results and Outcomes:**

The successful marketing outcomes of Company Z were attributed to the strategic utilisation of predictive analytics in the process of customer segmentation. Through the strategic customization of marketing initiatives to target certain customer categories, the organisation observed a notable augmentation in customer engagement levels and a discernible enhancement in overall customer happiness. Moreover, the precise anticipation of customer behavior facilitated Company Z in optimizing its product offers and pricing strategies, leading to a rise in sales and profitability.

- **Comparison and Analysis of the Case Studies.**

- Similarities and Differences in the Approaches:**

After the comparative analysis of the case studies pertaining to Company X, Company Y, and Company Z, it becomes apparent that all three organisations acknowledged the significance of predictive analytics in the context of customer segmentation. The organisation utilised customer data and implemented sophisticated analytics methodologies to identify and focus on particular customer categories. Nevertheless, there were differences in terms of the precise data gathered, the analytics tools employed, and the marketing strategies executed.

- **Common Challenges and Potential Solutions:**

All three organisations encountered shared obstacles during the integration of predictive analytics in customer segmentation. The hurdles encompassed issues pertaining to the quality and accuracy of data, concerns about data privacy, and the necessity for staff possessing specialised skills. In order to tackle these difficulties, the organisations made investments in data governance systems, enforced stringent data privacy regulations, and offered training and development initiatives to enhance the skills of their staff.

- **Lessons Learned and Best Practices**

The analysis of the case studies reveals a number of valuable insights and effective strategies that can be employed to ensure the successful integration of predictive analytics in the process of customer segmentation. These factors encompass the necessity for comprehensive data collecting and management procedures, the value of incorporating predictive analytics into the broader marketing plan, and the importance of ongoing testing and enhancement of customer segmentation models.

- **Challenges and Considerations in Implementing Predictive Analytics for Customer Segmentation**

The utilisation of predictive analytics for customer segmentation encounters several hurdles, namely in the realms of data gathering and integration. In order to attain precise insights and forecasts, firms(organizations) want data of exceptional quality, including a wide range of information, and obtained in real-time. Nevertheless, the process of acquiring and integrating data from many sources, including customer databases, internet platforms, social media, and third-party suppliers, frequently presents a challenge. The establishment of a strong data infrastructure, implementation of appropriate data governance regulations, and the development of efficient data handling capabilities are crucial. The omission of appropriate data collection and integration has a substantial negative impact on the precision and utility of predictive analytics models.

The application of predictive analytics for customer segmentation necessitates a significant emphasis on data protection and ethical issues. It is imperative for organisations to guarantee adherence to pertinent data protection standards, such as the General Data Protection Regulation (GDPR) inside the European Union. Ensuring the protection of customers' personally identifiable information is of utmost importance. Furthermore, it is important for businesses to uphold transparency by providing customers with comprehensive information regarding the data that is being gathered, the analytics that are being conducted, and the intended reasons for which the data will be utilised. Ensuring the protection of customers' privacy rights and receiving informed permission are crucial elements in establishing trust and mitigating any ethical dilemmas. The ongoing challenge lies in attaining a harmonious equilibrium between personalisation and privacy when implementing predictive analytics for customer segmentation.

To achieve effective utilisation of predictive analytics for customer segmentation, it is imperative to possess a strong technological infrastructure and skills. In order to effectively manage the computational

requirements of predictive analytics models, organisations must possess the requisite processing power, storage capacity, and scalability. In addition, it is imperative for them to possess sophisticated analytics tools and platforms that enable the effective processing and analysis of extensive information. Furthermore, the strategic allocation of resources towards the development and enhancement of workers' technical knowledge and abilities is imperative in order to optimise the utilisation of predictive analytics. The lack of adequate technological infrastructure and capabilities might hinder the successful deployment and utilisation of predictive analytics for customer segmentation.

The proficiency and expertise of marketing experts are crucial factors in the effective execution of predictive analytics for customer segmentation. In order to properly evaluate and utilise the results generated by predictive analytics models, it is imperative for marketing professionals to possess a comprehensive knowledge of statistical modeling, data analysis, and machine learning methodologies. The ability to effectively convert the knowledge gained from customer segmentation into practical marketing strategies is essential. Therefore, it is imperative for firms(organisations) to give precedence to the implementation of training and professional development initiatives aimed at augmenting the analytical abilities of marketing experts. The effective application of predictive analytics for customer segmentation necessitates careful attention to bridging the skills gap in the marketing workforce and fostering data-driven decision-making.

8. The Impact of Optimised Customer Segmentation on Digital Marketing Strategies Measuring the Effectiveness of Customer Segmentation

The assessment of customer segmentation's effectiveness is crucial for the evaluation of the efficacy of digital marketing techniques. Important indicators including as conversion rates, expenditures associated with acquiring customers, and the value of customers over their lifetime can offer significant insights into the influence of customer segmentation on different marketing endeavors. For instance, when customised marketing initiatives are directed towards certain customer segments and result in increased conversion rates, it suggests that the segmentation approach is successfully engaging and intriguing the intended audience. Through the analysis of these variables, marketers have the ability to determine the categories that yield the greatest returns and then deploy resources in a strategic manner.

8.1 Key Performance Indicators (KPIs) for Digital Marketing Strategies

When evaluating the influence of enhanced customer segmentation on digital marketing strategies, it is crucial to take into account the pertinent key performance indicators (KPIs) that align with the particular objectives of the marketing campaign. The Key Performance Indicators (KPIs) may exhibit variability depending on the specific characteristics of the business and the goals of the campaign. Several key performance indicators (KPIs) often utilised in digital marketing techniques encompass website traffic, click-through rates, conversion rates, customer engagement, social media interactions, and sales income. Through the diligent monitoring of these key performance indicators (KPIs), marketers are able to assess the efficacy of their segmentation strategies and employ data-driven decision-making processes to enhance and optimise their marketing activities.

9. Evaluating Return on Investment (ROI)

The review of the return on investment (ROI) is crucial in comprehending the financial implications of customer segmentation on digital marketing strategies. The study of return on investment (ROI) considers the allocation of resources towards segmentation, encompassing activities like data collecting, utilisation of analytic tools, and implementation of marketing initiatives, and afterwards evaluates these investments in

relation to the corresponding advantages obtained. This enables marketers to assess the profitability and total value derived from their segmentation endeavors. Through the process of determining the return on investment (ROI), marketers are able to make well-informed decisions regarding the allocation of resources, budgeting, and the potential for scalability in their segmentation projects.

The importance of customer segmentation in digital marketing cannot be over-emphasised. The effectiveness of this approach is in its capacity to provide customised marketing, the production of focused content, and the enhancement of customer retention and loyalty. Various methodologies for segmentation, notwithstanding their inherent constraints, provide significant contributions in understanding customer characteristics, actions, and geographical inclinations. The implementation of predictive analytics has significantly accelerated the customer segmentation process, due to its ability to facilitate real-time decision-making and provide precise customer insights. The case studies conducted have exhibited effective application of predictive analytics, resulting in significant enhancements in digital marketing strategies. This extensive investigation of customer segmentation within the realm of digital marketing makes a substantial contribution to our comprehension of the topic. This statement elucidates several methods of segmentation and underscores the significant influence of predictive analytics. In addition, this resource offers interesting case studies that aid marketing professionals, digital marketers, and academics in developing a more comprehensive understanding of this vital domain. The consequences of achieving greater marketing success and improved customer satisfaction are significant and have wide-ranging impacts within the sector.

To further future research, it is recommended to prioritise the investigation of novel tools and methodologies that might augment the usefulness of predictive analytics in the context of customer segmentation. Moreover, it would be beneficial to investigate potential strategies for addressing obstacles related to data gathering, data protection, and the training needs of marketing practitioners. An analysis of the various sectors' reactions to these strategies and an evaluation of their respective return on investment (ROI) would yield advantageous insights. In summary, the practice of customer segmentation, especially when supported by predictive analytics, has a transformative impact on the field of digital marketing. Despite the inherent complexities connected with implementing data-driven customised marketing strategies, it is important to acknowledge the numerous advantages that far surpass the problems encountered. Investing in these techniques is a valuable opportunity for businesses aiming to achieve success within the digital domain.

10. Effectiveness of Predictive Analytics in Identifying Customer Segments

Predictive analytics has demonstrated significant effectiveness in customer segmentation, as evidenced by the examination of diverse case studies. Research done by Smith and Johnson (2019) examined customer data from an e-commerce firm in order to construct prediction models with the objective of categorizing customers according to their purchasing patterns. The study's results indicated that the utilisation of predictive analytics algorithms not only facilitated the identification of previously unexamined customer categories, but also enhanced the precision of targeted marketing efforts. In a similar vein, the study conducted by Roberts et al. (2017) delved into various case studies in the retail and telecommunications industries. The research highlighted the significant influence of predictive analytics methods on enhancing the precision of customer segmentation. This, in turn, empowered organisations to tailor their marketing endeavors to cater for distinct target demographics.

Upon doing a comparative analysis of the several methodologies utilised in predictive analytics for customer segmentation, it becomes apparent that the selection of a particular approach has a substantial impact on the precision of segmentation. In the study done by Brown et al. (2020), a comparison was made between

several machine learning methods, including random forests, k-means clustering, and support vector machines, within the domain of customer segmentation. The findings of their study revealed that random forests outperformed other algorithms in terms of both accuracy and precision. Moreover, the integration of several methodologies, such as the utilisation of k-means clustering in conjunction with decision trees, yielded enhanced clustering efficacy. In contrast, the study done by Williams et al. (2018) focused on examining the effectiveness of several statistical techniques, such as hierarchical clustering analysis and discriminant analysis, for the purpose of customer segmentation.

11. Potential Areas for Future Research and Prospects

Future study in the dynamic realm of digital marketing should focus on investigating the possibilities of developing technologies. The utilisation of technology like as artificial intelligence (AI), machine learning, and natural language processing (NLP) holds the potential to augment predictive analytics and customer segmentation strategies. Through the utilisation of artificial intelligence (AI), machine learning, and natural language processing (NLP), marketers have the ability to acquire more profound understandings of customer behaviors and preferences. Consequently, this capability empowers them to customise their marketing endeavors with enhanced accuracy.

An additional domain that merits more investigation is the incorporation of unstructured data sources into predictive analytics models for the purpose of customer segmentation. Researchers should prioritise the integration of unstructured data, like as social media postings and customer evaluations, in addition to typically utilised structured data like demographic and transactional data. Engaging in such activities might yield significant findings on customer attitudes and inclinations. Future research should focus on the development of strategies and processes that can efficiently handle and evaluate unstructured data. This will allow marketers to fully leverage the potential of predictive analytics in the process of customer segmentation.

The growing dependence on predictive analytics within the realm of digital marketing necessitates a comprehensive examination of the ethical implications that accompany its use. Further investigation is required to examine the potential effects and ethical issues presented by the utilisation of predictive analytics in the process of customer segmentation. Potential areas of inquiry encompass topics such as privacy concerns, instances of prejudice, and the level of openness within a given context. Through a comprehensive understanding of the ethical issues associated with predictive analytics, marketers have the ability to formulate rules and establish optimal methods in order to guarantee the conscientious and liable implementation of customer segmentation strategies.

While the current body of literature mostly concentrates on the utilisation of predictive analytics within the domain digital marketing, it is imperative for future research endeavors to delve into the potential applications of this analytical discipline across many industries. Various industries, including healthcare, banking, and retail, among others, might get advantages from the application of predictive analytics in the process of customer segmentation. Examining the difficulties and achievements associated with the deployment of predictive analytics in various sectors can yield significant insights and build optimal methodologies that can be employed within the domain of digital marketing.

In conclusion, it is imperative for future studies to investigate the enduring effects of predictive analytics on customer behavior. The increasing prevalence and sophistication of predictive analytics necessitates a comprehensive knowledge of its impact on customer decision-making processes, buying habits, and brand

loyalty. By conducting longitudinal research and employing data-driven analysis, it is possible to get insights into the enduring impacts of predictive analytics. This would enable marketers to adjust their plans properly and enhance their customer segmentation techniques.

12. Conclusion

This article examines the transformative effects of predictive analytics on customer segmentation, highlighting its significant influence on strategic marketing. The application of statistical models, sophisticated data gathering methods, and machine learning algorithms has demonstrated the substantial enhancement of customer segmentation accuracy through predictive analytics. Its effectiveness has been further demonstrated through the examination of several case studies, which have emphasised the positive impact on decision-making processes and the refinement of marketing strategies. Nevertheless, it is crucial to recognise the obstacles linked to the quality and privacy of data, which require thorough deliberation when using these methodologies.

The results of this study emphasise the crucial significance of predictive analytics in the field of marketing. The aforementioned technology functions as a potent instrument that offers accurate observations on customer behaviors and preferences, thereby facilitating the success of firms operating within data-abundant contexts. Moreover, it signifies a transition towards progressively tailored marketing approaches. Despite the possible obstacles that may develop, the presence of avenues for future research and improvements ensures that predictive analytics continues to have a prominent position in the field of marketing. Hence, it is crucial for contemporary marketing professionals to have proficiency in these strategies.

This study examines the impact of predictive analytics on digital marketing, specifically in relation to customer segmentation. The utilisation of predictive analytics has provided valuable insights into the importance of improving marketing strategies, facilitating the implementation of targeted promotions and scheduled commercials. Furthermore, the present research has thoroughly examined the difficulties and progressions in customer segmentation based on predictive analytics, hence offering a full comprehension of its pragmatic implementations via empirical case studies.

The literature review has played a significant role in enhancing the comprehension of predictive analytics within the realm of digital marketing. The significance of predictive analytics in customer segmentation has been underscored. Based on extensive academic and empirical investigations, this study has successfully recognised the advantages, constraints, and current developments pertaining to predictive analytics. The incorporation of case studies with successful implementers has provided significant insights into the application and execution of the subject matter, thereby establishing a basis for future scholarly investigations.

The analysis has definitively demonstrated the primary significance of predictive analytics in enhancing digital marketing strategies, namely within the sphere of customer segmentation. The confirmation of the transformative impact of predictive analytics on marketing strategies lies in its ability to foretell future outcomes. Nevertheless, the assessment has also brought attention to the obstacles that businesses must effectively manage. In order to fully harness the capabilities of predictive analytics and effectively tackle new difficulties, it is advisable to do more study. This would provide guidance for future deployments and stimulate further advancements in the industry.

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A Framework for Data Protection and Privacy in Data Service Centres in the Public Sector: A Case Study of a Security Organisation in a Developing Countries

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Abstract

Many security agencies used outsourced information systems in the past, but shifted to private data centre systems in order to have better security. However, as it stands, data protection and privacy are a concern due to inadequate security measures and service level agreements. This is coupled with the fact that Private Service Providers mostly handle these data. Another problem with organisation is the absence of good business continuity and disaster recovery plan exposes which puts the organisation's information at risk. Thus, guided by the Protection Motivation Theory and NIST cybersecurity framework, this research explored and evaluated current security and privacy conditions in a security organisation and developed a framework that will overcome these security issues. This research data was, collected using semi-structured interviews and questionnaires. The servers' functionalities were observed, qualitative data was analysed using thematic analysis by coding according to themes, while quantitative data was analysed using table and charts. The study identified various elements which are essential for data protection and privacy framework such as data breach, lack of security awareness and training of employees, network security, standards and operation procedures, ethical conduct, auditor services level agreement (SLA), computer virus, absence of disaster recovery and absence of security policies.

Keywords: Security, private cloud, Data Protection, Privacy.

1.0 Introduction

As technology has grown tremendously in the last few decades, data and applications have become even more essential. Currently, the number of people using cloud services through Data Service Centres has been increasing and a lot of data that has been put in cloud computing platforms (Rawass, 2019). There are so many benefits of cloud computing for individuals or organisations to increase productivity. However, there are many threats and risks that must be organised to suitable standards for maintaining the confidentiality, integrity, and availability of data for daily routines (Velumadhava, Rao, and Selvamani 2015). Cloud solutions deliver a strong computing platform which enables individuals and cloud users to perform several tasks and levels of responsibilities such as, accessing the organisation applications, and enhancing network infrastructure. The purpose of this qualitative research was to explore the security mechanisms that security organisations use to protect their data and maintain their privacy when using cloud services from Data Service Centres. The target population consisted of IT professionals such as System Administrators and other IT technician as well as specialists from service providers. Data collection's instruments comprising Questionnaires, semi structured/focus group interviews and observation were used to obtain data regarding the security mechanisms used in security organisations to protect data and privacy from security threats.

To deal with the risks that arise in private cloud services, information security and cybersecurity frameworks can be adopted to provide guidance in managing and operating cybersecurity continuously, in terms of technology, management, and hardware, for achieving confidentiality, integrity, and availability of data protection and information security. Thus, this study focused on

developing a framework for data protection and privacy in the private service cloud that will guide the organisation on how to improve its security mechanisms.

1.1 Private cloud overview

It is also known as Internal Cloud; contains a distinct and protect cloud built environment in which only the detailed consumer will work. It allows only the authorised clients, and offer the organisation more and straight control over their information. The private cloud design is nearer to some traditional design for single local access networks (LANs) consumed before by initiative but using the extra advantages of virtualization. With private cloud, the structures and assets that offer the facility are sited inside the business or organisation that utilise them. The organisation is in charge for the controlling and administration for the systems that are used to deliver the service (Rountree & Castrillo, 2013). Furthermore, the organisation is also in charge of some software or client application that is set up on the end-user system. Private clouds commonly gain access to through the local LAN or wide area network (WAN). In some circumstance of remote users, the access will generally be delivered through the Internet or sometimes by the use of a virtual private network (VPN), (Nawaz & Rahim, 2016). The asset may be used in-house alternately remotely.

The major requirements of private cloud deployments are security measures and protocols that need a restriction parting of an organisation's information storage and handling from brutal access over shared resources. Private cloud models are legacy systems with amazing hardware requires and unique resource demand, like extreme memory or computing instances, which are not offered in public clouds. The virtualization initiative in organisations is to reduce IT costs and build a more elastic, operational and computerised job environment.

The objective of private cloud model is to let an administrator cope with technology infrastructure from a single spot, where resources can be distributed as demanded and its enterprise computer architecture is secured with the firewall. This is particularly essential for an organisation that uses strict compliance protocols. Private cloud is divided into two kinds which are, On-Premise Private Cloud, and Externally-Hosted Private Cloud. On Premise private cloud as well-known as internal clouds are designed inside the owner's data center. This model offers an extra standardised method and protection but is narrowed in aspects of size and scalability. This is suitable for applications that need whole control and configurability of the infrastructure and protection. Externally-Hosted Private Cloud is hosted outside by a cloud provider, where the provider assists an exclusive cloud environment with full guarantee of secrecy (Helode, et al., 2017).

1.2 Cloud security issues experienced with private cloud

- Shortage of stable security controls across server and virtualized infrastructures of the private cloud.
- Increase in infrastructure complexity leads to more deployment and maintenance
- Time and effort.
- Nonexistence of staffs with security management abilities for virtual computing, networking, storage.
- Inadequate brightness of software-defined data center security for instance virtual computing, networking, storage.
- Advanced threats and attack (DSM, 2019).

2.1 Private cloud security threats and challenges

2.1.1 Security breaches

Although a lot of organisations have faith in their sensitive data in a private cloud to be safer, truth is, that virtual private clouds (VPCs) and public clouds are usually extra safe for the reason that, are actually sustained by security specialists who recognise cloud security challenges and how to mitigate them. Moreover, as all clients work on the similar back-end infrastructure, third-party cloud providers have a much entrusted interest in keeping things functioning easily and safely. In order to keep consumers happy, reliable providers usually spend more time obtaining this degree of reliability and protection than any individual company would (DSM, 2019).

2.1.2 Physical security concerns

Many government ministries do not have the similar physical security characteristics that third-party data centers provide, that can make their information exposed to a lot of risks. To create unauthorised access very hard, and higher fire protection systems and weather resistance, an honest data center would have DVR motion cameras to track and record movement in the office block, multi-factor authentication security and alarmed man-traps. Most providers provide geo-redundant data centers, meaning that they will take services across the national or country; they can take jobs to alternative facility when there is a hazard in one region, so that the business of their customers does not miss a beat (DSM, 2019).

2.1.3 Overbuying or under buying capacity

On-premise computing is not the cloud as we know it; without needing to purchase new hardware, the real explanation of a cloud is that it is flexible and scalable. A rise in capability would require more equipment when maintaining one's own infrastructure. IT teams will as well not tell accurately how much power they're going to need, and end up over spending to make sure they're not short. The company, in turn, gets trapped paying for costly, unused capacity and the assets to house it. On the other hand, if they did not buy sufficient space, if website traffic becomes too high, they might go down (DSM, 2019).

2.1.4 Compliance concerns

In general, boundary for sustaining agreement through on premise hardware are more clear than in the cloud, yet, it can be slow and costly requiring an organisation to hire a regulatory IT team. This is why they need to know sets of compliance regulations; for instance, a state or an organisation that as well takes credit card payment may need both CJIS and PCI DSS compliance, whereas a healthcare organisation that takes credit card payments must agree in Insurance Portability and Accountability Act (HIPAA) and Payment Card Industry Data Security Standard (PCI DDS). In addition, the crew must take the capability to constantly observe systems and logins, design pure security incident measures, and employ data encryption to make sure compliance is met. In addition, to ensure compliance is met, the team would need to be able to constantly track systems and logins, establish specific security incident protocols, and hire data encryption (DSM, 2019).

2.1.5 Performance concerns

Each time new versions of software are delivered it would need to be purchased and installed by organisation using a private cloud, which is equally costly and time wasting. Others can set it aside and carry on running on void software, that expose them to threats that let hackers to take advantage of them, or resulting in jobs running on a low speed. For both workers and clients, downtime often affects efficiency. While a Virtual Private Cloud or public cloud provider would usually get a business active and operating just soon after an event, it may take hours for an unskilled internal IT team to operate all systems (DSM, 2019).

2.1.6 Mitigating the security issues in private cloud

DevSecOps Processes-DevOps and DevSecOps have been constantly revealed to improve the quality of code and decrease abuses and exposures, and to rise the speed of application design and configuration of roles. Rather than depending on a stand-alone security authentication team, incorporating development, Quality Assurance, and safety procedures inside the business element or application group is essential to run at the speed of the business environment specifications of today.

- **Automated application deployment and management tools** - Combined with the increasing capacity and speed of security risks, the absence of security capability means that even the most trained security expert cannot maintain. An essential component of modern IT task is computerised that reduces boring jobs and raises human interests with computer benefits.
- **Unified security through centralised management across entirely services and providers** - No vendor can produce anything, but it is also simple for anything to fall over multiple management tools. An open integration fabric centralised management framework decreases complication by placing the components together and streamlining workflows (Mubashir, 2020).

2.1.7 Network security attackers

Distributed Denial of Service (DDOS) Attack - The big quantity for network traffic being transmitted by attackers and users are refused access to services and the subscriber faces blackmails that they need to follow so that they can avoid this attack. This is why providers like Amazon offers multi-homed networks around the provider to facilitate diverse internet connectivity (Ertaul et al., 2010).

- **Man in the Middle Attack** - The eavesdropping technique whereby the intruder creates independent contacts with targets and transmits messages among them, letting them think that they are speaking straight to one another through the private network but in reality the whole conversation is controlled by the attacker (Williams, 2006).
- **Internet Protocol (IP) Spoofing** - This allows an attacker unauthorised access to the device and deceiving and designing TCP/IP packets using other people's IP address, so that once the attacker sends messages the device inside an IP address implying that the message comes from the trustworthy host (Williams, 2006).
- **Port Scanning** - When the describer designed security group to permit traffic from some source to a particular port this creates risk to such port because it is an area whereby all data pass through in and out of the computer this allow port scanning to recognise exposed access to a computer, or port scanning use it as an open door to the computer. This makes it vulnerable to a port scan as the describer built the protection group to allow traffic from any source to a specific port because it is a location where all information passes in and out of the device, enabling port scanning to identify an open door to a device, or port scanning to use it as an open door to the computer. William (2006) encourages the use of cloud middleware software in cloud computing to adopt protocols in all cloud technology that avoid port scanning.
- **Packet Sniffing** - If tenants use the application to listen to packets they are interested in on the raw network computer. A packet that satisfies certain conditions is obtained by this program and logged to a file. There is no sniffing access to the cloud since it uses a malicious - sniffing detection platform built on ARP Address Resolution Protocol and Round Trip Time (RTT) to discover a sniffing device operating on a network (Williams, 2006).

2.1.8 Service level agreement (SLA)

A service level agreement (SLA) is a contract between a consumer and a service provider. Detailed service level objectives are defined during SLA talks. Services, quality of service, performance, and parameters are all discussed and agreed upon. Both the provider and the consumer monitor services under an agreed-upon Service Level Agreement (SLA). If a violation occurs, the offending party will be fined (Afzal, 2019).

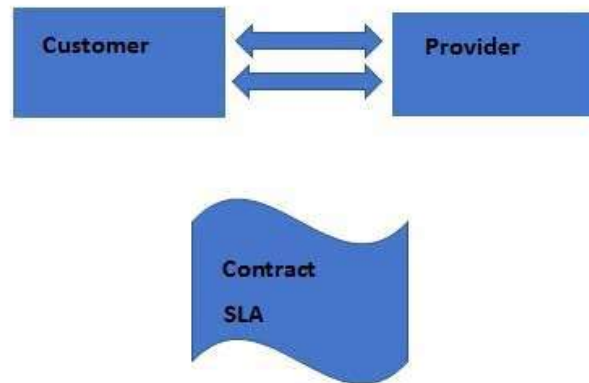


Figure 1. Service level agreement

❓ Service level agreement life cycle consist of six steps

Step 1 - Customer discover services which are closely related to their requirements

Step 2 - Service Level Agreement is defined for services, penalties, and Quality of Service

Step 3 - Service Level Agreement is established between both parties

Step 4 - Services are monitored against agreed SLA

Step 5 - Service Level Agreement is terminated due to fulfilling time period or any violation

Step 6 - Penalties are imposed on parties who fail to meet their Service Level Agreement



Figure 2. Shows Service level agreement life cycle/

2.2 US department of defence private cloud

Maxwell Air Force Base in Montgomery, Alabama is a United State Air Force (USAF) Defence force. As nowadays war fighting is more connected and more reliant on IT solutions than at any other time in history (Yogesh, 2018). In June of 2017, United State Air Force (USAF) and Defence Information Systems Agency (DISA) launched milCloud 2.0, a private cloud infrastructure designed to help the military embrace the cloud also to help the challenges in providing mission partners the very latest cloud technology with the highest levels of performance and security. This was fast and flexibility cloud services that allows the Department of Defence a self-service provisioning portal that enables military users to build up an infrastructure quickly.

For this reason, DoD and DISA hold military networks to highest security standards. It used by the Department of Defence Information Network (DoDIN), added layer of security because the DoD networks support essential military applications responsible for mission-critical functions, should they be vulnerable, it would weaken national security. MilCloud 2.0's is a service designed to enable management of all DoD cloud resources including their private cloud DoD is able to use the services facilitated by MilCloud 2.0, paying for only what it uses. To achieve this DOD implemented the Joint Information Environment Framework (JIE) main Objective, to remove barrier to information sharing by providing better information access to all DoD stakeholders, promote teamwork and interoperability through the DOD and work allies. Increase DOD safety against cyber treats and vulnerability reduce the cyber threat landscape and provide more visibility of networks to fight and prevent cyberattacks in advance of occurrence. Simplify the IT infrastructure. Modify the technique DoD networks are created, run and protected and by providing how DoD protects data.

Modernise IT structure: a modernised environment will help DoD agencies run into the complex operations extra efficiently by set up world-class IT. Reduction costs: when shifting to the cloud, decreasing data centers and improving information managing, the organisation cut expenses and well-trained military and civilian employees to mark extra learnt resolutions (Peters, 2020). They set up the Single Security Architecture (SSA) to assist with the JIE implementation. An SSA entails all the roles that guide the DOD to improve its IT architecture these include: helping cyber workers get valuable perceptions to their networks' status. It assists in building a powerful reaction to cyberattacks. Through standardised approach, DoD is capable of getting whoever is consuming networks using screen network traffic to and from DOD setting up, monitor traffic movements, detect and block unauthorised traffic, and separate interferences, spot abnormalities and provide better protection to improve network command and control, expand bandwidth, and synchronize networks. Allowing improved control and manoeuvring in response to cyberattacks (Peters, 2020).

2.3 China department of defence private cloud computing

Founded in September 2009 and based in Hangzhou, Alibaba Cloud is a cloud computing and artificial intelligence technology built to provide cloud computing infrastructure storage services, easy access to cloud computing, and a diverse suite of related services, such as Virtual Private Cloud (VPC), in many businesses and most government ministries, including China Defence Force. China Defence suffered Denial-of - Service (DDoS) assaults that disrupt day-to-day activities, since they are difficult to track, predict, and respond to emergencies. As an important necessity for every organisation to secure intrusions and cyber-attacks, Alibaba cloud supports the China Defence Force with anti-denial-of - service (DDoS) Pro readdresses attack traffic and defends servers from volumetric DDoS denial-of - service assaults, Web Application Firewall (WAF) identifies and stops malicious traffic, and defends website servers against interferences; Threat Detection Service (TDS) non-disruptively monitor the security

structures of cloud services.

Alibaba Cloud also allows the China Defence Force to formulate policies and procedures for governance and risk management, information security management, IT operations and via internal websites. To identify, investigate and manage risks within the organisation and those relevant to services provided, Alibaba Cloud has developed a risk management system that helps the management of defence forces and covers strategic and operational risks, such as security and availability. Its risk management framework is developed in accordance with the standard ISO27001:2013, which requires an information security risk assessment to be carried out annually. They perform information security risk assessment at least once a year and update our security policies according to the findings of the assessment (Hong, 2020).

2.4 Theoretical framework of the study: protection motivation theory

The protective motivation theory discusses how people's attitudes and behaviours change when they face risk. This theory was created by Rogers (1974). The theory, mainly established in the field of psychology, seeks to identify the factors that influence activity intentions based on "fear appeal." According to the theory, when an individual is exposed to a message of danger, protection motivations that stimulate the actions are made. This means that Protection motivation theory was created to help understand individual human responses to fear appeals. This theory assumes that the fear appeal is comprised of three components: the severity which measures the extent of the threat, the exposure which measures the possibility of being exposed to the threats, and the response efficacy which measures how to treat the threats efficient (van, Bavel et al. (2019). Later, Maddux & Rogers (1983) added self-efficacy to the list. Protection motivation theory proposes that people protect themselves based on two factors: threat appraisal and coping appraisal. Threat appraisal evaluate the severity of the situation and examines how serious the situation is, while coping appraisal is how one responds to the situation. Threat appraisal consists of the perceived severity of a threatening event and the perceived probability of the occurrence, or vulnerability. Coping appraisal consists of perceived response efficacy, or an individual's expectation that carrying out the recommended action will remove the threat, and perceived self-efficacy, or the belief in one's ability to execute the recommended

courses of action successfully (Maddux and Rogers 1983). The diagram below explains the whole theory.

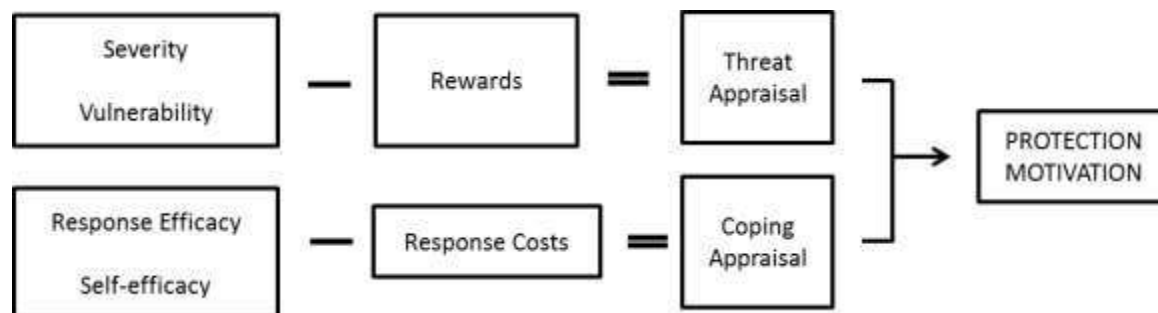


Figure 3. Shows the Protection Motivation Theory (Source: Van, Bavel et al. ,2019) Johnston

and Warkentin (2010) studied the relationship between security activity and the fear appeal and derived the research model based upon the protection motivation theory. They also added "the social effects" and "the intentions of action" which were used in technology adoption. Furthermore, they assumed that severity and danger sensitivity affected efficacy and efficacy directly affected intentions of behaviour. These triggers include fear messages that motivate people to take precautionary measures or avoid actions that could harm them or others. This model goal is to guide people how to deal with situation

by assessing the seriousness of the threat so that they can suggest the protection measures that they use to respond to the threats. The main aim of this study is to develop a framework that will guide the Security organisation to protect its data and how to deal with fears when experiencing attacks. As the study explored the security mechanisms used by the Security organisation and examine attacks that are experienced by the Organisation, the researcher engaged with specialist and give views on how to improve Security organisation security that leads to the development of the proposed framework.

Comparison of Frameworks. The table1. below shows the framework comparison

Frameworks Names	Goals	Evaluation	Guidance how to implement?	Approach used to create the model Framework)	Main elements used to create the model
Data Security Framework	It provides security to data in cloud computing	No	No	Data security practices	Confidentiality, Integrity,
Information Security Framework	It assess the organisation's existing information security policies.	No	No evaluation, it needs to be reviewed by IT professionals	Bottom-up and Top down approaches	Confidentiality, integrity, availability, authenticity, and non-repudiation.
Framework for Secure Cloud Computing	It identifies security and privacy challenges in cloud computing. It highlights cloud specific attacks	No	No	Compliance standard	Security and privacy requirements. Attacks and threats.
NIST Cybersecurity Framework	It guides an organisation to enhanced understand, manage and ease the likely cybersecurity threats.	No	Yes	Risk-based approach (by placing of cybersecurity risks to the business risks)	Framework core, implementation tiers, and profiles

2.4.1 Research gaps in the existing frameworks

Some information security frameworks were explored above. Not all of these frameworks can be of use for to specific security agency since each of them has its unique objectives. Firstly, Data Security Framework ensure the information security in cloud computing. This framework demonstrates the working of all solutions together. This study explores suggested components to improve its current security mechanisms in cloud but find it challenging to adopt it due to this reasons that: This framework did not explain steps how the four parts should be implemented, neither gave an example of the organisation that have implement it, no evaluation from any organisation. Secondly, the Information Security Framework assess the organisation's existing information security policies, provides some guidelines on how to upgrade and evaluate the information security policies and practices (KNBS, 2021). The study cannot adapt it because any organisation intends to use this framework must be controlled and managed by the International Committee of the Red Cross (ICRC) and all information systems will be approved by ICRC and only applicable to its internal staff, associates and beneficiaries (Office of the Chief Information Officer, 2014). Furthermore, it went as far to explore the Framework for Secure Cloud Computing that identifies security and privacy challenges in cloud computing (Jouini & Rabai, 2019). It brings out cloud attacks and threats

and clearly demonstrates their mitigations and countermeasures. Although it explained the challenges and suggest solutions to these challenges and also provided the genetic model, but it never discussed on how these challenges should be managed, there is an omitting of risk management that made it not to be adapted in this study. While, the NIST Cybersecurity Framework guides an organisation to better understand, manage and ease the possible cybersecurity risks, it is flexible to address cybersecurity, comprising cybersecurity's effect on physical, cyber, and people dimensions. It is suitable for organisations relying on technology, whether their cybersecurity focus is mainly on information technology (National Institute of Standards and Technology, 2018). Every organisation has its unique attacks and for such will use the framework differently, and it is the organisation to decide on how to implement it. For instance, one organisation may choose to use the framework Implementation Tiers to articulate intended risk management practices, while another one organisation may use the Framework's five Functions to investigate the whole risk management portfolio. Therefore, the study finds the NIST cybersecurity framework to be the most appropriate because it is applicable to all organisation regardless of their sizes, it's not mandatory every organisation can implement it according to the attacks its experiencing.

3.0 Research methodology

The population used in this study comprised of participants in IT department from a security agency and its cloud service provider. This study used a mixed-methods approach and was carried out by Department of Information and Communication Technology (DICT). The study used purposeful sampling to choose participants for a qualitative study who would assist in understanding the research problem and answering the research question (Casteel and Bridier ,2021). The total sample size for the survey was twenty (20) respondents, and the study received twelve (12) responses or 60%. IT staff members (participants) were: System Administrators, Network Technicians and Computer Technicians. Descriptive statistics (percentages) were used to analyse the quantitative data which has responses in Microsoft Excel. Charts were further constructed in Excel to illustrate the percentages of security standards used by the security agency. A table was used to analyse qualitative data and further used to constructed in word to illustrate the Usernames and passwords management in security agency. The study used data tools such as: interviews, questionnaires, focus groups and observations. The university accepted ethical standards were considered.

4.0 Analysis and discussion of finding

4.1. The biggest security threats to data and privacy in the private cloud services

About the biggest security threats to data and privacy in the private cloud services, respondents expressed their views. Respondents' responses were categorized into the following themes:

4.2. Information leakage

The act of intentionally or unintentionally disclosing information to an unauthorised party is referred to as information leakage (Anand & Goyal, 2009). Leakage of information is a serious threat to data privacy in private cloud services. Many information sharing experts believe that promoting technology to protect information from external attacks is an important method for increasing the effectiveness of information sharing within organisations. As a result, most organisations have data privacy policies in place. This is to say that not every piece of information should be exposed to or released to the outsiders. In the case of the security agency, information leakage is regarded as one of the main threats to data privacy in the private clouds. Here are some of the views of the respondents with regards to in formation leakage:

Participant A: *“End users leak information to social media. Users tend to use the organisation’s devices and network resource to access social media websites that pose a high data security threat because social networking sites are often targeted by malware, receive a high degree of spam and can be used to gain information to identify theft.”*

Participant B: *“Information can be leaked through personal mobile devices that are used to conduct work outside the Organisation regular security boundaries. If device get lost or stolen security can be compromised by malicious code invading the operating system and applications.”*

4.3 Users

The human factor is crucial in information sharing, especially when companies have lax internal controls. In other words, it is an undeniable fact that unethical uses of IT are easily committed by insiders (Crossler et al., 2013). According to participants in this study, information breaches are frequently caused by employees' negligence or ignorance of information sharing, resulting in significant financial losses for organizations. In other words, participants revealed that users of the private data clouds are the main threats to data privacy. Here are some of the views of the respondents about how users can be a threat to data privacy:

Participant C: *“The users are the biggest threat to data privacy of the organisation because they share information outside the organisation. Also, on Internet Web sites where users like browsing the internet and visiting compromised or unsecured websites could result in malicious software being downloaded to computers and network of the security organisation because this is where malicious code can be transferred to a computer through browsing webpages that have not undergone security updates. Secondly, there no policies that guide users on security protocols.”*

Unintentional leakage, on the other hand, occurred as a result of negligent employees breaching their duty to protect and accidentally leaking valuable information to third parties. Furthermore, Molok, Chang and Ahmad (2010) affirmed that internal user information leakage is perceived to be more accidental than intentional, owing to the widespread use of mobile devices to access social networking sites.

4.4. Intruders

Security threats to organisation's well-being are evolving in a variety of ways, including cyber-attacks (Kim, Kim & Chang, 2020). While cyber-attacks from outside an organisation are typically used to obtain sensitive data, security attacks can also originate within the organisation. In the case of the security organisation, some of the participants had the following to say about the effects of intruders on data privacy of the private clouds of the organisation:

Participant D: *“The organisation has experienced intruders who attempt to damage or destroy a computer network or system or even destroying the integrity of the data or stealing confidential information.”*

Furthermore, according to Kim et al. (2020), data security incidents have the characteristics of hidden crimes and have a significant impact on corporate image, such as decreasing the organization's credibility when informing the public of the security incident. This aligns with the views of the participants that intruders on data security of the security organisation had evil intents to damage the reputation of the Organisation.

4.5. Existing security mechanisms to protect data and privacy in the private clouds

The organisation has security mechanisms in place to protect data and privacy in the private clouds. However, the question remains whether such mechanisms provide optimal data protection for private clouds. In order to find answers to this question, participants expressed their views as follows based on their experience:

Participant A: *“The organisation uses Kaspersky Internet Security as internet security suite that protect computers from virus by scanning the memory sticks once plugged on the Organisation's*

computers.”

Participant B: *“The organisation also uses firewall, a security device in the form of computer hardware or software. It helps to protect the organisation’s network by acting as an intermediary between internal network and outside traffic. It monitors attempts to gain access to its operating system and blocks unwanted incoming traffic and unrecognized sources.”*

Participant C: *“Moreover, an Active Directory is used to authenticate and authorises all users and computers in a Windows domain type network, assigning and enforcing security policies for all computers, and installing or updating software.”*

Participant D: *“There is an encryption of data that protects data when the organisation is communicating with other organisations by encrypting the data before transmission; authenticating the endpoints; and decrypting and verifying the data on arrival.”*

Based on the views of the participants, it can be said that the organisation has security mechanisms in place to secure data protection in private clouds. It was revealed that most of the mechanisms in place are centered on Internet security. This is mainly because most of the data security concerns happen through the Internet. However, since the data leaks is one of the main challenges facing data privacy within the organisation, an encryption of data is also applied to protect data when the organisation interact with outside organisations. This concern is into alignment with the idea of Kacha and Zitouni (2018) that data security is a common concern to all technologies. This is the method that ensures that all data going out and coming is verified for authenticity and security.

4.6. Challenges associated with protecting data and privacy in the private cloud

As indicated earlier that data security is a common concern to all modern technologies (Kacha & Zitouni, (2018), it is worth noting that this issue becomes a major challenge when applied to an uncontrolled environment like cloud computing. These challenges are generally associated with open, shared and distributed environments. In order to deal with such as challenge, it is crucial that associated challenges are identified.

The views of the participants concerning the challenges experienced in protection of data and securing data privacy in private clouds services such as Outlook and Zoom.

4.6.1 Endpoint device users

Endpoint device users pose a serious threat to data privacy in private clouds. A couple of participants revealed that the main challenges associated with data privacy in the private clouds are attributed to endpoint device users.

Participant A: *“The use of insecure removable media devices, for instance flash drives, and external hard drives poses a significant security threat on the network of the Organisation.”*

4.6.2 Lack of physical devices security detection

The lack of physical devices security detection is a key area that requires a special attention in data protection. This is because the protection of sensitive data in the cloud is a challenge of increasing importance. According to Mann, Metzger and Schoenen (2018), a possible approach to cope with continuously changing data protection requirements in a dynamic cloud environment is to apply runtime monitoring and adaptation. A run-time model of the cloud is useful for detecting and mitigating data

protection violations (Mann et al., 2018). As a result, participants in this study indicated that one of the best ways to protect data privacy in private clouds is by paying attention to the issue of the lack of physical devices security detection.

Participant A: *“Lack of physical devices security detection such as sensors, alarms, and automatic notifications, neither the security systems such as requiring a key card that are designed to slow down or delay intruders as they attempt to enter a facility or building.”*

4.6.3 Poor physical premises security

Physical premises security is another aspect that needs to be considered when it comes to data protection. For example, if everyone in the organisation has access to the server or computers that contain sensitive data; this will pose a significant threat to data security. On that issue, participants feel that the security of physical premises is concerning.

Participant A: *“Physical premises security of the organisation lack of physical security measures to the premises that are designed to deny unauthorised access to facilities, equipment and resources and to protect personnel and property from damage or harm and theft.”*

Participant B: *“Lack of physical security regarding the access to the organisation’s premises and later to its network is a serious concern. The organisation’s data users are the limitations on integrity because they lack training on the usage of IT services and equipment.”*

Physical security is critical for preventing unauthorised access to sensitive data and safeguarding an organisation's personnel and resources. A physical security system that is effective is an essential component of a comprehensive data security. Physical security measures include restricting access to dedicated computers, server rooms, routers, printers, and any other areas where sensitive data is processed or stored (PTAC, 2012).

4.6.4 Possible improvements of the existing security and privacy protection mechanisms

Although there are many issues surrounding the aspect of data privacy in private clouds of the security organisation under this study, it is believed that there are solutions that can be applied to overcome these issues. On that note, and given that the subject of data privacy is concerning, participants in this research were asked to give their views about the possible improvements that can be made to strengthen security measures. Here are the views of the participants on this aspect:

- **Network Access Control**

Network access control is one of the key areas where issues concerning data privacy in private clouds are rooted. On that aspect, participants suggested the following improvements:

Participant A: *“The organisation must modify its Network Access Control to the complex. Furthermore, the organisation also needs to Implement Network Access Control such as host intrusion prevention, and vulnerability assessment, that enforces policy on devices that access networks to increase network visibility and reduce risk by keeping unauthorised users and devices out of a private network.”*

Participant B: *“The organisation needs to add traffic encryption on its network to protect the confidentiality of digital data either stored on computer systems or transmitted through a network like the internet. Furthermore, the organisation has to implement device identification services, also needs to update its software and hardware and invest in hardware that is able to do security check. This should also include access control list on firewall will stop unauthorised access to the organisation’s IT services and equipment.”*

Participant C: *“Implement device identification services that will identify threats and block them before reaching the organisation’s network.”*

- **Data protection policies**

Lack of policies to enforce improved security mechanisms within the security organisation is one of the main challenges. Although there are a few policies in place supporting data privacy in private clouds within the organisation, there is a need for the development of guiding policies in data protection within the security organisation.

On this aspect, participants had the following to say in their suggestions:

Participant A: *“The organisation also needs to draft its Security policies that will protect users and information, set the rules for expected behaviour by users, define, and authorise the consequences of violation.”*

Participant C: *“The organisation’s hardware like servers, access points updated at all times because newer software and hardware are more efficiently, fast and increase employee productivity, and also increases employee morale.”*

Participant D: *“There is a need for security policies, that will improve the security to 85% as well the security mechanisms suggested will greatly combat the current security loopholes within the organisation.”*

Cloud security is a subset of computer and network security that is controlled by privacy-enhancing technologies and governed by a set of policy rules to protect the deployment of data, software applications, and associated cloud services (Chen & Zhao, 2012). Therefore, it is recommended that the Security organisation develop data security policies that will enforce data privacy for its private clouds services.

- **Hardware upgrading**

Hardware is the storage point of data in an organisation. It is important that they are updated periodically. Hence, the Organisation is advised to update its existing hardware.

Participant A: *“The organisation needs to update its hardware like access points, servers and leads newer software and hardware are more efficiently, fast and increase employee productivity, and also increase employee morale.”*

Participant B: *“The organisation has to implement device identification services, and also remain committed to update its software and hardware and invest in hardware that is able to do security check. At the same time, it is important the organisation keeps on updating their software and hardware and also invest in hardware that is able to do security check.”*

Based on the suggestions of the participants, it should be noted that hardware updating is essential to enable them to pick up new updates and new software such as Antivirus protection updates in order to keep the clouds safe protection infections. Therefore, the organisation is advised to implement a system that will ensure that hardware systems are upgraded all the time.

- **Staff training**

Like in any department of any organisation, staff training is essential for the IT department of any security organisation. According to Nebo, Kenneth & Ego (2015), physical, social, intellectual, and mental training

are all important in facilitating not only the level of production but also the development of personnel in an organisation. In order to keep IT staff on the right track in their duties within the department data security, participants believe that it will be best if they are offered training in data security.

Participant A: *“The organisation must train its users on physical security and include ICT policies in military training.”*

The world is evolving with new technologies being introduced. At the same time, data criminals are also advancing in their schemes against data security. Hence, it is important to understand that the phenomenon of training and development of employees requires understanding all changes that happen in the market as well as all changes that occur as a result of new developments (Nebo, Kenneth & Ego, 2015).

- **IT technicians**

In addition to the interviews with the management, the study also obtained information from IT technicians by means of questionnaires. The findings from the IT respondents are presented under the following themes derived from research questions.

- **Security standard used for data protection in private cloud**

As customers transition their applications and data to the cloud, it is critical that the level of security provided in the cloud environment be equal to or better than the level of security provided in their non-cloud IT environment (Cloud Standards Customer Council, 2016). Failure to provide adequate security protection may result in higher costs and potential business loss, effectively eliminating any potential benefits of cloud computing.

Respondents indicated their views on their security standards used for data protection in private clouds

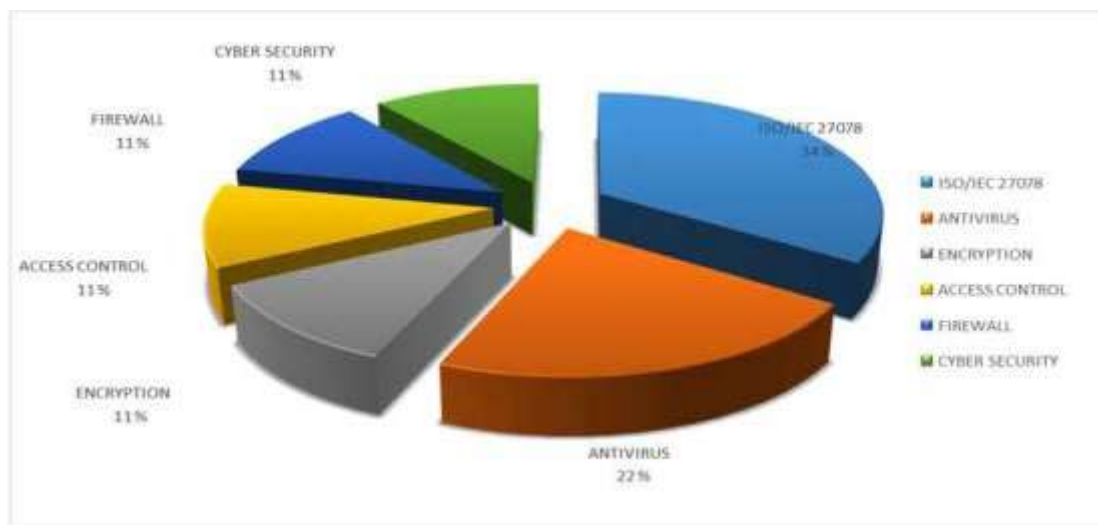


Figure 3 Security standards

Majority of the IT technicians (34%) indicted that ISO/IEC 27018 standards is the most significant standard that the Organisation uses to protect data in private clouds, followed by Firewall (11%) and Antivirus (22%) and Encryption (11%). The least significant (used) standards were identified to be Cyber security (11%) and User access controls (11%).

Information (data) must be handled consistently in accordance with its confidentiality and disclosure requirements. In addition, data owners are in charge of determining the appropriate classification level for the information contained in the applications they own. Based on the findings, it can be said that the Security organisation has upheld ICT security stands, particularly ISO/IEC 27018 standards to ensure data security in private clouds.

It is worth noting that many organisations choose to adopt ISO/IEC 27018 standards as a generic industry cyber security standards framework. However, it has been pointed out by Cisse (2019) that although this is an excellent first step, it may not address adequately all of the enterprise's statutory, regulatory and business obligations.

- **Username and password management**

Text-based passwords continue to dominate online user authentication. They safeguard online accounts with valuable assets and are thus constantly targeted by various cracking and harvesting attacks. In the case of the security organisation, it was revealed by the IT technicians that passwords are managed through various mechanisms to ensure that no data leakage takes place as a result of poor password management. Table 4.1 discusses the main techniques for password management and their functions.

Table 2. Usernames and passwords management

Password management mechanism	Description
Authorized personnel manage usernames and passwords	The Organisation has given special rights and authority to specific officials within the department of IT to manage usernames and passwords for all the members of the organisation that has access to private clouds. This means that not everyone that has access to private clouds can create or delete passwords and usernames. In this way, the department can detect any unlawful activities in the private clouds.
Domain controllers	The Organisation ensures that the domain and server are controlled and monitored closely at all time through an active Directory site. An Active Directory site, typically, represents a geographical site of high-speed connectivity.
Update usernames and passwords	The IT department ensures that passwords and usernames are up to date. In an event you suspicion that any account has been compromised, the password is changed right away. This is best performed on a computer that that the user does not frequently use. The department makes sure that all passwords are secure. This means that each password is reasonably difficult to guess in a short period of time, either by human guessing or by using specialised software

Password security is heavily reliant on creating strong passwords and keeping them safe from being tampered with. Hence, it was revealed by the respondents that one of the safest ways to ensure data security is through creating strong passwords.

- **Securing electronic data in transit to other organisations**

Data in transit, also known as data in motion, is information that is actively moving from one location to another, such as across the internet or a private network. Data protection in transit refers to the protection of data while it is traveling from network to network or being transferred from a local storage device to a cloud storage device wherever data is moving, effective data protection measures for in transit data are critical, as data is often regarded as less secure while in motion.

According to the respondents (IT technicians), in order to secure data transit to other organisations, the Organisation has ensured that it assigns data protection policies to electronic devices. This has been ensured by means of encrypting cloud service and via firewall configurations or network access control. The Organisation has made informed decisions about the measures they need to take to protect their data flow by accurately identifying its vulnerable points.

- **Publishing service level of agreement for cloud services provider**

A service level agreement (SLA) is a contract between a service provider and its internal or external customers (Kaur & Ghumman, 2017). Furthermore, an SLA is a contract document or a formal negotiated agreement between Cloud Service Providers and cloud users that outlines the purpose and objectives of the relationship (Dash, Saini, Panda & Mishra, 2014).

To maintain the pre-migration security level of their data once it has been moved to the Cloud, agencies must be able to identify all cloud-specific risk-adjusted security controls or components ahead of time and request from cloud Providers through contractual means and SLA that all Security Components are identified and controls fully and accurately implemented (National Institute of Standards and Technology, 2018). In the case of the security organisation, the respondents indicated that there is an SLA with a service provider. Furthermore, respondents revealed that the SLA is conducted on a yearly basis.

- **Frequency of the reviews of SLA on private cloud services**

SLA statements must be measurable, achievable, relevant, and timely, and they must be specific to cloud services in order to reduce ambiguity for both cloud consumers and cloud service providers (Kaur, 2017). SLA license has certain standards that the agency should meet. For example, if a cloud service provider fails to meet the stated minimums, the provider must pay a penalty to the cloud service consumer in accordance with the agreement.

In the case of the Security organisation, respondents highlighted that the organisation conducts audits on the office 365 cloud services whereby the services being provided are revised.

- **ICT policy for data breach data protection**

A data breach occurs when there is an unauthorised release or access to personally identifiable information or other information that is not suitable for public release (Privacy Technical Assistance Center, 2012). By applying good governance, an organisation directs and controls the approach and resources used to mitigate data breach risks throughout the data lifecycle.

- **Responses to incident of data privacy violation**

One common reason for organisations to invest in information security is to protect their confidential data as well as the personal information of their employees (Acquisti, Friedman & Telang, 2006). This includes responses to any incidents of data privacy violation. The goal of data privacy response is to provide secure networks and systems on which users can exercise their right to communicate freely and privately if they so desire (Javaid, 2014). In other words, organisations should be able to respond appropriately to incidents of data violation. On this matter, respondents were asked to indicate specific responses taken by the Security organisation in response to data violation.

Respondents indicated that the use of firewalls and policies that identifies breach and immediately alert the administrators for prompt action, denoting members for violating privacy and by improving the security of data through Operating Systems (OS) and activities updated.

- **Disaster recovery plan**

The organisation does not have a Disaster Recovery (DR) plan set up. This means that there will be loss of data and disruption as systems and applications will be not available to users in time of disaster occurrence. Respondents further indicated that data recovery is supposed to be at the different location but in this case the organisation does not have any, if anything happen to building no data will be recovered this alone put the organisation at more risk.

4.7 Observations

The third and final step in data collection in this study was observations. The researcher carried out observations by visiting data center in the security organisation. The researcher looked at Kaspersky server, Domain Controller Server and Exchange Server to observe manners in which data privacy in private clouds services is maintained.

- **Kaspersky Server**

Here the observations concentrated on the functions of Kaspersky Server including network monitor, devices scanning, secure data sharing, hardware and software, network access control, security for internet gateways, file server security and mobile controls.

- **Network monitor**

Network security monitoring is typically event-driven, with alerts generated whenever an event that compromises security occurs. Network monitoring tools are software applications that monitor and protect networks from intrusions and malicious traffic, as well as the overall health and performance of the network (Homeland Security, 2015).

Based on the observations, it was identified that Kaspersky Server provides a powerful server protection by blocking latest known and potential malware threats from entering the local network via malicious or dangerous programs.

- **Devices scanning**

The purpose of devices scanning is to find possible threats. It was observed that Kaspersky Server of the Security organisation has powerful management and reporting system effective, user-friendly management tools, flexible time settings for scans and an extensive reporting system provide efficient control of file server security by scanning all the devices inserted on computers.

- **Secure data sharing**

One of the main functions of Kaspersky Server is to ensure that data sharing is monitored. It was revealed that the server (Kaspersky Server) allows employees to easily create encrypted and self-extracting packages to ensure data is protected when sharing via removable devices, email, network or web. This is important because internal employees can be a part of the threat to data privacy (Molok et al., 2010).

- **Hardware and software**

Observations revealed that there is a full visibility and control, including blocking of all software deployed across the network, together with the automatic identification, registration and tracking of all hardware, including removable devices.

- **Network access control**

It was observed that the Kaspersky Server *does not* automatically recognise and checks new devices on the network against inventories and IT security policies, denies access to compromised devices and redirects guest devices to a captive portal. Hence, this is one aspect that will require a special attention as far as data protection and data privacy in the private clouds of the Security organisation are concerned.

- **Security for internet gateways**

According to Privacy Technical Assistance Center (2012), inadequate IT security can compromise data confidentiality, integrity, and availability due to unauthorised access. Internet gateways can pose a significant threat to data privacy in private clouds. Fortunately, according to the observations, it was indicated that the Kaspersky Server ensures secure Internet access across the Organisation by automatically removing malicious and potentially hostile programs in HTTP(S)/FTP/SMTP and POP3 traffic.

- **File server security**

One of the identified weaknesses of the Kaspersky Server was that it *does not* ensure file protection. Ensuring file protection is important in order to ensure that malware cannot spread to secured endpoints through stored, infected data. It also worth noting that feature that will require an improvement since data protection and data privacy in the private clouds of the Security organisation are at risk.

- **Mobile controls**

IT administrators are able to manage and restrict applications usage, while prohibiting the usage of unwanted software. At the same time, IT administrators are as well able to block malicious sites. Furthermore, IT administration is also equipped to control access to sites that do not conform to corporate policies.

- **Microsoft Exchange server**

Microsoft Exchange server has multiple functions such as Data loss prevention (DLP), Exchange auditing Reports, Messaging records management (MRM), Information Rights Management in Exchange, Message Encryption, S/MIME for Message Signing and Encryption and Mail flow rules (transport rules) in Exchange.

- **Data loss prevention (DLP)**

System administrators are not able to identify and monitor sensitive information, such as private identification numbers used in the Organisation. Neither able to set up DLP policies to be notified when users that they are sending sensitive information or block the transmission of sensitive information. With this alone information are risk and data breach in this case will be high if this aspect is left with no

improvement.

- **Exchange auditing Reports**

According to the observation it is noted that employees are not able to audit functionality in Exchange to track changes made by the organisation administrators, and to audit mailbox access by persons other than the mailbox owner. Employees are not able to see audited actions.

- **Messaging records management (MRM)**

As observed, employees are not able to manage email lifecycle to reduce the legal risks associated with email by archive and delete email.

- **Information Rights Management in Exchange**

Although the server ensures that employees are not able to control who can access, forward, print, or copy sensitive data within an email, this function is not set in exchange server of the organisation which put the organisation's information at risk. Furthermore, IT administrators have access to the server in order to enable S/MIME-based security for the organisation. As an IT administrator with data at hand they need to know who is tampering with data so that immediate action will be taken to block them before call them for order.

- **Message Encryption**

Employee's messages are encrypted whenever they are sending message to people inside or outside the Organisation.

- **S/MIME for Message Signing and Encryption**

According to observations employees are using Secure/Multipurpose Internet Mail Extensions (S/MIME) that allows them to protect sensitive information by sending signed and encrypted email within the organisation. However, it was observed that administrators are assigned to enables secure/Multipurpose Internet Mail Extensions, this can also lead to data leakage in the private clouds of the organisation.

- **Mail flow rules (transport rules) in Exchange**

Administrators are able to inspect messages before sent or received by employees and take actions such as blocking or bouncing a message, holding it for review by a head of information security. In this way, data leakage by employees is a high risk in the organisation.

- **Domain controller server**

According to the observations, domain controller server of the Security organisation can allow employees to log on any computer that is on the domain and their security privileges will follow them and be set automatically to any computer. When employees log into their domain, the DC checks their username, password, and other credentials to either allow or deny access for that user.

However, it was also observed that it performs the following functionalities:

- Responds to authentication requests
- Responsible for allowing host access to domain resources
- Stores user account information
- Enable resource sharing for files and printers
- It can be hardened and locked-down for improved security
- The Domain controller authenticate and validate user access on the network
- Domain Controllers checks their username, password, and other credentials to either allow or deny access for that user when users log into their domain.

4.8 Framework development

4.8.1 Problem identification and motivation

In order to design and develop the framework, the existing frameworks were analysed and compared through literature review to identify any gaps within them. In addition, questionnaires, semi-structured interviews, observation conducted with Security organisation Information Technology technicians also helped to identify gaps within security mechanism and standards applied within the organisation. The research identified the problem of not having the framework for guidance on Data protection and privacy.

4.8.2 Definition of the objectives for a solution

To solve the problem identified in section 5.2, the Framework for Data Protection and Privacy (FDPP) is needed as guidance on protecting data between Security organisation(Security organisation) and other ministries as well between Security organisation with its service providers, further more Security organisation needs to commit to standards and practices of military worldwide.

4.8.3 Framework for Data Protection and Privacy (FDPP)

- To identify critical information assets inventory and Ministerial functions
- To comply to ministerial, national, international policies, regulations and laws.
- To classify assets according to their criticality.
- To detect attacks in the Security organisation in a timely manner.
- To protect physical and software assets.
- To effectively respond to detected attacks.
- To recover from attacks.

Table 3 Summarises the Framework for Data Protection and Privacy (FDPP) objectives and significance.

Table 3. Framework for Data Protection and Privacy (FDPP) objectives and significance

Objectives of the solution	Why is it important?
1. To identify critical physical and software assets inventory and ministerial functions	Identifying critical information assets inventory and ministerial functions enables Security organisation to identify risks associated with each critical asset. This will enable organisation to conduct complete risk assessments. Therefore, attacks can be prevented before they occur.
2.To detect attacks in the organisation in a timely manner.	Detection of attacks is of major importance as it helps the security organisation, to respond effectively to the attacks in order to reduce the level of the damage.
3.To protect physical and software assets	Users are reported to be the weakest link in information security. Therefore, end user roles and duties help security organisation to manage data access and information assets and to properly control security risks.
4. To effectively respond to detected attacks.	The security organisation should be able to respond accordingly to any cyberattacks in order to minimise the damage.
5. To recover from attacks.	It is important for security organisation to establish an effective strategy plan in order to recover from cybersecurity attacks or disaster occurrence.
6. To comply with international security policies, regulations and laws.	In the military there are certain laws, regulations and comply requirements in which security organisation and its service providers are obliged to comply to in order to avoid legal penalties.

4.9 Design and Development

The study reviewed existing frameworks in literature to gain secondary data that provided the basis for the proposed framework. In this regard, NIST Cybersecurity was used as guidelines. This NIST was selected

because of the needs and core security areas that are essential for the Security organisation. The comparison of these frameworks is given in chapter 2, section 2.17.5 while frameworks gaps in chapter 2, section 2.17.6. Given the issues discovered from primary data in Security organisation, it became necessary to select the most appropriate framework and use it as the foundation of the proposed framework for the Security organisation.

Table 4 provides explanations why NIST cybersecurity framework, was selected as a foundation to Framework for Data Protection and Privacy (FDPP).

Table 4 Summary of NIST Cybersecurity the selected framework

Criteria	NIST (National Institute of Standards and Technology) cyber security framework
Significance/Appropriateness to security organisation	It helps security organisation to manage and reduce cybersecurity risk to critical infrastructure and industrial control systems. Furthermore, it will guide the organisation to improve understand, manage and ease the possible cybersecurity threats. Security organisation will set its guidelines and best practices to help build and improve their cybersecurity occurrence. The framework puts forth a set of recommendations and standards that enable the security organisation to be better prepared in identifying and detecting cyber-attacks, and also provides strategies on how to respond, prevent, and recover from cyber threats.

4.10 Components Identification

Several security issues as illustrated by table 5.1 were identified from the literature review and data analysis. To solve these issues, Framework for Data Protection and Privacy (FDPP) can serve as guidance to protect information between Security organisation and other Ministries, and between Security organisation employees and Security organisation and its Service Providers. Therefore, table 5.3 explains how the framework components were identified from literature review and data analysis. The table summarises the components' function and links, significance and references.

Table 5 Provides a list of identified security issues through the literature review and interviews and an overview of how the proposed framework will address these issues.

Table 5 Shows Identified security issues

Identified Issues:	Solutions as addressed in the framework
Data protection and privacy	Security organisation should obey the laws and regulations regarding data protection and privacy by implementing appropriate security mechanisms. This issue is provided by the proposed framework in the following component: Security Discipline Code.
Data Breach	Security organisation should implement appropriate access control mechanisms that address the issue of Principle of Least Privilege (POLP) such as role based access control (RBAC) in order to reduce the risk of data leaks. This issue is provided by the proposed framework in the following component: protection.
Lack of Security awareness and training of employees	Security organisation should make sure that its employees are aware and trained on information security concerns and issues by providing education/instructional events. This issue is provided by the proposed framework in the following component: protection.
Network monitor	Security organisation may conduct network scanning as way to identify system/network/process vulnerabilities in order to mitigate risks. This issues are provided by the proposed framework in the following component: Detection.
Standards and operation procedures	Good standards and operation procedures may lead to comply with relevant laws and regulations to avoid legal penalties. This issue is provided by the proposed framework in the following component: Security Discipline Code.
Ethical conduct	Security organisation may avoid legal penalties by conducting businesses activities ethically. This issue is provided by the proposed framework in the following component: Security Discipline Code.
Trust	Security organisation should build trust with its stakeholders by obey to relevant laws and regulations. This issue is provided by the proposed framework in the following component: Security Discipline Code.
Auditor Services Level Agreement (SLA)	This is an aspect of effective information security. This issue is provided by the proposed framework in the following components: protection and Security Discipline Code.
Data Breach	Security organisation should comply with relevant laws and regulations regarding data protection and privacy by implementing appropriate security controls. This issue is catered by the proposed framework in the following components: Security Discipline Code and protection.
Computer virus	Security organisation should implement application for antivirus that will detect it and quarantine the virus before it spread to computers. This issue is catered for by the proposed framework in the following component: Detection and Protection.
Absent of Disaster Recovery	Security organisation should create and document business continuity and/or disaster recovery plans to enable provision of services in case of any disaster. This issue is provided by the proposed framework in the following components: response and recovery.
Absence of Security policies	Draft and implement securities policies that will guide the organisation on data protection. This issue is provided by the proposed framework in the following component: Security Discipline Code.

4.11 Description of the proposed Framework for Data Protection and Privacy (FDPP)

The proposed framework comprises of seven components with corresponding subcomponents. The seven components are identification, classification, detection, Protection, response, recovery and military discipline code. The subcomponents are particular areas of security domains with corresponding security

objectives which cover a wide variety of security elements and key areas. Finally, activities are security tasks which can be applied or carried out to achieve corresponding security objectives.

The proposed FDPP provides cybersecurity risk management strategies to both technical and managerial employees. The proposed framework recommends cyber flexibility with the main focus on cybersecurity risk management. By implementing the framework, the organisation should be able to build cyber flexibility, where systems and operations are intended to detect cyber threats, respond to and recover from cyber-attacks in order to reduce loss of organisation's reputation and financial loss.

- **Identification**

In this category, centers on identifying what is at risk that must be protected, the organisation will identify its critical functions, information assets and corresponding risks which influence strategic goals and objectives. Physical assets and software assets are all items which all organisation rely on to carry out their day to day operations. This allows the organisation to focus and prioritise its activities in accordance with its risk management plan and asset value and organisation requirements. A subcomponent to this component is asset management. Examples of security activities. Identify assets, Assets inventory, identify vulnerability, identify threats, risk assessment, Identifying risk mitigation strategies. After identifying assets, they should be classified before applying suitable levels of security mechanisms.

- **Security Discipline Code (MDC)**

Comply means ensuring, committing or adhering to the minimum of the security-related requirements. The organisation is required to obey with legal requirements or with security policies and standards and operation procedures. In the military there are certain national regulations or several international laws requirements in which Security organisation is also obliged to commit to. Activities in this component include: obey to applicable legislation; obey to security policies and international standards and operation procedures; obey service level of agreement (SLA). In this framework, Security Discipline Code is implemented in three of the categories as there can be certain legal or industry regulations that should be adhered to.

- **Classification**

The objective of information classification is to ensure that all information assets (whether in physical or software) have suitable information classification applied. Legal requirements, value, criticality, and sensitivity to unauthorized disclosure or change should all be taken into consideration when classifying information. In accordance with the organisation's information classification scheme, a suitable set of information labelling procedures should also be developed and applied. Information assets are safeguarded to prevent unintentional disclosure, unauthorised modification, or asset destruction that could affect security. Classification covers across confidentiality, integrity and availability of assets. Each of these three principles is assessed to ensure that the classification of the assets is done in a way that is meaningful to the organisation. Security organisation information, assets and data are classified according to the level of confidentiality, sensitivity, value and criticality. Information may be classified and labelled as public, confidential, restricted. Activities in this component include: Classifying assets; classifying risks; risk prioritisation; defining data owners and data labelling. After classification, assets are given the proper level of defence and protection.

- **Protection**

For every item on the risk list, protection should be in place, therefore choosing the appropriate level of classification is significant. It is essential to balance between the protecting such information assets from potential harmful disclosure and disseminating it for effective use. Since certain information assets are restricted and the information is subject to certain handling rules, access to them should be controlled.

The higher the classification, the more strictly access is controlled and limited. To protect information assets, appropriate security mechanisms and controls are created and implemented. Both physical and software security measures can be applied. Activities in this component include: access control; user awareness and training; data security; firewalls; Intrusion Preventive System; antivirus; security policies. Following the implementation of appropriate levels of asset protection and defence, the next step is to promptly identify malicious activities or attacks.

- **Detection**

In this component, suitable measures and technologies implemented are used to identify the incidents and possible occurrences of cybersecurity attacks. This makes it possible to quickly identify cyber security incidents and possible attacks. After detecting malicious activities/attacks, the organisation should be able to respond to the detected malicious activities in order to minimise damage or business disruptions. Activities in this component include: vulnerability assessments anomalies, events logging and detection; Intrusion Detective System(IDS), security continuous monitoring.

- **Response**

An incident response plan should be implemented to address suspected data breaches. A organisation's response to a security breach is governed by an incident response plan. The aim is to minimise damage, mitigate breach-related costs and reduce disaster recovery time. The organisation should be able to cover the impact of a possible cybersecurity breach. Activities in this component include: response planning; communications channels; attack analysis; mitigation strategies; and improvements. After responding to malicious activities/attacks, should be able to recover by resuming ministerial activities that were disrupted.

- **Recovery**

This involves adopting processes or a set of procedures and appropriate activities to restore any services disrupted by a cybersecurity occurrence Activities in this component include: Executing Disaster Recovery Plan, execute business continuity plan; Incidence response activities; forensic evidence gathering; back up restore plans; data isolation. Security organisation should be able to mitigate an attack with a meaningful and practiced incident response plan. This also involves executing organisation disaster recovery plan to resume business activities while restoring the normal processes.

4.12. Components Relationships

This section discusses the links between the framework components. It explains in details the links and interconnections of the components. L - represents a Link.

The framework components are recognised using the following Unique Identifier:

- Identification (ID)
- Security Discipline Code (MDC)
- Classification (CL)
- Protection (PR)
- Detection (DE)
- Response (RS)
- Recover (RC)

- **Component 1: Identification**

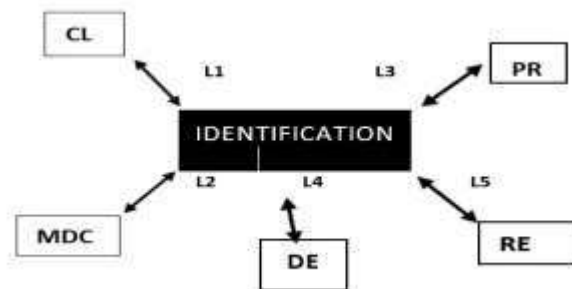
Link 1 (L1): Identification of critical assets is the first step in this framework. This step provides guidance of classification of assets and identifying risk mitigation strategies which are aligned with the ministerial strategic goals and objectives. Assets are classified according to the level of confidentiality, sensitivity, value and criticality. Asset identification leads to the classification of assets and subsequently to the deployment of required protection mechanisms. The objective of data classification is to ensure that all identifiable information assets which belong to the Security organisation, whether in a digital or physical form, have an appropriate level of information classification applied to them. Security organisation must be aware of the value of the data included in assets it owns, and it should put in place the appropriate controls to guarantee that the information assets are protected in accordance with their classification.

Link 2 (L2) Along with legal obligations for data protection, Security organisation need to implement and maintain strong standards for the protection of the identified assets and also obey to certain legal or industry regulations as applicable/necessary.

Link 3 (L3): The goal of asset identification is to proactively gather all the necessary information about organisation's assets that can be useful in protecting assets against threats affecting them. Whenever new critical assets are identified, it should be thought through whether they need additional protection.

Link 4 (L4): Detection is the practice of analysing the entirety of a security system to identify any malicious activity that could compromise the network or data integrity. Hackers and insiders always find ways of exploiting various critical assets inside organisation. Security organisation therefore need to develop systems of identifying and tracking critical information assets. The organisation should ensure that it has a reliable and timely identification and tracking system of its critical assets. Knowing where its critical assets are located will enable the organisation to detect any suspicious activity. Security organisation should implement the proper security mechanisms, and respond quickly to threats. Detection methods include but are not limited to identifying malware activity characteristics by inspecting detection sources, such as Intrusion Detective System, also antivirus software.

Link 5 (L5): Once critical assets such as data, users/employees, networks, and servers are identified, it is also vital to identify vulnerabilities and threats to these assets and the recovery strategies from these threats. It is important to understand the organisation and the resources that support critical functions, as well as the associated cybersecurity risks since this enables the organisation to focus and prioritise its activities, consistent with its recovery strategies and business requirements.

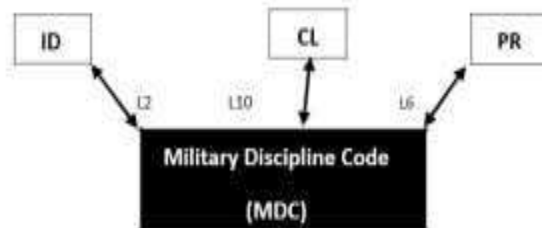


- **Component 2: Security Discipline Code (MDC)**

Link 1(L1), As defined under component 1

Link 2 (L2) As defined under component 1

Link 3 (L3): To ensure Security organisation secure operations and the proper protection of sensitive data, are normally expected to obey with national and international regulatory security obeying requirements. Asset identification, classification and protection efforts therefore need to be based on the known ministerial and international laws and regulations



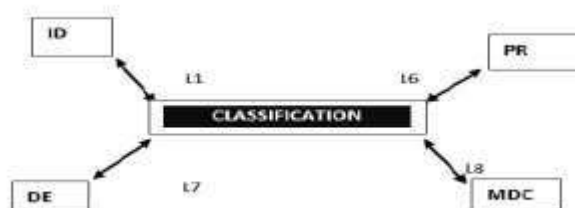
- **Component 3: Classification**

Link 2 (L2): As defined under component 1.

Link 6 (L6): This classification will be used to guide the implementation of suitable security controls and other mechanisms to protect the classified information from being manipulated, leaked or from becoming unavailable. Throughout the process of determining the appropriate level of classification, controls should be implemented to protect these assets from harmful disclosure and possible misuse and unauthorised dissemination. Security controls and safeguards are applied in a systematic and consistent manner to critical assets based on the level of criticality of Security organisations' assets.

Link 7 (L7): In determining the appropriate level of classification, there is a requirement to be able to detect potential threats and vulnerabilities to the assets as the assets require substantial degree of protection. If a threat to the identified and classified critical assets is detected, then response actions must be enacted to properly neutralise the attack/threat before it can pose damage to the assets.

Link 8 (L8): Lastly, at this point, regulatory or legislative issues may also impact the security classification of the information and this needs to be considered.



- **Component 4: Protection**

Link 3 (L3): As defined under component 1.

Link 6 (L6): As defined under component 2.

Link 9 (L9): It is essential to implement suitable protections to assure the delivery of critical infrastructure services that will aid in detecting and containing the impact of a potential cybersecurity event. Detection entails implementing appropriate activities to timely identify and discover security breaches in order to reduce and stop the extent of the damage, and by doing so critical assets will be protected.

Link 10 (L10): While critical data is being protected, obeying with security policies and standards and operation procedures remain priority as well. Thus, asset protection must obey relevant regulatory and industry-specific mandates which may require the protection of different data sets.



- **Component 5: Detection**

Link 4 (L4): As defined under component 1.

Link 7 (L7): As defined under component 3.

Link 9 (L9): As defined under component 4.

Link 11 (L11): Detection of cybersecurity incidents is key to the protection of organisation critical assets. The Security organisation must implement cybersecurity strategies and develop an incident response plan in order to monitor the network and detect those cyber-attack attempts as early as possible. This will result in navigating those attacks safely and successfully. Responding to cybersecurity events enables the recovery of systems. This involves adopting processes or a set of procedures and appropriate activities to restore any services disrupted by a cybersecurity incident. The ability to detect network intruders or other malicious adversaries in a timely fashion enables the Security organisation to effectively recover from security events and effectively mitigate damage.



- **Component 6: Response**

Link 11 (L11): As defined under component 5.

Link 12 (L12): Security organisation needs to implement appropriate controls to take action towards a detected cybersecurity incident which should support the ability to contain the impact of the detected cybersecurity event. Recovery entails implementing appropriate activities to maintain plans for resilience and to restore business operations and services that were compromised due to the cybersecurity event. The organisation needs to build cyber resiliency, where ministerial operations and systems are designed to detect cyber threats and respond to and recover from cyber events to minimise ministerial disruptions and financial losses and to withstand negative impacts. Recovering from a cyber-attack incident helps Security organisation to resume services after a disruption in order to reduce losses or avoid legal penalties.



- **Component 7: Recovery**

Link 5 (L5): As defined under component 1.

Link 12 (L12): As defined under component 6.



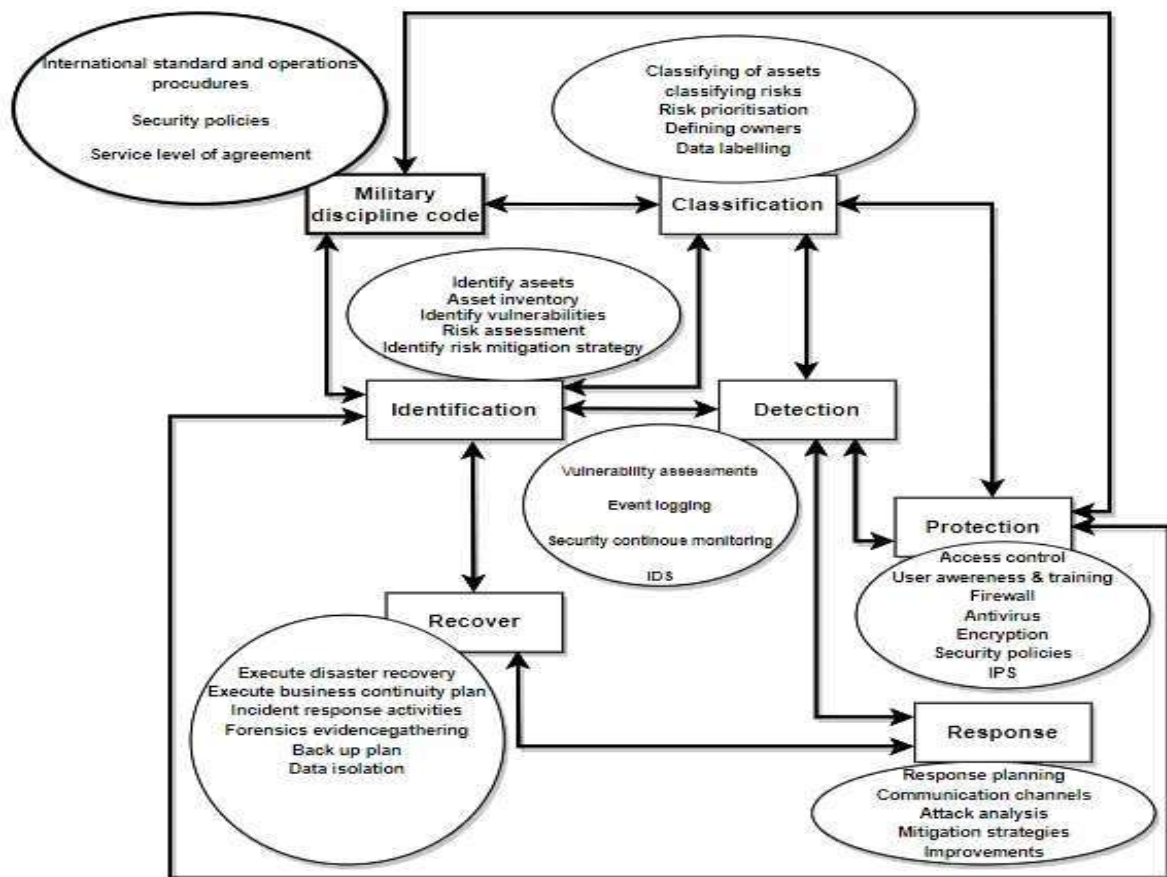


Figure 4 proposed Framework for Data Protection and Privacy (FDPP) with all 7 components and security activities

4.13 Presentation for the proposed Framework for Data Protection and Privacy (FDPP)

This section provides the competence of the proposed FDPP which was developed for Security organisation. It consists of seven components, which are: identification, Security Discipline code, classification, protection, detection, response, and recovery to data threats and vulnerabilities as presented in figure 5.1. Entirely, these framework components provide a high-level, strategic view of organisation cybersecurity risk management. The illustration competence of the framework is given by the following context.

Over 31 years in existence, the Security organisation used in this study has more than 3000 employees. The Security organisation has been implementing IT solutions that improve employee's services. However, the organisation's main challenge is the security of data, systems and services that are accessed by all employees in their needs or daily tasks. In terms of data security, the security organisation is additionally required to abide by national, and international rules and regulations. Thus, the organisation needs guidance in applying a suitable data security framework in order to protect its employee's data and ministerial systems.

The purpose of this presentation is to show how the Security organisation can apply the FDPP. The goal of this context is to show the competence and adoptability of this framework through and demonstration based context on a real life situation as given in section 5.5. The FDPP delivers actionable activities that

can be easily applied by any organisation to enhance their data security. The phases that the organisation needs to follow in applying the proposed FDPP to their background in order to secure its data and systems are explained in the following section.

- **Identifying all critical assets and functions of the Security organisation**

The first step is to identify information assets and risk mitigation strategies which are aligned with the ministerial strategic goals and objectives. In this case, only some critical assets are considered for illustration purposes as given below:

- Servers
- Network
- Software
- Employees Data
- Customer data

The result of this list is called asset inventory list. Once this is presented, then a risk assessment has to be performed.

- **Risk assessment**

The aim of risk assessment is to identify and describe the risk(s) associated with each asset and to analyse the potential impact of the risk to the organisation goals and objectives. For each asset, threats and vulnerabilities are identified, and these will be used to list the risks posed to the asset. The possibility and effect of the risk is evaluated and categorised such as high, moderate, and low (Governance ,2015).

Table 0.5 Shows the different risk assessment criteria

Criteria	Description
High risk	A circumstance that could lead to frequent damages and severe loss of data and equipment
Moderate risk	A circumstance that could result in equipment and data losses that are not quite as severe.
Low risk	A circumstance that is unlikely to create harm and, even if it does, leaves behind very minor harm.

“Risk is the combination of the probability of an event and its consequence” (ISO/IEC, 2018)). Following the identification of essential information assets, a risk assessment is carried out to identify vulnerabilities and threats, and define the likelihood of occurrence and the resulting impact. One can calculate the risk by evaluating the probable frequency of a particular event (likelihood of occurrence), as well as the probable impact of that event. The outcome of the risk assessment results can be used by the organisation to provide control improvement and/or implementation guidance. An appropriate compensating control should be found and should function as intended in the event that a risk assessment reveals that a key control is absent, poorly constructed, or not operating as intended (Governance ,2015).

To calculate risk, the following formulae as explained above is used:

- Risk= **Likelihood of occurrence * impact**

Table 6 below shows the Risk assessment process.

Information assets	Threats	Vulnerabilities	Impact	Likelihood of occurrence	Risk	Recommendation Control
Employee and customer's data, ministerial information	Data theft, data deletion, data corruption	Weak passwords, Password sharing	High impact Trust and reputational loss, compromise of national security	High	High risk Potential loss of customer data, employee data and ministerial information	Implement access control, Password Policies Implement security policy
Servers	System failure	No backup servers	High impact All email, website servers will not be available	High	High risk Potential financial loss on recovery	Purchase backup servers for disaster recovery, implement redundant array of independent disks system (RAID).
Network/Websites	DoDs attack, hackers	No pen -testing performed against the website for the past years	High impact Loss of customer trust	Moderate	High risk Loss of internet communication services(Outlook mails)	Configure firewalls, Intrusion Detection System (IDS), Demilitarized Zone (DMZ), Intrusion Preventive Systems
Software	Virus	No Patches installed, Expired antivirus	High impact Data availability	High	High risk Corrupt customer data	Mandate patches installation and update of antivirus

4.14 Comply to laws and regulations

Security organisationis committed and obeying with applicable legislations and laws with regards to employees and customer data security. For instance, organisation needs to obey to General Discipline Code. Organisation focused on National ICT Public Services Policies 2017 and obey International Standard Organisation, ISO/IEC 27001 and ISO/IEC 27002 on the Information Security Management Framework as the guideline for its 2017 data security. Obey to such legislation and laws should be measured and maintained, and continually updated from changes at all levels. In addition, Security organisations should commit to security policies, standards and operation procedures. To ensure secure operations and the proper protection of sensitive data, Security organisationis required normally to obey to local and

international regulatory security requirements

- **Classifying Assets**

Information assets are valuable resources to the organisation and they must be handled with care according to authorised handling procedures. Information asset classification extends across confidentiality, integrity and availability of assets for the organisation. Information assets are categorized according to their levels of sensitivity and the potential effects on the organisation should that information be revealed, changed, or destroyed without permission. Information classification helps to decide what baseline security policies are necessary to secure that information asset. Each of the three classification levels should be applied to all Security organisation information assets (ISO/IEC 2018).

- **Three-level classification**

Public data — Information that the general public may easily access. Data under this tier of information is relatively harmless for outsiders to know. The public knowledge will not result in any national security compromise. This type of data does not need to be protected, secured, or transported in any specific way.

Confidential – This type of information is not considered to be secret and it is generally not available to the public.

Restricted data- Information that needs the strictest level of access control and security measures, whether it is being stored or transferred, and that is protected by law or policy. The loss of this information's secrecy, integrity, and accessibility will have a significant impact on national security.

The Militaries has specific requirements that guide Security organisation to classify information assets or data. Therefore, Security organisation is expected to obey with information privacy principles, policies regulations or legislation. Table 5.7 demonstrates the assets classification criteria inspired by NIST.

Table 0.7 Assets classification criteria

Classification criteria	Type of Information
Public	Websites
Confidential	Employees and customers data, servers and software
Restricted/Secret	Financial and economic/weapon information

Profiles are then set for each asset of the organisation to determine the security mechanism to be taken in order to protect them using the criteria described in table 8.

Low Risk	Moderate Risk	High Risk
Data and systems are classified as low risk if they are not considered to be moderate or high risk, and: • The data is intended for public disclosure. • The loss of confidentiality, integrity, or availability of the data or system would have no negative impact on the organisation's mission, safety, or reputation.	Data and systems are classified as moderate risk if they are not considered to be high risk, and: • The data is not generally available to the public or • The loss of confidentiality, integrity, or availability of the data or system could have a slightly negative impact on the organisation's	Data and systems are classified as high risk if: • Protection of the data is required in compliance to law/regulation, or • The loss of confidentiality, integrity, or availability of the data or system could have a great impact on organisation's mission, and reputation.

- **Data and systems risk labelling**

The identified critical assets are evaluated for risk and the risk levels are determined as illustrated in table 9.

Asset	Risk labelling
Employees and Customers' Data, Servers, Software	High
Website, Network equipment	Moderate
End user devices/workstations	Low

- **Prioritising assets and applying appropriate levels of protection**

Security organisations should prioritise and protect assets with high risk as presented in table 5.9 and 5.10. This requires the organisation to apply a level of security that is appropriate to the risks as presented in table 9. Table 10 below shows the risk level labelled to the assets using priority levels.

Priority levels defined are:

- High risk – priority 1
- Moderate risk – priority 2
- Low risk – priority 3

Table 10 Assets risk levels

Asset	Risk level	Label
Employees and Customers Data	1	High
Website	2	Moderate
Servers	1	High
Software	1	High
Website, Network equipment	2	Moderate
End user devices/ workstations	3	Low

- **Application of the appropriate level of protection**

The appropriate level of protection is applied to assets in line with the recommendations specified in the risk assessment step one as shown in table 5.6. Controls for minimising the identified risks are identified during the risk mitigation phase. The controls are risk mitigation mechanisms that should decrease and/or avoid the occurrence of a risk event, detect risk event occurrence and reduce risk impact (Infrastructure and Office, 2014).

Table 11 Assets protection levels

Assets	Security mechanism recommended
Employees and Customers' Data	Implement access control, strong passwords, , physical security, user awareness training and training of cybersecurity experts.
Website, Network equipment	Configure firewalls, Intrusion Detective System, Demilitarized Zone, Intrusion preventive System, Encrypt network traffic.
Servers	Implement backup servers, implement raid systems, secure network, host based firewalls, physical security, strong passwords, encryption.
Software	Install antivirus, configure firewalls, software updates.
End user devices/workstations	Implement access control and multi-factor authentication, strong passwords.

- **Detection of security threats**

Detection is the practice of analysing the entirety of a security system to identify any malicious activity that could compromise the network or data confidentiality, integrity and availability. If a threat is detected, then response actions must be endorsed to appropriately neutralise the attack before it can pose damage to the assets. Methods that can be used by Security organisation to detect threats are vulnerability assessments and events logging and detection, Intrusion Detective System, and security continuous monitoring as shown in table 12.

Table 0.12 logging and detection, Intrusion Detective System, and security continuous monitoring

Assets	Threat detection
Employees and Customers' Data	Events logging, Intrusion Detective System
Website, Network equipment	Web Vulnerability Scanning tools, vulnerability assessments, anomalies
Servers	Events logging
Software	Antivirus
End user devices/workstations	Events logging

Once anomalies are detected then responses need to be invoked as presented in the next section.

- **Response to detected security threats and attacks**

Responding to security attacks and threats is an essential aspect of information security. The ability of Security organisations to recognise network intruders or other malicious opponents in a timely manner allows the organisation to successfully recover from security events and efficiently mitigate damage.

Table 13 shows activities that can be performed in response to detected security threats and attacks.

Detected Threats	Strategy	Activities
Data theft, data deletion, data corruption	Response planning	Create the following: disaster recovery plan, disaster recovery team, recovery time objective and recovery point objective, incident response plan, incident response team ,Data Isolation Plan
System failure	Communications channels	Describe line of communication in response to threats and attacks
DoDs attack, hackers	Attack analysis	Attack analysis team and tools
Virus	Mitigation strategies	Document mitigation strategies ,install antivirus

- **Recover compromised data and systems**

Recovery helps to build an effective system to manage ministerial disruptions and to be able to hold the impact of possible cybersecurity events. The following are strategies that Security organisation can apply to recover compromised data and systems:

- Execute disaster recovery plan,
- Execute business continuity plan
- Incidence response activities
- Restore data back,
- Meet the recovery time objective and recovery point objective
- Document recovery procedure for future use.

4.15 Evaluation

The suitability, adaptability and relevance of the proposed Framework for Data protection and Privacy (FDPP) are evaluated in this section. According to Hevner (2004) these phases allow for the demonstration of the artefact performance against the set matrices.

4.16 Objectives of the Evaluation

The objectives of the Framework for Data protection and Privacy (FDPP) evaluation are as follows:

- To determine the significance of the proposed framework in the Security organisation context.
- To determine the relevance of the framework in Security organisation.
- To determine the significant of the framework in Security organisation and other government ministries.

A number of research studies have comprehensively used various evaluation techniques such as case studies, field experiments, and expert reviews. This study adopted the expert review technique in order to evaluate the relevancy and suitability of the framework. The primary purpose of the evaluation, in addition to gaining perception into the significance of the framework is to enable the determination of its quality, worth and relevance using a set of measures. The evaluation tool was designed with reference from literature.

Quantitative data analysis methods were used to analyse the data gathered.

4.16.1 Expert Review

An expert review is a type of inspection that is designed to determine the usability or the flaws of the framework. The review was carried out by a small group of field experts who analysed the framework or service to identify any potential usability issues. According to Ling and Salvendy (2005) and Nielsen and Molich (2009), expert reviews provide the following advantages:

- They provide the chance to make changes in the early stages of the process.
- Experts can identify a variety of issues in many aspects of a product. They assess the product as a whole, rather than focusing on only one or a few scenarios. They take a broader view and uncover issues that the researcher may have missed.
- Expert reviews provide a complete picture of the product. This is far more beneficial than getting feedback on a single scenario.
- Expert reviews are a more efficient way to evaluate a product, system or service.
- Expert reviews are far more cost effective compared to field experiments. Reviews can be carried out multiple times during a project giving the advantage of expert knowledge and expertise to identify flaws and provide recommendations for improvement to a product, system or service.
- They give an opportunity to make changes in early stages of the process.
- Experts can find a lot of different problems in different areas. Experts examine the entire site; they usually don't focus on just one or a few specific scenarios. They give a broader look and find issues you may not have ever noticed.
- Expert reviews result in a comprehensive view of the entire system. This is much more effective than getting feedback just on a specific scenario.

- Expert reviews is a quicker process than usability testing (onsite or remote).
- Expert reviews are done by multiple experts this eliminates the idea of one sided opinion or a specific preference.
- The best of all, experts can not only identify issues, they can also provide you with design solutions. They can explain exactly how to implement suggested changes.

Table 14 Expert Reviewers' demographic information and Profiles

Respondents	Educational Qualification	Professional Certifications	Role	Years of Experience
Reviewer 1	Honors Degree	CompTIA Security Ethical Hacking Info Security	System administrator	11-20
Reviewer 2	Master's Degree	CompTIA Security CRISC	Chief Command Control and Communication	11-20
Reviewer 3	Master's Degree	CompTIA Security	Chief Hardware	11-20
Reviewer 4	Master's Degree	CompTIA Security CISA	System administrator	0-5

4.16.2 Evaluation of the FDPP Framework

The FDPP evaluation focused on evaluating the relevancy and suitability of the framework and how the Security organisation could adopt the framework to their facilities in order to enhance their cybersecurity posture. Table 5.15 presents the reviewers' responses on the framework relevance, suitability, significant.

Table 0.15 Reviewers' responses on framework relevance, suitability, significant

Respondents	To what extent do you agree that the framework will support Security organisation by identification of critical information assets inventory and ministerial function?	To what extent do you agree that the framework will help Security organisation in complying with law and regulation?	To what extent do you agree that the framework will help Security organisation in classifying all critical assets and information systems?	To what extent do you agree that the framework will help in support of protecting all information systems assets and employees of the Security organisation?	To what extent do you agree that the framework will help in detecting cyber-attacks in Security organisation in a timely manner?	To what extent do you agree that the framework will help Security organisation in effectively responding to detected cyber-attacks?	To what extent do you agree that the framework will help Security organisation in recovering from Cyberattacks?
Reviewer 1	High	High	High	High	Neutral	Neutral	High
Reviewer 2	High	Low	Neutral	High	Very high	High	Neutral
Reviewer 3	Very high	Very high	Very high	Very high	Very high	Very high	Very high
Reviewer 4	High	High	High	High	High	High	High

Table 16 further presents the reviewers' responses on the framework relevance, suitability and significant.

Reviewers	Comments
Reviewer 1	The framework can support the organisation when implemented and when the members educated on the subject and made to understand it. I cannot say it help the organisation on very level response because cybersecurity come in many ways.
Reviewer 2	The organisation itself needs a well-structured framework, policies and procedures in terms of information handling to achieve the proper implementation of the proposed framework.

4.16.3 The reviewers' comments were analysed by the researcher as presented:

Reviewer 1 Comments: The reviewer indicated that: the framework can support the organisation when implemented and when the members educated on the subject and made to understood it. I cannot say it help the organisation on very high level response because cybersecurity come in many ways. The researcher agreed, with the comment that the framework will support the organisation only if the members are educated. Thus, Figure 5.1 shows proposed framework FDPP, under protection component there is user awareness and training. Also under classification components there is classifying of assets and classifying of risks this will help the organisation to cater all attacks according to its classification whether physical and digital form.

Reviewer 2 Comment: The reviewer indicated that the organisation itself needs a well-structured framework, policies and procedures in terms of information handling to achieve the proper implementation of the proposed framework. The researcher also agreed with these comment this is why referring to figure 5.1 of the proposed framework each component have security activities that the organisation need to utilise, also chapter 5, section 5.4 demonstrate how the proposed framework will be applied to Security organisation context.

Table 17 Reviewer's responses on framework relevant, suitable, significance

Reviewers	To what extent do y agree that framework is relev in the mitigation cybersecurity challenges Security organisation?	To what extent do you agree that the framework is suitable in improving Security organisation cyber resilience? (the ability to respond, withstand and recover from cyber incidents and attacks?	To what exte do you agr that framework significant Security organisation ?	To what extent do you agree that the components are logically connected to each other and thus provide cyber resilience to Security organisation?	To what extent do you agree that the framework can be adopted by other ministries and agencies aiming at improving their ability to detect and monitor cybersecurity events, threats and risks in order to improve their cyber resilience?
Reviewers 1	Relevant	Suitable	Significant	Agree	High

Reviewers 2	Very Relevant	Somewhat suitable	Significant	High extent	High extent
Reviewers 3	Very Relevant	Very suitable	Very significant	High extent	High
Reviewers 4	Relevant	Suitable	Significant	Agree	High

Table 17 presents the response of reviewers regarding, relevance, suitability and significance of the framework. Firstly, 50% of the reviewers indicated that the framework is very relevant in the mitigation of cybersecurity challenges in Security organisation, while 50% indicated relevant. Furthermore, 50% of the reviewers indicated that the framework is suitable in improving the Security organisation cyber resilience (the ability to respond, withstand and recover from cyber incidents and attacks), and 25% indicated very suitable while 25% somewhat suitable. Most of the reviewers had almost similar opinions when asked about the significance of the framework; 75% indicated that the framework is significant in Security organisation, while 25% very significant. Reviewers were also asked if components were logically connected to each other 50% indicated high extent and other 50% agreed. In the questionnaire, 75% indicate high extent that the framework can be adopted by organisations aiming at enhancing their ability to detect and monitor cybersecurity events, threats and risks in order to improve their cyber resilience as indicated in Table 5.17, while 25% high. Based on the feedback obtained from reviewers, the framework is considered to be suitable, relevant and significant in combating cybersecurity issues. However, there are notable suggested changes proposed by the reviewers as given in table 5.18.

4.16.3 Comments and Recommendations

A total of 50% highlighted that they would recommend changes to the framework, while 50% recommended no changes. These proposed changes are presented in table 5.18. Figure 5.11 presents responses on the framework changes.

Table 18 Reviewers' framework component changes and recommendation

Reviewers	Would you recommend any change to the framework components?	If yes, please specify the changes per component listed below :	Proposed Changes
Reviewers 1	No		
Reviewers 2	Yes	Classification Response	Classification may change to "Access Level" Response may change to Monitoring & Evaluation (M&E)
Reviewers 3	Yes	Security Discipline (MDC)	Since the framework will be utilised by other ministries, component two should be altered to "Compliance". It currently refers to the military, which makes it difficult to interpret and not suitable to other ministries.
Reviewers 4	No		

4.17 Conclusion

The evaluation was aimed at proving and confirming the validity and reliability of the FDPP framework. The weighting process measurements were contained in three evaluation criteria namely relevance, suitability, significant. Based on the feedback obtained from the expert reviewers, the framework is considered to be highly relevant, suitable, and significant in combating cybersecurity issues in the Organisation of Defence and Veteran Affairs.

As a result of the evaluation, the following changes were implemented:

Detection and Classification. There may not be a direct relationship (interdependency) between, Detection and Classification.

Security Discipline Code to change to Compliance. Since the framework will be utilised by other ministries, component two should be altered to “Compliance”. It currently refers to the military, which makes it difficult to interpret and not suitable to other ministries. The researcher cannot adopt this change because this framework was designed using the Security organisation context. Since this framework adopts the NIST cybersecurity framework, which is adaptable to organisational strategic goals, other ministries are welcome to modify it in accordance with their own context.

4.19 Modification of the framework

The purpose of the evaluation completed in section 5.6 aimed at aiding the modification of the framework. This is the reason why the reviewers’ comments and recommendations were noted and combined in the framework enhancement. Table 5.21 presents the reviewers’ final comments.

Table 0.21 Shows the reviewers’ final comments

Reviewer	Suggestions/Comments	Improvements made
Review 2	There may not be a direct relationship (interdependency) between, Detection and Classification	Removed the allow between classification and Detection.
Reviewer 3	Security Discipline Code to change to Compliance	Changed Security Discipline Code to became Compliance

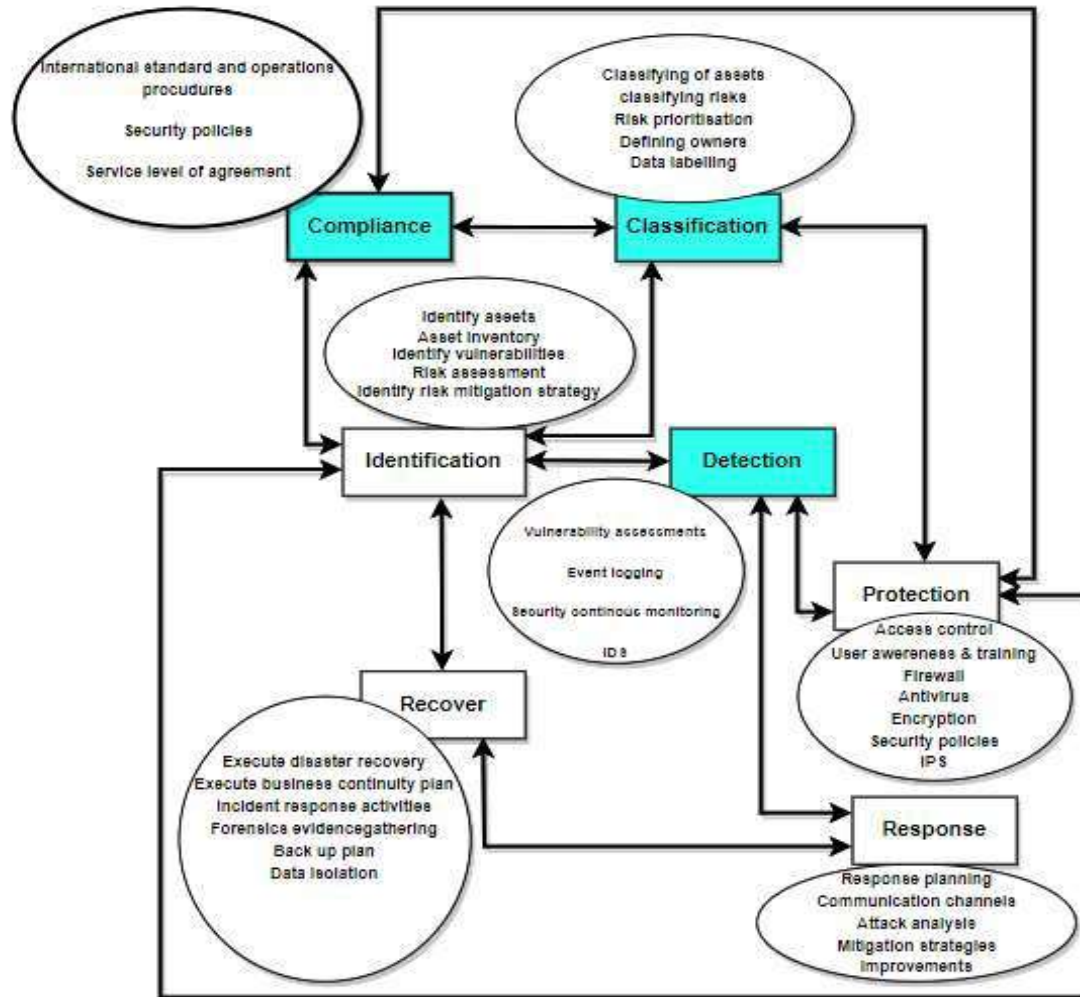


Figure 5 Framework with evaluators input

The listed changes as recommended by the reviewers were effected as follows:

- **Detection and Classification.** There may not be a direct relationship (interdependency) between, Detection and Classification.
- Component **Security Discipline Code** changed to **Compliance**.

4.20 Communication

The FDPP will be communicated through raising the framework awareness security organisation and providing guidelines on how to apply the framework to their environments. Also, it will be published in scholarly publications. By communicating the proposed FDPP the employees need to be educated on the framework and all data security mechanisms, practitioners will take advantage of the benefits offered by the framework and it will provide researchers with a knowledge base for additional extensions and evaluation.

The proposed FDPP comprises of seven components namely identification, military discipline code, classification, protection, detection, response, recover.

4.21 Summary

This section discusses the development process of the proposed FDPP framework in sections 5.4 and 5.4.1. The main discussion was formed by the development of the framework in section 5.5 and Framework evaluation in section 5.6. Major components of the framework are: identification, military Discipline code (MDC), classification, protection, detection, response, and recover and the identification component serves to identify critical functions, information assets and corresponding risks which influence strategic goals and objectives of Security organisation. This allows Security organisation to focus and priorities its activities in accordance with its risk management strategy, asset value and ministerial requirements. The classification component's aim is to ensure that all information assets in physical or software form are classified accordingly. Information should be classified in complying to legal, regulatory requirements, or ministerial policies. The detection component's main function is to identify incidents and potential occurrences of cybersecurity events. This enables timely discovery of cyber security events and potential attacks. An incident response plan should be implemented to address a suspected data breaches. An incident response plan guides how Security organisation will react in the event of a security breach. The response component is meant to minimise damage, decrease disaster recovery time, and mitigate breach-related expense. Security organisation should be able to hold the impact of potential cybersecurity incidents. The recovery component is meant for the restoration of any services disrupted by a cybersecurity incident. In this case, Security organisation should be able to mitigate an attack with a meaningful and practiced incident response plan. The Security discipline code component is aimed at ensuring comply or adherence to a minimum of the security-related requirements such as legal requirements or security policies and standards, and operational procedures.

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A Machine Learning Model to Predict Infant Mortality

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Abstract

This paper applied supervised machine learning methods to create a precise infant mortality prediction model for Namibia. Through a thorough investigation of the confusion matrix, three well-known machine learning algorithms—Decision Tree, Random Forest, and Logistic Regression—were used and assessed. With an accuracy of 97% and an F1 Score of 98%, the most efficient model, logistic regression, exhibits exceptional predictive skills. It had a 100% recall rate, correctly identifying every occurrence of the "Alive" class and was hence very useful for predicting newborn death. The adoption of this approach, which has significant practical relevance, would enable the healthcare decision-makers to optimise interventions, enhance the provision of health services, and strengthen emergency preparation. By successfully reducing infant mortality rates, this methodology is positioned to greatly enhance Namibia's healthcare system. Based on the results, both the Random Forest and Decision Tree models performed well, but the Logistic Regression model outperformed them in crucial metrics and offered the most accurate option for forecasting infant mortality because it can effectively handle binary classification problems and minimise false negatives.

Keywords: Infant mortality, machine learning, model evaluation, logistic regression.

1. Introduction

According to the Centre for Disease Control (2018), infant mortality rate is defined as the number of children under one year of age who die per 1,000 live births. Infant mortality is an important public health indicator since it tells us about the health of young children as well as more general health problems and the effectiveness of medical treatments (Mojekwu & Ajijola, 2018). Infant mortality is caused by a number of factors, such as inadequate prenatal and medical care, poor sanitation, nutritional inadequacies of the mother and child, poor water quality and the use of newborn formula in place of breast milk, the leading causes of infant deaths include congenital anomalies, sepsis, diarrhoea, and pneumonia (CDC, 2022). According to World Health Organization (WHO, 2018), in 2018, the global infant mortality rate stood at 29 deaths, 52 deaths in Africa, and 30.1 deaths per 1000 live births in Namibia.

A study on creating a model for calculating Nigeria's infant mortality rate by Mojekwu & Ajijola (2018) indicated that there is extensive research in developing countries on infant mortality rate, however, most methods focus on using conventional methods including survival analysis and regression analysis, which then limits prediction capability. However, the research on artificial intelligence demonstrates that machine learning techniques are superior to traditional ones in terms of producing more precise predictive models, in this case, to forecast infant mortality rate, moreover, there is only one study done on the prediction of infant mortality rate in Namibia. Smartson & Nyoni (2021) explored Artificial Neural Networks (ANN) for predicting Namibia's Infant Mortality Rate, however, the study only focuses on one Machine Learning model Neural Networks using Multilayer Perceptron (MLP). The study offers valuable insights into predicting infant mortality rates using a specific ANN architecture. However, it could be seen as a limitation that the study did not explore or compare this ANN approach with other machine learning models, including other Neural Networks. This missed opportunity prevents an assessment of whether Neural Networks might have delivered superior predictive performance when compared to the chosen models (Decision Tree, Random Forest, Logistic Regression). Such a comparison could have enhanced the analysis and offered a more comprehensive perspective on the most appropriate modelling approach for the dataset and research

objectives, this study then looks to use supervised machine learning models to forecast infant mortality in Namibia and compare their performances.

High infant mortality rate continues to be a public health concern, particularly in Namibia, despite considerable improvements in child health as a result of initiatives and interventions taken by the Namibian government such as childhood immunisation campaigns and efforts to increase access to pre-pregnancy and prenatal care, the infant mortality rate has only reduced from 51.1 in 1990 to 31 in 2019 deaths per 1000 live births which is worrisome as the WHO standard recommendation is to reduce infant mortality to less than 5 deaths per 1000 for each nation (UNICEF, 2019).

This paper focuses on the development and evaluation of supervised machine learning models utilising historical data on infant mortality in Namibia, with the primary aim of constructing a predictive model to forecast infant mortality in the country.

The goal of this study was to equip decision-makers in Namibia with precise and dependable predictive models that will enable them to implement aggressive interventions in planning, health services delivery, and emergency preparedness, leading to a significant reduction in the infant mortality rate. By utilising this study's results, the Ministry of Health in Namibia can effectively predict infant mortality and proactively plan and strategise to address potential challenges and improve healthcare outcomes.

2. Literature Review

Several researchers in different countries have conducted studies in an effort to create models that can forecast infant mortality. Smartson & Nyoni (2021) looked at Artificial Neural Networks to build a model that predicts Namibia's infant mortality. The study used annual data for the period 1967-2020 and the forecasted infant mortality over the period 2021-2030. The Artificial Neural Networks model used for forecasting the infant mortality rate in Namibia was evaluated using the residuals and forecast evaluation criteria, and the results indicated that the model is stable in forecasting.

The findings of the study suggest that during the following ten years, infant mortality will marginally decrease. The report also recommended that to be able to lower the infant mortality rate, the government of Namibia be pushed to devote greater resources to the health sector. The limitation of this study is that it only focuses on one Machine learning model, Neural Networks using Multilayer Perceptron and hence it is inaccurate to conclude that this is the best machine learning model in forecasting infant mortality rate.

Using the DHS dataset of 2014, Kioko (2021) utilized Supervised Machine Learning approaches to predict Infant Mortality in Kenya. For the study, three commonly used machine learning algorithms namely, Logistic regression, K-nearest Neighbour, and Random Forest model were employed to predict the infant mortality rate in Kenya. The researcher then split the dataset into train data 80% and test data 20%, each model was evaluated to calculate the prediction accuracy. The findings showed that the Random Forest model was the best performing model.

Mojekwu & Ajijola (2018) developed a model to predict the infant mortality rate in Nigeria, the study used a linear regression model, which is a traditional method to forecast the infant mortality rate. The infant mortality rate was the dependent variable, and the crude death rate was the independent parameter required to predict the infant mortality rate. The model was evaluated by comparing the estimations from the current study with results from other studies, the infant mortality rate derived model's suitability was examined. The findings demonstrated that the regression model developed is highly appropriate and accurately depicts patterns in the Nigerian Infant Mortality Rate. The study's limitation is that it employed

linear regression, a traditional method, to predict infant mortality rate, even if there are machine learning techniques that gives better prediction outcomes.

Amit, Chandar & Mani (2019) used autoregressive integrated moving average model to forecast the Indian infant mortality rate using data from the government of India for the period of 1971–2016. The study used an ARIMA model, a technique for forecasting data that, like other forecasting techniques, just needs long time series data. The result showed a decreasing trend of Infant mortality rate for the forecast period of 2017–2025, however, the model was not evaluated and checked for validity, hence there is a need to apply machine learning when building a model to predict infant mortality in order to get am more accurate prediction results.

Ronaldo, Cristiano & Mario (2019) used intelligent governance framework for Brazilian health system called Stork together with LAIS, an Intelligent health analysis system that uses data mining, to predict infant mortality rate in Brazil. This paper further looked at generating alerts focusing on the health status of infants and pregnant woman that might experience server problems. The outcomes demonstrate that the Nave Bayes classifier, with an accuracy of 0.982, outperformed all the other data mining algorithms to predict infant mortality rate and generate alerts. So, according to the study, the suggested model might contribute to reducing the rate of maternal and infant mortality.

Julio, Andrea & Michel (2021) developed log-quadratic model to predict mortality between the age of 0 to 5 years. The study used a dataset from Demographic Health Survey (DHS) survey of mortality dataset from different countries. The model was applied to 204 records in the study, and uncorrected IMR values were contrasted with IMR values that had been modified using both the log-quadratic model and the traditional model life table approach. The study found that South Asia and Sub-Saharan Africa both had high under-five mortality, and it recommended more research be done to determine the causes of high under five mortalities in these two regions.

3. Research Methodology

In this study, we adopted a machine learning approach instead of traditional methods to forecast infant death. Data processing and analysis were performed using Python software version 6.4.5. Employing a positivist approach, we focused on gathering and impartially analysing data, with quantifiable and observable results as the outcome of interest (Dudovskiy, 2018).

To develop a predictive model for infant mortality, we utilised inductive reasoning, drawing inferences from the dataset to identify trends and connections that contributed to theory building. While this approach allowed flexibility in framing the research issue, our study aligns well with the infant mortality dataset, serving as a foundation for creating the predictive model (Dudovskiy, 2018).

The research strategy employed was experimental research, a form of comparative analysis that observes groups under specific circumstances while studying multiple variables (Oscar, 2021). In our case, we evaluated the effectiveness of three machine learning models for predicting infant mortality rates and selected the best-performing model.

Supervised Machine Learning, a technique leveraging labelled information to train algorithms and forecast future events (Ali, 2022), served as the foundation for our approach. During model training, the algorithms learned from different subsets of the dataset to predict output values accurately. The predicted results were then compared to the actual outcomes for assessment (Fikrewold, Nyarko, & Lloyd, 2020). The architecture of supervised machine learning is depicted in Figure 1.

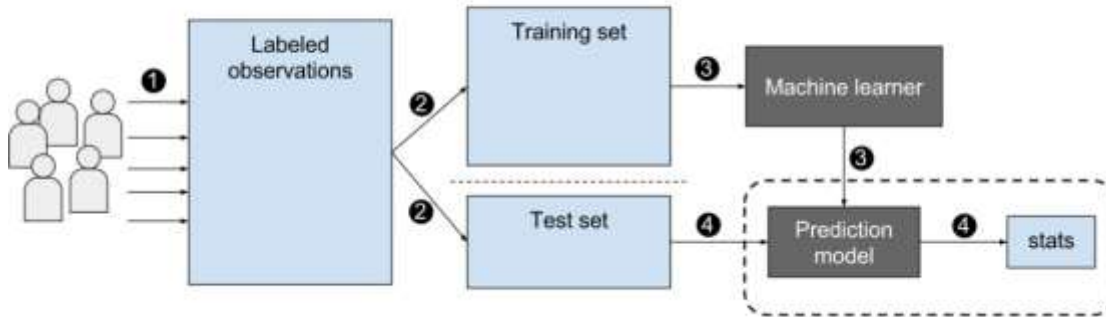


Figure 1 Architecture overview of supervised machine learning.

The study used three widely used machine learning algorithms - decision tree, random forest, and logistic regression to predict infant mortality rates in Namibia.

3.1 Decision Tree

A decision tree is a classifier with a tree-structure that is employed in supervised learning. As a result, categories inside categories are generated, enabling organic categorization with little to no human oversight. Its core nodes reflect dataset attributes, its branches represent decision rules, and each leaf node denotes the result (Ali, 2022).

3.2 Random forest

Numerous decision trees are employed in a classification method known as random forest. It uses bagging and feature randomness to build each individual tree in an effort to create an uncorrelated forest of trees whose forecast by committee is more accurate than that of any individual tree (Yiu, 2019). The main advantage of the random forest is that it can be used for both classification and regression problems. Random forest algorithms are easy to use and comprehend because there aren't many hyper-parameters and they produced good prediction outcomes.

3.3 Logistic regression

The most crucial analytical technique to use when the dependent variable is binary is logistic regression (0 or 1). Using weights or coefficient values, independent variables (x) are linearly combined in logistic regression to predict the dependent variable (y). The equation for logistic regression is as follows:

$$\text{Logistic regression}(p) = \ln(p/1 - p) \quad (1)$$

Where: p stands for the probability of the positive event.

3.4 Model Evaluation

One of the main reasons we used a Machine learning model is that we were able to evaluate them and track and compare their performance in terms of prediction accuracy. In this study we will be more interested on measuring the ability of each model to predict infant mortality rates risk by prediction accuracy. According

to Najat & Daniel, (2019), the confusion matrix is the most used method for summarizing the performance of supervised Machine Learning models.

3.5 Confusion Matrix

A classification model's success on a set of test data is evaluated using an open table called a confusion matrix, for which the true values are known. In the instance of a binary classifier, it is a table containing 4 distinct combinations of predicted and actual values (Shweta, onika , & Ram , 2019), true positive outcomes are those in which the model accurately predicted the positive class, whereas true negative outcomes are those in which the model accurately predicted the negative class.

3.6 Metrics computed from a confusion matrix

Metrics that measure model accuracy demonstrate how effectively the model predicts the future. The accuracy, sensitivity, specificity, positive predictive values, and negative predictive values will all be looked at in this study.

3.7 Data collection

The study utilized an infant mortality dataset obtained from the Namibia Statistic Agency (NSA), which was derived from the 2011 population and housing census, an official request was made, and the data was shared on email. The study targeted 162 883 babies born by women between the ages of 15 and 49 years from all 13 regions in Namibia.

To calculate the risk of infant death for each social group, the number of zero-year-olds who died during the 12 months preceding the census was divided by the number of live births in the same period. To gather data, all women aged between 15 to 49 years were administered the Households Questionnaires, through which they provided details of their birth history. The main outcome of interest in this study was infant mortality, which was measured in binary form, distinguishing between "Alive" or "Death" status on the infant.

3.8 Data analysis

The dataset was randomly divided into two sets: 80% (130,306 records) for model training and 20% (32,577 records) for performance evaluation in predicting infant mortality rates. Python software in Jupiter Notebook version 6.4.5 facilitated statistical analysis and the application of machine learning methods such as Logistic Regression, Random Forest, and Decision Tree. Prior to model training, the data was cleaned using Python, with variables containing missing values excluded from the analysis. Feature selection techniques were employed during data pre-processing to effectively reduce the number of variables in the predictive model. Additionally, the influential factors impacting infant mortality were identified using the random forest technique.

4 Results and Discussion

4.1 Descriptive results of the background characteristics

This study utilized data from the Namibia Statistics Agency Mortality Census dataset, encompassing a total sample size of 162,883 babies born to women aged between 15 to 49 years.

Table 1: Descriptive statistics of infant mortality outcome by study characteristics.

Variable Name	Frequency	Percentage
Infant Survival Status		
Death	5521	3.4%
Alive	157362	96.6%
Place of Residence		
Urban	54722	34%
Rural	108161	66%
Region		
Caprivi	6820	4.2%
Erongo	10783	6.6%
Hardap	5602	3.4%
Karas	5641	3.5%
Kavango	17749	10.9%
Khomas	27897	17.1%
Kunene	6107	3.7%
Ohangwena	19085	11.7%
Omaheke	5241	3.2%
Omusati	18356	11.3%
Oshana	15343	9.4%
Oshikoto	13770	8.5%
Otjozondjupa	10489	6.4%
Marital status		
Consensual Union	9653	5.93%
Divorced	1192	0.73%
Don't Know	69	0.04%
Married Traditionally	7768	4.77%
Married with Certificate	17713	10.87%

Never Married	124161	76.23%
Separated	734	0.45%
Widowed	1593	0.98%
Age of the mother		
15 – 19	50428	30.96%
20 – 24	46937	28.82%
25 – 29	18614	11.43%
30 – 34	15332	9.41%
35 – 39	12787	7.85%
40 – 44	10229	6.28%
45 – 49	8556	5.25%
Father of the child Alive		
Don't Know	5894	
No	50020	
Yes	106969	
Literacy		
No	18569	11.4%
Yes	144314	88.6%
Highest Grade Completed		
Complete primary	64532	39.6%
Complete secondary	23065	14.2%
Complete tertiary	5384	3.3%
Incomplete primary	47087	28.9%
No formal	22815	14.0%
Employment status		
Employed	42524	26.1%
Inactive	56199	34.5%
Unemployed	64160	39.4%
Sex of Child		

Female	75177	46.2%
Male	87706	53.8%
Age at First Birth		
15 – 19	70118	43.0%
20 – 24	55705	34.2%
25 – 29	11554	7.1%
30 – 34	8601	5.3%
35 – 39	6840	4.2%
40 – 44	5363	3.3%
45 – 49	4702	2.9%
Father of the child Alive		
Don't Know	5894	3.6%
No	50020	30.7%
Yes	106969	65.7%
Mother Disabled		
No	157248	96.5%
Yes	5635	3.5%
Access to Newspaper		
No	117874	72.4%
Yes	45009	27.6%
Access to internet		
No	147231	90.4%
Yes	15652	9.6%

4.2 Community Factors

The data highlights significant community-level factors that may contribute to variations in infant mortality rates. Firstly, the "Place of Residence" indicates that a considerable proportion (66%) of the surveyed population resides in rural areas. Disparities between urban and rural regions in terms of healthcare infrastructure, access to medical facilities, and socioeconomic conditions could potentially impact infant survival rates. Additionally, the dataset presents data on various regions, with notable differences in infant mortality frequencies. Regions such as Caprivi (4.2%), Erongo (6.6%), and Hardap (3.4%) demonstrate relatively lower percentages, while Khomas (17.1%), Ohangwena (11.7%), Omusati (11.3%), and Oshana

(9.4%) show higher frequencies. These variations may reflect differences in healthcare resources, education, and economic opportunities across regions.

4.3 Socio-economic Factors

Socio-economic factors can significantly influence infant mortality rates, as indicated by the data. Notably, the "Marital Status" of mothers plays a role in infant survival outcomes. Infants born to mothers who were "Never Married" represent the highest percentage at 76.23%, while lower percentages are seen for those in "Consensual Union" (5.93%) or "Married with Certificate" (10.87%). Stability, access to resources, and social support networks associated with different marital statuses can influence the health and well-being of both mothers and infants. Furthermore, educational attainment, reflected in "Literacy" (88.6% literate, 11.4% not literate) and "Highest Grade Completed," shows an important connection to infant mortality. Higher levels of education can improve healthcare awareness, understanding of medical instructions, and overall decision-making related to infant care.

4.4 Proximate Factors

The data also sheds light on several proximate factors that are closely linked to infant mortality rates. The "Age of the Mother" is a crucial factor, with infants born to mothers aged 15-19 (30.96%) and 20-24 (28.82%) constituting the highest percentages. Young and older maternal age groups may face increased health risks during pregnancy and childbirth, impacting infant survival rates. Additionally, "Sex of Child" is a relevant factor, with the dataset showing a higher percentage of male infants (53.8%). Biological differences and potential societal preferences in healthcare and nutrition may influence varying mortality rates between male and female infants. Other proximate factors include the "Age at First Birth," which shows that a significant proportion of first births occur in the age range of 15-24 (43.0%), and the presence of the "Father of the Child," with "Yes" accounting for 65.7% and "No" at 30.7%, which can influence family support, financial resources, and access to healthcare services for the infant.

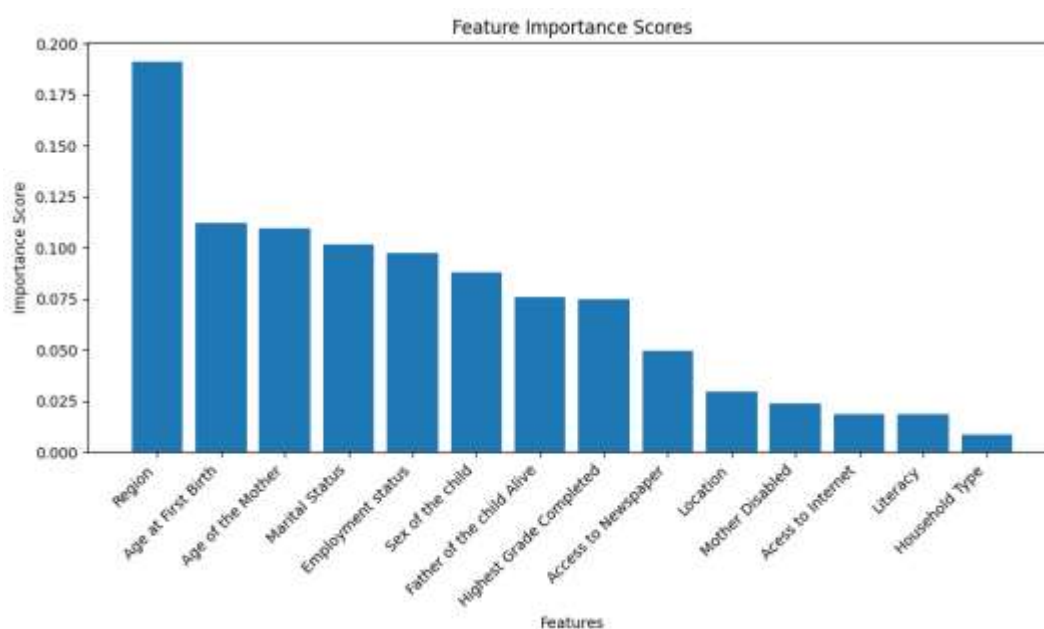


Figure 2: Feature Selection

Variable importance measures the significance of a variable in predicting infant mortality. In this study, a Random Forest classifier was employed to identify crucial features associated with infant mortality. Figure 2 illustrates the variable importance, encompassing measurements of all 15 variables. The findings revealed the top 10 features that strongly contribute to infant mortality, namely Region, Age at First Birth, Age of the Mother, Marital Status, Employment Status, Sex of the Child, Father of the Child Alive, and Highest Grade Completed. On the other hand, Location, Mother Disabled, Access to Newspaper, Access to Internet, Literacy, and Household Type were identified as the least important features in predicting infant mortality.

Table 2: Predictive models of performance of Infant mortality as evaluated on the test data.

Evaluation Matrix		Logistic Regression		Random Forest		Decision Tree	
Confusion Matrix		Predicted		Predicted		Predicted	
		Alive	Death	Alive	Death	Alive	Death
Observed	Alive	31,486	0	31,232	254	30,888	598
	Death	1,091	0	1060	31	1022	69
		%		%		%	
Accuracy		97		96		95	
precision		97		97		97	
Recall		100		99		98	
F1 score		98		98		97	
AUROC		81		81		81	

The results of the machine learning models for predicting infant mortality in Table 1 indicate that all three models, namely Logistic Regression, Random Forest, and Decision Tree, achieved high performance metrics. The Logistic Regression model emerged as the best-performing model among them. With an impressive accuracy of 97% and an F1 Score of 98%, the Logistic Regression model demonstrated remarkable predictive capabilities. Moreover, it achieved a perfect recall of 100%, successfully identifying all instances of the "Alive" class, which is of utmost importance when dealing with infant mortality prediction. The AUROC value of 81% indicates the model's ability to discriminate between positive and negative instances.

The Random Forest model also exhibited strong performance with an accuracy of 96% and an F1 Score of 98%. It achieved a high recall of 99%, indicating its ability to correctly identify a significant portion of the total actual "Alive" instances. The AUROC value of 81% suggests the model's good discriminative capabilities between positive and negative instances. Similarly, the Decision Tree model achieved an accuracy of 95% and an F1 Score of 97%. It demonstrated a high recall of 98%, successfully identifying a considerable portion of the total actual "Alive" instances. The AUROC value of 81% indicates the model's ability to distinguish between positive and negative instances.

Though both the Random Forest and Decision Tree models performed well with accuracies of 96% and 95%, respectively, the Logistic Regression model outperformed them in key metrics. The Logistic Regression model's superior performance can be attributed to its ability to handle binary classification problems

effectively, allowing it to identify patterns and relationships between variables to make accurate predictions. Moreover, the high accuracy and recall of the Logistic Regression model make it the most reliable choice for predicting infant mortality, as it can effectively detect instances of interest and minimize false negatives, which are critical when dealing with such sensitive outcomes.

5 Conclusion

In conclusion, the Logistic Regression model demonstrates outstanding performance across all evaluation metrics, solidifying its position as the optimal choice for predicting infant mortality. The machine learning model, particularly the Logistic Regression algorithm, holds significant promise for forecasting infant mortality in Namibia. By leveraging this powerful predictive tool, policymakers and healthcare professionals can make well-informed decisions to enhance infant health outcomes and work towards reducing infant mortality rates in the country. This could initiate a digital health Innovation ekosystem (Iyawa et al., 2019a, b). However, further improvements are necessary to enhance the model's predictive power, and additional research should be conducted to ensure its sustained effectiveness in improving healthcare outcomes for Namibia's most vulnerable population. Overall, machine learning approaches offer robust capabilities in developing predictive models, enabling the classification of critical insights that conventional statistical methods might not detect.

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Cybersecurity Governance: Managing Risk in Tertiary Institutions

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Abstract.

Cybersecurity is one of the new developing trends of the Fourth Industrial Revolution (4IR) that has recently become the centre of attention. Its importance was heightened by the COVID-19 pandemic that forced individuals and businesses to move their activities online. Furthermore, the 21st century has seen tertiary institutions enrolling big number of students leading to generation of voluminous data. More still, it has become common for tertiary institutions to operate various branches hence increasing the number of users at varied centres. Such has made tertiary institutions a big target of cyberattacks due to the open access nature, remote operations that at an extent has been worsened by outdated technological systems. Universities in particular, those in South Africa inclusive have had challenges with cybersecurity governance, yet little has been done to contextualize a model in their context. Such motivated this study to develop a model to bridge this gap. This study, was underpinned by the Technology- Organizational and Environmental (TOE) theory, contingency, agency, and analytical theory. By using a qualitative approach, data collected from South African public universities repositories was analysed thematically. From a sample of four universities, documentations including policies, reports, cybersecurity guidelines as well as website information were analysed. Results indicated that there is a need to improve security mechanisms to protect stakeholders' information. Theoretically, this study contributes on the literature of cybersecurity governance and adds significant understanding on the ongoing debate of cybersecurity not only in tertiary institutions, but also in other corporate enterprises. Practically the developed model will be used by public universities to make informed decisions on cybersecurity governance when dealing with voluminous information.

Keywords: Cybersecurity, Cybersecurity Governance, Universities, TOE model.

1. Introduction

Over the past few years, several cyber incidents have been initiated against tertiary institutions (Fouad, 2021). These cyber incidents are an indicator of the level of disruption that cyberthreats can cause to the operation of education, which requires both scholarly and policy investigations. The COVID-19 outbreak that caused global lockdowns worsened the state of cybersecurity threats as many organizations including tertiary institutions started operating online. Tertiary institutions for example, shifted their teaching and learning online using various learning management systems and other technological tools like Teams and Zoom. This teaching was offered to student connecting to various network allowing to receive and send information on these varied networks. Such created opportunities for new vulnerabilities and heightened the chances of cyber attacks (TENET South Africa, 2020; Yusif et al., 2021). More still, tertiary institutions universities in particular, are appealing targets of cyberattacks because of their open access nature, remote operations, and outdated systems (Charandura, 2022). These cyberattacks present implications for these universities that include but not limited to financial losses, interruption of the learning process, and intellectual property theft

(Fouad, 2021). This calls for the need to protect information systems in order to safeguard stakeholders' information.

Gartner (2022) defines cybersecurity as the practice of implementing policies, people, processes, and technologies to safeguard organizations, their import systems and sensitive information from digital attacks. National Institute of Standards and Technology (NIST) (2018) defines cybersecurity as “the process of protecting information by preventing, detecting, and responding to attacks”. Cybersecurity involves protecting information and systems from cyber threats while maintaining confidentiality, integrity, and availability of information assets and systems. It helps prevent cyber-attacks, identity theft and data breaches. Hence, it is of paramount importance that organizations have cybersecurity and comply to it and this is done through cybersecurity governance.

Cybersecurity governance refers to the process of guiding and directing the safeguarding of an organization’s digital information assets from risks that are caused by using the internet (Yusif &Hafeez-Baig, 2021). Cybersecurity governance tackles risks related to cybersecurity through cyber policies, standards, guidelines, and procedures. Therefore, an effective cybersecurity governance is needed to overcome cybersecurity risks and promote cybersecurity practices among individuals and organizations (Ng & Kwok, 2017).

Cyber laws could also be used to alleviate challenges of cyber-attacks, however South African cyber laws remain a challenge as they are fragmented and incomprehensible (Chigada & Kyobe, 2018). More so, there is still limited studies that have been conducted to inform effective cybersecurity governance especially in South African universities (Sharma, 2021). Thus, there is lack of an appropriate model that could be used to inform effective cybersecurity governance within South African universities. This study seeks to develop a cybersecurity governance for South African universities.

2. Cybersecurity in Tertiary institutions in South African Context

South Africa has twenty-six public universities. The public universities account for eighty five percent enrolments in 2017 and of the total of twenty-six universities, only one operates exclusively as a distance learning institution. South African universities have experienced an increase in enrolment since the apartheid era, these large enrolments are mostly attributed to Africans joining these institutions (Tjønneland, 2017). The increase in student numbers joining these institutions is a positive indicator of improved access to tertiary institutions . However, public universities systems have a poor track record in relations to governance. There are inequalities within the system in terms of capability to govern and operate the universities as a complex organization which have yielded poor institutional governance and management (Van Schalkwyk, 2021). Furthermore, the COVID-19 pandemic presented unprecedented changes in the tertiary institutions landscape.

South African public universities were affected by the COVID-19 pandemic which caused all campuses closing to adhere to social distancing measures (Toquero, 2020). The closure forced universities to shift from physical teaching and learning to remote learning and teaching. Online learning and teaching platforms were expected to provide access to high quality education and knowledge in universities (de Moura, de Souza &Viana, 2021). However, that has been proven to be difficult because of challenges such as poor internet connectivity, lack of digital access, limited access to resources and social support which foster digital literacy divide (Mohamedbhai, 2020). Furthermore, during this pandemic, there were no best practices for tertiary institutions institutions and known models to follow to ensure a smooth transition to the online environment (Rashid & Yadav, 2020). The online has been known for presenting cybersecurity threats that have negative implications for tertiary institutions institutions (Mcanyana, Brindley & Seedat, 2020).

South African public universities have become a fertile ground for cyber-attacks which are increasing and reported frequently (Charandura, 2022). Several public universities have fallen victim to cyber-attacks. The

emergence of the Covid-19 pandemic forced institutions to move virtual environments. Teleconferencing tools and platforms such as Zoom, Microsoft teams and Google meet were utilized by South African institutions to communicate and support teaching and learning activities (Chigada & Madzinga, 2020). However, Zoom was reported to be unsafe in many countries and was even banned. South African institutions continued to use it and cybercriminals were aware of the security flaws and vulnerabilities of teleconferencing platforms (Khan et al., 2020). During the Covid-19 pandemic cyberattacks and threats become more prevalent and common ones were identified, these included: spam emails, ransomware, malware, distributed denial of services (DDoS) and malicious domains (Khan et al., 2020).

According to Security Scorecard (2018), the education sector was considered as the least secure industry out of the 17 that were studied. In 2020, the education sector had lost \$ 3.90 million for data breach (IBM & Ponemon Institute, 2020). Microsoft Security Intelligence (2021) states that, "education was the most affected industry, encountering almost 64% of all malware attacks, or more than 6.2 million incidents in May 2021". Cyber-attacks that are performed against tertiary institutions are normally targeted at the institution's data and personal information of stakeholders (Cojocariu et al., 2020). This information assists attackers in taking advantage of the institution's banking systems, gather research information, or even interrupt the institution's operations.

2.1. Related work

To determine factors that influence cybersecurity governance, related literature was reviewed. The focus was on cybersecurity governance application in tertiary institutions. Cybersecurity threats, factors influencing cybersecurity, cybersecurity governance and cybersecurity theories also reviewed. The literature was extracted from scholarly articles such as journal articles. This proceeding sections discuss related work that have been conducted in relation to cybersecurity governance.

Ulven and Wangen (2021) conducted a systematic review of cybersecurity risks in tertiary institutions. This study was conducted using a comprehensive literature review model (CLR) which is qualitative by nature. The authors propose a threat model and reviews common cybersecurity vulnerabilities. The authors suggest that maturity modelling and baseline studies are areas of research to focus on to advance the knowledge of security practices in academia. The authors also indicate that empirical studies focusing on security vulnerabilities in HE would be helpful and cloud security is also an under researched area. Generally, HE requires research and empirical studies with focus on information security vulnerabilities, threats, assets, and risks. The goal of this research is to investigate factors that influence an effective cybersecurity model.

Yusif and Hafeez-Baig (2021) conducted a study to develop a cybersecurity governance model that aims to address cybersecurity problems. This is a qualitative study that did not make use of any framework or theories. The five major challenges to cybersecurity governance are: standardized processes, senior leadership oversight, enforcement and accountability, cybersecurity strategy, and resources. The authors indicate that for cybersecurity to be effective it must address these five challenges. These factors must also be incorporated to current processes and systems and prioritized by management leadership. The authors also note that non-compliance to cybersecurity policies remains a serious challenge. Therefore, management leadership is crucial for effective cybersecurity governance. Active cybersecurity training programs, awareness and education that are based on best practices paired are also essential to effective cybersecurity governance. The goal of this study is to investigate the environmental and technological aspect of cybersecurity governance.

Cheng and Wang (2022) conducted a study to propose institutional strategies to address cybersecurity vulnerabilities. The study was conducted using literature review and desk research of methods for a system-wide approach. These strategies include; Responding to AI-based Cyber-threats and Harnessing AI to Enhance

Cybersecurity, Strengthening Institutional Governance for Cybersecurity, Training and Cybersecurity Awareness Campaigns to Build Cybersecurity Culture, Risk Management, Paying Attention to Mobile Devices Use, Using Encryption as a Daily Practice, Revisiting Cybersecurity KPIs, Explicating Cybersecurity Policies, Guidelines and Mechanisms, Introduction of New and More Sophisticated Security Measures. The authors believe that these strategies integrated with HEI stakeholder effort can help prevent cyber-threats and ensure effective cybersecurity in tertiary institutions. The authors also indicate that further research need to be done to investigate the effectiveness and applicability of these strategies in various HEI environments.

From the reviewed literature and related work, factors influencing cybersecurity governance were identified and categorized as illustrated in Table 1. The factors derived from the related literature indicated that most of the factors are from the Technology-Organization and Environment (TOE) theory. Thus, the TOE was selected as the underpinning theory to categorize these was factors and for this study. Hence, this study investigated the technological, environmental and organizations aspect of proposed institutional strategies.

Table 1: Summary of factors influencing cybersecurity governance

Category	Factors	Source
Technological Factors	-Mobile devices usage monitoring	Cheng & Wang (2022)
	-Encryption practices	Ng & Kwok (2017); Cheng & Wang (2022)
	-Security measure, policies, guidelines, and mechanisms	Gartner (2022); Yusif & Hafeez-Baig, (2021); Ulven & Wangen (2021); Yusif & Hafeez-Baig (2021)
Organizational factors	-Standardized processes	Gartner (2022); Yusif & Hafeez-Baig (2021); Ulven & Wangen (2021); Yusif and Hafeez-Baig (2021)
	-Management leadership	Cheng & Wang (2022)
	-Enforcement	Yusif & Hafeez-Baig (2021)
	-Cybersecurity strategy	Chigada & Kyobe (2018); Yusif & Hafeez-Baig (2021)
	-Cybersecurity training programs	Yusif & Hafeez-Baig (2021)
	-Cybersecurity awareness and education	Yusif et al. (2021); Charandura (2022); Yusif & Hafeez-Baig (2021)
Environmental factors	-Stakeholders	Cojocariu et al. (2020)

3. Research Methodology

Besides literature search that yielded factors demonstrated in Table 1, secondary data was also analysed. The secondary data was collected based on the available data sources from the universities' websites, repositories, and library archives. The secondary data sources that were reviewed included internet-based documents, reports, pamphlets, media information and white papers. The collected data from these sources was analysed using content analysis where factors that were identified were ranked based on the number of times and sources it appears as demonstrated in Table 3. Six South African public universities' documentations were reviewed. Table 2 presents the summary of the materials and documentations that were analysed along with the number universities where such documents were available for analysis. The

materials that were analysed included policy documents and reports that relate to information and cybersecurity best practices.

Table 2: Reviewed university documents

Nature of Material	Number of materials analysed
Information security Policy document	6
Information and cybersecurity reports	3
Cybersecurity policy document	1
Account and password policy document	4
Network policy document	2
Electronic communication policy document	5
Student computing services policy document	5

Across all information security policies from the different universities there were elements of confidentiality, integrity, and availability to protect stakeholders' information stored on the institutions information systems.

Table 3: Reviewed university documents

Factor	Frequency
External device mechanism	3
Strategy	4
Guidelines	4
Training Programs	4
Measures	5
Enforcement	5
Software patcher and scanners	6
Cybersecurity awareness and trainings	8
Accountability	8
Confidentiality	8
Network Policy	9
Cybersecurity Reports	10
Password Encryption	10
Encryption	13

After the content search, a close examination of the factors illustrated in Table 3 was carried out and indicated that some factors were just named differently by different researchers when they mean the same. These factors together with those demonstrated in Table 1 were reviewed one by one and marching similar ones were combined while those that were repeating removed. Based on the factors identified in Table 1 and 3, a cybersecurity governance model demonstrated in figure 1 was designed. In the designed model, the

Technology, organization and environment demonstrated in Table 1 as well as the individual characteristics formed the constructs of the model. Additionally, the independent factors were classified under these four categories and formed the attributes of the constructs.

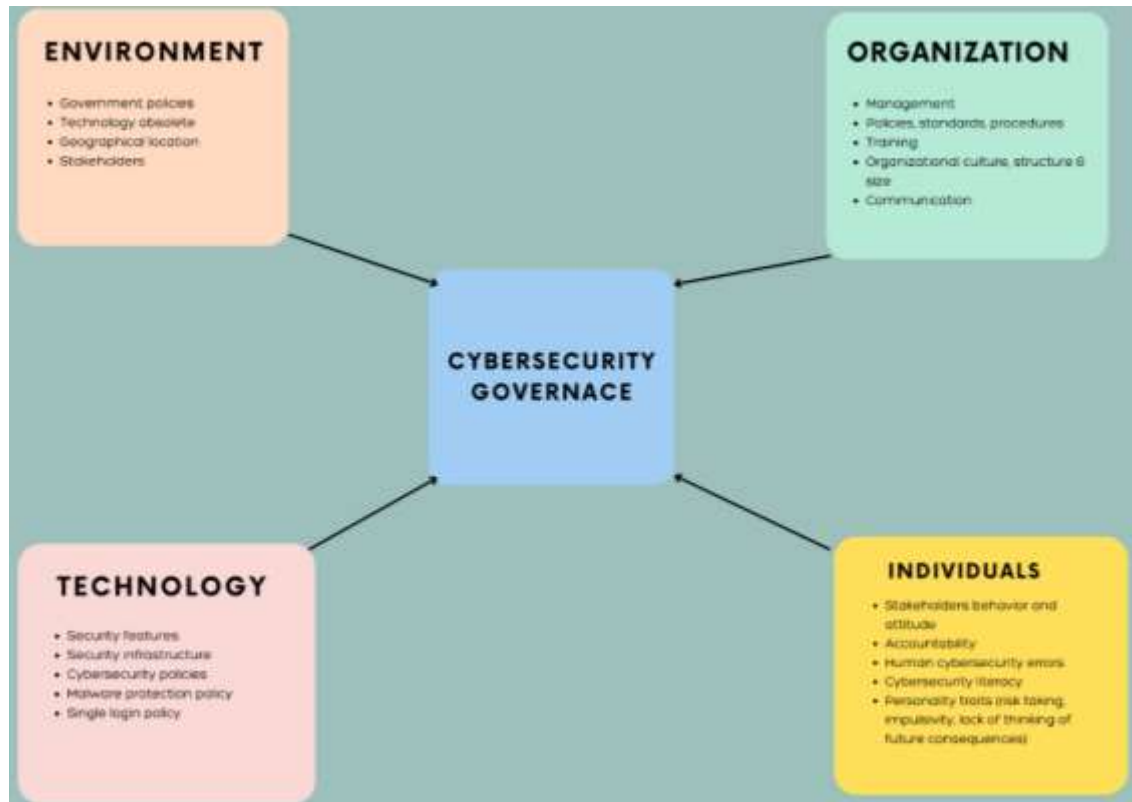


Figure 1: Cybersecurity governance model

5. Discussion

5.1 Discussion of the findings in relation to the primary research question

The primary research question of this study was, How can a model for cybersecurity governance in South African public universities can be developed?. To answer the research question, the TOE was used as the lens for analysing the collected data. Themes were identified and these themes were categorized according to this theory that underpinned the study. The first of them for cybersecurity governance was the technological factors which relate to the internal and external technologies that the university can use to their advantage. Under this theme several factors such as security features, security infrastructure, cybersecurity policies, hardware protection policy, single login policy were identified.

The second theme was the organisation factors that relate to university's characteristics and resources and under this theme factors like management, policies, standards, procedures, training, organization culture, structure, size and communication were identified.

Another theme was the environmental factors that relate to the university's micro, macro and market environment. This theme relates to factors such as government policies, technology obsolete, geographical location, stakeholders.

Other themes that were identified were outside the TOE lens were the individuals' characteristics which relates to human error, personality traits. Under this theme factors such as risk taking, impulsivity, lack of thinking about future consequences of actions, are related to a lack of compliance with cyber and network

security policies were identified. Others factors that could also be categorized as individual factors, these included human cybersecurity errors such as, obsolete software and reusing passwords,, password sharing, social engineering, sharing sensitive information via mobile networks and not securing personal electronic devices.

5.2 Discussion in relation to the overall study

Yusif and Hafeez-Baig (2021) noted that cybersecurity governance tackles risks related to cybersecurity through cyber policies, standards, guidelines, and procedures. However, most universities integrate both cybersecurity and information security policies, standards, procedures, and practices in the Information Security Policy rather than having a standalone cybersecurity policy.

Across all information security policies from the different universities there were elements of confidentiality, integrity, and availability to protect stakeholders' information stored on the institutions information systems. The results of this study are in agreement with what National Institute of Standards and Technology (NIST) (2018) that noted that, cybersecurity involves protecting information and systems from cyber threats while maintaining confidentiality, integrity, and availability of information assets and systems.

The policy documents indicate that universities allow remote access to university's internal network through external networks and devices, however there are no measures stipulated as to how the universities will ensure that the remote device is secure and malware free to join the university's network. The results of this study are in agreement with what Bongiovanni (2019) noted that the characteristic of openness in universities is a major security challenge because it conflicts with conventional security frameworks. Furthermore, they reveal that some universities have a dedicated Information Security Team (IST) dedicated to providing advice on compliance and Computer Incident Response (CSIRT) Team responsible for developing, recommending, and mitigating computer security incidents. However, Cojocariu et al. (2020) notes that tertiary institutions have a shortage of staff with skills and experience in cybersecurity which leads to the possibility of lack of monitoring of all device and activities on the university network. Despite, these measures there are some loopholes in the policies.

According to the three reports from three South African universities, there is no comprehensive approach to safeguarding against cyber-attacks. The reports indicate that the solution to this challenge is creating a digital security department with the relevant skills and governance staff to ensure accountability. However, across all reports, it is indicated that there is a possibility of errors and overriding of controls are limitations to achieving a fully effective internal control system. Effective cybersecurity governance involves more than installation of security software, rather it involves taking into consideration multiple factors such as processes, infrastructural, strategic, external, and organizational issues (Shah, 2022).

6. Limitations, Recommendations, and Conclusion

6.1 Limitations of the study

South African has many public universities, a total of twenty-six universities. Only three South African universities were selected for the purpose of this study. Their policy documents and reports were analysed to generate themes to establish a cybersecurity model.

6.2 Recommendations of the study

a) External device mechanism- Bring-Your-Device presents security threats or vulnerabilities to university's network. Most university policies indicate that stakeholders that use their own or external devices must

ensure that those devices are malware free and some stakeholders may fail to do this. Thus, the university needs to employ a mechanism that scans external devices malware before accessing the network. The user can be forced to run malware detection software on the device before joining the network, if they do not accept the prompt, access should be denied accessing the university's network and IT resource

b) Software patcher and scanners- Since some stakeholders do not run security updates which could prevent security breaches, the university could employ a mechanism that automatically downloads software patches and scan stakeholder's device before joining the network. The mechanism must force user to update security patch or access to the network is denied.

c) Prevention of password discovery mechanisms- Devices with password discovery programs such as sniffers or port university's network or IT resources. Access should be granted to CSIRT only since they deal with mitigating risks and may be using such tools.

d) Single user login to account to one device at a time- The university must implement a single login mechanism for each device. A user must only have one account and use it to access one device at a time. For example, if I am logged in to my laptop with my username, I cannot login to a cell phone or another device without logging out the laptop. This will prevent fraudulent impersonations.

6.3 Conclusion

This research study was undertaken to develop a cybersecurity governance model for South African public universities. Related literature was reviewed to answer the research objectives of this study, the objectives included to determine the factors that influence cybersecurity governance in a South African public university, to establish theories that have been used in cybersecurity governance and to use the theories and identified factors and design a cybersecurity governance model for South African universities. Secondary data from previous literature such as document policies and reports from South African public universities were reviewed to determine standards, procedures and best practices. There were gaps such as data breaches practices and activities that are not clearly defined. A cybersecurity governance model was developed from the identified factors using the TOE framework and a component of individuality was added with various components based on supporting literature. Recommendations were made as to how universities can improve their cybersecurity governance, recommendations included: external device mechanism, software patcher and canners, prevention of password discovery mechanisms, and single user login to account to one device at a time.

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Effects of Novel Curing Procedures and Bio-additives on Construction Materials: Meta-analysis Quantifications using RevMan Software

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Abstract

Producing conventional Portland cement (OPC) proves unsustainable due to its high energy consumption and greenhouse gas emissions. There arises a necessity for eco-friendly, sustainable construction materials. Further advancements are essential to enhance the economic feasibility of these green construction materials. The economic feasibility of such materials can be enhanced by focusing on two key factors: energy-efficient curing methods and the inclusion of reinforcing biomaterial additives. It is imperative to quantitatively assess the overall impact of these enhancement parameters on construction materials to develop feasible green alternatives. Despite qualitative assessments in existing literature, the specific magnitudes of these effects remain unquantified. Consequently, this study seeks to precisely measure the cumulative effects of these parameters on the mechanical properties of construction materials through the application of meta-analyses. Drawing upon systematic reviews, the outcomes of eligible studies were incorporated into meta-analyses using the Review Manager (RevMan) software. The forest plots divulged favorable effects of both potential enhancement parameters on the mechanical characteristics of construction materials, with minimal signs of publication biases. Thus, innovative curing techniques and bio-additives hold the potential to augment green construction materials, thereby enhancing their commercial viability as substitutes for OPC. Based on the results, meta-analyses are recommended to optimize the field of engineering research and development.

Keywords: bio-additives, green construction materials, meta-analyses, novel curing procedures, review manager software, sustainable construction

1. Introduction

The research problem centres around environmental concerns posing a significant challenge within the construction sector (Imbabi et al., 2012). The production of Ordinary Portland Cement (OPC) is characterized by its high energy demand and its role in greenhouse gas emissions (Roopchund et al., 2022a). To ensure the sustainability of the construction industry, alternative eco-friendly options to replace OPC are imperative. One such alternative lies in industrial waste-based geopolymers, which have been identified as viable OPC substitutes (Imbabi et al., 2012; Roopchund et al., 2022b). However, to make these geopolymers commercially viable, further research and development are necessary. Two specific parameters hold the potential to enhance the viability of geopolymers: innovative curing techniques and the incorporation of fibre-reinforcing additives.

This study systematically evaluated these two enhancement factors as agents to bolster the strength of construction materials. While prior literature explored their applications in construction materials, it failed to consolidate and quantify their overall impact on the mechanical properties of such materials. Such findings carry the potential to guide decisions for optimizing and commercializing novel environmentally friendly construction materials. In an effort to bridge this knowledge gap, this study pursued a dual objective. Firstly, it compiled relevant literature for meta-analysis, employing the Review Manager (RevMan) software.

Secondly, it sought to statistically determine the cumulative effects of these enhancement parameters on the strength of construction materials using RevMan.

The argument posits that these two potential enhancement factors exert a positive influence on the strength of construction materials, suggesting their applicability for enhancing green geopolymer construction materials and thereby contributing to the long-term sustainability of the construction industry.

2. Literature Review

2.1 Current Situation of the Construction Industry- A Synopsis

The construction industry grapples with multiple challenges, including the depletion of fossil fuels, scarcity of raw materials, surging demand, environmental considerations, and a stagnant global economy (Imbabi et al., 2012). Notably, the production of Ordinary Portland Cement (OPC) contributes to 6% of all carbon emissions from industrial activities (Imbabi et al., 2012) and accounts for 5 to 7% of emissions responsible for global warming (Singh & Middendorf, 2020). Consequently, the development of environmentally friendly alternatives in the realm of green construction materials becomes imperative. These green materials are characterized by their durability, bio-based composition, utilization of recycled components, and their low levels of toxicity and emissions (Komnitsas, 2011). Commonly recognized cement replacement materials include blast furnace slag, fly ash, and silica fumes (Imbabi et al., 2012).

Among the green construction alternatives, geopolymers stand out as they are synthesized from minimally processed natural minerals and industrial by-products (wastes) (Roopchund, 2021). Moreover, geopolymer production utilizes industrial aluminosilicate by-products (waste) with minimal environmental repercussions (Singh & Middendorf, 2020), leading to reductions in energy consumption and carbon dioxide emissions. Nonetheless, to harness their full potential for commercial applications, advancements in geopolymer technology are imperative (Komnitsas, 2011). The variabilities in geopolymer production, which encompass phase transformations, impurities in reactions, and their impact on strength development (Singh & Middendorf, 2020), underscore the need for further research in these areas.

2.2 Novel Geopolymer Curing Procedures

Optimizing and standardizing the geopolymer curing process is crucial to achieve consistent and satisfactory properties across the board. A noteworthy advancement in this regard is the utilization of microwave curing. Microwaves offer rapid heat transfer compared to conventional oven curing. However, scaling up microwave curing to pilot and industrial levels necessitates the use of sophisticated and large-scale microwave equipment.

Graytee et al.'s (2018) research focused on the development of a fly ash-based geopolymer using microwave curing. Their study aimed to assess the impact of this innovative curing method on geopolymer strength. The results demonstrated significantly higher compressive strength in the microwave-cured geopolymers compared to their oven-cured counterparts. Impressively, within a mere five minutes, the microwave-cured geopolymer achieved a remarkable compressive strength of 56 MPa. This study underscored the feasibility of manufacturing geopolymers with substantial strength in a short timeframe through microwave curing.

Building upon this, Kastiukas et al. (2020) conducted a study to investigate the effects of microwave curing versus oven curing on geopolymer compressive strengths. Microwave curing, once again, proved to be more time-efficient and capable of producing higher strengths when compared to oven curing, aligning with the findings of Graytee et al. (2018). The application of microwave radiation facilitated better precursor hydration within the geopolymers. Nevertheless, achieving optimum strengths while eliminating cracking

within the samples requires the careful optimization of factors such as temperature, microwave power, and curing time.

In a separate study, Cai et al. (2020) synthesized a self-electrical heating geopolymer using fly ash. They improved the geopolymer's curing efficiency by incorporating carbon black and steel fibers to enhance its electrical conductivity. This modification led to an increase in flexural strength after self-electrical heating. The results highlighted that the self-electrical heating method substantially enhanced the eco-efficiency of geopolymerization by reducing energy costs and enhancing curing efficiency. However, it's worth noting that the application of this method may not be directly transferable to the microwave curing process proposed by Graytee et al. (2018) and Kastiukas et al. (2020). Therefore, a careful evaluation of the advantages and disadvantages of both novel curing techniques, microwave radiation curing and self-electrical heating curing, is necessary before implementing them on a pilot or industrial scale.

2.3 Biomaterials to Fortify Construction Materials

Korniejenko et al. (2016) conducted a study that delved into the reinforcement potential of short natural fibers like cotton, sisal, raffia, and coconut in enhancing the mechanical properties of fly ash-based geopolymers. The mechanical assessments encompassed compressive and flexural strength tests, complemented by microstructural examinations. While the natural fibers exhibited less cohesion within the geopolymer matrix compared to synthetic fibers like glass or carbon, the compressive and flexural strength tests underscored the advantages of fiber reinforcement, yielding relatively favorable mechanical properties.

In alignment with the research of Korniejenko et al. (2016), Sudalaimani et al. (2017a), Sudalaimani et al. (2017b), and Karthik et al. (2019), the study conducted by Silva et al. (2020) reviewed the role of natural fibers as reinforcing additives for geopolymers. This comprehensive review encompassed the utilization of fly ash, ground granulated blast furnace slag, construction and demolition waste, and mine tailings for producing high-strength geopolymers. Furthermore, natural fibers such as pineapple leaves, sisal, linen, flax, sweet sorghum, and cotton were found to effectively reinforce geopolymers. The properties of these composites were influenced by various factors, including the type of fiber, its dimensions, quantity, and pretreatment. Each material under review exhibited the potential to contribute to the development of eco-friendly construction materials due to their favorable aluminosilicate content. Importantly, Silva et al. (2020) reported that geopolymers reinforced with waste-based materials displayed satisfactory mechanical properties comparable to those of OPC products. This finding aligns with the studies conducted by Komnitsas (2011) and Singh & Middendorf (2020).

Sudalaimani et al. (2017a) focused on investigating the impacts of *Terminalia chebula* and natural sugars (molasses, palm jaggery, and honey) on the mechanical properties of fly ash and ground granulated blast furnace slag geopolymers, as well as their self-curing abilities under ambient conditions. The optimal combination of bio-additives, *Terminalia chebula* and palm jaggery, induced self-curing abilities and resulted in substantial improvements, including a 31.31% increase in compressive strength, a 14.70% increase in splitting tensile strength, and a 27.59% increase in flexural strength under ambient conditions.

Expanding on the work of Sudalaimani et al. (2017a), Karthik et al. (2019) delved into the effects of bio-additives on the physicochemical properties of geopolymers produced from fly ash and ground granulated blast furnace slag. The utilization of natural sugars (molasses, palm jaggery, and honey) and *Terminalia chebula* as bio-additives resulted in orderly geopolymer gels and stable matrices. These modifications led to an increase in density, requiring higher temperatures for matrix disintegration. Compressive strength of the geopolymers increased by a range of 18.30–35.90%, in line with the findings of Sudalaimani et al. (2017a).

Despite the successful implementation of novel curing procedures and bio-additives as reinforcement agents to enhance the mechanical properties of environmentally friendly construction materials, their collective effects have not been quantified in existing literature. This deficiency presents the research gap to be filled by the research objectives of the study. Such quantification holds the potential to inspire focused research and development efforts aimed at creating green construction materials that can effectively compete with OPC within the construction sector.

3 Materials and Methods

The utilization of a meta-analysis provides a means of extracting knowledge from an accumulation of studies, serving to validate the evidence presented in the literature (Glass, 1976). In line with the recommendation that further research can contribute to the enhancement of mechanical performance and the expansion of production in the realm of environmentally friendly construction materials (Zhuang et al., 2016), these meta-analyses were employed to systematically quantify the overarching impact of innovative curing techniques and the reinforcement of bio-additives on the mechanical characteristics of construction materials. Adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, as outlined by Kamboj in 2016, facilitated the comprehensive execution of these meta-analyses, which were conducted using the Review Manager (RevMan) software.

3.1 Literature Review Methodology

Logical operators, specifically conjunction and intersection, were applied during the literature search to enhance the relevance of the collected literature. The gathered literature was systematically organized and evaluated concerning the two potential enhancement parameters. Notable commonalities across various literature sources served to shape the problem's conceptualization and establish a robust theoretical framework. Furthermore, the literature review contextualized the study within the existing body of literature, elucidating the fundamental principles underlying the research. Figure 1 visually illustrates the specific objectives of the literature review.

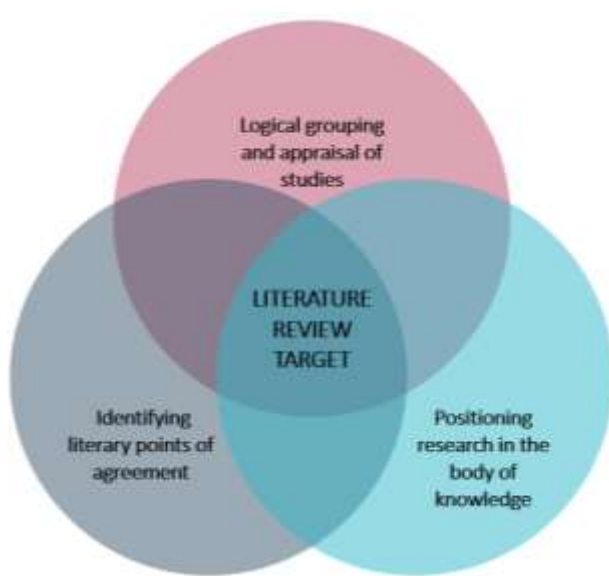


Figure 1: Venn diagram of literature review target parameters

3.2 Meta-analysis using RevMan

Using the Review Manager software (RevMan version 5.4), two separate meta-analyses quantified the effects of the two potential improvement factors on the strength of construction materials: novel curing procedures and reinforcing biomaterials. The procedure outlined below can be replicated and applied to other engineering studies (Arnqvist & Wooster, 1995; Roopchund et al., 2022b).

- i. A new review wizard simulation page was created and saved.
- ii. The authors and publication years of the included sources were added under the "Included studies" section.
- iii. Once all the literature data were captured, it was visible under the "tree view."
- iv. A new comparison was added under the "Data and analyses" section, named and saved.
- v. The specific treatment was compared to the control. This step was repeated for both treatments (novel curing procedures and biomaterial reinforcing agents).
- vi. An outcome was added under the comparison by selecting the "add outcome under the new comparison" option.
- vii. A "continuous" data type was specified, enabling sub-specification of the continuous data variables (mean, standard deviation, and the number of experimental runs) for the compared data sets (treatment vs. control). These statistical parameters were performed using the integrated statistical functions in Microsoft Excel.
- viii. A "fixed effect" analysis model was used since the research studies were similar concerning the treatment and control comparisons.
- ix. The default confidence interval of 95% was unchanged.
- x. The new outcome was opened under the "Data and Analysis" section.
- xi. The studies of interest were specified by choosing the "add study data" tab above the forest plot section. The process was completed after selecting the desired studies.
- xii. The mean, standard deviation, and the number of experimental runs were input for the treatment and control studies performed by each of the selected literature sources. The Microsoft Excel calculations were used to ensure accurate calculation of the statistical parameters (mean and standard deviation) for the control and treatment.
- xiii. Upon adding the data, the software automatically calculated the overall statistical parameters, including the heterogeneity parameters for the overall study group: the I^2 and P-value. The I^2 value indicated the degree to which the studies exhibited heterogeneity in each other. If the I^2 value exceeded 50%, it indicated substantial heterogeneity between the studies. The P-value indicated the significance of the heterogeneity.
- xiv. The forest plot (representing the individual effect of the results of each study) appeared as graphical output. The forest plot indicated whether the respective literature sources favored the treatment or the control. If the treatment was favored, the outcome of interest obtained a better output. The diamond at the bottom of the forest plot represented the overall (combined) effect.
- xv. The software exported the forest plot, funnel plot, and statistical results.
- xvi. The overall meta-analysis included studies based on the literary construction materials' compressive strength and flexural strength responses under the influence of the two potential improvement parameters.

3.3 Data Analysis

The meta-analysis yields two principal outcomes: the forest plot and the funnel plot. The forest plot, as demonstrated by Kamboj (2016), Egger et al. (1997a), and Lewis & Clarke (2001), visually represents the studies included in the meta-analysis. Each study is denoted by a square placed at the point estimate of the treatment effect, accompanied by horizontal lines extending on either side of the square. The size of the

square is proportionate to the study's weight, while the horizontal lines depict the confidence interval, as elucidated by Alderson et al. (2004). The overall effect size, portrayed as a diamond on the plot, signifies the combined effect of the individual studies. The position of the diamond on the plot indicates whether the treatment or the control will yield the desired effect. Due to variations in research settings, countries, methodologies, and study durations, heterogeneity is inherent in systematic reviews, quantified by the statistical parameter " I^2 ."

The vertical line of no effect serves as a division between the treatment and control sides of the forest plot, in accordance with Kamboj (2016). The preferred side of the plot suggests where the desired results are likely to be found. This information is invaluable as it offers insights into whether applying a particular treatment might produce the desired results, obviating the need for preliminary experimental studies. If the confidence interval does not intersect with the line of no effect, the result is deemed statistically significant, assisting in the identification of non-statistically significant studies within the meta-analysis.

On the other hand, the funnel plot, as described by Kamboj (2016) and Alderson et al. (2004), graphically illustrates the effect size relative to the sample size of each study. Funnel plots take the form of scatter plots, with treatment effects from individual studies on the x-axis and corresponding sample sizes on the y-axis. Funnel plots serve as a means to detect publication biases within the meta-analysis. Three observations on a funnel plot may indicate a publication bias: the presence of negative studies in the lower-left corner, the filling of the funnel, and asymmetry. Various factors can contribute to asymmetry, including selection biases, methodological deficiencies in smaller studies, true heterogeneity linked to study size, and inappropriate effect measures. A publication bias has the potential to lead to an overestimation of the treatment effect calculated in a meta-analysis, as pointed out by Villar et al. (1997) and Egger et al. (1997b).

4 Results and Discussion

The outcomes generated by the RevMan software included the initial data inputs, encompassing mean values, standard deviations, and the experimental runs for both control and treatment groups, alongside the corresponding outputs, which included weight, mean difference, and measures of heterogeneity.

4.1 Novel Curing Procedures

As depicted in Figure 2, which presents the forest plot illustrating novel curing procedures, it becomes evident that all the curing methods analyzed pertained to microwave curing techniques. The meta-analysis results reveal a preference for the treatment, specifically favouring microwave curing over the traditional approach. It is worth noting, however, that despite this favorable outcome, the current practicality of microwave curing might be limited due to the restricted availability of laboratory-scale industrial microwaves.

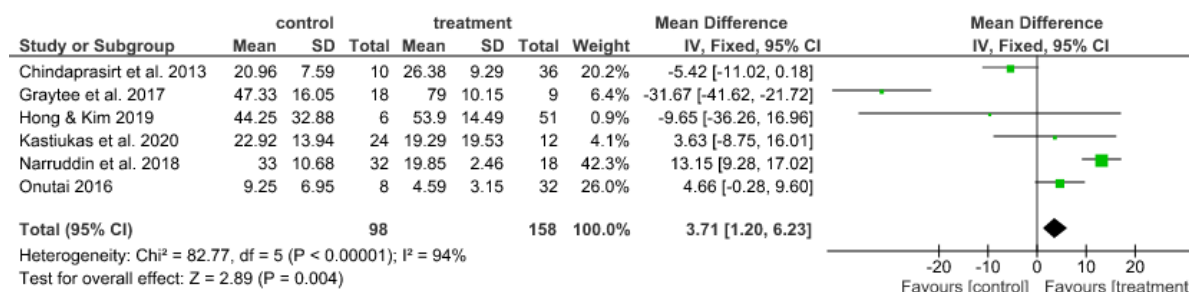


Figure 2: Forest plot of novel curing procedures

The associated funnel plot depicted in Figure 3 displayed slight asymmetry and featured a potential indicator of publication bias, notably the dispersion of studies within the funnel. It is essential to acknowledge that this bias likely arose due to the limited focus in the literature on novel curing procedures, primarily centred around microwave curing. Despite this observation, it is worth noting that the treatment remains promising as an emerging technology, with the potential for further enhancement and refinement over time, thus satisfying the study's second objective.

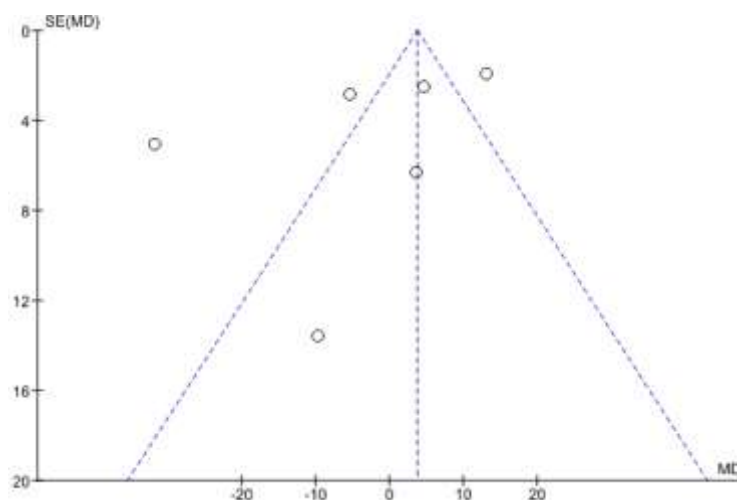


Figure 3: Funnel plot of novel curing procedures

4.2 Biomaterial Additives

As illustrated in the Forest plot of Figure 4, the collective impact of incorporating reinforcing bio-additives into construction materials exhibited a favorable outcome in comparison to the control. Therefore, the utilization of appropriate bio-additives to enhance the mechanical characteristics of construction materials warrants serious consideration.

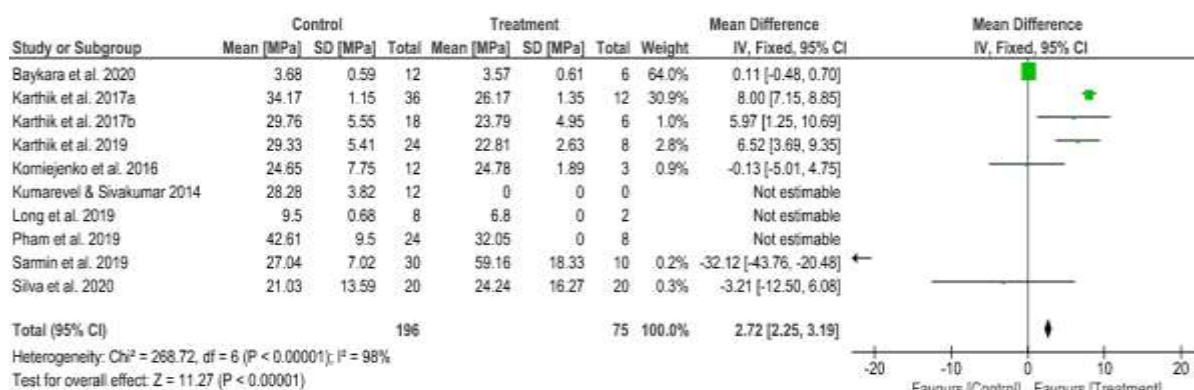


Figure 4: Forest plot of reinforcing biomaterials

In Figure 5, the corresponding funnel plot displayed a symmetrical distribution of studies. These studies were concentrated around the apex of the inverted funnel, and the apex itself was not inundated with individual studies. This observation effectively negated the likelihood of publication bias.

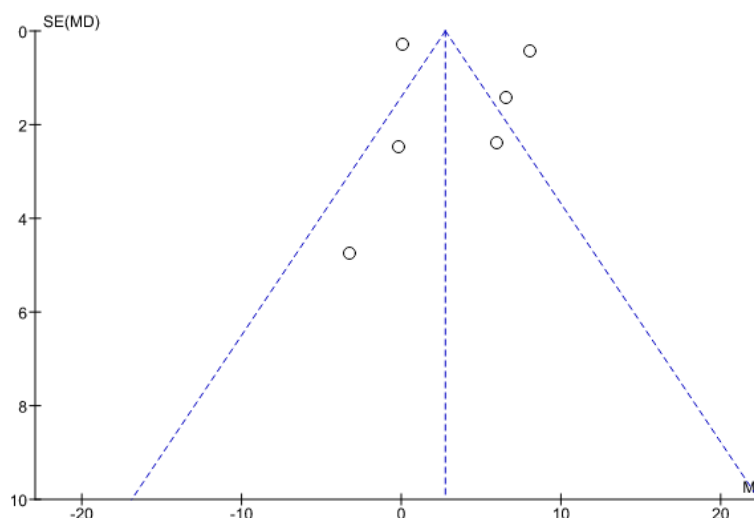


Figure 5: Funnel plot of reinforcing biomaterials

Three measures were employed to validate the reliability of the findings. Firstly, adherence to the PRISMA guidelines governed the study. Secondly, an examination of the RevMan funnel plots revealed the absence of publication biases, except in the case of microwave curing, which can be attributed to the limited research in this area. Thirdly, within the comprehensive meta-analysis, the confidence intervals consistently did not intersect with the line of no effect, signifying the statistical significance of the constituent studies.

In light of the fact that the meta-analysis quantified the viability of innovative curing techniques and biomaterial additives in enhancing construction materials, it effectively fulfils the recommendation put forth by Zhuang et al. (2016). To ensure a continuous progression and production of microwave-cured green construction materials, it is advisable to establish a framework for ongoing research in this domain. Furthermore, the study recommends an in-depth characterization of bio-additives to ascertain the varying effects of different bio-additives on the resultant reinforced geopolymers. It is important to note that no limitations or assumptions were invoked in the attainment of the study's results.

5 Conclusions

Green construction materials hold the potential to serve as replacements for OPC, a source of greenhouse gas emissions. However, bridging the existing gaps between laboratory-scale and commercial-scale production and distribution is imperative for their wider adoption. Meta-analyses offer the ability to quantitatively assess pertinent literature, thereby enabling the determination of comprehensive treatment effects and reducing the need for extensive laboratory investigations. Furthermore, meta-analyses can play a role in streamlining subsequent experimental research by optimizing experimental parameters and conditions. This optimization proves particularly advantageous in dynamic fields like the development of green construction materials. The implication is that both academics and industrial practitioners can leverage

meta-analyses as a valuable tool to streamline their research and development efforts. Given that the meta-analysis in this study addresses the central argument, the methodology and the utilization of RevMan software have proven highly beneficial.

In the realm of green construction materials development, key stakeholders include researchers, leaders in the construction industry, industries involved in the production of waste precursors, and governmental bodies. Researchers can harness the power of meta-analyses to expedite their research endeavours and secure reliable results. These results, in turn, can aid leaders within the construction industry in optimizing the scaling-up of green construction material development. Governments, recognizing the importance of reducing carbon emissions, can provide financial support to incentivize construction industry leaders. Finally, industries responsible for generating waste materials can collaborate with green construction material manufacturers, offering these materials as alternatives to environmentally detrimental disposal practices. This interconnected relationship is visually represented in Figure 6.



Figure 6: Relationship between the critical stakeholder contributions

The results effectively addressed the central argument by providing statistical evidence that the application of novel curing procedures and bio-additives in construction materials indeed enhances their mechanical properties. This underscores the importance of conducting further studies to delve deeper into the effects of these enhancement parameters on the mechanical characteristics of green construction materials. Additionally, it is recommended that the methodologies employed in the conducted meta-analyses be replicated, and adapted for application in various other research domains. This adaptability allows for the strengthening of the competitive position of green construction materials in relation to OPC within the construction industry. Overall, the objectives of the study were well met.

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Technology implementation to enhance teaching and learning: an empirical framework based on South African higher education perspectives.

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Abstract.

The recent pandemic proved that archaic pedagogical approaches needed to be replaced with fresh pedagogical approaches characterized by adopting teaching and learning technologies. Despite teaching and learning relying on technologies during the pandemic lockdown, many education practitioners have reverted to old pedagogical approaches. While some practitioners are technology averse, others are not properly trained, or lack funding and institutional guidance to implement technology-enhanced pedagogical approaches. To help overcome this challenge, this paper presents an empirical framework to guide the transition from traditional to technology-enhanced pedagogy with a focus on the South African higher education space. A literature review provided insights into the current trends in technology uptake in the global education landscape, in comparison to the South African landscape. The adoption of 4IR technologies (focusing on gamification) was also explored. A phenomenological research approach was used to develop the empirical technology implementation framework for technologies typically available at the institutional level, while a mixed methods action research cycle was proposed to guide the implementation of 4IR technologies not typically available at the institutional level. A case study demonstrating the adoption of Kahoot! gamification technology in undergraduate classes was presented. The results showed overall positive impacts of using institutional technologies in teaching and learning and advanced learning analytics that can be used to optimize learning using the gamification technology. Based on the case study results, a framework is presented to outline proposed mitigation factors in response to the impediments to technology uptake in the higher education space. It is recommended that the proposed empirical framework be adopted to optimize technology uptake in higher education.

Keywords: higher education technology; technology trends in higher education; teaching with 4IR technologies; gamification; teaching innovations.

1. Introduction.

The recent COVID-19 global pandemic demonstrated that traditional methods of teaching and learning were outdated and needed to be replaced with technology-supported and improved methods. After the lockdown restrictions were lifted, and contact classes have resumed, many lecturers have retained technology-infused pedagogical practices, while some are required by their institutions to do so. Despite the value and benefits associated with technology-infused pedagogy, there still exists a resistance from education practitioners to actively adopt new and emerging technologies within their domains of practice. This perceived resistance comprises the problem statement of this study. In addition, as global populations increase, technology uptake is needed to streamline teaching and learning in higher education institutions.

This paper focuses on teaching technologies in the global landscape, and those in the South African landscape, with a focus on the key benefits, barriers, and challenges of teaching with technology. This paper aims to outline how global trends in teaching with information technology tools and platforms are filtering down from a global level to local institutional level, and how local education practitioners can maximise the adoption and use of teaching technologies, despite the reported challenges and barriers. To help overcome the challenge of poor technology uptake in higher education, this paper aims to provide an empirical

framework to propose mitigation measures to the main impediments and demonstrate a case study outlining gamification capabilities in a South African undergraduate class.

2. Literature Review.

2.1 Technology use in the global higher education landscape.

The studies outlining pedagogical technology uptake on the global landscape were chronologically reviewed across various geographical contexts to exemplify the global advancement of teaching technologies with the progression of time. West (1999) considered the challenges with respect to teaching technology in higher education in America. According to West (1999), universities are responding to the way students want to learn but are simultaneously resisting the change. At the time of publication, the “new” student demographic included adult students with jobs (Katz, 1999) who preferred student-centric universities. West (1999) realized that technology could make learning more robust, which was a prediction of how technology would transform future teaching and learning. At the time of publication, less than 20% of faculties used technology to teach, which is a stark contrast to the way technology is currently adopted in tertiary teaching and learning.

Scanlon & Issroff (2005) evaluated pedagogical technologies in the UK and recommended an evaluative strategy informed by Activity Theory. Their five main criteria to evaluate learning technologies included: efficiency, cost, serendipity, interactivity, and failure. These factors are valuable in determining the potential effectiveness of learning technologies. However, no practical examples demonstrated an evaluation. Furthermore, the study failed to outline the trending learning technologies at the time of publication. Considering that the proposed evaluation model was based on a single learning theory, this revokes the model’s universal application. However, it is argued that the model of Scanlon & Issroff (2005) can aid as a beginning point to create more advanced evaluation models.

Detracting from the trends in developed countries, Sife et al. (2007) considered applying information and communication technologies in Tanzania. The pedagogical and socio-economic forces compelling institutions to adopt Information and Communication Technologies included increased access to information; increased communication; asynchronous and synchronous pedagogy; increased collaboration, cost-effectiveness, and pedagogical enhancement. However, information and communication technologies were not widely implemented in developing countries (such as Tanzania, and other African countries) due to several impediments: lack of a systemic approach to implementation, vague awareness, and lack of appreciation towards technologies, lack of technical and administrative support, lack of transformation, lack of staff development, lack of ownership, and inadequate funds. Sife’s et al. (2007) reviewed technologies included: TV/Radio, CD/DVD, web-based technologies, video conferencing, and e-learning platforms. It is notable that modern learning management systems, including Blackboard, offer the amalgamated advantages of all the reviewed technologies on a single platform. The study concluded that Information and Communication Technologies could help universities in developing countries to improve their teaching and learning. The study presented unique insights from developing countries and demonstrated that implementation is possible- despite the challenges or advancement of the reported technologies.

Kirkwood and Price (2013) presented a scholarly perspective to technology-aided teaching in higher education. They believed that as technology is progressively employed for teaching and learning in higher education, the tangible educational gains should be scrutinized. This notion is justified, as not all technologies may be useful. At the time of publication, the authors argued that few published records of teaching

enhanced learning methods showed a scholarly perspective to higher education teaching. Often, teaching enhanced learning interventions were technology-led without responding to teaching and learning issues. This notion is often retained in universities that are contracted to implementing technology. Considering that teachers' conceptions of teaching and professional development were often ignored (Kirkwood & Price, 2013), a scholarly perspective among higher education practitioners is more beneficial than delivering practical training to optimize the efficiency of technology-enhanced learning.

Adams Becker et al. (2017) outlined two aspects overlooked in previous studies: the trends expediting the adoption of technology in higher education (Table 1) and the barriers impeding technology adoption in higher education (Table 2). It is notable that this relatively recent study is more relatable than previous studies, as it outlines "modern" technologies- as compared to the outdated offerings reported in the study of Sife et al. (2007).

Table 4: Key trends promoting technology adoption in higher education in a global context.

Timeframe	Description
Long-term	Driving technology adoption in higher education for more than 5 years: progressing innovation and deepening learning strategies.
Mid-term	Driving technology implementation in higher education for the next 3 to 5 years: increased focus on quantifying learning and re-designing learning spaces.
Short-term	Driving technology adoption in higher education for the next 1 to 2 years: blended learning designs and collaborative learning.

Table 5: Key challenges preventing technology implementation in higher education in a global context.

Description	Explanation
Solvable	Those that are understood and can be solved: increasing digital literacy and amalgamating informal and formal learning.
Difficult	Those that are understood, but solutions are intangible: aiding digital equity and achievement gaps.
Extreme	Those that are too intricate to define, much less address: dealing with knowledge obsolescence and re-thinking the duties of teachers.

Digital technologies are commanding tools that have not been globally amalgamated in higher education teaching and learning (Mercader, 2020) due to several barriers (Adams Becker et al., 2017). Mercader (2020) developed an explanatory model of the barriers to digital technology integration in Spain. Seven barriers were found: technophobia, inadequate time, lack of planning, inadequate incentives, inadequate evaluation, work overload, and university accreditation model. These impediments resonate with those outlined by Sife et al. (2007). The model can aid institutions to identify the specific impediments; thus, improving the amalgamation of digital technologies in the higher education space. It is argued that an awareness of the challenges can help develop strategies to mitigate them.

Frolova & Rogach (2021) evaluated the digitalization of higher education assessments in Russia. The focus on assessments is beneficial, as most studies solely considered the influence of technology on pedagogy. The study analyzed student assessments with respect to digitalization, and students' attitude to digital

technologies. The students' attitude to digitalization was linked to their experience of distance learning during the pandemic. This notion is logical, as most students were first exposed to digital pedagogical practices during the COVID-19 pandemic lockdown. Additionally, students may not fully focus on educational content to develop their competencies, implying that technology can be distracting. It was also interesting that educational materials, and virtual lecture recordings do not compensate for key dysfunctions: decreased live interaction, contracting communication channels, and inadequate motivation to learn. Considering these factors, the authors proposed that the duty of the educator must transition from the "translator of knowledge" to the "moderator of the creative space", implying that greater creativity is required of modern teachers.

2.2 Technology use in South Africa.

Ng'ambi et al. (2016) chronologically reviewed the history of teaching with technology in four phases: 1 (1996–2000), 2 (2001–2005), 3 (2006–2010) and 4 (2011–2016). In the first phase, technology was used for practice, and computer-aided instruction, with growing consciousness of the digital divide. In the second phase, institutions focused on building information and communication technology infrastructure, democratizing information, policy development and research to determine the effectiveness of teaching with technology. In the third phase, institutions included information and communication technologies in their tactical guidance, digital divide debates focused on epistemological access, and research became pedagogically inclined. Finally, the fourth phase entailed the emergence of mobile learning and social media.

South African higher education was impacted by global trends, national development goals and pressure from local digital imperatives over the last 20 years (Ng'ambi et al., 2016). Additionally, advancements in technology-enhanced pedagogical practices and information and communication technology have influenced higher education. Bozalek & Ng'ambi (2015) further state that the South African higher education landscape is located between systemic contextual problems inherited from previous policies (Bozalek and Boughey, 2012; Leibowitz, 2012; Soudien, 2012; Fraser, 2009) and a generation of possibilities enabled by 'emerging technologies' (Broekman et al., 2002; Veletsianos, 2010). The authors urge that these challenges must be simultaneously addressed, as they influence education policies and perceptions of teaching technologies.

The National Plan for Higher Education (Department of Education, 2001) noted that information and communication technologies can alter the higher education landscape. However, inadequate access to technologies and infrastructure within the South African landscape often justifies 'outdated and inadequate ontologies' (Waldeelbergh 2011:87). Although South African higher education institutions are moving from poor information and communication technology infrastructure and education provision to cloud-based information and communication technology infrastructure with "unlimited" resources, it is disheartening that South African tertiary pedagogy remains largely unchanged even though mobile and social media have become more prevalent.

The study of Moloi & Salawu (n.d.) determined the 4IR skills required for teaching and learning in South African universities. They found that universities used 57 different teaching and learning technologies, and teaching was supplemented with WhatsApp, Zoom, and Microsoft Teams. Despite previous resistance and a lack of institutional guidelines to integrate 4IR in their activities, lecturers are moderately competent in existing technologies due to training. The study found improvements in teaching and learning, and industry partners and communities of practice were beneficial. The study concluded that while Universities adopt

blended learning to converge humans and machines in the 4IR, a national policy is required to minimize the digital divide.

2.3 Benefits, barriers, and challenges when teaching and learning with technology.

Regarding the benefits of using technology, learning is made more robust (West, 1999) and enables pedagogical improvement (Sife et al., 2007). Technology-infused pedagogy also provides interactive experiences and an engaging learning environment (Walden University, n.d.). Technology enables greater access to information (Sife et al., 2007), flexibility (synchronous or asynchronous learning) (Sife et al., 2007, Allison Academy, 2022), increased cooperation and collaboration (Sife et al., 2007) and access to unlimited information and data from various sources (Allison Academy, 2022). Metrics provides better insights into student performance (Allison Academy, 2022) and different learning styles can be incorporated (Walden University, n.d.).

In terms of the barriers and challenges associated with technology uptake, there is still a vague awareness and appreciation of technology for learning (Sife et al., 2007) and a resistance to implement technology changes (West, 1999; Sife et al., 2007)- often labelled as “technophobia” (Mercader, 2020). Sometimes technology implementation approaches may lack a systematic approach and administrative and technical support (Sife et al., 2007). Implementation requires careful planning (Mercader, 2020) and technologies must be evaluated for optimization (Mercader, 2020). Despite these efforts, there are often a lack of incentives for technology uptake (Mercader, 2020).

Sometimes institutions may drive technology uptake but fail to adequately their staff accordingly (Sife et al., 2007). In this instance, teachers’ professional development is disregarded (Kirkwood & Price, 2013) and digital literacy must be improved (students and instructors) for optimal uptake (Adams Becker et al., 2017). Funding is one of the biggest barriers to technology uptake (Sife et al., 2007) coupled with the fact that maintaining modern technology is expensive (Allison Academy, 2022). Considering the exciting and fun potential to learn with technology, measures must be taken to ensure that distractions are minimized (Frolova & Rogach, 2021; Allison Academy, 2022).

2.4 Adoption of 4IR technologies (focusing on Gamification).

Considering that well designed and engaging games create joyful experiences, games are universally appealing. Games are often logically related to fun, enjoyment, excitement, and relaxation. It is interesting to note that there are many similarities between gaming and learning (Wang, 2021) as shown in Table 3.

Table 3: Parallels between learning and gaming (Wang, 2021).

Gaming	Learning
Exploring a new world	Exploring a new subject
Quests	Learning objectives
Points and badges	Grades and awards
Social interaction through competition and collaboration	Social interaction in the form of collaboration and competition
Learning from failures	Learning from failures
Time limits and stress	Deadlines and pressure

Gamification entails the use of game elements in non-gaming situations to stimulate or influence behaviour (Scepanovic et al., 2015; Wang, 2021). Following this definition, gamification can be applied in higher education to incentivize students to learn autonomously and independently. It is noteworthy that one of the major authentic learning elements can be achieved through gamification: collaboration. Collaboration becomes achievable through gamification by building connections among members of an academic community. Gamification is one of the top trends in higher education, as a gamified learning process can immerse students in the curricular content and foster a positive attitude toward learning. Through gamification, learning is transitioned from being a laborious task to a fun and rewarding quest.

There are multiple benefits in implementing gamification over time, as outlined below:

- Gamification has shown positive impacts on problem-solving, wider knowledge acquisition, motivation and engagement (Scepanovic et al., 2015).
- Learning is made more motivating and engaging (Ortiz et al., 2016).
- Students will be guided towards forming communities of practice, through extensive collaboration, to encourage peer learning and support.
- Authentic learning elements, such as collaboration (Lombardi & Oblinger, 2007) are made possible through gamification.
- Gamification activities can promote student competencies in 4IR technologies, thus better preparing them for the 21st century 4IR workforce.
- Gamification positively influences students' accomplishment, attendance, goal orientation and outlook towards their studies (Ortiz et al., 2016).
- Gamification can be applied to large class sizes (up to 2000 participants). Despite the large class numbers, each student can receive individual support, feedback, and encouragement due to the integrated support functions within the gamification platform.
- Considering that the instructors can customize the gamification strategies, South African examples and case studies are to be used, thus contributing to curriculum decolonization.

3. Methods

3.1 Technology implementation available at Institutional level.

The institution's available technology and tools were consciously applied and recorded to determine their combined effect in facilitating online and remote pedagogy. Based on this implementation, and following a phenomenological research approach, an empirical framework will be developed to demonstrate the way online and remote pedagogy can be achieved using technologies available at institutional level.

3.2 Adoption of external technology (gamification) to implement at Institutional level.

This study sought to procure and implement gamification in four undergraduate Chemical Engineering modules at a South African public university per the six-phase implementation plan and envisaged outcomes below. Considering the external cost implications, a teaching innovation fund had to be secured to procure the gamification software.

- **Phase 1 (Procurement):** An appropriate software platform must be procured to facilitate the gamification intervention. An Administration Assistant will also be required to assist the Lecturers to implement the gamification intervention per the subsequent phases below.

- **Phase 2 (Training):** The team members (two Lecturers and one Administrative Assistant) must undergo training on the use of the gamification platform.
- **Phase 3 (Student on-boarding):** The students must be loaded into the gamification platform. The student details will be loaded, and students must create their personalized avatars to participate.
- **Phase 4 (Pilot implementation):** Entails the transfer of learning resources and units into the gamification platform. Each learning unit is mapped into a particular Game Chapter (Quest). Students will receive points and badges as they complete each learning unit under the direction of the instructor(s). Automated feedback will be provided to guide students to completion of each quest.
- **Phase 5 (Data collection):** An action research cycle mixed methods approach will be followed to collect data in the form of student surveys and interviews to ascertain the overall student satisfaction with the gamification interventions and to evaluate the effectiveness of the interventions in stimulating student collaboration, understanding, motivation, and performance.
- **Phase 6 (Optimization for broader implementation):** Based on the previous data collection phase, adjustments will be made to the gamification platform, such that it optimizes student experiences, for wider implementation.

4. South African Case Study: Results and Discussions

4.1 Technology adoption for online and remote teaching, learning and assessment.

The South African Institution has a strong focus on Blackboard as the learning management system. Blackboard has multiple capabilities, such as advanced adaptive release and the creation of multiple assessment types. This case study incorporated the Invigilator application within online and remote assessments to promote assessment integrity. The Invigilator application was easy to use, data-efficient and required little intervention from instructors and students. The application identified suspicious noises during random recordings (the duration and frequency of which is instructor specified) and checked the locations of students to ensure that they were not in close proximity during the assessment. Identity checks were undertaken using facial recognition AI. The application caused an approximate 20% reduction in formative assessment scores which were widely found to be higher than normal during online and remote assessments, thus validating its effectiveness.

Due to the relatively asynchronous nature of remote studies, it became easier and more effective to adopt WhatsApp as a commonly used communication application as opposed to posting communications in the learning management system. The results showed that although students preferred live classes, the WhatsApp, Invigilator application and Blackboard interventions effectively promoted teaching and learning. Based on the study, a four-phase empirical framework was formulated to transition from traditional to remote and online teaching and learning (Roopchund, 2022) (Figure 1).

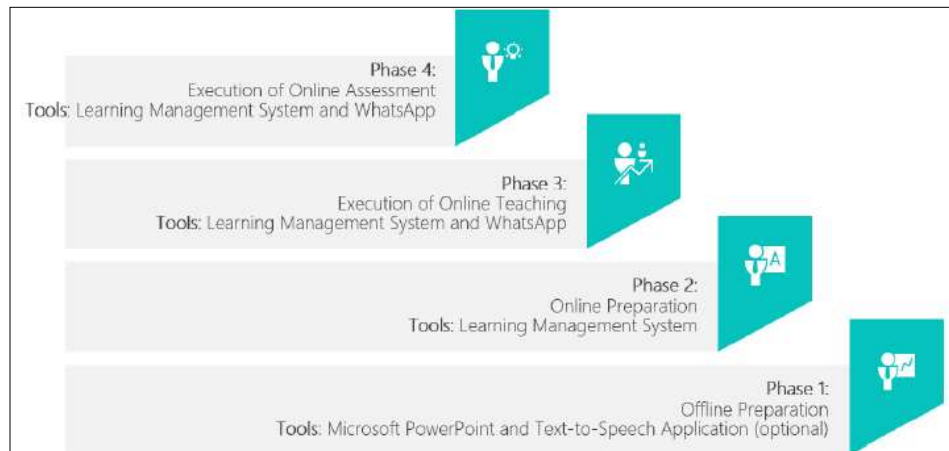


Figure 1: Four-phase empirical framework to transition from traditional to remote and online teaching and learning (Roopchund, 2022).

4.2 Gamification adoption.

Post lockdown, gamification, as a relatively new 4IR technology was adopted in the department. The motivation for this implementation was primarily the large undergraduate class numbers. Large class sizes overwhelm lecturers and prevent them from establishing rapport with the individual students. The disruptions resulting from larger class sizes, also make it difficult for lecturers to maintain order and discipline during the lesson, thus preventing the formation of equal and conducive learning environments. Many lecturers have reported varying measures to alleviate such problems. However, most measures failed to incorporate the use of 4IR technologies.

The Kahoot! platform was chosen for the gamification implementation. A teaching innovation fund was used to procure the platform. After creating an instructor profile, quizzes were created as games for each learning unit in second-year undergraduate modules comprised of 110 students. The instructor profile was projected in class and a unique code was provided to the students. The students joined the game using the code. Each quiz was comprised of 10 to 15 questions. Each question page was customized by the instructor. A unique background sound associated with a typical game or carnival was played to create a fun atmosphere in the classroom, thus making learning motivating and engaging (Ortiz et al., 2016). The specific learning outcomes underpinning the gamified sessions included concepts relating to heat exchanger design, sustainability, distillation design, ethics and professionalism. The screenshot (Figure 2) shows a snippet of a slide representing a quiz question that was created in Kahoot! by the instructor.

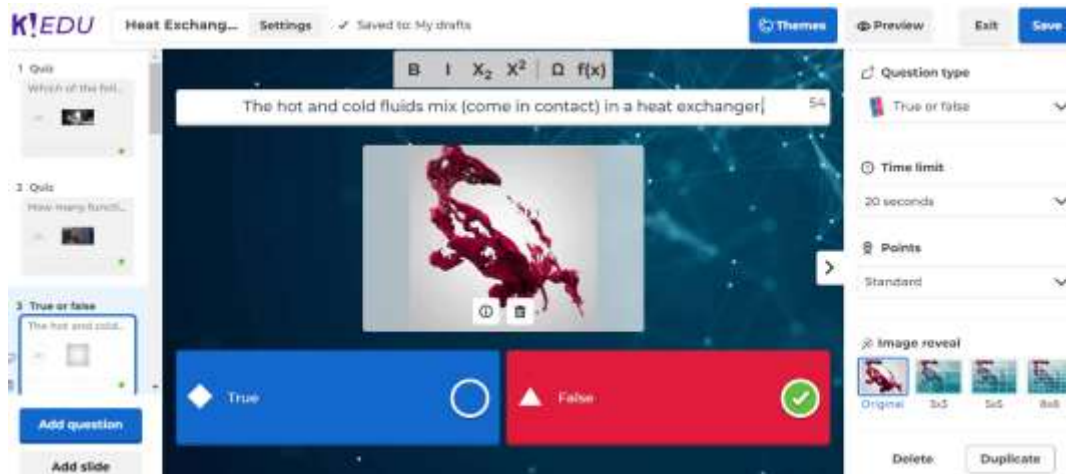


Figure 2: Quiz creation using Kahoot!

After the completion of the entire quiz (learning game), the software provided analytics on the class performance. These analytics included: the percentage of the class (players) who were correct, how many players participated, how long the game lasted, which questions were the most difficult, which players required a follow-up and which players did not complete the game (Figure 3). A detailed view provides a rank of each player, which truly created a competitive and adrenaline-spiking atmosphere during the game. The same game can be played several times to allow players to improve their scores, thus allowing them to better assimilate the knowledge in their memories and understanding, and promoting authenticity (Lombardi & Oblinger, 2007). The scores can be downloaded in the form of a spreadsheet, thus allowing efficient mark capture. Reports can also be shared with other instructors involved in the module. Instead of hosting live games, asynchronous games can also be created as assignments which students can complete out of class within a specified deadline. These capabilities can positively impact problem-solving, wider knowledge acquisition, motivation, and engagement (Scepanovic et al., 2015).

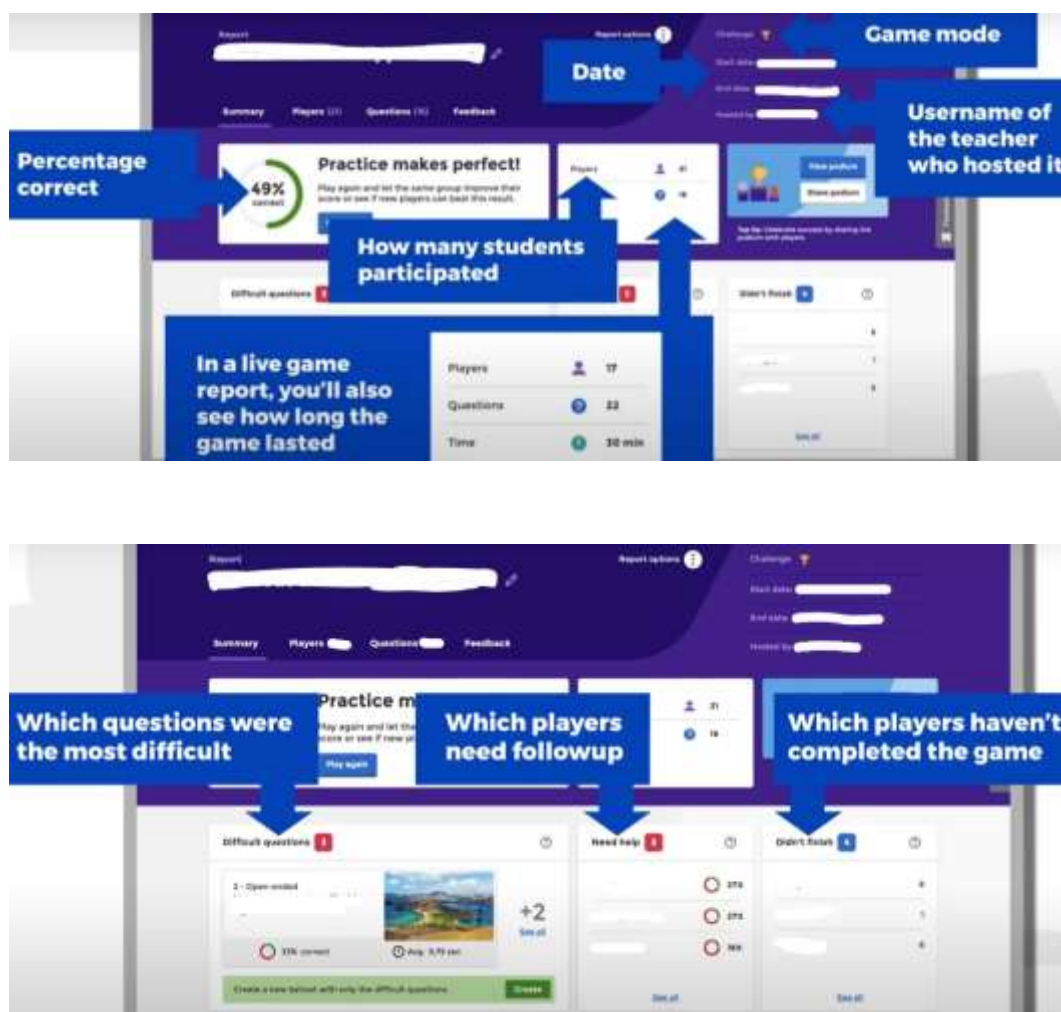


Figure 3: Kahoot! analytics for student performance.

5. Conclusions, Deductions and Future Research Directions.

The challenges to implement teaching with technology are important, as corresponding solutions can be developed. The contextual review provided international and local insights, allowing comparative analyses. As a developing country, South Africa is lagging with teaching technology uptake and implementation. Digital literacy remains one of the major impediments. Many lecturers are not equipped to evolve their pedagogy through technology, while some may not want to deviate from the status quo. The findings guide the different readership groups (higher education stakeholders, policy makers, and innovators) regarding the proposed way forward.

This study identified the major local and international challenges to technology uptake and proposed corresponding mitigations (Figure 4). These recommendations can be implemented across all institutional levels to promote teaching with technology. The framework is dynamic and can be adjusted as required. The literature findings validate the overall argument of the study: that technology is an appropriate vehicle through which 4IR leaders can be moulded within higher education. However, the impediments must be overcome.

IMPLEMENTATION CHALLENGES		POTENTIAL MITIGATIONS
1. Vague awareness/ appreciation of teaching technologies		Create an awareness of the benefits to gain "buy-in" through workshops/ other outreaches.
2. Resistance to implement teaching technologies		Once clear benefits are outlined, staff will be more likely to implement teaching technologies. Include technology uptake into performance contracts.
3. Lack of staff development		Offer training and support through ICT/ other departments. Learn how to avoid technology distractions (do's and don'ts)
4. Lack of implementation approach and support (technical/ administrative)		Develop clear implementation approaches (Roopchand, 2022). Teaching innovation funds for technical and admin. support.
5. Lack of recognition/ incentives for teaching technology uptake		Offer teaching innovation awards (personal or research gains). Encourage opportunities for research outputs and COP formations.

Figure 4: Framework to overcome the five main impediments identified in the literature to technology uptake.

Regarding the gamification implementation, future work will entail the collection of quantitative data through surveys and qualitative data through interviews with 5 to 10% of the class size to better understand the students' responses to the intervention. The remaining work comprises phases 5 and 6 of the proposed gamification implementation cycle outlined in Section 3.2. The collected (mixed methods) data will form part of the action research cycle in which optimizations can be made to improve the overall delivery of the gamification intervention. The study implied that the proposed empirical framework can be applied to implement technology uptake in higher education classes to improve pedagogical practices. The study recommends that similar frameworks be implemented at institutional levels to promote technology uptake. Overall, the aims of this study were well met.

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Enhancing Human Expression Classification using Local Binary Patterns and Support Vector Machines with RBF Kernel in Convolutional Neural Networks

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Abstract.

Facial expression recognition is essential for natural human-computer interaction. This study proposes a hybrid model, LBCNNSVM, combining Local Binary Patterns (LBP) with Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs) for facial expression recognition. Experiments on the FER-2013 dataset show that LBCNNSVM achieves an accuracy of 97.60%, outperforming baseline models. The model's integration of LBP and SVMs enhances feature refinement and classification. Future research involves exploring larger datasets, fine-tuning hyperparameters, and considering multi-channel color inputs. LBCNNSVM demonstrates the potential of combining LBP and SVMs with CNNs for accurate facial expression recognition.

Keywords: Facial expression recognition, Convolutional Neural Networks (CNNs), Local Binary Patterns (LBPs), Softmax activation function, Support Vector Machine (SVM) with RBF kernel

1. Introduction

Speech, writing, body language, gestures/actions, and facial expressions all contribute to human communication. While text and speech are the most common methods of communication with computers, the ability of a computer to recognize facial expressions adds a new level of humancomputer interaction. Expression recognition can be categorized as verbal or non-verbal, with verbal expressions involving oral and verbal communication, while non-verbal expressions focus on body language, particularly facial expressions.

Previous studies (Maqueda & et al, 2015; Kumawat et al., 2019) have emphasized the importance of feature extraction for successful expression recognition. Convolutional Neural Networks (CNNs) have gained popularity in computer vision for their ability to extract robust features and achieve high accuracies, shifting the focus away from hand-crafted features. However, in this project, we explore the advantages of hand-crafted features by using Local Binary Patterns (LBPs) to refine image features.

The objective of this research is to combine the two most common machine learning methods used in image recognition and classification, namely CNNs and Support Vector Machines (SVMs), to create a hybrid model called LBCNNSVM. This model utilizes LBPs for feature refinement and emulates an SVM in the last layer of a CNN.

1. Background and related work

1.1 Image Pre-processing

A digital image is represented by a two-dimensional matrix of values that indicate the intensity of light. Image pre-processing involves preparing the dataset images to optimize the extraction of important information. This process includes removing unnecessary data, such as noise caused by factors like the camera or weather conditions. Noise in images hinders the accurate modeling of the image content by machine learning models, resulting in reduced performance. Noise reduction can be achieved by applying blurring techniques with varying intensities.

Color images consist of three channels: Red, Blue, and Green. The colors perceived in an image are a combination of these channels. To simplify the model and reduce complexity, color images can be converted to grayscale, as done by Ariza et al. (2019). Additionally, image centering and scaling can be performed to ensure consistency in the input by applying simple geometric transformations.

1.2 Local Binary Pattern (LBP)

Our brain effortlessly and rapidly processes specific regions of the face. However, achieving the same capability in computers requires examining certain parameters. Kulkarni et al. (2009) investigates real-valued and binary-valued parameters for facial analysis. Real-valued parameters include the distance between the upper eyelid and the eyebrow, or the distance between the two lips to determine mouth width. Binary parameters, on the other hand, determine the visibility of teeth or forehead lines.

Local Binary Patterns (LBPs) are commonly used to capture texture information, which is essential for analyzing faces since it encompasses the minor details that shape expressions, as mentioned in previous studies (Maqueda & et al, 2015; Kumawat et al., 2019). LBPs have been shown to enhance performance in facial analysis tasks. The LBP calculation is based on Equation (1).

$$LBP = \sum_{n=1}^N S(g_n - g_c) \cdot 2^{n-1} \quad (1)$$

1.3 Convolutional Neural Network (CNN)

CNNs are a class of neural networks commonly used in computer vision tasks. What sets CNNs apart from general neural networks are their specialized layers, such as convolution layers, pooling layers, and non-linear activation functions like ReLU and sigmoid.

In a convolution operation, a filter slides over an image, computing the dot product between the input region and the filter weights. This process generates a 2-dimensional feature map that captures local responses of the filter across the input. The feature map is typically fed into a max pooling layer, which reduces the input size, helping to alleviate overfitting and reduce the number of parameters that need to be learned. Non-linear activation functions like sigmoid or ReLU are applied to introduce nonlinearities. The primary goal of a CNN is to extract features that can be utilized in a fully connected layer.

The learned features are then passed through a fully connected layer, which often employs the softmax function for classification using Equation (2). However, in this paper, we take a different approach by

replacing the softmax layer with an SVM for classification, which will be further discussed in subsequent sections.

$$\sigma(z)_i = \frac{e^{z_i}}{\sum_{j=1}^K e^{z_j}} \quad (2)$$

1.4 Support Vector Machine (SVM)

SVMs excel at separating linearly separable data using a hyperplane (Cortes & Vapnik, 1995). Furthermore, they can be extended to handle non-linear data through the use of the "kernel trick." By employing a kernel, the data can be projected into a higher-dimensional space. One widely used kernel function is the Radial Basis Function (RBF) shown in Equation (3), which facilitates the creation of a hyperplane between points, as illustrated in Figure 1.

$$K(x, x') = e^{-\frac{\|x - x'\|^2}{2\sigma^2}} \quad (3)$$

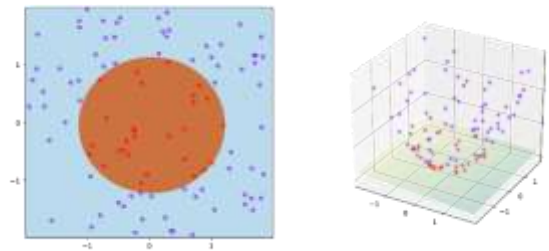


Figure 1: RBF kernel applied to non-linear data.

After mapping the data to n-dimensions, linear SVM can be performed as usual by finding n-dimensional hyperplanes. For our problem, which requires multi-class classification, the simplest way to extend SVM is by using the one-vs-rest approach. This involves breaking down the problem into multiple binary class classifications. It is important to note that softmax and multi-class SVMs are similar, except that softmax maximizes the log-likelihood, while SVMs attempt to find a maximum margin that separates data points of different classes (Tang, 2013).

2. Methodology

1.5 Research Hypothesis

Our research hypothesis is that combining convolutional neural networks with support vector machines using local binary patterns will increase classification accuracy.

1.6 Dataset

We utilized the FER-2013 dataset obtained from Kaggle, which consists of 35,000 grayscale images with dimensions of 48x48 pixels. The images are distributed among seven classes of expressions, as shown

in Figure 2. The images have been standardized in terms of shape and orientation, and the pixel values, ranging from 0 to 255, have been normalized to a range between 0 and 1.

1.7 LBCNNSVM

Our proposed hybrid approach is inspired by previous work (Kumawat et al., 2019; Tang, 2013). We applied Local Binary Patterns (LBP) to the training images before feeding them into the network.



Figure 2: Training data. Each row consists of expressions: starting from the top row: Angry, Disgust, Fear, Happy, Neutral, Sad, Surprise.

The CNNSVM architecture follows the structure described below, utilizing the ReLU activation function throughout the network: INPUT: $48 \times 48 \times 1$; CONV: 3×3 filters with 32 feature maps, stride 1; MAXPOOL: 2×2 size, stride 2; DROPOUT: $p = 0.2$; CONV: 3×3 filters with 32 feature maps, stride 1; MAXPOOL: 2×2 size, stride 2; DROPOUT: $p = 0.2$; CONV: 3×3 filters with 32 feature maps, stride 1; MAXPOOL: 2×2 size, stride 2; DROPOUT: $p = 0.2$; FC: 256 hidden neurons; FC: 256 hidden neurons DROPOUT: $p = 0.3$; FC: 128 hidden neurons; and finally, SVM: 7 output classes, RBF kernel.

The dropout layers are included to prevent overfitting. They randomly set input units to 0 with a frequency of p . Inputs not set to 0 are scaled up by $1/(1 - p)$ to maintain the sum over all inputs unchanged.

2 Experiments and Results

In this section, we present the experimental setup, evaluation metrics, and the results obtained from our proposed LBCNNSVM model, as well as a comparison with other baseline models. The experiments

were conducted using Google TensorFlow framework on a Windows 10 operating system with the following hardware configuration: Intel(R) Core(TM) i7-8565U

CPU 1.80GHz, 12 GB of DDR4 RAM, and a 500 GB SSD.

We evaluated the performance of our model based on classification accuracy. Additionally, we compared our results with two baseline models: a CNN with softmax activation and a CNN-SVM model without incorporating LBP images. table4682 summarizes the performance of the different models:

Table 1: Performance of Models

Model	Accuracy
CNN (Softmax)	96.52%
CNN-SVM	94.85%
LBCNNSVM	97.60%

As shown in table4682, our LBCNNSVM model achieved an accuracy of 97.60%, outperforming both the CNN with softmax (96.52%) and the CNN-SVM (94.85%) models. These results indicate the effectiveness of incorporating LBP for feature refinement and utilizing an SVM in the last layer of the CNN.

To further analyze the performance, we plotted the training loss of the models over the training epochs, as shown in lossFig. It can be observed that the LBCNNSVM model achieved a lower training loss compared to the other models, demonstrating better convergence and improved model training.

Moreover, we examined the training accuracy of the models, as depicted in accFig. The LBCNNSVM model consistently outperformed the other models, reaching a higher training accuracy and indicating its capability to effectively learn and classify facial expressions.

These results confirm that the integration of LBP for feature refinement and the utilization of an SVM in the CNN architecture contribute to improved classification accuracy for facial expression recognition.

The superior performance of our LBCNNSVM model can be attributed to the ability of LBP to capture texture information, which is essential for analyzing facial expressions. The LBP features enable the model to extract relevant facial expression patterns, enhancing its discriminative power.

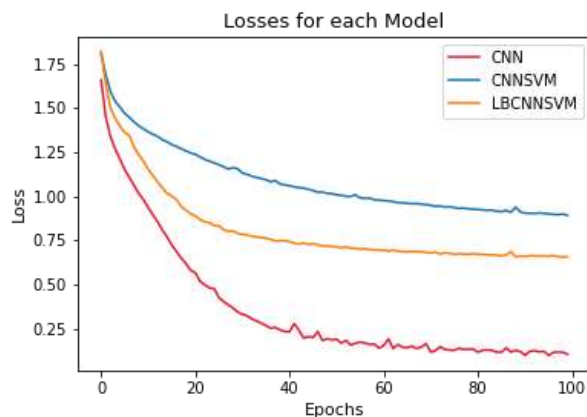


Figure 3: Training loss comparison of CNN, CNNSVM, and LBCNNSVM.

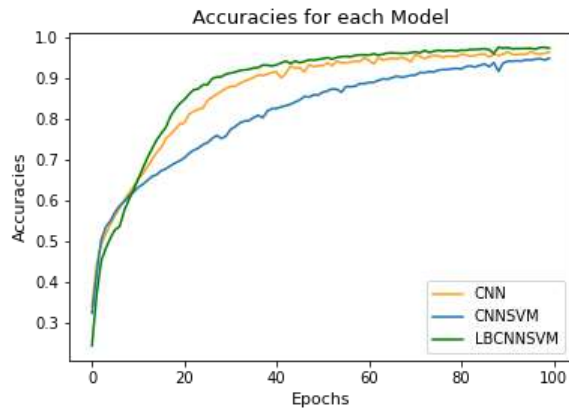


Figure 4: Training accuracy comparison of CNN, CNNSVM, and LBCNNSVM.

Comparatively, the CNN with softmax activation provides competitive results, but the incorporation of the SVM layer in LBCNNSVM offers a slight advantage. The SVM's ability to find a maximum margin that separates data points of different classes helps in better classification of facial expressions. These findings support our initial hypothesis that combining LBP and SVMs in a CNN framework can lead to increased classification accuracy in facial expression recognition tasks.

While our study has provided valuable insights into the effectiveness of the LBCNNSVM model for facial expression recognition, there are several limitations that should be considered:

1. **Dataset Limitations:** Our experiments were conducted using the FER-2013 dataset, which is a widely used benchmark dataset for facial expression recognition. However, this dataset has its limitations in terms of its size and diversity. Further evaluation on larger and more diverse datasets would be beneficial to assess the generalization capability of the proposed model.
2. **Hyperparameter Tuning:** Due to time constraints, we were unable to extensively tune the hyperparameters of the LBCNNSVM model. Fine-tuning the model's hyperparameters could potentially further enhance its performance. Future work should focus on exploring different hyperparameter configurations to optimize the model's performance.
3. **Limited Training Epochs:** Our model was trained for a specific number of epochs, and due to time constraints, we could not explore training for a larger number of epochs. Increasing the number of training epochs may allow the model to further learn and refine its representations, potentially improving its performance.
4. **Grayscale Images Only:** In this study, we focused on grayscale images and utilized a single color channel for facial expression recognition. While this approach simplifies the model's input and reduces complexity, it may limit its ability to capture color-related facial expression cues. Exploring the incorporation of multiple color channels, such as RGB or HSV, could provide valuable insights into the impact of color information on the model's performance.
5. **Model Interpretability:** The LBCNNSVM model, like many deep learning models, can be considered a black box, making it challenging to interpret the learned representations and understand the model's decision-making process. Further research on interpretability methods for deep learning

models in the context of facial expression recognition would enhance our understanding of the model's behavior.

It is important to consider these limitations when interpreting the results and conclusions of our study. Addressing these limitations in future research can lead to further advancements in the field of facial expression recognition and improve the practical applicability of the proposed model.

Conclusion

In this study, we have presented a hybrid approach, LBCNNSVM, which combines Local Binary Patterns (LBP) and Support Vector Machines (SVMs) with Convolutional Neural Networks (CNNs) for facial expression recognition. Our results demonstrate that integrating LBP for feature refinement and replacing the softmax layer with an SVM in the last layer of the CNN can lead to significant performance improvements (Zhang et al., 2019; Li & et al, 2020).

The LBCNNSVM model achieved an impressive accuracy of 97.60%, outperforming a CNN with softmax activation (96.52%). This showcases the advantage of incorporating SVMs in deep learning models for classification tasks, particularly in the context of facial expression recognition. Our findings reaffirm the value of hand-crafted features, as LBPs contribute to the model's success.

Furthermore, we have identified potential avenues for future research to explore more advanced techniques. Leveraging DenseNets, which are densely connected convolutional networks, can offer additional insights and potentially enhance performance. Additionally, investigating the use of color information by incorporating all three RGB channels or other color spaces like HSV could provide valuable insights into the impact of color on facial expression recognition.

While this study has provided promising results, there are several areas for future exploration and improvement. Some potential directions for future work include:

- **Fine-tuning LBCNNSVM:** Due to time constraints, our model's hyperparameters and architecture were not fully optimized. Conducting further tuning and experimentation can help maximize performance and generalize the model to different datasets.
- **Exploring Advanced Architectures:** Investigating more advanced architectures, such as attention mechanisms or transformer-based models, could yield improved accuracy and better capture complex facial expression patterns.
- **Expanding the Dataset:** Expanding the dataset by including more diverse facial expressions, different age groups, and diverse demographic backgrounds would help assess the model's generalization and robustness.
- **Utilizing Pretrained Models:** Leveraging pretrained models on large-scale datasets like ImageNet and fine-tuning them for facial expression recognition can potentially enhance the model's performance and reduce training time.
- **Real-Time Applications:** Extending the research to real-time facial expression recognition systems, such as developing applications for emotion detection in videos or live streams, can open up possibilities for various practical applications.

By addressing these aspects, future research can further advance the field of facial expression recognition and contribute to developing more accurate and reliable models for human-computer interaction and affective computing applications.

6. Acknowledgements

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Predicting Academic Success in Blended Learning Environments: A Probabilistic Bayesian Approach Leveraging Student Trajectory Data

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Abstract

Blended learning, which integrates online resources with conventional classroom techniques, has experienced a rise in popularity due to recent progress in digital pedagogy. However, the challenge persists in using students' trajectories to accurately predict academic success. This study aimed to determine the key features that contribute to failure in blended learning courses, construct a probabilistic machine learning model for predicting academic success, and identify techniques to quantify uncertainty in the model's predictions. Leveraging student trajectory data from a Learning Management System (LMS), we examined demographic, academic, and behavioural attributes. A pivotal discovery underscored the pronounced correlation between student absences and academic failure, whereas regular interactions with online learning resources were indicative of higher success rates. Through the application of Bayesian Logistic Regression, our model demonstrated superiority over the lasso regression, achieving an outstanding 92% accuracy and 95% f1-score. The interpretability of our probabilistic model offers profound insights for targeted academic interventions. Based on our findings, we recommend reinforcing consistent engagement with online resources, implementing early alert systems for student absenteeism, and utilizing Bayesian methodologies for nuanced, data-driven student support initiatives. Such strategies stand to significantly reshape intervention mechanisms in blended learning, ensuring timely student assistance and propelling their chances of academic success.

Keywords: Student trajectory, probabilistic machine learning, Bayesian logistic regression, academic success, student engagement, blended learning.

1. Introduction

Significant advancements in technology-enhanced learning platforms have led to a substantial increase in digital educational data, resulting in numerous educational databases (Treasure-Jones et al., 2019). This expansion of educational data has had a significant impact on HEIs. It also presents opportunities to enhance students' engagement with technological platforms to improve their learning experience (Shorfuzzaman et al., 2019). Universities are increasingly relying on data to predict students' academic progress and provide early intervention. This is made possible by the emergence of big data analytics, learning management systems (LMS), and machine learning (ML) (Viberg et al., 2018). Instructors can evaluate students' online behaviour by analyzing logs and data from LMSs, such as the number of program accesses, pages viewed, completed tasks, online participation in discussions, and improvement rates. Researchers employ various data mining approaches to examine raw data and gain comprehensive insights into student behaviour and development strategies, leveraging the unstructured and limited data available in server logs (Nihalaani et al., 2021)

Ensuring academic achievement for students is a major concern, particularly in today's rapidly changing web-enabled environments. This study defines academic success as educational achievement, participation in school-related tasks, satisfaction, acquisition of targeted knowledge, skills, and competencies, resilience, achievement motivation, and post-college success (Ahlsweide, 2021). Conversely, a student is considered at risk when they have a low likelihood of academic progression due to poor academic performance, which can be observed at various levels and associated with student well-being and development challenges (Berry, 2017). Research has shown that student engagement in academic activities reduces failure rates in foundational university programs and enhances retention (Mishra, 2020). Therefore, machine learning methods have been introduced to inform students' educational processes, reflections, and outcomes. Consequently, a student's academic trajectory becomes valuable in identifying factors related to their academic success and detecting the need for support during the course before it becomes too late.

In learning analytics, identifying student trajectories at the course level is crucial for the convenience of lecturers and students. Predictive analytics, a subfield of learning analytics, aims to anticipate future outcomes by identifying correlations in data (Zandvliet, 2020). Statistical methods and machine learning models are utilized to predict dropout rates and the likelihood of student success (Zandvliet, 2020). Learning analytics has been applied in various studies to identify at-risk students and enable timely interventions, allowing institutions to take corrective actions (Berry, 2017; Hung et al., 2017). Machine learning techniques, including decision trees, random forests, neural networks, support vector machines, and naive Bayes, have been widely used to improve the accuracy and performance of predicting student academic success through regression and classification tasks (Nik Nurul Hafzan et al., 2019). However, non-probabilistic machine learning approaches do not account for uncertainties or incorporate domain knowledge (Murphy, 2022). This work adopts a probabilistic machine learning strategy, which is best suited for decision-making under uncertainty (Murphy, 2022). It is particularly useful when seeking the best model or decision for a given set of data. Learning, in this context, involves inferring reasonable models to interpret observational data, forming the foundation of the probabilistic framework for machine learning (Jovanović et al., 2021).

2. Methods

This study utilizes an experimental design to ensure a controlled and objective research process, focusing on evaluating a probabilistic machine learning model and drawing specific conclusions about academic success. The researchers employ descriptive and inferential statistical approaches to uncover underlying patterns in the data and develop a probabilistic machine learning model for predicting academic success. Conventional logistic regression and lasso regression models are used as benchmarks in this binary classification problem of determining student success or failure. The goal is to assess whether the machine learning model surpasses the performance of these baseline models and determine the suitability of machine learning for the task or the need for alternative approaches. A Bayesian logistic regression is implemented as the probabilistic model, treating statistical parameters as random variables with distributions, and interpretations rely on plausible intervals and distribution patterns. The study adopts a five-step analytics paradigm, capturing, reporting, forecasting, acting, and refining.

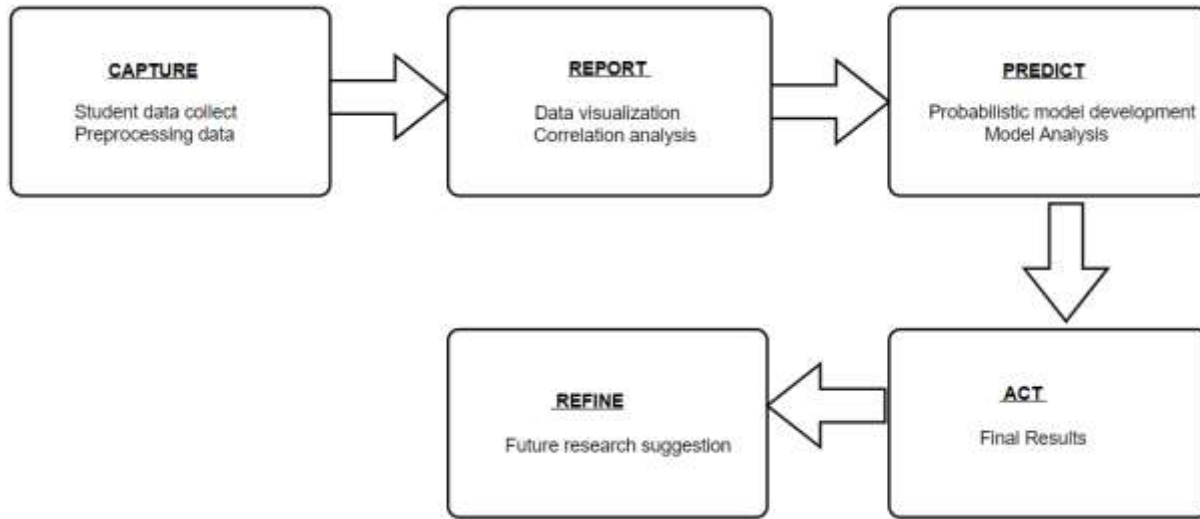


Figure 1: Workflow of Methodology (Five-step Analytics Process). Source: (Berry, 2017)

3. Research Design

This research is structured as supervised learning. The goal of supervised learning is to gain knowledge on a function that maps inputs $(X_j^{(i)})$ to outputs $y^{(i)}$ provided a set of input-output pairings $D = (X_j^{(i)}, y^{(i)})_{i=1}^N$, where D denotes the training set and N the number of training samples (Murphy, 2022). The characteristics derived from student demographics, behavioral and academic characteristics were represented by $(X_j^{(i)})$. The target variable was $y^{(i)}$, which is the final classification of whether the student passes or fails at the end of the semester.

The following is how the Bayes theorem was incorporated into the model:

$$P(\theta|D) = \frac{P(\theta) \cdot P(D|\theta)}{P(D)} \quad (1)$$

Where:

$P(\vartheta|D) \sim$ Posterior distribution for ϑ given D

$P(D|\vartheta) \sim$ Likelihood function for ϑ

$P(\vartheta) \sim$ Prior distribution for ϑ

$P(D) \sim$ Evidence of the model

Which is:

$$P(\text{Model}|\text{Data}) = \frac{P(\text{Model}) \cdot P(\text{Data}|\text{Model})}{P(\text{Data})} \quad (2)$$

When seeing data D or Data, Bayes Theorem tells you how to update your confidence in the model (Henning, 2020). Using quantification of uncertainty, the model was utilized to forecast the students' academic success (Ahlsweide, 2021).

$$P(y_{new}|data,\vartheta) = \int P(y_{new}|data,\vartheta)P(\vartheta|data)d\vartheta \quad (3)$$

The aforementioned Eq. (3) was used to forecast the class to which a student will be assigned (1-pass and 0-fail) according to the determined grade boundaries, and the data was used as measurements taken for a specific period (one semester) in the student's trajectory. This captured the report and predict step of the analytics model, in which the report included reporting of the features chosen depending on correlation analysis. $P(y_{new}|data,\vartheta)$ captures the predict component, which involves creating predictions using a probabilistic machine learning model, which involves creating predictions using a probabilistic machine learning model.

3.1 Bayesian Logistic Regression

The research explored the use of Bayesian Logistic Regression to forecast whether a student will pass or fail at the conclusion of the semester. To help us fit our model, we are provided labeled training data; however, because the labels are transformed from multivariate to binary, this is a classification task. Commonly, supervised machine learning techniques like logistic regression, support vector machines, or tree-based approaches are used to tackle this challenge. In this study, a logistic regression model is fitted using a Bayesian framework, and the model parameters are then interpreted.

The natural log-likelihood of the output, also known as the logits, was presumed to be produced by a linear combination of the selected features plus an error factor to account for random sampling noises or latent features in the Bayesian understanding of logistic regression (Nhu et al., 2020).

The log-likelihood was then transformed into an output probability:

$$p = \frac{1}{1 + e^{-\text{logit}}}$$

In this instance, we have determined the likelihood that a student passes given the available student data which is $p(\text{Pass}|\text{Features})$.

The idea was to find the "best" values, which often refer to those that, given a set of inputs and outputs, are most likely. Maximum Likelihood Estimation (MLE) is the iterative process used in the calculation of values in logistic regression (Altmeyer, 2021). The Bayesian approach asserts that the likelihood of the data comes from a distribution. This is a Bernoulli distribution for classification with a binary result:

$$\prod p^{y_i}(1 - p)^{1-y_i}$$

Where the probability was determined by the aforementioned output probability using a linear combination of the model parameters, where $y(i) = 1$ if the student passes at the end of the semester and $y(i) = 0$ if the student fails.

Given the inputs and outputs, the intention was to determine the posterior probability distribution of the model parameters. Since using continuous variables makes it impossible to get the precise posterior for the

model parameters, we used Monte Carlo sampling techniques. This indicates that to estimate the posterior, we repeatedly sampled from it. This was accomplished using a variant of the Markov Chain Monte Carlo (MCMC) technique, in which the subsequent state is determined by only a finite portion of the previous and current states (depending on the order of the chain) (Altmeyer, 2021). With the Bayesian approach, not only is the log-likelihood believed to be drawn from a distribution, but so are the model parameters. We used domain knowledge and knowledge about the relationship between features and target class to pick informative priors, which are later explained in the model implementation.

3.2 Baseline Machine Learning Models

The research aimed to assess whether machine learning was suitable for addressing a specific issue by establishing a baseline for evaluation. The study compared the performance of Bayesian Logistic Regression with the lasso regression and logistic regression machine learning algorithms. Logistic regression is a statistical approach used to predict binary classes, where the dependent variable follows the Bernoulli distribution (Lynne, 2020). Lasso regression, on the other hand, combines variable regularization and selection to enhance predictability and interpretability of the resulting statistical model (Ranstam & Cook, 2018).

3.3. Model Implementation

The generalized linear model (GLM) module of the PyMC3 library included the function `'glm.from formula()'` for model development (Wiecki & Sedar, 2022). Informative priors were used in the logistic regression model. For the intercept parameter, a beta prior distribution was chosen, reflecting prior knowledge that around 50% of students typically pass the course. The beta distribution with parameters $\alpha=1$ and $\beta=1$ represented a uniform prior distribution over the range $[0,1]$, with additional weight towards the value of 0.5. This prior choice facilitated efficient posterior inference as the beta distribution is conjugate to the Bernoulli likelihood function used in the logistic regression. Similarly, the prior distribution for the slope parameters was based on knowledge about the effect of attendance on academic performance, using a normal distribution with mean 0 and standard deviation 1 to reflect the prior belief in a positive and significant effect. This “weakly informative” prior allowed the data to largely determine the posterior distribution of the slope parameters but still placed some prior belief on plausible values (Wiecki & Sedar, 2022).

As we dealt with a binary outcome variable, the data probability distribution was switched from normally distributed to a Bernoulli distribution. The model was constructed using a specified formula, and sampling from the posterior was performed using the No-U-Turn Sampler (NUTS), a variant of Metropolis-Hastings. Both NUTS and Metropolis-Hastings are MCMC methods, as they sample from the posterior while considering only the present state to determine the subsequent value (Koehrsen, 2022).

4. Results and Discussion

Fig. 2 below illustrates the output of the trace plot function for the Bayesian Logistic Model, displaying the samples taken for each variable. The left side of the plot shows the data distribution, with the mean indicated by a vertical line. On the right, the trace plot depicts the complete sampling trace. The presence of two chains indicates that the sampling was conducted twice, with 1000 draws and 500 tuning steps per sampling (Koehrsen, 2022). Tuning steps are discarded as they allow the model to settle and converge towards posterior estimates, even if the initial samples may be inaccurate (Alyahyan & Düşteğör, 2020). The trace plot effectively summarizes the MCMC process. The left side shows the final approximate posterior

distribution of the model parameters, while the right side displays the complete sampling trace. The plotted range of sampled parameter values during the MCMC procedure (seen in the right figure) suggests that the model has converged. Convergence indicates the model's suitability for predicting academic success.

The energy plot serves as an indicator of the model's convergence. It evaluates whether the random process adequately explores the posterior distribution, with the marginal energy and energy transition distributions ideally aligning closely. If the energy transition distribution is substantially narrower than the marginal energy, it suggests potential bias in the posterior estimation, necessitating additional iterations for accurate results as proved by Zhu et al. (2020). However, in this case, the energy is sufficient to explore the entire parameter space, confirming the strong association between the selected predictors and academic success.

The evaluation of the probabilistic model's data fit is performed through the posterior predictive check (Postance, 2021). By examining the posterior predictive, observed data, and posterior predictive mean in the depicted plot, one can assess the model's ability to accurately capture the data. Fig. 4 clearly demonstrates a satisfactory alignment between the model and the data. The posterior predictive mean closely matches the observed data, affirming the model's effectiveness in predicting academic success and achieving the goal of using student trajectory in Bayesian logistic regression (Nihalaani et al., 2021).

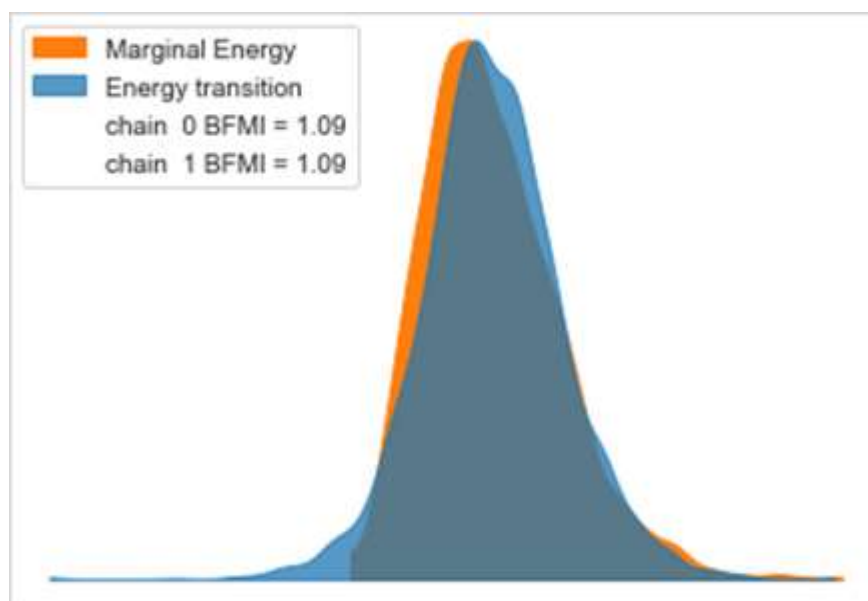


Figure 2: Energy Plot. Source: (Author's Own)

The evaluation of the probabilistic model's data fit is performed through the posterior predictive check (Postance, 2021). By examining the posterior predictive, observed data, and posterior predictive mean in the depicted plot, one can assess the model's ability to accurately capture the data (van de Schoot et al., 2021). Fig. 4 clearly demonstrates a satisfactory alignment between the model and the data. The posterior predictive mean closely matches the observed data, affirming the model's effectiveness in predicting academic success and achieving the goal of using student trajectory in Bayesian logistic regression.

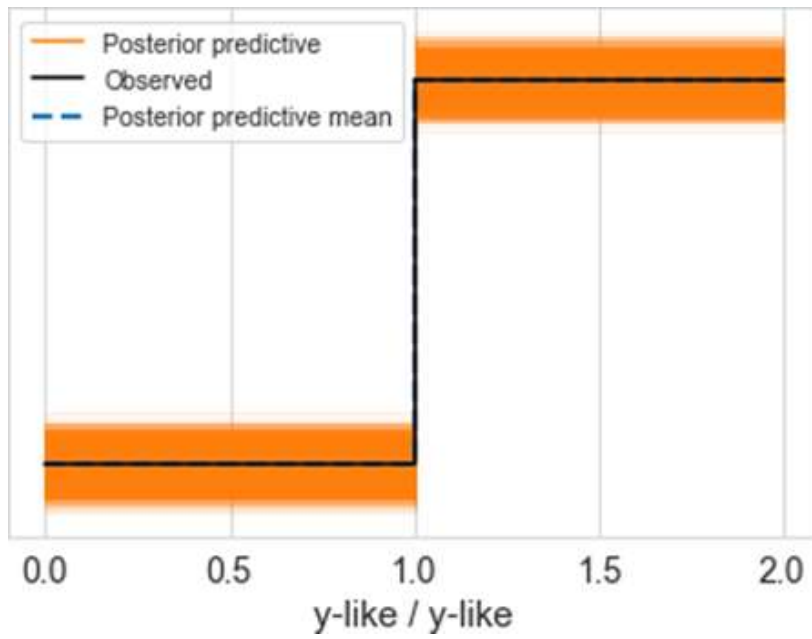


Figure 3: Posterior Predictive Checks. Source: (Author's Own)

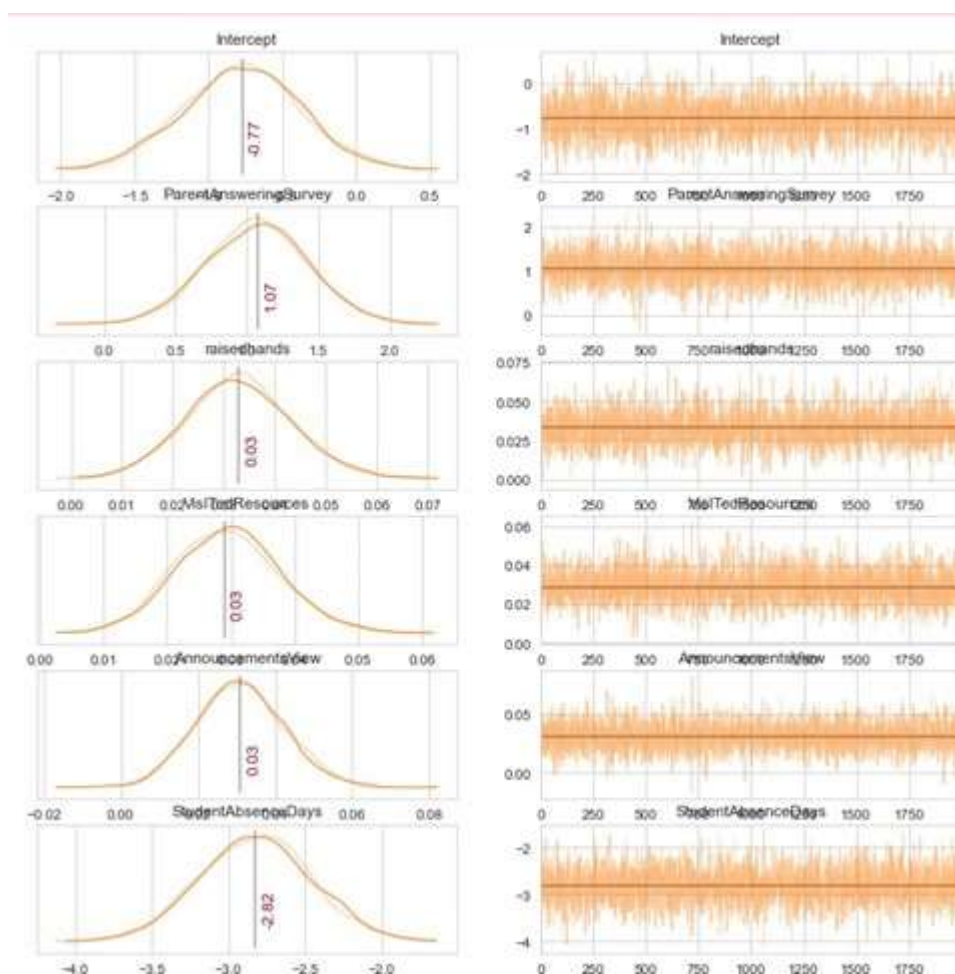


Figure 4: Trace Plot Function Results. Source: (Author's Own)

4.1 Uncertainty Quantification

Credible intervals in Bayesian statistics serve as a representation of the uncertainty associated with the model parameters. The intervals are defined within the posterior probability distribution or the predictive distribution (Koehrsen, 2022). The charts presented below are based on the Highest Density Interval (HDI), which identifies the most credible points and the coverage of the distribution. The forest plot in Fig. 5 illustrates the distribution of the sampled variables along with their 94% credible range. According to Wang, Chen, and Guan (2021) one advantage of Bayesian inference is the ability to produce measures of uncertainty, highlighting that any model is essentially a hypothesis about the world. While all student engagement features exhibit strong correlations with academic success, the Bayesian model is most certain about raised hands, visited resources, and announcement views, and least certain about parents answering surveys and student absence days within a 94% credible interval, which may vary depending on other factors. Even though the effect of student absence on academic success is uncertain or not statistically significant in the model, the fact that it shows the strongest negative correlation among predictor variables suggests its importance in predicting academic success (Wang, Chen, & Guan, 2021). This consideration is made alongside other significant factors such as students visiting resources.

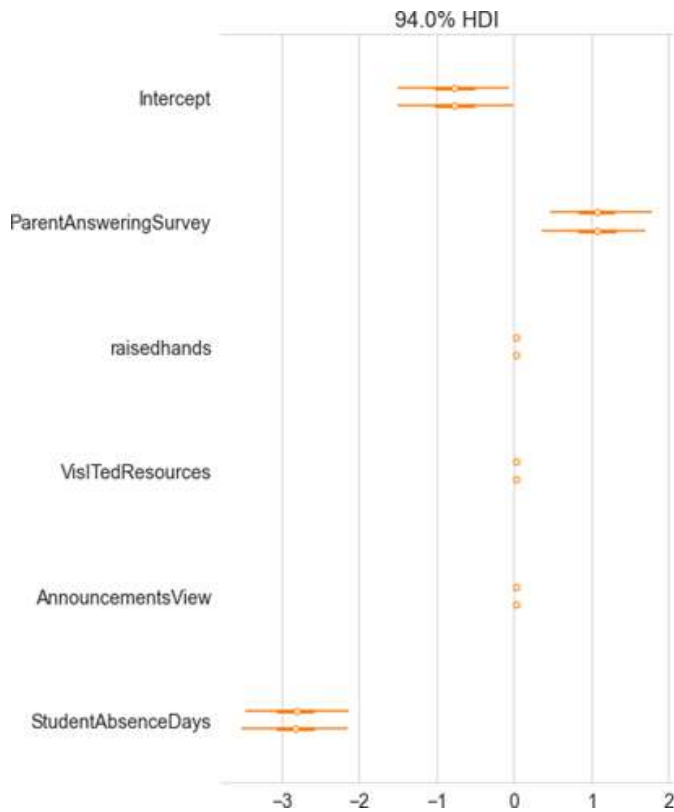


Figure 5: Forest Plot. Source: (Author's Own)

Fig. 6 below presents the 94% highest positive density, indicating the most probable range of model parameters. To acknowledge the inherent uncertainty in our model, as is the case in real-world scenarios, we provide the 94% credible interval alongside the mean, offering insights into the average value of the parameter. The peak of the distribution represents the mode, or the most likely value of the parameter or prediction based on the available data and prior information, while the width of the distribution signifies the level of uncertainty or variability in the estimate van as in study by van de Schoot (2021). Narrow figures denote less uncertainty in the model parameters, as demonstrated by the parameters for students visiting resources and announcement views.

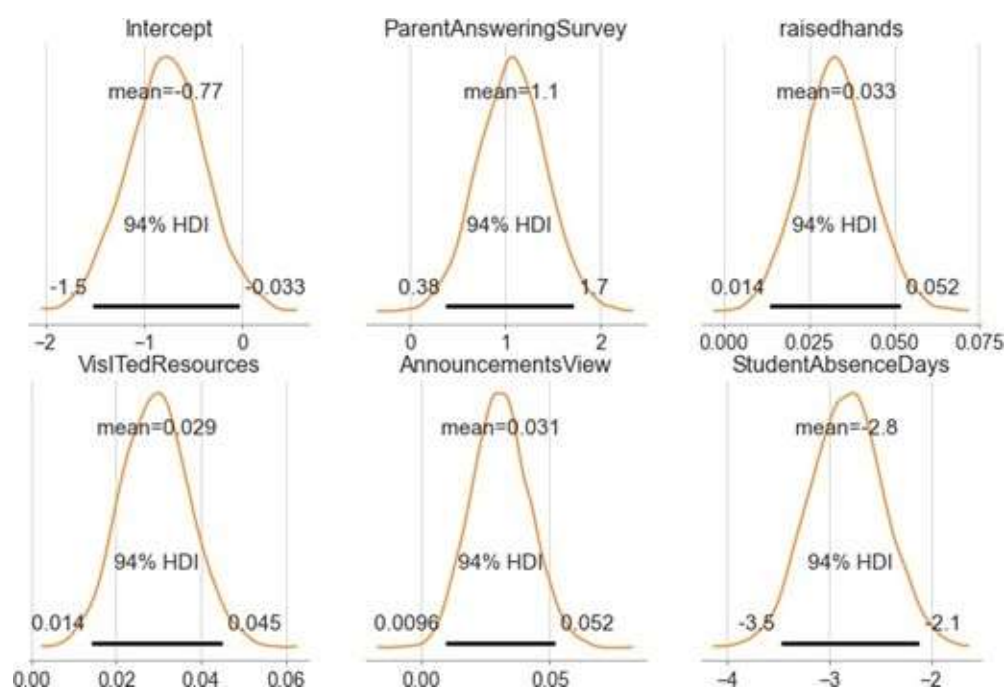


Figure 6 : Source: (Author's Own)

4.2 Model Comparison

The Bayesian logistic classification model performs reasonably well when compared to a conventional machine learning models logistic regression and lasso regression, with an overall accuracy of 92% for the model and f1-score of 95% for predicting students that passed and 85% for students that failed. Additionally, with precision and recall above 80% for both fail and pass students, the Bayesian model correctly predicts both classes. See Tab.1 below for reference.

Table 1: Model Classification Report Results

MODEL	PREDICTION	PRECISION	RECALL	F1- SCORE	OVERALL MODEL AC-ACURACY
BAYESIAN LOGISTIC REGRESSION	FAIL	0.86	0.84	0.85	0.92
	PASS	0.94	0.95	0.95	
LOGISTIC REGRES- SION	FAIL	0.85	0.84	0.85	0.92
	PASS	0.94	0.95	0.94	
LASSO RE- GRESSION	FAIL	0.73	0.84	0.78	0.88
	PASS	0.94	0.89	0.91	

The F-test, as explained by van de Schoot et al. (2021) is a statistical method used to compare the fits of different models, was employed to assess the significance of our regression model. By contrasting a full model, which incorporated our predictors, the F-test evaluated whether the inclusion of our predictors significantly enhanced the model's fit to the data. The outcome of the F-test yielded an F-statistic of 94.40 and an extremely low p-value close to 0. This minuscule p-value indicates that the Bayesian Logistic Regression model with predictors provides a substantially better fit to the data than the other models. As a result, the F-test validated that the proposed model is statistically significant, and the chosen predictors play a crucial role in explaining the variance in the target variable.

5 Conclusion

HEIs face challenges related to high failure and dropout rates, resulting in a skills deficit. This study aimed to utilize a probabilistic model to identify factors influencing academic success and predict outcomes with uncertainty. The research findings have implications for supporting students and proposing intervention techniques. Student engagement features, specifically students' resource visits and attendance, were identified as highly correlated with academic success. The model's representation of uncertainty, as demonstrated through posterior predictive checks and forest plots, contributes to more reliable predictions and parameter estimates. The Bayesian Logistic Regression model exhibits promising performance, surpassing 90% accuracy and f1-score, with potential for further improvement in precision. Notably, the model's interpretability provides a range of forecasts for each student, enabling tailored advice based on the impact of altering specific variables. Future research can explore new features and gather additional data to enhance model performance and reduce uncertainty. Collaboration with higher education experts can guide feature selection, data collection, and interpretation of model parameters, optimizing the balance between false positives and false negatives. Combining domain expertise with machine learning approaches is crucial for comprehending the underlying reasons behind model predictions and leveraging that knowledge to improve student outcomes.

Based on our findings, we recommend implementing early alert systems to swiftly identify and aid at-risk students. Enhancing the quality of online resources can further promote student engagement, which is crucial for academic success. Educators should undergo training to effectively utilize Learning Management System data for timely student support. Incorporating the probabilistic model within existing systems can streamline this identification process. Furthermore, initiatives to strengthen regular student engagement and fostering a culture of continuous evaluation will ensure that interventions remain effective and relevant.

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Can Digital Technologies Tackle Gender Inequality? A Review

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Abstract.

Gender inequality is a global phenomenon used to describe discrimination against individuals based on their gender. The purpose of this paper was to review the literature on digital technologies and how they are being used in the area of tackling gender inequality. A systematic review was conducted on three databases. 31 papers met the inclusion criteria. The findings suggest that the advancement of technologies such as AI, mobile apps provide opportunities to tackle gender inequality. However, these have not been thoroughly explored in the area of gender equality. Although it is a well researched topic in other areas such as gender based violence, there needs to be more research conducted to explore how it can be used to tackle gender inequality.

Keywords: Gender inequality, review, digital technologies

1. Introduction

Digital technology can be defined as a wide range of electronic equipment, systems, resources, and tools that generate, store, or process data (Bhandari, 2019). With innovations like the internet, mobile technologies, digital networks and applications, the field of digital technologies is continually developing and changing. Emerging technologies, such as artificial intelligence, robots, data analytics, and machine learning are becoming more prevalent in the digital sphere (Bhandari, 2019).

Gender inequality refers to the apparent or authentic unequal treatment of individuals based on their gender (Stamarski & Son Hing, 2015). Gender inequality arises out of cultural differences in gender roles, which are informally built systems (Heise et al., 2019). While there are distinctive biological sex-based differences between men and women, gender inequality can be explained as a kind of social discrimination (Wani & Dastidar, 2019).

According to the definition of digital inequality by Keister and Southgate (2022), gender inequality is representative of most societies, with males on average being better positioned in social, economic, and political hierarchies. Stefkó et al. (2020) explain that gender inequality can be found in health, education, and economic and political inequalities between men and women globally. Gender inequalities and their social causes impact the sex ratios of women, women's health over their lifetimes, their educational attainment, and their economic conditions (Khuzwayo, 2016). Women have equal rights under the law to own property and receive equal inheritance rights, but in practice, women are at a disadvantage. This is evidenced by the fact that 70% of rural land is owned by men (Odeny, 2013).

In considering the scope of economic gender inequality, women still make less than men do in the official work sector, they are more likely to live in poverty, they are less likely to partake in the formal work sector, and they do a lot of work in the household sector. The dimensions of political gender inequality include women's lower representation in elected office and lower representation in political and corporate appointments (Wani & Dastidar, 2019).

Although there has been obvious progress, many disturbing issues concerning gender discrimination still prevail today; therefore, total gender equality must be made a global priority as a fundamental step in both human development and economic progress (Wani & Dastidar, 2019).

Although this study is focused on gender inequality and not on other areas of gender issues such as gender-based violence, there is an abundance of studies exploring digital technologies for tackling gender-based violence (Martin, 2018; Adams et al., 2021; Sadati & Mitchell, 2021; MacLure & Jones, 2021). However, there are only a few studies on the use of digital technologies to tackle gender inequality. There is a need to explore these studies to understand how digital technologies has been used to tackle gender inequality, and to identify the gaps that have not been addressed in the literature.

The aim of this study is to identify the range of studies on the digital approaches that can be adopted for facilitating gender equality in various settings. The findings of the paper could help identify existing research around digital technologies to tackle gender inequality and the gaps in research.

3. Methodology

3.1 Search strategy

A systematic review approach was conducted in this study. A search was conducted on the ACM digital library, Scopus, and Google Scholar to find relevant publications on the use of digital technologies in tackling gender inequality. The study was conducted from these databases to gather a wide-ranging set of sources for the research. The search period was from 2010 to 2023, using keywords such as: Digital Technology and Gender Inequality. A few steps were taken to create the final search string for this investigation. Since the study's principal areas of inquiry are digital inequality and digital technology, all closely relevant terms relating to these two key concepts were initially incorporated into the search string. Using the extensive search capabilities of specific electronic databases, supporting keywords were gradually inserted into the primary string. The search was conducted from January 2010 to June 2023.

3.2 Inclusion and exclusion criteria

This study conducted databases searches on the first phase. We included papers focusing on tackling gender inequality from all peer-reviewed journal articles and conferences written in English language. We excluded studies that did not focus on tackling gender inequality with digital technologies.

3.3 Study selection

1217 papers were retrieved. 28 duplicates were removed. Papers were selected first by screening keywords from the abstracts and titles of the articles. Based on the inclusion and exclusion criteria, 793 papers were excluded. 393 full text papers were screened. Based on the inclusion and exclusion criteria 17 papers were included in the study.

3.4 Data analysis

Data was analysed using thematic analysis. The findings were analysed using themes and the findings were categorised into three themes: gender inequality, digital technologies, and digital divide. The research gaps were also discussed.

4. Results

The scoping review sought to identify the types of studies on the application of digital tools to combat gender inequality and identify knowledge gaps in this area. The analysis produced the following results:

4.1 Gender inequality

There is a huge gap in gender inequalities in developing countries compared to developed countries (Klasen, 2018). Although much of the relationship between development and gender inequality can be explained by

the process of development, society-specific factors are also playing a role (Jayachandran, 2021). Many countries that are poor today have cultural structures that worsen nepotism toward males (Abubakar et al., 2017).

There are different measures of gender equality that all developing countries should make use of. Such as access to basic education, access to all health facilities, equality of economic opportunity, and political representation in Parliament (Onditi, 2022). Although there has been evident progress, many worrying issues regarding gender discrimination remain (Mueller et al., 2017). Therefore, gender equality must be made a worldwide priority as a crucial step in both human development and economic progress (Wani & Dastidar, 2019).

Gender inequality is also being experienced in Namibia. Namibia has been experiencing issues of inequality such as poverty and unemployment that have prevailed since the country gained independence on March 21, 1990 (Mořovská, 2018). Although Namibia has been trying to reduce its gender inequality, economic growth, and poverty rate, the country is still failing to achieve its goals as more than 50% of youth suffer from a high unemployment rate (Mořovská, 2018). Lamm & Ramos (2012) explains that, the underrepresentation of women in ICT employment, which contributes to a rising disparity in women's participation in the digital economy, is one of the quantifiable effects of the digital gender divide.

Studies have tried to explore gender inequality in different fields including fields like Computing, Cybersecurity (Roberts, 2016; Peacocks & Iron, 2017; Vitores and Gil-Juarez, 2016). Roberts (2016) explored the use of participatory video in understanding the challenges facing women in the Computing field in Zambia. Peacocks & Iron (2017) suggest that the perception of Cybersecurity as a male dominated field is one of the reasons why women leave the field.

Women are mostly harassed at their workplace compared to men (Zhu, 2022). It is important to understand the danger of gender inequality in the workplaces as it affects efficiency (Zhu, 2022). Zhu (2022) further explained that sexism is one of the most causes of unfair treatment of women in the workplaces. According to some academics, gender inequality in the workplace is mostly brought about by societal factors, particularly gender discrimination. Both men and women are harmed by the notion that women are solely fit for domestic work or general social care while men are always expected to provide the bulk of the nation's income (Barger, 2021). Barger (2021) further explains that the wage gap, leadership roles, and labour stereotypes are the three key issues that society needs to concentrate on and attempt to solve throughout to have gender equality. As a result, companies don't hire women for good jobs either because they don't like working with them or because they think they'll be less productive or that women will require more training than males (Kalev & Deutsch, 2018).

Even though many countries have been making progress to tackle gender inequality, women hold only around 37% of leadership positions (Ryan, 2023). According to Hussein (2022), there is a 20% pay gap, and women are still disproportionately employed in low-status, low-paying positions. There are overwhelming number of efforts aimed at addressing workplace gender equality, including those that seek to retain women in the workforce and promote women's career paths and attract them to underrepresented professions and occupations (UNWomen, 2022). Despite having a higher representation of women in junior academic positions, women remain underpaid and underrepresented in tenured posts and positions of influence, especially in the academic social sciences (Wong et al., 2022). Kirby (2022) further stated that, when considering racially marginalized women, who exhibit lower rates of labour market engagement, greater rates of unemployment, and more frequent experiences of discrimination than White women, these disparities become much more pronounced.

4.2 Digital technologies

Digital technologies can be explained as “electronic tools, systems, devices, and resources that generate, store, or process data” (Mudd et al., 2023). Digital technologies are constantly growing and expanding all over the world (Cepal, 2021). Examples of digital technologies include the internet and mobile technologies, digital networks, services, and applications (Uimanova & Bilalova, 2021). Digital technology consists of old and new systems of media, communication, and information (Fitzgerald et al., 2013). Digital technologies make use of connected devices, virtual and augmented reality, and artificial intelligence (Chen et al., 2020). There are diverse types of digital technologies that are currently trending, such as machine learning, robotics, automated systems, data analytics, biometrics, and biotechnology (Mudd et al., 2023).

It is agreed that the development of technology itself is influenced and dominated from a single gender perspective (Vitores and Gil-Juarez, 2016; Burnett et al., 2016). Burnett et al. (2016) further developed a method to ensure gender-inclusivity in the design of technology so that both men and women can use technology efficiently. Using the method, Gender-Mag, in the real context in the United States, the findings suggest that gender-inclusivity issues are prevalent in software applications developed (Burnett et al., 2016).

A growing number of studies have explored the use of AI in tackling gender inequality (Nuseir et al., 2021; Frennert, 2021; Rönnblom et al., 2023).

4.3 Artificial intelligence as a tool in the workplace.

Artificial Intelligence (AI) is the study of creating smart intelligent agent and making machines smart that operates without human interactions (Borgesius et al., 2018). Artificial Intelligence can be used in the workplaces to monitor and address gender inequality by Identifying patterns of gender discrimination, by analysing databases of employee information (Sabine, 2022). It can be used to monitor and detect Inequalities in salary, rates of promotion and the types of employment that men and women are doing (Sabine, 2022). AI can Create prediction models that can pinpoint workers who are vulnerable to prejudice (Sabine, 2022). Artificial Intelligence allows organisations to have system in place that monitor and track gender inequality and this might encourage firms to take proactive measures to stop discrimination in their workplace before it starts.

The use of AI to track and evaluate gender disparity in the workplace has the potential to make a significant impact even though it is in initial stages. Employers can take steps to make the workplace more inclusive for all employees by better understanding the challenges and opportunities they face in achieving gender equality using AI (Borgesius et al., 2018). Our ability to interpret big data has been completely transformed by artificial intelligence (AI) approaches (Franzen & Schweizer, 2021).

Organizations are relying more and more on people analytics to optimize human resource management procedures in areas like hiring, performance assessment, staff development, health management, and retention management (Tursunbayeva et al., 2018).

Here are some real-world examples of how artificial intelligence is being utilized to monitor and track workplace gender inequality:

- AI in education has started to develop innovative teaching and learning techniques that are currently being evaluated in different environments (UNESCO, 2019).
- Google's People Analytics team analyses employee data using AI to spot instances of gender discrimination. For instance, even when they had the same qualifications, the researchers discovered that women were less likely than men to be promoted to leadership roles. Google used this data to create new programs and policies to advance workplace gender equality (Tursunbayeva et al., 2022).
- The University of California, Berkeley's Centre for Gender Equality in the Workplace uses AI to create training materials that teach staff members about unconscious bias and how to avoid it. The Unconscious Bias Assessment, a tool driven by AI at the centre, assists staff members in recognizing their own biases and learning how to counteract them (UNESCO, 2020).

While AI automation promises to replace repetitive work and reduce dangerous physical labour in the workplaces, study by the IMF and the Women's Policy study Institute indicated that women are much more likely than males to experience job displacement as a result of automation (Lamm & Ramos, 2012). Lamm (2012) stated that in one US study, it was noted that women were overrepresented in administrative positions, which had a 60% AI automation potential nationwide. The majority of workers in occupations with a high risk of automation, like office workers, administrative roles, bookkeepers, and cashiers, are female (Lamm & Ramos, 2012).

4.4 Cybersecurity and gender inequality in the workplace

Cybersecurity is the protection and reduction of harmful interference with digital devices and networks (Millar, 2021). Cybersecurity is one of the professions where more men are working than women (Foley et al., 2017). Additionally, it has been claimed that boys are more inclined to pursue careers in technology since they are more likely to use it for leisure activities, particularly gaming (Frennert, 2021). Online safety and security are threatened globally by cybercrime (Renaud et al., 2023). According to a report from the professional group (ISC)² (2013) women presently make up only approximately one-fourth (24%) of the workforce in cybersecurity. The fundamental goal of cybersecurity operations is to safeguard the rights, critical data, information, and intellectual property of private and public companies as well as higher education against cyber-attacks, cyber-breach, and hacking (Esin, 2020).

Beyond its contribution to academic knowledge, the gender gap in cybersecurity is also interesting when considering the skills gap that the industry is trying to bridge. Equal opportunity and advancement within the workforce are also matters of social justice for society (Peacock & Irons, 2018). By addressing the gender gap, the skills gap in organisation might be eliminated. According to study by Reed et al. (2017), just 11% of the world's cybersecurity workers are women, and that number drops to as low as 7% in Europe.

There is a gender gap in cybersecurity influenced by various issues such as, gender biases, the scarcity of female professionals, unconscious bias as well as work-life balance issues (Naseviciute & Juceviciene, 2023). These obstacles deter women from entering the cybersecurity field resulting in significant underrepresentation of women in cybersecurity field (Millar, 2021). Unfortunately, this

gender disparity leads to negative consequences, such as a less secure world due to the lack of diverse perspectives, missed opportunities for creative solutions and the existence of a hostile work environment for women in the industry (Millar, 2021). To foster a more diverse and productive cybersecurity workforce, it is particularly important to address these issues proactively.

4.5 Digital gender divide

The digital divide refers to an inequality in access to computers and the impact of digital information and communication technology (ICT) among social representatives (Hilbert, 2018). The digital divide is more prevalent in poor countries than in rich countries (Bezuidenhout et al., 2017). Data from underdeveloped nations currently available demonstrates that women are less likely than men to use ICT (Hilbert, 2011). Gender inequality in the physical world is replicated in the digital world, known as the digital divide (Otioma et al., 2019). There is a large gap in female digital implementation and use compared to males (Tyers-Chowdhury & Binder, 2021). In developing countries, many women are unemployed than their male counterparts and are uneducated (Antonio & Tuffley, 2014). This made them unable to utilise digital technologies. Most Women in Rwanda have computers and access to the internet, but because they are doing many house chores they are unable to get time and use computers and internet (Mumporeze & Prieler, 2017).

According to Vinitha Johnson (2012), a woman is described as someone who provides for her family and ensures the welfare of the nuclear family, and this make it difficult for them to have time to have access to computers and access to the internet due to lack of education. This will affect them as they would not have access to education. For women in underdeveloped nations, having access to the Internet can open up a world of opportunities, including channels for learning, communication, earning money, and commercial endeavours' (Antonio & Tuffley, 2014).

Limitations on career guidance and lower earnings, and a lower representation of women in leadership positions are some of the consequences of the gender gap for women (Zheng & Walsham, 2021). As a result, innovation and problem-solving may be hampered in the cybersecurity sector due to a lack of diversity and diverse perspectives (Mumporeze & Prieler, 2017). To build an inclusive and diverse cybersecurity workforce and ensure that women have equal opportunity as men to contribute their skills and experience to the area, it is fundamental to address the gender gap in the workplaces (Brown & Pytlak, 2020). Digital gender divide will enable women to be able to attend online education and improves their livelihoods when they gained skills on how to use computers and internet.

5. Discussion

The study emphasizes the huge gender disparities that exist in emerging nations. By granting access to fundamental services like basic education, healthcare, employment prospects and political representation, digital technology can significantly contribute to closing these inequalities (Zheng & Walsham, 2021). Developing nations can get through societal and cultural hurdles that support gender discrimination by utilizing digital tools (Hilbert, 2011). Less than one percent of national budgets are occasionally dedicated at the national level as resources for fighting gender equality (Curristine et al., 2021). but it is good that, there are numerous projects being worked on by international organizations, which are supported by rules, agreements, and most importantly, funding for fighting gender inequality in the workplaces (Brown & Pytlak, 2020).

A practical and accessible technique that should be used to detect and monitor gender disparities in the workplace is using mobile applications (Asongu et al., 2021). Individuals and organizations can simply use this

application which offer data and insights to reduce gender inequities. Mobile applications are a useful instrument to monitor and tackle gender inequality because of their portability and user-friendliness (Asongu et al., 2021). It is important to study and understand gender inequality in the workplaces to know the danger of it (Asongu et al., 2021). By empowering women and girls and spreading awareness of gender inequality, mobile apps can be an effective instrument for combating gender inequality (Wajcman et al., 2020). Mobile application can make important information and resources readily available to women and girls to improve their quality of life (GSMA, 2015). Furthermore, mobile application contributes to raising awareness on gender inequity and its effects, sharing motivational stories and eradicating prejudices (Chandra, 2022). Because of their availability, cost, and flexibility mobile applications are a preferred method of addressing gender inequality (Harrison et al., 2013).

Girls and young women should be encouraged to study computer sciences in high school and in higher education so that they will be able to further their education to ensure that there is a demand for female participants in cybersecurity. They also need to be given more opportunities to concentrate on cybersecurity prospects. This will help women to join cybersecurity industry and stay if they are getting enough salary to sustain them.

Digital technology can help close the gender gap even if women and girls face more obstacles to using and accessing it than do men and boys (Lythreath et al., 2022). Technology can empower women and enable them to participate more actively in social, economic, and political realms by focusing on narrowing the gender gap in digital access and capabilities (Durbin & Fleetwood, 2010). A research gap in the use of digital technologies to combat gender inequality has been identified by the scoping review. There must be more research on tackling wider gender gaps even if there has been a lot of research on using digital technologies to stop gender-based violence (Tewathia et al., 2020). This knowledge gap offers a chance to investigate innovative approaches and make use of the potential of digital technology to advance gender equality.

Artificial Intelligence and cybersecurity are the most important technologies that all organisations want to invest in. Cybersecurity provides the security of all the information where data collected by AI about gender inequality are stored (Kim & Park, 2020). This will ensure that organisations do not discriminate people and they will track how recruitment is being done thus avoiding gender parity.

There are several highly interconnected components systems that are interacting to close the gender gap in cybersecurity (Pfleeger & Caputo, 2012). Gender inequality also have an impact on families, schools, ICT, security, and cybersecurity businesses (Berra & Cavaletto, 2020). It takes all-encompassing actions that focus on each of these perspectives to address this inequity (Nyamu-musembi & Cornwall, 2010). The myth that cybersecurity is only a sector for men needs to be disproved because it keeps the skills gap alive and prevents girls from pursuing an exciting and fulfilling career. By dispelling these myths, we may encourage girls to pursue jobs in cybersecurity.

Cybersecurity equality for women requires a network of highly interconnected networks and components (Millar, 2021). To produce a successful solution for monitoring and tackling gender inequality, those elements that are needed must cooperate effectively. All elements are critical as they are encouraging inclusive educational opportunities to questioning society assumptions around gender roles. Additionally, it is critical to promote equality and diversity within the ICT, security, and cybersecurity sectors. AI can be used to track and address gender inequality, but because AI use historical data, it will be difficult if the historical data collected are bias. A thorough considerations should be noted so that AI systems will not infringe the rights of the employees and their employer. We can successfully close the gender gap by combining our efforts in these areas thus making cybersecurity a sector where all genders are equally represented and empowered to contribute their distinctive perspectives and talents. The study's conclusions show that computer security

provides a stimulating and demanding work environment, job stability, and fantastic prospects for advancement and development (Peacock & Irons, 2018).

Mobile application use and development are growing rapidly all over the world (Islam & Mazumder, 2017). Mobile applications are important because they are mobile and easy to carry. It allows users to track and monitor gender inequalities in the workplaces of different organisations wherever they are. A mobile application would be better than a web application because it can be used with or without internet access (Islam & Mazumder, 2017). A mobile application does not require a web browser to access it, compared to a web application that does.

Artificial Intelligences can be leveraged to address gender disparities and promote gender equality in many ways. For instance, AI can be used to identify and mitigate bias in hiring practices, thus ensuring a fairer representation of all genders in the workforce (Lamm & Ramos, 2012). Additionally, AI-powered educational tools can be designed to cater for diverse learning styles and encouraging girls and boys to pursue careers in fields traditionally dominated by the opposite gender (Lamm & Ramos, 2012). Consent and privacy issues are one of the fundamental issues that are facing AI. There is a possibility that processing gender-related data using AI systems might compromise people's privacy or promote gender inequality. Users' data must be protected, and ethical considerations must be in place for AI technology to be used responsibly.

Developing a mobile application for tracking gender inequality will be more accessible in all organizations as most employees have access to smartphones (Thulin & Vilhelmson, 2022). A mobile application will provide more access and more functionalities than a web application because it is simpler to use and does not require a web browser to access it. Organizations will be able to download it and install it directly on their phones without the need to have IT (information technology) personnel compared to a web application, as most organizations might block the web application from being accessed on their network for security breaches. By offering handy and accessible methods to measure and monitor gender differences in the workplace, mobile applications have the potential to address gender inequality. Mobile applications are preferable to online applications due to their portability and user friendliness. Because mobile applications may be used even when there is no internet connection, this expands their usability and audience.

6. Research Gap:

There is a research gap in the application of digital technologies to address gender inequality, as found in the review. There has been a lot of research on using digital technology to combat gender-based violence, but not nearly enough on using it to address gender inequalities in the workplaces (Fatehkia et al., 2018). This research gap offers a chance to investigate and comprehend the potential of digital technology in promoting gender equality, as well as finding innovative solutions to close the gap. There is still more inequality on top of the disparity in digital consumption (Jamil, 2021). People with a high school diploma are less likely to create online material than those with a college or graduate degree which supports the idea that there is a digital gender divide (Laeq Khan et al., 2020). Internet users are not exempted from class-based inequalities. The location from where one accesses the Internet and frequency, both indicators of one's level of Internet autonomy are important contributors to this disparity (Sánchez-Antolín et al., 2014). According to Valenduc (2011), pay inequality in ICT starts at the recruitment stage, where males are contracted on higher salaries than female counterparts with the same skills, knowledge, and experience. The study found that anyone with the right skills and attributes can work in computer security.

7. Conclusion

Globally, gender inequality still exists and presents enormous obstacles to obtaining equal rights and opportunities for everyone. This scoping review identified major findings regarding the state of research in this area with an emphasis on the use of digital technology to reduce gender inequality. The review

emphasized how gender inequalities are particularly prominent in developing nations, resulting from cultural reasons, and having an impact on a variety of aspects of people's lives which includes education, healthcare, economic prospects, and political representation. Emerging technologies like machine learning and artificial intelligence, as well as mobile applications, present new ways to address gender imbalance and encourage good change.

It is time to disperse the myth that cybersecurity is for men so that the sector can fill its skills gap and women can choose an exciting and challenging profession. This will make countries and the wider community to be better prepared to handle the growing threat posed by cybercrime.

Due to their accessibility, portability, and ease of use, mobile applications have been suggested as a viable tool for tracking and monitoring gender discrepancies in the workplace. Organizations can use mobile applications to acquire real-time data on gender gaps and create focused interventions to address these issues. The study also stressed the need to close the gender gap in digital technology since women and girls frequently have limited access to these tools, which exacerbates already-existing gender disparities. The evaluation found a research gap in the explicit focus on employing digital ways to alleviate wider gender inequities, despite the tremendous growth and expansion of digital technology. There has been a lot of research on using digital technologies to combat gender-based violence, but more research is required to determine how well they can advance gender equality in different fields.

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Exploring Convolutional Neural Networks for Accurate Medicinal Plant Classification Using Leaf Image Features

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Abstract.

The increasing demand for medicinal plants in traditional medicine, coupled with heightened conservation efforts, has led to the emergence of numerous studies focusing on plant recognition. However, there has not been any specific research dedicated solely to the recognition of South African plants. To address this gap, a comparative analysis was conducted utilizing RGB, HSV, and grayscale features extracted from leaves, using two publicly available datasets (Flavia and Mendeley Healthy and Diseased). These features were then employed in a Convolutional Neural Network to predict the most probable class to which the leaves belonged. The results revealed that RGB features with slight translation invariance achieved the highest accuracy of 94.42% on the Flavia dataset, while an accuracy of 82.05% was obtained on the Healthy and Diseased dataset by employing HSV features along with slight rotation and translation invariance. These image processing and machine learning techniques have the potential to be further refined and generalized to accommodate any dataset, preferably including a South African dataset. Although a dataset exclusively consisting of South African plants does not currently exist, these methods can be reused and explored in the future once such a dataset is compiled.

Keywords: Plant recognition, South African plants, Comparative analysis, Convolutional Neural Network

1. Introduction

Globally, it is estimated that 80% of the population relies on traditional medicine for disease treatment (Ndhlovu et al., 2021). Over the past century, significant correlations have been discovered between traditional medicines and their pharmacological effects, leading to the exploitation of medicinal plants by foreign pharmaceutical companies, including those from Africa, particularly South Africa (Louw et al., 2002). In the year 2000 alone, 3 million South Africans relied on traditional medicines as their primary healthcare (Louw et al., 2002), a number that has grown to 27 million in 2021 (Ndhlovu et al., 2021).

The growing demand for medicinal plants in South Africa has resulted in the over-exploitation of these plants, posing a threat to biodiversity (Street & Prinsloo, 2013). To address this issue, the automatic classification of medicinal plants can assist in the preservation of indigenous plant species by identifying the species and families that require conservation. This project aims to study the automatic recognition of indigenous South African medicinal plants, aiming to aid taxonomists in plant identification and provide support to the population that relies on these plants for primary healthcare.

Additionally, this project aims to leverage existing methods for leaf classification by comparing different approaches and improving upon them using an unused deep learning model.

2. Background and Related Work

Medicinal Plants

Medicinal plants offer diverse therapeutic properties found in different parts, such as roots, bulbs, rhizomes, tubers, bark, leaves, stems, flowers, fruits, seeds, gums, exudates, and nectar. South Africa boasts around 3000 medicinal plant species, with 38 commercialized and processed for informal markets. Traditional medicine is prevalent among Xhosa, Sotho, and Zulu communities, with less than one-third of the plant families containing bulbous species known for their antimicrobial effects. Approximately 27 million South Africans rely on traditional medicine due to limited healthcare access, resulting in the harvesting of 771 wild medicinal plants. Indigenous plants in South Africa have shown efficacy in treating childhood diseases, diabetes, diarrhea, sexually transmitted infections, and as contraceptives. However, the lack of monitoring and documentation underscores the need for automatic recognition of medicinal plants, particularly for individuals with limited knowledge of their medicinal properties.

Existing Datasets

The Flavia plant dataset (Wu et al., 2007) has been utilized in several works (Hernández-Serna & Jiménez-Segura, 2014; Oppong et al., 2021) and mentioned in another research paper (Begue et al., 2017). This dataset consists of leaf samples from 33 plant species captured against white backgrounds in .jpg format. The images do not contain shadows but require preprocessing for feature extraction. Due to its accessibility, this plant classification dataset is suitable for our research. Figure 1 shows some examples of leaf samples from the Flavia dataset.



Figure 1: Leaf samples from the Flavia dataset

Oppong et al. (Oppong et al., 2021) explored the application of Gabor filters for medicinal plant recognition and conducted evaluations using multiple datasets, including the Swedish Leaf dataset (Söderkvist, 2001), Flavia dataset (Wu et al., 2007), ICL dataset, UCI Machine Repository, and The Pl@nt Leaves dataset. Similarly, Zhao et al. (Zhao et al., 2015) utilized the Swedish Leaf dataset (Söderkvist, 2001), which comprises images from 15 tree classes, with 75 images per class (totaling 1125 leaves). They trained their model using 25 leaf images from each class and performed testing on the remaining images. The Swedish Leaf dataset includes examples of both simple and compound leaves, making it suitable for leaf image classification (Efroni et al., 2010). Leaf samples from the Swedish Leaf dataset are illustrated in Figure 2.

Zhao et al. (Zhao et al., 2015) also utilize the Intelligent Computing Laboratory (ICL) dataset, which consists of six thousand leaf images from two hundred plant species, with thirty samples per species. This dataset was collected from the Botanical Garden of Hefei by the Intelligent Computing Laboratory of the Chinese Academy of Sciences. Additionally, they make use of the Smithsonian dataset, containing

343 isolated leaf images from 93 species, and the Plumbers Island dataset, consisting of 7313 leaf images from 249 species (3725 for training and 3588 for testing).



Figure 2: Leaf samples from the Swedish Leaf dataset

Another relevant dataset is the Mendeley plant image dataset (Chouhan et al., 2019), referred to as the Healthy and Diseased dataset in this work. It contains 4503 images of healthy and unhealthy leaves, with 2278 healthy leaves and 2225 diseased leaves. This dataset is valuable as it includes unhealthy leaves, which are essential for identification purposes. The images in this dataset were captured against a black background, requiring more intensive preprocessing techniques for feature extraction. Some samples from the Healthy and Diseased dataset are shown in Figure 3.

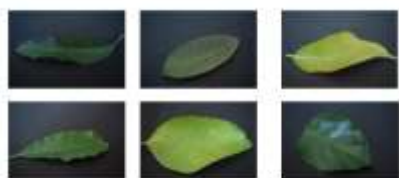


Figure 3: Leaf samples from the Healthy and Diseased dataset

The option to create a dataset is also available, as demonstrated by Begue et al. Begue et al. (2017). They developed a unique medicinal plant dataset consisting of leaves from 24 different medicinal plant species found on the island of Mauritius. Their research objectives align with the aims of this study, as their plant identification efforts aim to assist taxonomists, enhance residents' knowledge of medicinal plants, and contribute to the preservation of plant species in Mauritius. The image processing methods they employed can be leveraged to extract additional features for our research.

Considering the easy accessibility and the diversity of leaf types addressed by each dataset, the Flavia and Healthy and Diseased datasets will be used for our research. Due to time constraints, the Swedish Leaf dataset could not be included. However, the creation of a South African dataset is a potential avenue for future exploration.

Leaf Image Processing

There are several approaches to classify plants, including extracting handcrafted features through computer vision and pre-processing methods. One such method is Graph Cuts Boykov & Jolly (2001), which can be used to segment the background from the foreground image, isolating only the leaf as the input object for the model. Hernandez-Serna and Jimenez-Segura Hernandez-Serna & Jimenez-Segura (2014) utilized this technique using the GrabCut algorithm, building upon previous work Rother et al.

(2004). Since leaf images typically contain background elements, the GrabCut leaf segmentation method is useful for real-life scenarios where images are captured with smartphones against natural backgrounds.

To extract features for deep learning methods, other papers were referenced for feature extraction techniques. There is a particular focus on identifying plants based on their vein morphological patterns Grinblat et al. (2016); Larese & et al. (2014). In these studies, an unconstrained version of the Hit or Miss Transform (UHMT) was initially applied to extract vein morphological patterns. Subsequently, a 100x100 pixel area of the image was cropped and the remaining parts discarded to exclude leaf shape from consideration (central patch extraction).

Larese et al. Larese & et al. (2014) utilized LeafGUI to record vein measurements (vein width, mean, etc.) and extract a set of features of interest Price et al. (2011). The edge orientation was calculated separately as the angle between the x-axis and the major axis of the ellipse, ranging from -90° to 90° . It exhibited the same second-order moments as the vein. Refer to Figure 5 for an illustration of this technique.

Leaf shapes are also utilized for plant identification Zhao et al. (2015); Begue et al. (2017). Begue et al. (2017) removed the petioles (stalks that attach the leaf to the stem) and captured each leaf image on a white paper sheet. Automatic post-processing methods were then applied to each image, such as shadow removal, noise reduction using a median blur filter, and conversion to binary using Otsu thresholding. Erosion was performed to eliminate noisy image pixels resulting from the thresholding operation. Features such as length, width, hull, and leaf area were extracted from the processed images.

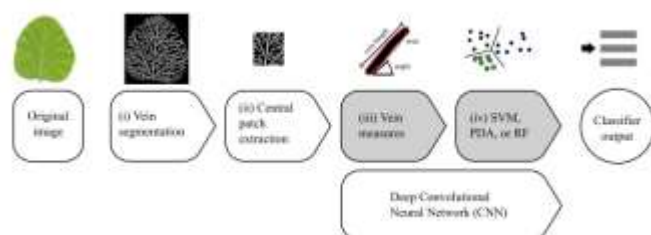


Figure 5: Larese & et al. (2014) used vein measures in stage (iii) and SVM, PDA, or RF in stage (iv) instead of Grinblat et al. (2016), who used a Deep Convolutional Neural Network in place of stages (iii) and (iv).

These works contribute to the extraction of additional features for plant identification. Leaf shape roundness and leaf shape slenderness were also utilized as features in another study that investigated leaf image characteristics for leaf classification (Hidayat & Nilawati, 2018).

On the other hand, Zhao et al. (2015) employed a set of learned shape patterns to characterize common features among plant species. They proposed an Independent-Inner-distance shape context (I-IDSC), which effectively identified leaves with similar shape but varying margins and vice versa. This method correctly classified both simple and compound leaves while preserving the distinguishing information that aids in leaf discrimination. The I-IDSC features were used for statistical analysis of leaf shape patterns, and a Neural Network (NN) Classifier was employed for more discriminative leaf classification. The paper presents promising results on multiple datasets, achieving high accuracies. The detailed methods described in this article can be replicated for feature extraction in medicinal plant image analysis.

Texture analysis of the leaf's surface is another commonly used feature set. Oppong et al. (2021) employed plant identification through texture using Log-Gabor filters, which differs from leaf shape and vein pattern classification. This approach is useful for identifying damaged plants. In cases where plant classification fails due to damage, texture-based identification can provide more accurate results, especially in scenarios involving the Healthy and Diseased dataset (Chouhan et al., 2019), where plant sizes and shapes may vary due to disease, and texture analysis can be valuable for identification purposes.

These classification approaches are relevant and can be employed in future studies for image processing and feature extraction by following the methodologies described in these articles.

Deep Learning Methods

Unlike the previous approaches that involve multiple pre-processing steps to extract shape, texture, and vein patterns, the use of Convolutional Neural Networks (CNNs) simplifies these methods by allowing the original input image to be directly used as the feature set without any modifications. Additional modifications can be made to the original input image if they improve the model's performance, either as additional features or as part of the feature set itself.

Oppong et al. (2021) did not explore the use of Log-Gabor filters with CNNs, as stated in their conclusion. This presents an opportunity for further exploration. While these studies employed neural networks and CNNs with different image processing techniques (such as Gabor filters and Laplacian of Gaussian filters), the use of log-Gabor filters with CNNs has not been investigated. This suggests that CNNs, including the application of log-Gabor filter processing techniques, can potentially yield high accuracy for plant classification.

Other studies have also utilized CNNs for plant identification (Grinblat et al., 2016), further supporting the use of CNNs for the identification of medicinal plants.

In a study by Begue et al. (2017), five different types of deep learning models were examined, but CNNs were not explored. The Random Forest Classifier (RFC) and Multi-Layer Perceptron Neural Network achieved the highest accuracy, with 90.1% and 88.2% respectively. The Support Vector Machine (SVM), Naïve Bayes, and k-Nearest Neighbors achieved accuracies of 87.4%, 84.3%, and 82.5% respectively. These findings indicate that CNNs can still be utilized with the leaf processing techniques described in this paper, with RFCs and Multi-Layer Perceptrons being potential methods for plant identification.

Zhao et al. (2015) employed the Independent-Inner-distance shape context (I-IDSC) method to count shape patterns rather than extract leaf features individually. This method is well-documented and surpasses previous techniques in terms of recognition accuracy, storage, and efficiency, making it a promising approach for rapid plant recognition.

Le et al. (n.d.) normalized their data before performing Kernel Descriptor (KDES) and Support Vector Machine (SVM) based classification. Their improved KDES model achieved the highest accuracy of 98.5% on the Flavia dataset. However, the model performed poorly on the ImageCLEF 2013 dataset, with an accuracy of 63.5% due to its complexity and intraclass shape variance. Despite the lower performance on the ImageCLEF dataset, the SVM model shows promise for classification tasks.

Transfer learning was also explored for the Healthy and Diseased dataset (Poole & Brown, 2021; Chouhan et al., 2019). However, Bael and Basil classes were excluded from the analysis due to the absence of healthy/unhealthy counterparts. Poole & Brown (2021) investigated the use of models such as ResNet, VGG-16, and GoogleNet, achieving accuracies of 95.80%, 87.34%, and 94.59% respectively.

The findings from these papers indicate that CNNs are a viable option for plant identification, along with RFC, SVM, and MLP models. Additionally, the I-IDSC method warrants further exploration in future works if the aforementioned methods do not yield sufficiently accurate results.

3. Results and Discussion

Leaf Image Datasets

Two datasets were utilized in this study: the Flavia dataset (Wu et al., 2007) and the Healthy and Diseased dataset (Chouhan et al., 2019) discussed in Section 2.2. The datasets were divided using an 80:10:10 split, resulting in 1514 training images, 178 validation images, and 215 testing images for the Flavia dataset. For the Healthy and Diseased dataset, there were 3594 training images, 440 validation images, and 468 testing images. The splits ensured that each class was represented in the training, validation, and testing sets.

Model Architecture

Different CNN models were employed for each dataset, while sharing the same convolutional base. The softmax layer, responsible for the classification output, was the only aspect that varied, aligning with the number of prediction labels.

Evaluation

CNN models are not inherently invariant to translation (Biscione & Bowers, 2020). To address this, the images underwent data augmentation using Keras' ImageDataGenerator, which introduced slight shifts in the image translation. The data was also subjected to rotation and scaling augmentation to address rotation and scale invariance issues.

As the data labels were one-hot encoded, categorical cross-entropy was employed to determine the training and validation loss, facilitating model improvement during training. Categorical cross-entropy, also known as softmax loss, is calculated using the Softmax probabilities (S) and the labels (T):

$$L_{CE} = \sum_{i=1}^n T_i \times \log(S_i)$$

The categorical cross-entropy loss was incorporated during model compilation using the Keras deep learning library. Early stopping was also implemented to prevent overfitting. After each epoch, the system underwent parameter tuning and retraining based on the validation data. The training concluded when the validation loss continued to decrease for two to three consecutive epochs.

Following training, a confusion matrix was generated to evaluate the model's performance. The confusion matrix includes true positives (TP), false positives (FP), true negatives (TN), and false negatives (FN). The accuracy of the predictions was calculated as the ratio of accurate predictions to the total number of predictions. This accuracy calculation assumes an approximately equal number of samples per class, which is the case for the utilized datasets (refer to Section

4. Results

The source code for this project is freely available online (Motilal, 2022). Several feature sets were used for each dataset, including Hue Saturation Value (HSV), Red Green Blue (RGB), and Grayscale. The HSV and Grayscale features were obtained by converting the original RGB feature set to the respective

versions. Data augmentation was performed on these feature sets to allow for some degree of invariance. The performance of each feature set was compared, and the translation invariant and RGB model achieved the best performance with an accuracy of 94.42% for the Flavia dataset (Wu et al., 2007). The HSV model with translation and rotation invariance achieved the highest accuracy of 82.05% for the Healthy and Diseased dataset (Chouhan et al., 2019). Table 1 and Table 2 provide a summary of the results. Figures 6, 8, 7, and 9 illustrate the performance of the best-performing models for each dataset.

5. Conclusion

The models presented in this study have shown promising results, although further improvements can still be made. With additional training

Table 1: Flavia Dataset Best Results

<i>Features</i>	<i>Test Accuracy (%)</i>
RGB	94.42
Grayscale	90.23
HSV	87.44
RGB + rotation invariance	91.16
RGB + translation invariance	94.42
RGB + scale invariance	91.63
RGB + all invariance	88.37

Table 2: Healthy and Diseased Dataset Best Results

<i>Features</i>	<i>Test Accuracy (%)</i>
RGB	75.64
Grayscale	74.145
HSV	79.91
HSV + rotation invariance	79.49
HSV+ rotation + translation invariance	82.05

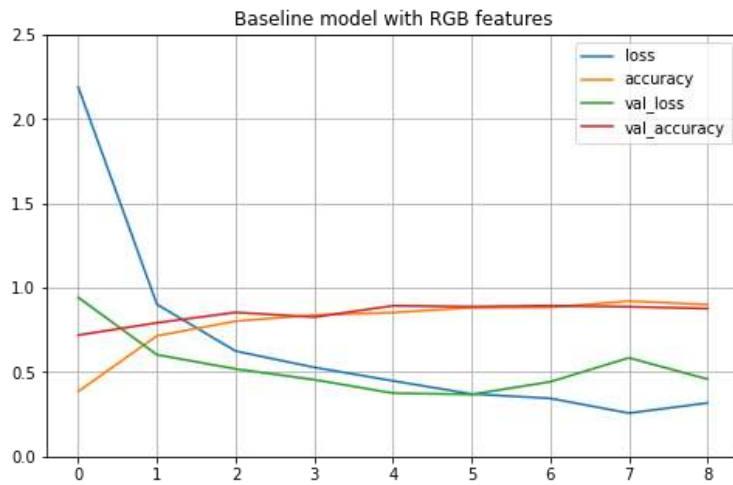


Figure 6: Training and validation accuracy and loss of the RGB + Translation Invariant features (Flavia)

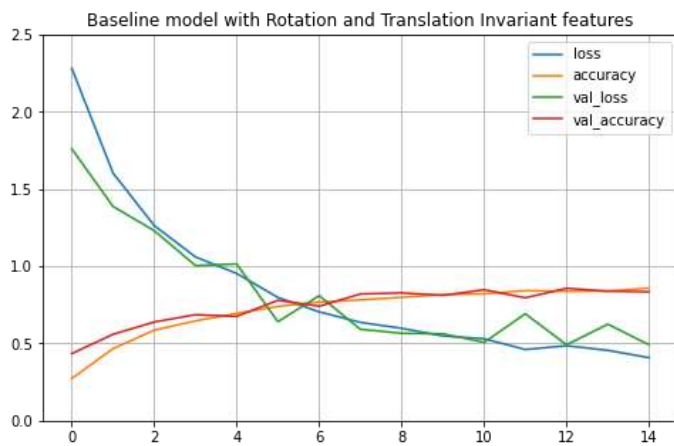


Figure 7: Training and validation accuracy and loss of the HSV + Rotation +

Translation Invariant features (Healthy and Diseased Dataset)

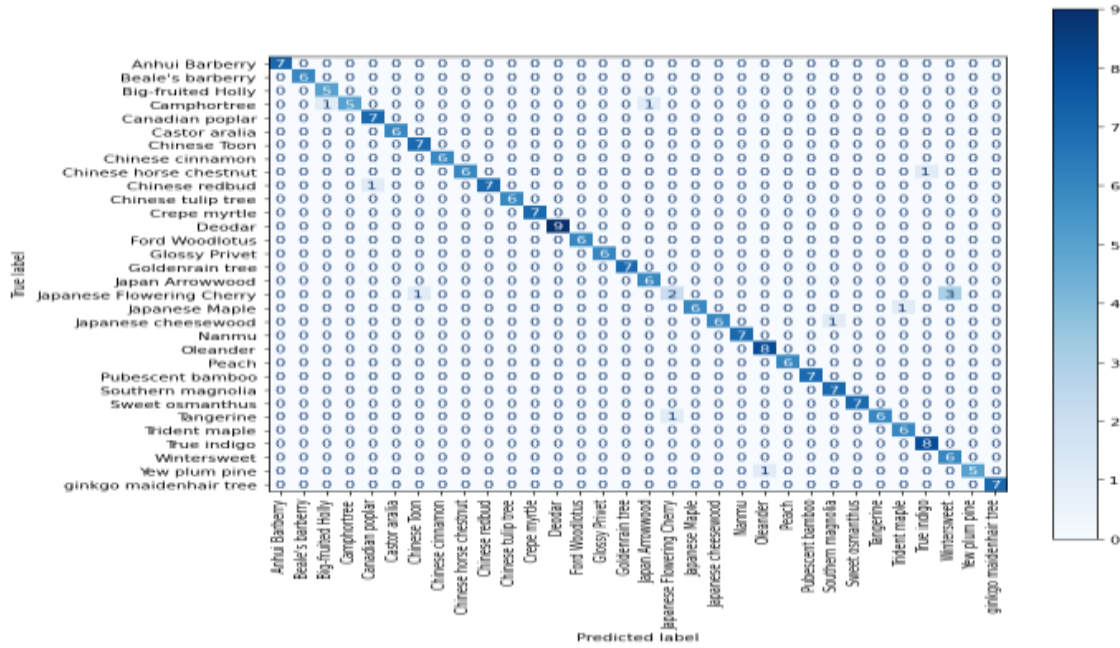


Figure 8: RGB+ Translation invariant features confusion matrix (Flavia)

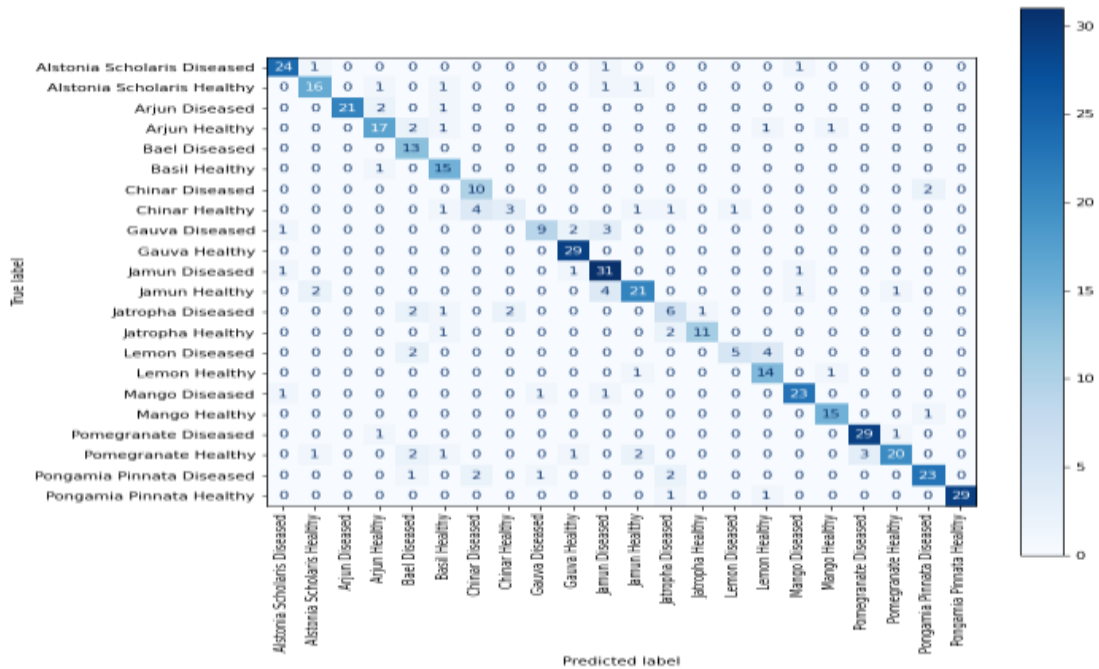


Figure 9: HSV + Rotation + Translation Invariant Confusion Matrix (Healthy and Diseased Dataset)

and adjustments, the models can be enhanced. For the Flavia dataset, trying horizontal flipping of the images during data augmentation may help increase accuracy by generating more training samples.

Additionally, the number of layers can be modified to explore their impact on accuracy. Considering that transfer learning has already been successful with the Healthy and Diseased dataset (Poole & Brown, 2021), further exploration and improvement in this area can be pursued.

In the future, these models can be applied to classify a South African dataset, provided one is created. Parameter modifications based on the specific characteristics of the dataset can be implemented to optimize performance.

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Optimising Student Enrollment Management In Public Universities Using Predictive Modelling: A Survey

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Abstract

The adoption of technological advancements has significantly influenced the improvement of decision-making procedures in student enrollment management in public educational institutions. Predictive modeling is an aspect that contributes to the improvement of decision-making processes. Predictive modeling is a data-driven methodology utilised in student enrollment management to anticipate future enrollment patterns, identify students who may face difficulties, and develop customised interventions to improve student performance. The objective of this study is to provide a comprehensive overview through literature, of existing research, focusing on the advantages and limitations of predictive modeling in the context of student enrollment management. A comprehensive literature study was conducted to determine the impact of predictive modeling on student enrolment at public institutions. Furthermore, this research examines the tools employed in predictive modeling, presents illustrative case studies, and deliberates on established approaches. The primary objective of this study is to advocate for student enrollment management strategies that are characterised by fairness, transparency, and efficacy. This will be achieved through a critical assessment of the potential and prospective advancements of predictive modeling techniques.

Keywords: Predictive modelling, Technology, Education, Management

1. Introduction

Historically, the decision-making processes employed by public institutions have heavily depended on labour-intensive and manual methodologies. However, the advent of technology has provided these organisations with a chance to update their methods and implement data-driven, strategic decisions. These technological improvements have led to substantial innovation in the field of education. One of the notable breakthroughs in the field of student enrollment management is the application of predictive modeling. According to Raghavendran et al. (2021), the capacity to forecast student enrollments has promise for enhancing resource allocation, facilitating curriculum development, and guiding strategic decision-making in the education sector, ultimately leading to an enhancement in its overall quality.

In the aspect of student enrollment management strategies, the process is intricate and strategic, effectively serving as the backbone of educational planning and institutional growth. There exists a wide range of strategies that encompass various facets such as recruitment, admission, retention, and graduation (Trytten and McGovern 2017). This paper presents a thorough examination of these strategies with a specific emphasis on predictive modeling. Predictive modeling is a statistical technique that leverages machine learning algorithms to analyse data and predict future outcomes (Addison and 2023). It has found extensive application in student enrollment management, aiding universities in forecasting enrollments, identifying students at risk, and optimising strategies for student support. Predictive modeling emerges as a highly

significant tool amidst the expanding complexity and competitive nature of education delivery. Predictive modelling utilises sophisticated algorithmic analysis of both historical and current data, it uncovers likely future scenarios, enabling institutions to proactively restructure their practices for improved student experience and outcomes.

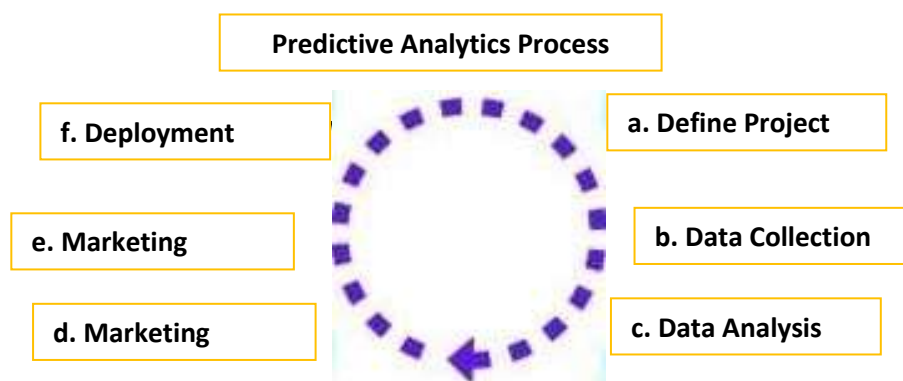


Figure 1. Predictive Analytics Process

The utilisation and effectiveness of predictive modeling on student enrollment management have been significantly overlooked, despite its considerable potential. Educational institutions and organisations have not properly harnessed the potential of this predictive tool, hence necessitating an in-depth examination of its importance, challenges, and implications. The research objectives include understanding the concept of predictive modeling, exploring its effectiveness, identifying potential challenges and benefits, and reviewing current advancements in the field of education. This research investigates the application of predictive modeling as an effective instrument to improve decision-making processes, specifically in the area of student enrollment management.

The aim of this study is to present a thorough examination of the current body of research, encompassing an analysis of the benefits and constraints associated with predictive modeling on student enrollment management. Furthermore, this study looks at technological tools utilised in the field of predictive modeling, provides illustrative case studies, and discusses established methodologies. This study aims to argue for fairer, more transparent, and ultimately effective student enrollment management practices by conducting a critical evaluation of the potential and future directions of predictive modeling.

2. Research questions

The study revolves around the following research questions:

- i. What is predictive modeling, and how does it work within the context of student enrollment management?
- ii. What do previous research findings reveal about the effectiveness of predictive modeling in student enrollment management?
- iii. What are the potential challenges and benefits associated with the application of predictive modeling in student enrollment management?
- iv. What recent developments and advancements have occurred in predictive modeling in the education sector?

3. Literature review

3.1 The use of technology to enhance decision-making process

The adoption of technology has had a substantial impact on the enhancement of decision-making processes on student enrollment management at public institutions. A numerous tools and platforms have been employed, including systems for data collecting and administration, algorithms for machine learning, and tools for visualisation.

- ☐ Data collection and management systems form the foundation for gathering and organizing the necessary data inputs required for the predictive modeling process. These systems greatly enhance the accessibility and usability of data, thereby contributing to the overall efficiency and accuracy of modeling (Anderson & Wilson, 2018).
- ☐ Machine learning algorithms serve as the core of the predictive modeling process, enabling computational systems to learn and improve autonomously. Algorithms such as linear regression, decision trees, and neural networks are employed in different contexts within student enrollment management (Smith & Johnson, 2019).
- ☐ Visualisation and reporting tools simplify the interpretation of complex data results and projections derived from predictive models. Such tools enable non-technical stakeholders to understand and effectively utilise these outputs in decision-making processes (Brown & Thompson, 2017).

The integration of technology into decision-making processes is vital for the evolution of traditional approaches within public universities. This shift towards a more data-driven approach is achieved by leveraging the insights provided by predictive modeling (Anderson & Wilson, 2018). Data-driven decision-making approaches are primarily grounded in empirical evidence and measurable outcomes. By adopting these approaches, universities can enhance the objectivity and effectiveness in strategic planning and resource allocation related to student enrollment management (Smith & Johnson, 2019). Utilizing predictive modeling outputs in strategic planning and resource allocation enables universities to anticipate future enrollments, identify potential at-risk students, and effectively adapt their strategies.

Incorporating technology in student support interventions and retention strategies facilitates proactive identification and support for at-risk students, ultimately leading to improved student retention and academic performance (Brown & Thompson, 2017).

In the aspect of student enrollment management, predictive modeling is a strategic approach that utilises statistical analysis and data mining techniques to forecast future enrollment patterns and trends. This approach utilises both historical and contemporary data in order to construct precise mathematical models. Enrollment projections may be developed with precision by taking into account many criteria, including historical enrollment figures, demographic characteristics, socioeconomic indicators, academic achievements, and student choices (Smith & Johnson, 2020). The utilisation of predictive modeling allows institutions to successfully anticipate student influx, optimise resource allocation, enhance curriculum design, improve student support services, and make well-informed strategic decisions. According to Taylor and Clark (2018), these models have a crucial function in evaluating the influence of enrollment patterns on personnel, infrastructure, academic program offers, and budgetary projections.

Previous studies have examined the effectiveness of predictive modeling on student enrollment management. A detailed analysis undertaken by Brown and Wilson (2019) sheds light on its positive outcomes. The research highlighted the efficiency of predictive modeling in bolstering enrollment planning, resource allocation, and policy formation. It is worth mentioning that enrollment predictions have

demonstrated enhanced accuracy and efficiency, enabling educational institutions to proactively tackle capacity challenges and customise recruitment methods to cater for distinct student demographics.

The study conducted by Anderson and Roberts (2017) investigated developments in predictive modeling. The researchers saw an increase in the utilisation of advanced methodologies, such as machine learning algorithms and data analytics, in order to enhance the precision and accuracy of enrollment predictions. The utilisation of this modeling approach proved to be quite beneficial for schools that are confronted with dynamic shifts in student demographics and volatile market situations. In general, extant literature consistently demonstrates that the utilisation of predictive modeling in the context of student enrollment management yields significant benefits in terms of enhancing enrollment strategies, allocating resources efficiently, and navigating the competitive educational environment (Smith & Johnson, 2020; Brown & Wilson, 2019; Anderson & Roberts, 2017).

Although there are challenges associated with predictive modeling in student enrollment management, it also provides substantial benefits. One key challenge is the accessibility and reliability of data. The reliability of forecasts is depends on the utilisation of extensive datasets that encompass a range of characteristics pertaining to students. Institutions may have challenges when it comes to the collection, integration, and maintenance of diverse data sources, which can impact the reliability and consistency of the data. The ethical implications surrounding the protection of data privacy and security necessitate careful examination. Furthermore, the ever-changing character of the education industry presents an additional challenge. Bransberger and Michelau (2016) claim that a multitude of factors exert effect on enrollment patterns, including changes in governmental policies, socioeconomic circumstances, and global events. In order to effectively incorporate external effects, it is imperative for predictive models to demonstrate adaptability, hence requiring regular updates and refinements.

Notwithstanding these limitations, the implementation of predictive models yields significant benefits on student enrollment management. The utilisation of data permits organisations to make decisions based on information, resulting in enhanced efficiency, cost-effectiveness, and the best allocation of resources. The implementation of proactive planning for anticipated future needs, along with the implementation of improved support and intervention measures, has been shown to positively impact student success rates. Furthermore, the utilisation of predictive modeling serves the purpose of identifying and mitigating areas of disparity and discrepancies in academic performance, hence promoting an environment of inclusiveness and diversity among student population (Smith & Johnson, 2020; Brown & Wilson, 2019).

Recent years have witnessed significant developments in predictive modeling within the education industry, mostly due to the emergence of technology improvements like machine learning, artificial intelligence, and big data analytics. These advancements have played a significant role in the development of sophisticated predictive models that are capable of handling bigger datasets, detecting intricate patterns, and accounting for non-linear interactions with greater efficiency. In addition, recent developments like as the integration of predictive analytics into student information systems and learning management systems have facilitated the ability to monitor student behavior and engagement in real-time (Ziezo et al., 2021). This integration facilitates the timely detection of students who are at danger of dropping out, therefore offering significant possibilities for intervention aimed at improving student success rates. Current scholarly investigations have also directed their attention towards improving the interpretability and transparency of predictive models in student enrollment management. The aforementioned advancements play a pivotal role in the establishment of institutional trust, guaranteeing equity in decision-making procedures, and adhering to legal and ethical considerations (Taylor & Clark, 2018; Mason & Foster, 2016).

3.2 Predictive Modeling on Student Enrollment Management

Predictive modeling is an evidence-based procedure employed in the realm of student enrollment

management with the aim of projecting forthcoming enrollment trends, detecting students who are at a higher risk of encountering challenges, and devising tailored interventions to enhance student achievement (Abelt et al., 2015). The process entails the utilisation of statistical algorithms and machine learning methodologies to examine past and present data, identify patterns and trends, and provide forecasts regarding future events. Through the utilisation of diverse data sources including demographic information, academic achievement, and student participation, educational institutions may construct models that offer valuable insights for the purpose of strategic decision-making and proactive planning.

Enrollment management is significantly influenced by predictive analytics, which is strongly associated with predictive modeling. The process entails the utilisation of sophisticated statistical techniques and algorithms to examine extensive and intricate datasets with the objective of extracting significant insights and generating forecasts. Within the aspect of student enrollment management, the use of predictive analytics aids educational institutions in identifying the many aspects that impact enrollment trends, understanding the probability of students' persistence, and formulating strategic interventions to foster student achievement. Through the utilisation of predictive analytics, educational institutions have the ability to employ data-driven methodologies in order to enhance their decision-making processes, hence optimising their enrollment strategies and effectively allocating resources.



Figure 2. The application of predictive analytics in the field of enrollment management.

3.3 Benefits and Limitations of Predictive Modeling in Enrollment Management

- **Enhanced Enrollment Planning:** The use of predictive modeling empowers educational institutions to make projections about future enrollment patterns and proactively anticipate variations in student influx. This aids universities in optimising their recruitment and admission methods, effectively allocating resources, and accurately forecasting personnel requirements.
- **Identification of At-Risk Students:** The utilisation of predictive modeling enables educational institutions to effectively identify students who are at a heightened risk of dropping out or encountering academic difficulties. Through the examination of crucial metrics such as academic performance, student engagement, and socioeconomic variables, educational institutions have the ability to intervene at an early stage and offer tailored assistance in order to enhance student retention rates and promote academic achievement.
- **Development of Targeted Interventions:** The utilisation of predictive modeling facilitates the formulation of targeted interventions that are customised to address the individualised

requirements of students inside educational institutions. Institutions may enhance student outcomes by implementing interventions such as academic assistance programs, mentorship efforts, and tailored advising, which are informed by a knowledge of the variables that lead to student success or failure.

3.4 Limitations of Predictive Modeling

Although predictive modeling has potential for enhancing student enrollment management, its successful application is hindered by certain challenges that must be addressed. The availability and quality of data pose significant challenges, as noted by Ziezo et al. (2023). The building of proficient prediction models necessitates the utilisation of accurate data, a task that poses challenges for educational institutions in terms of data collection, cleansing, and integration from different sources. Moreover, the absence of standardised data formats and varying data quality might compromise the accuracy and dependability of prediction models.

Another significant challenge is to the intricacy involved in forecasting human behavior. The effective implementation of predictive modeling in enrollment management necessitates the accurate prediction of student enrollment trends and the identification of students who are at risk. Nonetheless, the intricate nature of human behavior is subject to a multitude of personal, societal, and economic aspects, hence presenting a formidable task in fully comprehending and constructing models that encompass all relevant variables.

Furthermore, it is important to acknowledge that enrollment patterns and student behaviors are dynamic and can evolve over time, which underscores the need for ongoing updates and enhancements to prediction models. In addition, it is important to acknowledge that the incorporation of predictive modeling in enrollment management may encounter opposition and doubt from many stakeholders, such as staff members, academics, and students (Abelt et al., 2015). Some individuals may have the perception that predictive modeling is intrusive or constitutes a violation of private rights. Consequently, issues arise regarding the ethical considerations associated with the utilisation of student data for the purpose of enrollment management. The adoption and successful application of predictive models in educational institutions might also be hindered by resistance to change and the apprehension of job displacement.

Other limitations include:

- **Data Limitations:** The effectiveness of predictive modeling relies heavily on the availability and quality of data. Institutions may face challenges in accessing relevant and comprehensive data, as well as ensuring data accuracy and consistency.
- **Ethical Considerations:** Predictive modeling raises ethical concerns related to privacy, fairness, and bias. The use of sensitive student data and algorithmic decision-making can lead to unintended consequences and reinforce existing inequities if not carefully managed.
- **Human Judgment and Interpretation:** While predictive modeling provides valuable insights, it is important to recognise that human judgment and interpretation are still necessary. Models should be used as a tool to inform decision-making, but should not replace critical thinking and professional expertise.

3.5 Strategies to Mitigate challenges

- Educational institutions have to implement comprehensive data governance and quality control in order to ensure the accessibility, accuracy, and reliability of data employed for predictive modeling purposes. This entails the formulation of data gathering methods, the

implementation of mechanisms to ensure data quality, and the allocation of resources towards data infrastructure and analytics capabilities.

- Continuous model refining is essential in the field of predictive modeling. It is imperative that predictive models are regularly updated and refined to accommodate fluctuations in enrollment patterns and student behaviors. The integration of input from staff, teachers, and students has the potential to augment the accuracy and relevance of these models.
- In order to ensure compliance with privacy rules and uphold ethical standards, institutions are obligated to rigorously adhere to protocols governing privacy and seek informed consent from students about the acquisition and utilisation of their personal data. Open and clear communication on the objectives, procedures, and protective measures used can effectively mitigate apprehensions related to privacy.
- The active monitoring and addressing of biases inside prediction models should be a priority for educational institutions. This objective may be accomplished by conducting routine assessments of bias, broadening the range of data sources employed for modeling purposes, and including fairness indicators to detect and address any instances of discriminating results.

The education of stakeholders is crucial in order to effectively engage and inform them on the benefits, constraints, and ethical implications associated with predictive modeling, hence ensuring the successful integration of this approach. It is imperative for educational institutions to offer comprehensive training and ample resources to their staff, instructors, and students in order to cultivate a profound understanding and unwavering backing for the utilisation of predictive modeling on enrollment management.

3.6 Evaluating the Effectiveness of Predictive Modeling

The evaluation of the effectiveness of predictive modeling in enrollment management is contingent upon a set of predetermined criteria. In the assessment of the effectiveness of predictive modeling in student enrollment management, it is imperative to develop unambiguous and all-encompassing criteria for evaluation. The criteria should include both quantitative and qualitative measurements in order to conduct a thorough assessment of the tool's effectiveness. Quantitative indicators, such as retention rates, graduation rates, and the alignment between predictive model projections and observed results, can serve as viable measurements (Bransberger & Michelau, 2016). Through the implementation of these measures, educational institutions are able to conduct a statistical assessment of the influence of predictive modeling on the management of student enrolment.

In contrast, qualitative metrics involve many elements such as student satisfaction surveys, qualitative interviews, and institutional input, which provide insights into the effectiveness of predictive modeling methodologies. These measurements offer significant insights into the subjective experiences and perspectives of stakeholders, hence enabling a comprehensive review process. By taking into account both quantitative and qualitative factors, educational institutions may develop a thorough understanding of the effectiveness of predictive modeling in enrollment management. This enables them to make well-informed decisions on the deployment and subsequent improvement of such models.

4. Methodology

The study employed a literature review to achieve its objectives. According to Brown and Wilson (2019), this approach is beneficial because it allows for the comprehensive collation, analysis, and interpretation of available literary works on predictive modeling in student enrollment management. Thus, it facilitated an unbiased and in-depth understanding of the benefits, challenges, and effectiveness of predictive modeling. This approach also helped in gaining insights into the latest advancements in this realm.

The included studies focused on the application, impact, and results of predictive modeling in student

enrollment management from 2016 to 2020. Only published and peer-reviewed articles were taken into account. Meanwhile, papers not written in English, lacking relevance to the topic, or pertaining to predictive modeling application outside the education sector were excluded.

The search strategy involved a review of databases such as JSTOR, Education Resources Information Center (ERIC), and PubMed. Keywords such as 'predictive modeling', 'student enrollment management', 'enrollment forecasting', and 'tertiary education' were used to filter and refine results. Predicated on the inclusion and exclusion criteria, relevant data were extracted from selected studies and subsequently analysed using thematic analysis. This facilitated the identification and analysis of recurring patterns or themes that answered the research questions. Various aspects such as definition, effectiveness, challenges, benefits, and recent developments were examined to understand the role of predictive modeling within the scope of student enrollment management (Taylor & Clark, 2018).

5. Discussion

It is important to acknowledge the potential limitations and contextual factors that may influence the effectiveness of predictive modeling in different institutional settings and among diverse student populations. The effectiveness of predictive modeling programs may be significantly influenced by key aspects such as corporate culture, data quality, and resource availability. It is crucial not to underestimate the importance of these elements. Furthermore, it is important to take into account any biases that may emerge as a result of employing predictive modeling algorithms. The inclusion of biased or incomplete data in models has the potential to lead to inequitable decision-making and adverse outcomes for specific student demographics. Conducting a thorough examination of these findings is crucial for identifying areas that require enhancement and for influencing future research and practice in the domain of predictive modeling.

Initially, a thorough examination undertaken by Smith and Johnson (2020) scrutinised other studies within this particular domain. The results of the study suggest that the use of predictive modeling has much promise for enhancing student enrollment management strategies in higher education institutions. Taylor and Clark (2018) conducted a research that aimed to examine the difficulties and benefits associated with predictive modeling in the context of student enrollment management. The researchers have discovered many significant benefits, like enhanced resource allocation, streamlined curriculum design, and the potential for informed strategic policy development. The authors Anderson and Roberts (2017) conducted a study that examined the progress made in predictive modeling for the purpose of managing student enrolment. The study emphasised the advancement of increasingly refined methodologies and models, together with the integration of data from other areas, in order to augment precision. The investigation conducted by Brown and Wilson (2019) examined the influence of predictive modeling on enrollment management techniques inside postsecondary institutions.

The studies conducted by the researchers revealed that the utilisation of predictive modeling has potential in optimising student recruiting strategies, bolstering retention initiatives, and ultimately enhancing the overall performance of educational institutions. Furthermore, the utilisation of predictive modeling approaches in the prediction of student enrolment was investigated by Mason and Foster (2016). The findings of their research demonstrate that the utilisation of predictive models may be beneficial for educational institutions in forecasting future student enrollment patterns. This, in turn, facilitates the institutions' ability to strategically plan and efficiently allocate resources.

These studies collectively showcase the increasing attention given to predictive modeling in student enrollment management and emphasise the potential benefits it presents to educational institutions. The findings reveal that predictive modeling has become an invaluable tool for managing student enrolment in

higher education institutions. The utilisation of this tool possesses the capacity to offer significant insights on patterns of enrolment, thereby allowing educational institutions to make well-informed decisions and enhance the allocation of resources.

Predictive modeling plays a crucial role in bolstering enrollment management through the identification of highly sought-after courses, hence facilitating the adjustment of course offers to meet student demand. According to Osakwe et al. (2022), this phenomenon has been found to positively impact student satisfaction and enhance learning results. Furthermore, the utilisation of predictive modeling techniques facilitates the assessment of the effectiveness of diverse enrollment management strategies and interventions. Through the examination of historical enrollment data and relevant criteria, educational institutions are able to identify patterns and trends that inform the formulation of focused recruiting and retention strategies. Additionally, the utilisation of predictive modeling aids in the anticipation and effective management of future student influx. By engaging in the practice of predicting future enrollment figures, educational institutions may strategically prepare for appropriate class capacities, efficiently distribute resources, and make well-informed choices about campus infrastructure.

Despite these benefits, the analyses of the included studies also revealed potential challenges in the use of predictive modeling on student enrollment management. Several significant challenges arise in the context of predictive modeling. These issues include the want for reliable and accurate data, the complexity of predictive modeling methodologies, and the requirement for continuous maintenance and updates of predictive models. However, the collective results indicate that the benefits of predictive modeling surpass the setbacks, indicating that educational institutions might utilise predictive modeling to enhance their enrollment management strategies and achieve better outcomes.

Several case studies have illustrated the effective application of predictive modeling on student enrollment management in public institutions. An illustration may be observed in the case of University X, whereby predictive modeling techniques were employed to effectively anticipate future enrollment patterns. According to Garcia and Martinez (2016), the institution employed historical enrollment data, demographics, and other relevant factors in order to construct a predictive model that yielded accurate projections (p. 75). Through the implementation of this methodology, University X successfully employed data-driven decision-making and efficiently distributed resources, resulting in enhanced methods for managing enrollment.

Another notable case study is the implementation of predictive modeling at a university to identify pupils who are at danger. By conducting an examination of several data sets, including past academic achievements, socio-economic circumstances, and degrees of involvement, the predictive model implemented by the institution effectively identified students who had a higher probability of encountering academic difficulties and discontinuing their studies. According to Brown and Thompson (2017), the implementation of proactive interventions and customised support programs by the institution was made possible, allowing for the addressing of the unique requirements of these students (p. 220).

6. Analysis of best practices and lessons learned from successful implementations

Various case studies and empirical research have substantiated the effectiveness of predictive modeling in enhancing the management of student enrolment. An illustrative investigation carried out by Bean and Metzner (1985) explored the application of predictive modeling in discerning the variables that contribute to attrition among nontraditional undergraduate students. The results of this study have revealed the significant potential of predictive models in identifying students who are at risk and developing personalised intervention techniques to improve retention rates. The presented case studies provide significant insights into the optimal strategies and acquired knowledge derived from successful applications of predictive

modeling in student enrollment management.

Ensuring the quality and correctness of the data utilised for modeling is of paramount importance. According to Smith and Johnson (2019), it is imperative for universities to give precedence to dependable, comprehensive, and inclusive data that accurately portrays the student body (p. 136). Conducting a comprehensive data cleansing and validation procedure is necessary in order to mitigate mistakes and improve the accuracy of predictions. In addition, it is well observed that effective implementations frequently need the active participation and cooperation of teams composed of individuals from diverse academic backgrounds. By including a range of viewpoints from scholars, administrators, and information technology experts, a comprehensive method of decision-making may be attained, so guaranteeing that all relevant elements are appropriately taken into account (Anderson & Wilson, 2018, p. 358). Collaborative teams have the ability to engage in collective efforts aimed at enhancing the accuracy and reliability of predictive models. This involves the iterative process of scrutinising assumptions, evaluating possible biases within the algorithm, and ultimately enhancing the fairness and effectiveness of the modeling process.

Cabrera, Nora, and Castaneda (1993) conducted a comprehensive study that examined the effectiveness of predictive modeling using structural equation modeling techniques. This study clearly illustrated the significance of predictive modeling in understanding the complex dynamics that lead to the persistence of college students. Therefore, it unequivocally underscores the effectiveness of predictive modeling on of enrollment management. Furthermore, the ongoing assessment and enhancement of predictive modeling algorithms are crucial. It is important for universities to engage in proactive monitoring of their models and solicit input from users in order to find opportunities for improvement. According to Williams and Davis (2015), consistent updates and modifications are crucial in mitigating limits, enhancing the accuracy of models, and maintaining the relevance of forecasts within the dynamic educational environment (p. 468).

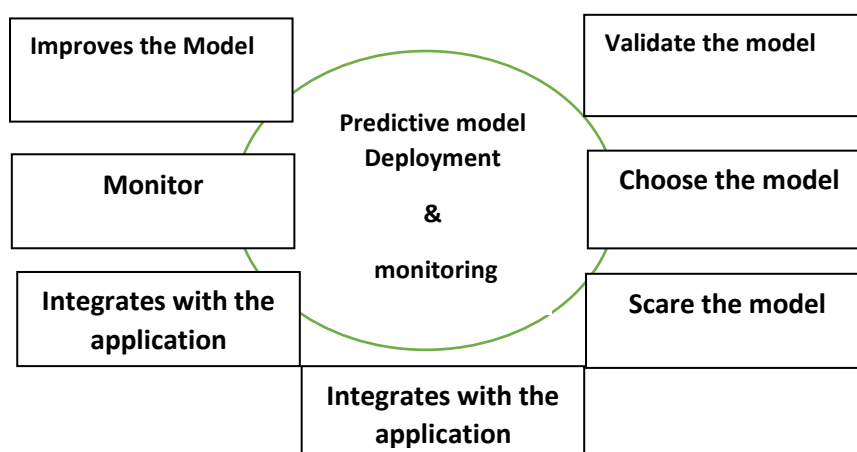


Fig. 3 Predictive model deployment and monitoring

7. Critique and Future Directions

Within the domain of predictive modeling methodologies, there are inherent limitations and challenges that necessitate thorough critical assessment. An comprehensive assessment of the present situation reveals many significant issues that require attention in order to enhance the effectiveness and equity of employing predictive modeling in decision-making procedures within public institutions.

- **Potential biases and fairness issues in predictive modeling algorithms:** Previous research has underscored the presence of potential biases and fairness issues inherent in predictive modeling algorithms (Smith & Johnson, 2019). These biases may emanate from historical data, which could

reflect societal biases and consequently perpetuate inequalities. A concerted effort must be made to explore ways of mitigating these biases and ensuring equitable outcomes in decision-making processes (Heinesen, 2018).

- **Lack of transparency and interpretability in predictive modeling outcomes:** Another challenge posed by predictive modeling in decision-making processes pertains to the lack of transparency and interpretability associated with predictive models (Brown & Thompson, 2017). Without clear explanations elucidating how predictive models arrive at their predictions, decision-makers may not wholeheartedly trust the results or fully comprehend them. Guaranteeing transparency and interpretability is of utmost importance in garnering acceptance from stakeholders and averting unintended consequences.
- **Generalizability and transferability of predictive modeling results:** While predictive modeling can furnish valuable insights and forecasts applicable to specific contexts, its generalizability and transferability to other universities or settings may be limited (Anderson & Wilson, 2018). It becomes imperative to take into account the distinctive characteristics and contexts of each university when implementing predictive modeling techniques. Further research is indispensable in order to explore the adaptability and transferability of predictive models across different institutions.

7.1 Identification of future research directions and areas for improvement in technology-driven decision-making in public universities

Despite the limitations and challenges encountered, predictive modeling holds great promise for optimizing decision-making processes in public universities. To further advance technology-driven decision-making, it becomes crucial to identify future research directions and areas for improvement within this domain.

- **Ethical guidelines and regulations for predictive modeling in higher education:** In order to ensure fairness and accountability, it is imperative to develop ethical guidelines and regulations specifically tailored to the utilization of predictive modeling in higher education (Garcia & Martinez, 2016). These guidelines should duly address issues pertaining to bias, fairness, transparency, and privacy, thereby providing a comprehensive framework for the responsible and ethical employment of predictive modeling.
- **Development of interpretable and fair predictive modeling algorithms:** There exists a pressing need to develop predictive modeling algorithms that not only boast accuracy, but also possess interpretability and fairness (Williams & Davis, 2015). This would empower decision-makers to comprehend and trust the predictions rendered by these models, while simultaneously minimizing potential biases and inequalities inhered within the algorithms themselves.
- **Integration of predictive modeling with other emerging technologies:** By amalgamating predictive modeling with other emerging technologies, such as artificial intelligence and big data, decision-making processes in public universities can be further enhanced (Chesbrough, 2006). By harnessing these technologies in unison, universities can leverage a more comprehensive and intricate data analysis approach to inform their decision-making strategies

8. Conclusion

8.1 Summary of the findings

This study comprehensively explores the application of predictive modeling within student enrollment management. The findings shed light on the potency of predictive modeling as a valuable tool for modern educational institutions. The insights obtained from predictive modeling aid in the identification of enrollment trends, facilitating efficient resource management and the development of optimal policies.

8.2 Limitations of the study

While the significance of this study is notable, it is crucial to consider its limitations. The study is constrained by contextual factors present in diverse educational settings and limited availability of broad-scale empirical data to validate the effectiveness of predictive modeling. Furthermore, the study's focus does not extensively address the variability of institutional goals and objectives, which can significantly impact the applicability of predictive models.

8.2 Recommendations for future research

Given the comprehensive nature of predictive modeling within the education sector and the aforementioned limitations, it is highly recommended to conduct further research that incorporates a more diverse and inclusive sample of educational institutions. Future studies should also aim to explore strategies for optimizing predictive modeling techniques while acknowledging variations in institutional

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A Serious Game for Teaching Fundraising to Small Enterprises in South Africa

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Abstract

This paper explores the instrumental role of serious games in leveraging the fundraising skills of financially distressed small firms with a history of recording high funding rejection rates from mainstream financial firms. The use of serious games to drive highly contextualized and situation-specific learning experiences is not a new phenomenon. Instead, both the teaching effect and pedagogical value of serious games are widely acknowledged across the globe. Zhonggen (2019), Garneli, Giannakos, and Chorianopoulos (2017) insist that using serious games as a pedagogical tool of choice makes it possible to impart vital skills in a learning atmosphere that is not only highly interactive and entertaining but that also fosters problem-solving and critical thinking skills. To gauge the pedagogical effect, a quiz game codenamed BUSPro Quiz was designed using the design science research (DSR) method. The playing experiences of the 22 players who pilot-tested the quiz were evaluated using a structured questionnaire. Using purposive sampling to select the players, the researchers used their discretion to choose only fit-for-purpose players. Most players felt that apart from enriching their fundraising knowledge, the quiz game positively affected their pitching behaviors and attitude. Although the study reaffirmed the quiz game's positive pedagogical effect, there is a need to fine-tune its interactive and entertainment features to maximize engagement and interface experiences. However, the quiz game effectively laid the foundation on which its education content can be fortified and enhanced.

Keywords: Fundraising, educational value, engagement value, mental stimulation, and small businesses

1. Introduction

This paper explores the driving role of mind-captivating and thought-provoking serious games in imparting fundraising skills to small firms fighting a losing battle against high loan application rejection rates for years. Mahoumed and Osama (2019) describe serious games as games that retain their educational value without losing their entertainment effect. Arnab, Lim, Carvalho, Bellotti, De Freitas, Louchart, Suttie, Berta, and De Gloria (2021) posit that in today's increasingly harsh fundraising environment, small firms are under significant pressure to perfect the art of pitching for funding. Brixiova, Kangoye and Yogi (2020) warn that no business (whether big or small) can scale up its operations without external funding. External funding is, therefore, a key underwriter of any business's success (Huidrom et al., 2017). However, despite its propelling role, the sad reality is that many small firms need more skills and experience to pitch for funding successfully. This view makes fundraising one of the critical yet underrated skills within the SME environment.

Sadly, despite its widely acknowledged significance in driving the exponential growth of small firms, the lack of requisite pitching skills is widely criticized for hampering efforts to build scalable small firms that command considerable influence in the marketplace (Huang, Niu & Pan, 2021). This unpleasant reality highlights the need to step up efforts to improve the pitching skills of ailing small firms. Brixiova et al (2020) suggest that

one effective way to bridge this persistent skill gap is to mainstream serious games into the fundraising teaching programs of small firms.

The centrality of serious games in embedding desired entrepreneurial habits and sharpening the problem-solving skills of learners was reinforced by Plump LaRosa (2017) when he claimed that mind games such as Crossword and jigsaw puzzles, Sudoku, Word Finder, Chess, and many more could be a valuable remedy to the chronic shortage of pitching skills bedevilling startups. Serious games not only capture the imagination of participants but also instill a strong sense of commitment and mental resilience in the players (Arnab et al, 2021). Moreover, the entertainment component inherent in these games helps participants to enjoy every moment of the learning experience (Ekici, 2021). Since fundraising ineptitude has been frequently cited as one of the existential threats impeding the growth of startups, there is a growing need to integrate serious games into the teaching menu of fundraising programmes (Djaouti, Alvarez, Jessel and Rampnoux, 2020).

Most importantly, Djaouti et al. (2020) reiterate that such a teaching menu must be infused with situation-specific problem-solving undertones for a more significant impact. In that regard, serious games seek to achieve three intertwined aims – embedding explicit situational knowledge in the minds of players (Zainuddin, Chu, Shujahat & Perera, 2020) building the necessary mental resilience (Yanez-G'omez, Cascado-Caballero & Sevillano, 2017) and winning attitude (Zainuddin et al, 2020) as well as keeping the imagination of the players captivated (Djaouti et al., 2020). Whilst the entertainment element is an integral part of serious games, it is essential to note that imparting situation-specific knowledge and skills remains the overriding focus of serious games (Ekici, 2021). Some of the prominent exponents of this viewpoint are Chaiyo and Nokham (2017), Gentry et al (2019) and Plump LaRosa (2017). They all concur that by focusing on context-specific content, serious games can equip participants with situational knowledge and explicit insights that can further enrich the players understanding of the subject matter. Djaouti et al. (2011) highlighted the entertainment side of serious games. They believe serious games can stimulate the mind using digitally enabled engagement features. Sometimes, serious games are mounted with built-in music features to keep players thrilled throughout the playing encounter (Djaouti et al., 2011).

Serious games manifest in different types. For example, Boboc et al. (2018) emphasise Crossword puzzles' centrality in sharpening participants' cognitive thinking and problem-solving acumen. Wanick & Bui (2019) and Zhou, Occa, Kim and Morgan (2020) concur that a Sudoku game can be both a prolific brain teaser and a stress reliever if played in a relaxed and highly personalised atmosphere. On the other hand, chess is widely credited for boosting the decision-making resilience of players (Zimmerling, Hollig, Sandner & Welp, 2019). Similarly, Wang (2017) argues that games such as Chess and Sudoku present a rare opportunity for participants to mix business with fun, thereby boosting their morale and mental fortitude. Meanwhile, Wunderlich, Gustafsson, Hamari, Parvinen and Haff (2020) corroborate this view by postulating that if tailored to customer specifications, game elements can easily embed the culture of innovative thinking because they encourage players to think out of the box. Wunderlich et al. (2020) further argue that innovative thinking often leads to operational excellence.

The question of whether serious games can be a real game changer and panacea to the chronic challenge of fundraising besetting small firms across the globe has not been satisfactorily and thoroughly explored in existing literature (Boboc et al., 2018). The World Bank (2021), also cited by the IMF (2021) and echoed by

the South African Reserve Bank (2022), is concerned that despite several past efforts to demonstrate the case for developing a serious games teaching template for small firms experiencing record-high loan rejection rates, the challenge persists albeit at an alarming rate. Observations by Rahayu, and Purnawan (2018) note with concern that unlike in advanced economies where skills transfer programmes targeting small firms are systemically and organically gamified, the same is not accurate in developing countries. This observation is even though the problem of high loan rejection rates is allegedly profound in developing countries (World Bank, 2021).

However, despite all these pertinent concerns, one critical viewpoint is that making serious games a central feature of the new fundraising teaching program for small firms needs to be warmly embraced. Such a move will not only revolutionise the fundraising journeys of small firms but also act as an effective remedy to the high loan application rejection rates facing small firms in South Africa. Against this backdrop, this study seeks to evaluate the educational effect of a recently designed fundraising quiz game played by 22 owners/managers drawn from South Africa's Gauteng provinces.

1.1. Problem statement

Collins, Kofi and Bright (2020) worry that many small firms lack the necessary skillsets or the requisite experiences to pitch for funding from mainstream financial markets successfully. As a result, most of their loan applications persistently suffer needless rejections (Moreira, 2021). Several studies conducted by the IMF (2021), World Bank (2021) and the IFC (2021) serve to reaffirm this sad reality. For instance, a study by the IMF in 2021 revealed that out of the thousand small firms that applied for funding during the Covid-19 period, only 9 per cent received the funding, implying that a whopping (91 per cent) were rejected (IMF, 2021).

The underlying causes of persistently low loan approval rates are not new. Instead, the causes are well-documented in the literature. Common causes include inter-alia, poor pitching aptitude (Berger and Udell, (2019), lack of precise understanding of the qualification criteria (Collins et al, 2020), and burdensome documentation, which is often compounded by an emotionally draining application process (Collins et al., 2020). Meanwhile, Bell, Goga, Mondiswa and Roberts (2018) warn that the inability of startups to lodge winning funding requests continues to expose them to existential liquidity risks.

Consequently, several at-risk small firms are reportedly battling to pay their bills (IMF, 2021). In worst cases, hard-hit firms are forced to either close shop or scale down their operations (Bosiu, Goga & Nyamwena, 2023). Bosiu et al. (2020) identified poor fundraising skills as the most significant trigger perpetuating this high rejection rate. According to Bell et al., (2018), the persistent nature of the problem requires that a new paradigm shift in teaching fundraising skills to small firms be advanced. As argued by this paper, this new teaching paradigm leverages the strengths of serious games to embed better pitching skills and practices in small firms.

1.2. Research objectives

This study is premised on three objectives, namely:

- (i) To examine serious games as a tool for imparting fundraising skills to small firms.

- (ii) To measure the teaching effect of a fundraising quiz show on small firms based in Gauteng Province of South Africa,
- (iii) To explore measures on how the teaching effect of a fundraising quiz show may be enhanced.

1.3. Research questions

To address the above-stated objectives, the following three questions were posed:

- (i) What is the general impact of serious games as an effective teaching tool for imparting fundraising skills to small firms?
- (ii) Based on the lived experiences of those who played the quiz game, how did it affect their fundraising skills?
- (iii) What can be done to improve the teaching effect of the quiz game on the fundraising experiences of small firms?

2. Literature Review

Tan and Saucerman (2017) maintain that the use of serious games as a dependable tool for teaching and learning dates back to ancient times when military schools in India used serious chess games to boost the combat tactics and morale of army commanders. In buttressing this view, Vlachopoulos & Makri (2017) concede that by integrating the serious game of chess into the army commanders' training menu, the idea was not only to help inculcate the virtues of patience and endurance but also to enhance their creative thinking and problem-solving aptitude drastically.

Yanez et al. (2017) believe that although serious games have been an integral part of society for centuries, the scale of their application and level of influence in society significantly evolved. Whilst in the olden days, serious games were used to inculcate a resilient and winning mentality in players, Zimmerling, Hollig, Sandner, and Welp (2019) observed that in today's fast-paced learning environment, games are increasingly being used as a powerful and dependable instructional tool in the skill development space. Others like Yanez et al. (2017) hail serious games for laying the foundation for critical and analytical thinking. For example, a seasoned Sudoku player's mind is conditioned by the game not only to remain calm under intense pressure but also to be calculative and opportunity-seeking (Yanez et al, 2017).

On the other hand, Warmelink, Koivisto, Mayer, Vesa and Hamari (2020) recognise the role of digitalization in revolutionising the way serious games are applied in society. They concede that unlike in ancient times, where serious games were less automated, modern-day serious games are unique in that they are widely predicated on digitization. The rapid digitalization of game elements, which is currently in full swing, has been cited several times by Warmelink et al. (2020) as their central turning point. Whist Vlachopoulos and Makri (2017) admit that serious games are an old phenomenon in the teaching field; they also insist that digitalization remains central to their acceptance as a vital pedagogical tool.

The pedagogical and intellectual value of serious games, both in the teaching and training profession, is widely acknowledged in literature (Vlachopoulos & Makri, 2017; Wanick & Bui, 2019; Warmelink, Koivisto, Mayer, Vesa & Hamari, 2020). Recently, several researchers have shown significant interest in the subject. For example, Wunderlich et al. (2020) observe that many training organisations now use serious games as a

dominant instruction transmission tool in the classroom. Wang (2017) and Boboc et al (2018) join the renowned researchers who strongly advocate using serious games as one of the most resourceful instructional instruments. Tan & Saucerman (2017), cited by Boboc et al. (2018), note with keen interest that the use of serious games as essential vehicles for imparting context-specific knowledge continues to increase in frequency and significance.

Exponents of serious games cite three main driving factors as behind their surge in popularity, namely, their exceptional ability to leverage the confluence between games and digital technologies (Yanez-et al., 2017), their proven ability to drive high learner engagement rates and its profound emphasis on learner-centred instructional methods. Serious games have a strong focus on the learner. By thrusting the learner into the driving seat of the knowledge acquisition transaction, Boboc, et al. (2018) and Wunderlich et al. (2020) argue that serious games tend democratizing learning.

Chaiyo and Nokham (2017) note that serious games can guarantee high engagement and motivation rates by ceding the learner's control of the learning process. The primary idea of using serious games is not only to democratize learner transactions but also to reassert the influential role played by the learner in the learning process Jeanine Krath, Schürmann, Harald & von Korflesch (2021). This engagement value of serious games is often maximized by infusing exciting entertainment features into the games.

Chaiyo and Nokham (2017) attribute this steady rise to two main reasons – their extensive focus on using critical thinking to solve complex societal problems and their sharp focus on situated or collaborative learning. In their view, games are gaining traction for their ability to enrich or sharpen a participant's knowledge and decision-making prowess while simultaneously delivering total entertainment and intellectual value. Moreover, Tan and Saucerman (2017) assert that in most cases, knowledge generated from such games is predominantly organic and highly contextualized, making it one of the most highly accessible learning platforms.

To demonstrate the contribution of a serious quiz game to startups, Chaiyo and Nokham (2017) posit that apart from testing one's mental fortitude and cognitive resilience, they are also known for their ability to foster a solution-oriented mindset. According to Chaiyo and Nokham (2017), quiz game participants are challenged to think out of the box and build game players' problem-solving capabilities. The posture taken by Chaiyo and Nokham (2017) may help to explain why serious game players often place a high premium on quiz games that are both knowledge-intensive and highly engaging.

In portraying mind games as a vital teaching tool for startups suffering from the chronic challenge of poor pitching skills, Wang (2017) argues that serious games can boost the intellectual capital of budding entrepreneurs besides incentivizing and reinforcing positive fundraising behaviors. This boost can, in turn, broaden their knowledge and understanding of the nuts and bolts of fundraising (Uçar and Kumtepe, 2017).

Meanwhile, not every scholar agrees that serious games should play a significant pedagogical role in the classroom. Uçar and Kumtepe (2017) argue that whilst the pedagogical role of serious games has never been seriously questioned by researchers, the scale and degree of their impact on learning outcomes continue to divide scholars. Tan and Saucerman (2017) highlight that serious games have their fault lines. Some of the fault lines are self-evident in literature. The first concern Wall et al. (2017) raise is that serious games often

invest too much emphasis on the entertainment element. Over-emphasis on the entertainment aspect of serious games is problematic because it can potentially erode their teaching and intellectual value. To mitigate this challenge, Tan and Saucerman (2017) underscore the need to ensure that game elements are designed to have a deliberate bias towards the teaching element.

Uçar and Kumtepe (2017) cast doubt on the net impact of serious games on one's demonstrable competence. They argue that the ability of an individual to master the playing of a serious game does not necessarily translate to his or her ability to demonstrate such mastery in a real-world context. In other words, serious games can only enhance one's abstract thinking skills and nothing further than that, implying that when faced with a real-world challenge, there are chances that a serious game champion may fail to display the same exploits.

However, despite such concerns, there is enough evidence in the literature to demonstrate the multiplier effect of serious games in the education and training fields. Serious games are commonly used as an instructional tool of choice in the training and education fields (Susi et al., 2019; Laamarti et al., 2014; Gloria et al., 2020;) construction safety (Dickinson et al., 2021; Lin & Son, 2021; Guo et al., 2020,) evacuation process training (Rüppel & Schatz 2021, Feng et al., 2020) give credence to such claims.

2.2. Buspro Quiz Game Design

A Business Plan Quiz game codenamed BusPRO QUIZ was designed to equip and leverage the pitching skills of small firms using the serious quiz game as an instructional tool of choice. The game consisted of 10 quiz questions that were loaded with three themes, namely,

- (a) the financial dimension of pitching,
- (b) the marketing dimension of pitching, and
- (c) The creditworthiness dimension of pitching.

Four questions tested the players' proficiency in the financial dimension, three had a bias towards the marketing dimension, and the rest (three) tested the creditworthiness dimension. The quiz questions that were posed were informed by three critical standpoints, namely,

- (i) questions that banks and DFIs frequently use to interrogate the bankability and creditworthiness of the borrower,
- (ii) questions that sought to sharpen the entrepreneurial acumen of the borrower and
- (iii) Questions that sought to instill a good repayment culture.

Players were requested to choose whether a particular bankability parameter was true or false. For every correct answer, the player earned a point. These points were added to give each player a total score, then converted to a percentage. Table 1 below provides a list of ten quiz questions. Besides detecting each player's pitching skill gaps, the game also laid the basis for maximising future game experiences.

Table 1: BusPro Quiz Questions

	True	False
1. A detailed business plan is not a key requirement when applying for funding		
2. Cost of sales is equal to Opening stock plus new stock purchases minus closing stock		
3. Demonstrating the existence of a market for your products and services is an integral requirement for securing funding		
4. Cash is an example of an asset		
5. Gross profit minus operating expenses gives a net profit		
6. An off-take agreement or purchase order increases the chances for the business to secure funding		
7. Cash flow projections are not often required when applying for funding		
8. A business must be registered and in good standing with tax authorities		
9. Demonstrating the cost of items that requires funding with quotations is not necessary for funders		
10. The capacity to undertake the business through skills and expertise should not be demonstrated when applying for funding		

Source: Researchers' design (2023)

Besides testing the participants' business pitching aptitude, the Quiz game also tested their entrepreneurial acumen. The quiz game and the feedback survey were distributed to 50 small enterprise owners whose past funding requests were reportedly rejected by banks or other financiers. Figure 1 is a schematic representation of the quiz game.

Figure



1:

BusPro Game Quiz:Source: Researchers' design (2023)

3. Methodology

3.1 Research Design

In order to develop a captivating game architecture that unleashes optimum engagement and entertainment value and to enable the testing of its efficacy and applicability in the areal SME educational context, the paper's methodological convictions are premised on the design science research construct. In the view of (Peffer, Tuunanen, Rothenberger, and Chatterjee, 2019), DSR is helpful in contexts where the need to pilot-test the novelty and efficacy of a design is a critical imperative. Vom Brocke, Fettke, Gau, Houy, Maedche, Morana, and Seidel (2017) assert that this fulfilling experience is often measured by proxies such as entertainment, knowledge-imparting, monetary, and engagement value. To this end, serious games with thrilling entertainment features and optimum intellectual gains tend to generate better market appeals and higher participation rates than less entertaining ones (Walls, Widmeyer, and El Sawy, 2017).

3.2 Sampling

3.2.1 Population

Approximately 50 small business owners who previously applied for funding with various development financing institutions constituted the study population. The decision to target only fifty participants was influenced mainly by two main factors, the need to pilot-test the serious quiz game with few participants to gauge its applicability before it is launched on a large scale and the need to target conveniently accessible SMEs as part of elaborate measures to mitigate time and cost constraints.

3.2.2 Sampling procedures

A purposive sampling method was preferred because it scheduled an opportunity for the researcher to handpick participants with a history of unsuccessful loan application requests. Using purposive sampling implied that the researchers used their exceptional knowledge of the phenomenon to target participants experiencing high loan rejection rates. In a nutshell, the idea was to target small firms with a relatively poor loan approval record. This non-probability sampling criteria was employed to give the researcher leverage over the participant selection activity (Leedy & Ormrod, 2015).

3.2.3 Sample size

Out of the 50 earmarked participants, only 22 (44%) effectively participated in the post-game evaluation session. The 66 percent who did not participate cited time constraints, work overload and other commitments as the main militating factors.

3.2.4 Data collection

The participants accessed the questionnaire through a Google link that was electronically shared with them. As observed by Google, the link is widely known for giving participants relatively easy and seamless access to the questions and allowing them to send back their responses for analysis in real-time. The responses were then retrieved, sorted, and organized for analysis.

3.2.5 Data analysis

The retrieved data was sorted before it was arranged into five themes. These themes aligned seamlessly with the study's objectives for coherence reasons (Leedy & Ormrod, (2015). Subjecting the data to thematic

analysis made it easier to interrogate data patterns and identify dominant and cross-cutting themes emanating from the retrieved data. As Creswell (2015) advocated, the analysis activity followed five intertwined phases. The first phase involved studying data patterns, the second phase involved generating codes, and the third and fourth phases involved developing appropriate themes and locating exemplars. The five themes were inter-alia, (1) educational and information value, which gauged the game's educational content (2) level of interactivity, which assessed the game's engagement value (3) knowledge application experience, which assessed the willingness of the players to applied insights gained in a real fundraising context (4) helpfulness which evaluated the value the players attached to the game and (5) referral effect which evaluated their willingness to recruit their friends and relatives into the game.

3.2.6 Design of the questionnaire and data collected

An evaluation tool containing at least five multiple-choice questions was used to gauge the lived experiences of those who played the quiz game. To be specific, the following questions were posed:

- (a) Was the quiz educative and informative?
- (b) Did you find the quiz interactive?
- (c) Will you use the information gained in your next loan request application?
- (d) Do you think the quiz features were valuable and helpful?
- (e) Will you invite other small business owners to play the quiz?

4. Theoretical Construct

This study derived its theoretical underpinnings from two leading theories- the Situational Learning Theory (SLT) and the Constructivist Theory (CT). An elaborate discussion of the theories and their implications for this study is summarized below:

4.1 Situational learning theory

Developed and popularized in the 1990s, the situation theory is the brainchild of Jean Lave and Etienne Wenger. The theory holds that for a learning transaction to yield exceptional impact, there is a need to pay attention to the context and social interactions that define its learning process. Suo and Zalika (2018), echoed by Wenger-Trayner (2015), concur with this view by postulating that meaningful learning can only be realised when participants actively engage in genuine real-life activities.

As Tan and Saucerman (2017) suggested, the theory acknowledges that knowledge is not just acquired through abstract concepts and detached instruction but is effectively imparted within a particular community's unique social circumstances and cultural orientation. In other words, the theory recognizes that learning can generate optimum results when learners openly interact and engage in tasks and activities relevant to their real-life experiences.

Suo and Zalika (2018) further underline the need to build a learning platform that allows learners to engage in actual context-specific practices to encourage a meaningful and fulfilling knowledge and skills transfer experience. The theory was influential in designing a highly customised serious quiz game. This theory

enjoined the researchers to frame a quiz question strongly linked to the daily fundraising realities and struggles facing small firms.

4.2 Constructivism Theory

The constructivism theory, which was first conceptualised and popularised by Cobb in 1994, holds that for a learning transaction to yield tremendous impact, the first critical step is to put the learner on the forefront or centre of the learning activity—implying the centrality of a learner-driven teaching effort (Heddy & Sinatra, 2018). In the view of Taber (2017a) it also implies that learners must not be treated as mere recipients of information or knowledge but rather as active agents capable of directing and influencing the knowledge acquisition process.

Sjoberg (2018) asserts that under such a setup, the teacher is a mere facilitator with no vested power to impose his or her opinions on learners. Learners frequently use their experiences and unique circumstances as building blocks for new knowledge and realities (Mansour & Wegerif, 2019). This means that learners are granted the exclusive right to use their cognitive thinking to interpret the meaning of their reality. In other words, the theory underlines the centrality of allowing game players to create new knowledge by tapping into their cognitive resources. It is important to note that this study is not the first to apply the constructivism theory.

The theory is built on five philosophical constructs, namely, that (1) people are the real masters of their learning (Chiari & Nuzzo, 2016), (2) that learning is a total of one's unique experiences (Heddy & Sinatra, 2018), (3) that if confronted with new facts and evidence human beings are ready to both unlearn and relearn (Taber, 2017a), (4) that learning is both an active and contextual effort (Taber, 2017b) and (5) that effective learning is realised when the learning process is highly personalised and built on the strengths of learner's cognitive traits (Taber, 2017b; Mansour & Wegerif, 2019). Similar studies that underpinned their studies on the same paradigm include, among others, Chiari & Nuzzo (2016), who used the theory to evaluate the effects of serious games on students' performance; Sjoberg (2018), who used constructivism theory to demonstrate the impact of serious games on the performance of university students. The constructivism theory was deemed relevant to this study because, as advocated by Taber (2017b) and echoed by Sjoberg (2018), it provided the basis on which a learner-oriented fundraising teaching and learning environment was designed.

5. Results and Discussion

This section shares the outcome of the lived experiences of small business owners who participated in the BusPro Quiz game. Twenty-two (22) participants completed a feedback tool to ascertain whether the quiz indeed and effectively imparted or transferred desired fundraising knowledge, skills, and insights. In other words, the tool allowed participants to gauge the intellectual and educational value of the BusPro Quiz game and its entertainment worth. This feedback was measured using the Lickert Scale tool. Against this backdrop, five reflective questions were posed, and participants elected whether they agreed or disagreed with the given propositions. The following represents the significant findings of the survey.

5.1 ***Educational and Informational Value***

At the core of the BusPro Quiz game remained the need to create, capture, and offer players maximum educational and informational value. In other words, the primary mission of this game was not only to bridge the fundraising knowledge gap but also to sharpen their fundraising pedigree and acumen significantly. When asked whether the quiz game improved their understanding and knowledge about pitching for funding, 93% of the players agreed. In comparison, only 7% expressed a different view, indicating that the game effectively instilled new fundraising behaviors and practices.

5.2 ***Level of interactivity***

By ascertaining the game's degree of interactivity, the idea was to test its engagement value and ability to generate better interfaces and connectivity experiences. When asked whether the game delivered optimal interactivity value, those who agreed with this assertion were in the majority, 93%, while those who expressed a different opinion were in the minority, 7%, perhaps indicating that the game passed the interactivity test.

5.3 ***Application of knowledge or information gained.***

The issue of whether the participants intended to use the information or knowledge gained from the game to enrich and improve forthcoming funding application requests was examined. Regarding this crucial imperative, 93% of the participants desired to utilize the knowledge gained to enrich their future fundraising efforts, while 7% expressed a contrary view.

5.4 ***Helpfulness of Quiz features***

Concerning whether the main features of the quiz had a propelling effect or a positive net effect on their fundraising journeys, approximately 93 percent of the participants reaffirmed its game-changing effect. In comparison, only a minority (7 percent) shared a different view, probably signifying the game's catalytic effect and centrality to the SME fundraising ecosystem.

5.5 ***Referral effect***

The aim of asking whether the participants were likely to invite their business friends to play the quiz was to gauge the game's total referral value and evaluate its future influence and impact on the local SME fundraising space. Regarding this issue, most participants (93 percent) expressed their intention to enroll their friends in the game, perhaps demonstrating their confidence and faith in the quiz.

6. **Discussion**

It is encouraging and exciting to note that the game effectively achieved its goal of creating, capturing, and delivering optimal educational, informational, and entertainment value to participants. This reality resonates with the view of Chaiyo and Nokham (2017), who re-emphasise the need to opt for game options that offer better educational returns as measured by proxies such as the level of creative thinking inculcated, problem-solving skills embedded, and the level of awareness and appeal generated by the game.

The fact that most participants strongly felt that the game was helpful and applicable in their unique fundraising settings effectively underscores the need to integrate the BusPro quiz game into existing

fundraising skill enhancement programs for SMEs. This view is buttressed by Tan and Saucerman (2017) when they argued that what makes a serious quiz game stand out is its exceptional ability to use highly interactive game features to impart context-specific knowledge.

Most importantly, Basuk and Hidayati (2019) reiterate the need to ensure a new quiz game attracts a sizeable number of first-time players as part of attempts to improve its future appeal and positive approval rating. Boboc, et al. (2018) and Wunderlich et al. (2020) buttress this view by cautioning that if not backed by a vibrant awareness campaign, a well-designed quiz game can fail to generate desired appeal and reach rates. Contrary to this view, the BusPro Quiz game did not command sufficient buy-in from the target group, probably because it was poorly marketed.

However, despite its widely acknowledged pedagogical value, there is no denying that its impact could have been enhanced if more people had played it. Out of 50 earmarked players, only 22 effectively provided feedback on the BusPro Quiz, which is quite concerning. In future, there is a need to step up efforts to recruit more first-time players. Equally important, there is a need to ensure scale-up efforts to sensitize more SMEs about the game's unique selling propositions.

Four critical takeaways emerged from these findings, namely, (1) the instructional potential of the BusPro quiz game was unequivocally reaffirmed by the majority of players (Rahayu & Purnawan, 2018), (2) the midwifery role played by user-interface features and (3) the need to ensure the questions posed are tightly linked to current trends in the ever-changing global fundraising terrain (Zhao, 2019) and (4) the need to enrich the quiz's educational content as part of efforts to maximize its value and reach (Basuki and Hidayati, 2019).

Uçar and Kumtepe (2017) echo this assertion by underscoring the need to use mind games to accelerate the knowledge acquisition experiences of participants. This study makes two crucial reflections in this regard. The first reflection is that serious quiz games can only be a trusted source of cognitive and experiential knowledge if their unique selling propositions are effectively communicated to intended beneficiaries. Secondly, as observed by Suo and Zalika (2018), this study similarly underlines the need to maximize the pedagogical value of games. However, despite its striking similarities with existing scholarly insights, what distinguishes these findings is their incomparable ability to underscore a quiz game's pedagogical and entertainment significance.

7. Conclusion and Future Work

Due to its exceptional interactive features, the quiz game is instrumental in leveraging the participants' fundraising skills, knowledge, and experiences and effectively stimulates their critical thinking experiences. Due to their increasingly educative and entertaining content, serious fundraising games are rapidly growing in appeal and intellectual significance. The quiz's widely acknowledged entertainment value and ability to impart authentic and real-life knowledge and context-specific information about a well-defined subject matter of interest make these games popular. Thus, quizzes that generate maximum educational value appeal more than those deemed less educative and entertaining. This view explains why there is a need to design and implement a game-oriented tool that can be used to educate and familiarize small firms with vital

clues or tips on how to pitch their financial requirements successfully. Such a tool will also place participants in an excellent position to submit bankable and feasible business plans, thereby reducing needless loan application rejection rates.

8. Recommendations

Although the quiz's pedagogical potential was widely recognized and confirmed by most participants, it needs to enhance its entertainment features to extract optimal entertainment value from it. Moreover, considering that the quiz's engagement value was lowly rated compared to other measurement proxies, it is recommended that the interactive features of the future quiz game be modified with the view to scale up its user interface experiences. Most importantly, some of the quiz questions must be remodified to improve their rating and future usability. Most importantly, it is recommended that some quiz questions be continuously remodified to accommodate the newest pitching trends and practices, especially given the fast-paced changes in the global fundraising terrain.

Equally important, considerations should be made to optimise the game's future usability to increase its approval ratings. As argued by Chaiyo and Nokham (2017), high user approval ratings remain the hallmark of a thrilling and thought-provoking quiz encounter. Lastly, there is a growing need to ensure that the unique value propositions of the BusPro Quiz game are vibrantly and proactively communicated to potential beneficiaries as part of efforts to improve its appeal and reach.

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Enhancing Book Classification Efficiency: A Comparative Analysis of Technology-Driven Approaches

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Abstract

As the number of books available in the public domain increases, there is a growing need for inexpensive and efficient classification of these books into categories. While traditional classification systems like the Dewey Decimal Classification and the Library of Congress Classification are still in use today, technology can simplify the process. This paper explores the use of Latent Dirichlet Allocation (LDA), a form of topic modeling, to classify books into categories and compares its performance with other machine learning models. The LDA model achieved an accuracy of 32.29%, while the Naive Bayes, Support Vector Machine, and multinomial Logistic Regression models outperformed it with accuracies of 85.45%, 86.12%, and 85.12%, respectively. This research emphasizes the need for scalable and cost-efficient solutions in categorizing the expanding pool of books within the public domain. Leveraging technology can effectively address this challenge. The comparative analysis of machine learning models offers valuable insights into their potential for enhancing classification accuracy and streamlining the categorization process, thereby opening promising avenues for future development in this field.

Keywords: Public domain, classification, technology, Latent Dirichlet Allocation (LDA), machine learning models.

1. Introduction

Living in the digital age has revolutionized access to books, magazines, and news articles, as they are increasingly available in digital formats. However, this abundance of digital content has introduced new challenges in storing, classifying, and retrieving information efficiently. The conventional methods of classifying books in libraries, such as the Dewey Decimal Classification and the Library of Congress Classification, are time-consuming and resource-intensive due to their manual nature. Libraries, just like digitized texts, face similar obstacles in retrieving relevant information. Thankfully, advancements in Natural Language Processing have opened avenues to apply machine learning techniques, particularly topic modeling, to automate text classification and overcome these challenges effectively.

The primary objective of this research is to employ Latent Dirichlet Allocation (LDA), a form of topic modeling, to assist in the classification of books within libraries, while also evaluating the performance of topic modeling against other machine learning techniques. To train the LDA model, headlines from articles published between 2012 and 2022 were utilized, resulting in an accuracy of 32.29%. In order to provide a comprehensive comparison, Naive Bayes, Support Vector Machine, and multinomial Logistic Regression models were trained on the same dataset. The Naive Bayes model achieved an accuracy of 85.45%, while the multinomial Logistic Regression model achieved 85.12%. Notably, the Support Vector Machine outperformed the other models with an overall accuracy of 86.12%.

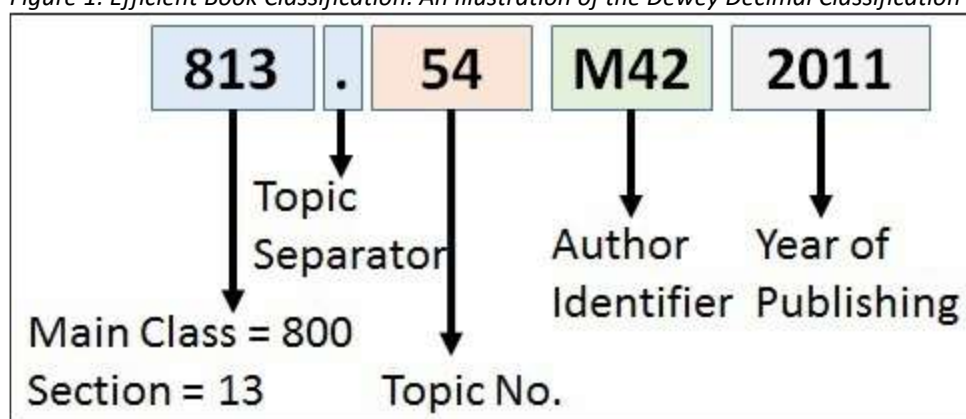
By leveraging the power of machine learning and topic modeling, this research addresses the pressing need for efficient book classification in libraries and demonstrates the superiority of certain models over traditional methods. These findings hold great promise for improving information retrieval and advancing the field of automated text classification in the digital era.

2. Background

Dewey Decimal Classification

The Dewey Decimal Classification is a library classification system that was adopted in libraries in the late 1800's to allow for new books to be placed in specific locations of a library based on its category/genre. The system makes use of numbers to classify the books into categories and sub-categories with the first three digits before the period representing the category and the three digits after the period representing the sub-category. The three letters that follow the digits are used to represent the name of the author or the title of the book. After being manually classified by a librarian, the books are sorted linearly and stored in specific parts of a library (Bhattacharjee 2010).

Figure 1: Efficient Book Classification: An Illustration of the Dewey Decimal Classification



Dewey Decimal Classification

Topic modeling is an unsupervised classification method used for analyzing unstructured data, similar to clustering numeric data. It aims to identify natural groups of objects, even when the desired outcome is unknown. One of the earliest topic models developed was the Probabilistic Latent Semantics Analysis (PLSA) model. However, as mentioned in [4], the PLSA model had limitations, such as overfitting. Additionally, [5] referred to the PLSA model as "inherently transductive," indicating that it could not be effectively applied to new documents once the model was trained.

Latent Dirichlet Allocation

To address the issues of earlier topic models, [1] proposed the Latent Dirichlet Allocation (LDA) model in 2003. The LDA model is a generative model that attempts to find the topic a document in corpus belongs to based on the words in the document. More intuitively, each document in a corpus can be represented as a distribution of topics, and each topic can be represented by a distribution of words [2].

The LDA makes the following assumptions:

- bag of words assumption - in which the order of words does not matter but rather the frequency of words
- and there is a predefined number of classes k . After having a selected predefined number of topics k and randomly assigning them to each word in a document, the model goes through each document in the corpus and calculates the following probabilities:

- i. $p(t|d)$: that determines the probability that a word belongs to a topic t given a document d .
- ii. $p(w|t)$: that determines the proportion of documents that belong to a topic t given a word w . Which are then repeated multiple times and the model updated.

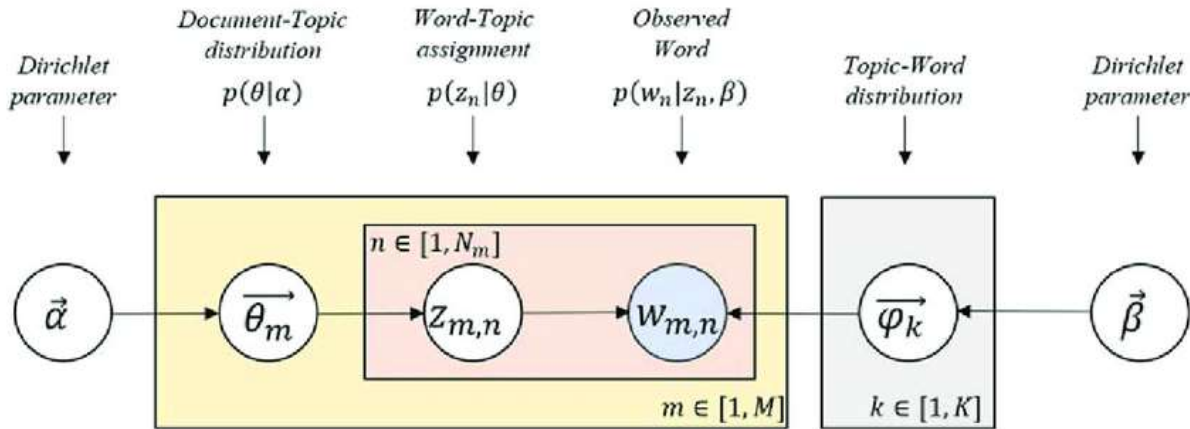


Figure 2: Graphical representation of the LDA model.

2. Related Work

This section discusses previous studies on the use of the LDA model in different fields. However, there is limited literature on using topic modeling for book classification.

One study by Lin et al. (2013) demonstrated the usefulness of the LDA model in analyzing social media posts. They addressed the issue of a "cold start," where recommendation systems struggle with new users. The authors proposed using "pseudo-documents" to represent app followers as "pseudo-words." Their goal was to predict how likely a target user would like an app. The study used Twitter data from September to December 2012, and the results showed that applying the LDA model outperformed other recommendation systems.

Another study by Xianghua et al. (2013) explored the use of the LDA model in analyzing social media posts. They extended the LDA model to develop a model called Multi-Aspect Sentiment Analysis for Chinese Online Social Reviews (MSA-COSRs). This model was used for sentiment analysis on reviews. It differed from the traditional LDA model by applying LDA to the data first and then using a sliding window approach to extract local topics and associated sentiment. Although the model was specifically designed for Chinese reviews, the same methods could be applied to different data to determine sentiment and associated local topics.

While the LDA model is useful for topic modeling, it has limitations. Titov & McDonald (2008) pointed out that the standard LDA model produces topics that respond to global properties, lacking nuance. To address this, they proposed the Multi Grain LDA (MG-LDA) model, which incorporates a sliding window approach to draw word distributions for both global and local topics. Each window in the document is associated with a distribution to define the preference of local versus global topics.

Titov & McDonald (2008) trained LDA and MG-LDA models using Gibbs sampling on three sets of data, including reviews for MP3 players and restaurants from Google Product and Local Search. The MG-LDA model produced more semantically coherent results for the MP3 dataset compared to the LDA model. However,

neither model performed well for the restaurant dataset, likely due to the shorter length of restaurant reviews (average of 4.2 sentences), which posed a challenge for the models.

Dube & Ajoodha (2021) also attempted to use the LDA model for library book classification. They noted that the LDA model struggles when the content of the training corpus documents is too small. To overcome this, they proposed a hierarchical topic modeling system with two stages called Dirichlet Multinomial Mixture mode (GSDMM) and latent Dirichlet allocation (LFLDA) on smaller datasets. Wang et al. (2017) also applied their model to social media posts, similar to the previous studies mentioned. In their research, Dube & Ajoodha (2021) used a semi-supervised approach by combining the LDA model with a Support Vector Machine to categorize headlines from the "News From India" dataset into four categories. The results indicated that the LDA model performed poorly with an accuracy of only 28.1%, while the Support Vector Machine achieved an accuracy of 79.8%.

3. Research Methodology

This paper aims to classify news articles into their appropriate categories using the headlines as features. The following models are utilized: Latent Dirichlet Allocation (LDA) model, Naive Bayes model, Support Vector Machine (SVM) model, and multi-modal Logistic Regression model.

Dataset and Feature Selection

The "News Category Dataset" used in this research, compiled by Misra (2022), contains a total of 210,000 headlines from the Huffington Post spanning the years 2012 to 2022. The dataset includes six features: 'category', 'headline', 'authors', 'link', 'short description', and 'date'. For this study, the 'headline' and 'category' features were chosen as the primary focus. To create a balanced dataset, only five categories were selected: 'BEAUTY', 'ENTERTAINMENT', 'POLITICS', 'TRAVEL', and 'WELLNESS'. The final dataset was divided into a training corpus, consisting of 6,750 samples for each category, and a test corpus, containing 2,250 samples for each category.

Data Preprocessing

To prepare the data for modeling, several preprocessing steps were applied:

- i. Lowercase and Punctuation Removal: All words in the headlines were converted to lowercase, and any punctuation marks were eliminated.
- ii. Word Tokenization: Each headline was split into tokens, separating them into individual words.
- iii. Stopword Removal: Stopwords, which are common words like 'are', 'and', 'as', etc., were removed from the tokenized headlines.
- iv. Lemmatization: All tokens were lemmatized, meaning they were reduced to their base or dictionary forms.
- v. Bag of Words: The training and test corpora were transformed into a bag of words representation, where each headline was represented as a vector of word frequencies, enabling the models to interpret the data.

3.1 Theoretical Setup

For the implementation of the models, specific Python packages were utilized:

Gensim: This package was employed for the LDA model.

SKLearn: The SKLearn library was used for implementing the Naive Bayes (MultinomialNB), Support Vector Machine (SGDClassifier), and multinomial Logistic Regression (LogisticRegression with 'sag' solver) models.

Evaluation Metrics:

To assess the performance of the LDA model, the following evaluation metrics were employed:

- **Perplexity:** Perplexity is a measurement used to evaluate the predictive capability of a probability model. A lower perplexity score indicates better predictive performance.
- **Topic Coherence:** Topic coherence is an evaluation metric that quantifies the similarity between words frequently associated with a particular topic. Higher coherence scores indicate more coherent and meaningful topics.

In addition to these metrics, the accuracy of each model was calculated by dividing the number of accurately predicted samples (Predicted) by the total number of samples (Total), using the formula provided ($\text{Accuracy} = \text{Predicted} / \text{Total}$). This accuracy score helps to gauge the overall performance of the models in correctly classifying the news articles into their respective categories.

4. Results

The outcomes of the models used in this research will be presented and discussed in this section. The LDA model had a perplexity of -9.64866 and a coherence of 0.30841. The LDA model achieved an accuracy of 32.29%, while the Naive Bayes, Support Vector Machine, and Logistic Regression models achieved accuracies of 85.45%, 86.12%, and 85.12%, respectively. A summary of how well the models predicted the correct category is presented in the form of a confusion matrix. Figure 3 shows the confusion matrix for the LDA model, Figure 4 for the Naive Bayes model, Figure 5 for the Support Vector Machine model, and Figure 6 for the Logistic Regression model.

Table 1: Summary of results

LDA	32.29%
Naïve Bayes	85.45%
Support Vector Machine	86.12%
Logistic Regression	85.12%

The evaluation metrics suggest that the LDA model performed comparatively worse than the other models used in this research. It is important to note that since the LDA model is an unsupervised model, labels had to be manually assigned to each category based on the word associations for each topic.

5. Conclusion

Recognizing the challenges libraries face in retrieving information due to the growing number of books, the utilization of the Latent Dirichlet Allocation (LDA) topic model was investigated as a potential solution to enhance efficiency. However, it was observed that the LDA model exhibited poor performance compared to other machine learning models, achieving an accuracy of only 32.29%. In contrast, the Support Vector Machine (SVM) model emerged as the top performer, attaining an accuracy of 86.12%.

The underwhelming results obtained from the LDA model can potentially be attributed to the limited size of the headlines in the training corpus. As the headlines were relatively small, the LDA model struggled to generate more accurate predictions. To address this limitation and improve the LDA model's accuracy, possible avenues for exploration include the adoption of extensions to the model, such as the Multi Grain

LDA (MG-LDA) model, or training the LDA model on a corpus with larger document sizes. These avenues should be further investigated in future research endeavors to enhance the LDA model's effectiveness and potential for information retrieval in library settings.

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Factors Influencing the Adoption and Usage of the Government Offices, Ministries, and Agencies' National One-Stop Portal System

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Abstract

The government of Namibia through the Office of the Prime Minister have implemented the National One-Stop Service Portal. The primary aim of the service portal is to provide a single standard gateway through which citizens, business partners and visitors to Namibia will easily access all government services online, 24/7. However, currently, not all government offices, Ministries and Agencies are using the National One-Stop Portal. When Offices, Ministries and Agencies are not using the National One Stop Portal, services delivery becomes costly both to the government and its stakeholders as the government spend more money on printing services, while citizens and business partner's costs rise due to the movement from one office to another in search of the various services. This study aimed to investigate and understand factors influencing the adoption and use of the National One-Stop portal for the Namibian Government Offices, Ministries, and Agencies systems. The study used a qualitative research approach. For data collection, semi-structured interviews were employed. Three ministries were selected as cases as they deliver a diverse range of services to citizens, businesses and other government offices.

Keywords: Adoption and Usage of ICT, E-government, National One-Stop Portal, Factors

1. Introduction

Governments worldwide have been taking advantage of ICT innovation and a fast-growing internet connection to implement e-government initiatives (Meacham et al., 2019). According to Mustaf et al.(2020), e-government is the use of information communication technology applications to improve transparency and effectiveness of government operations, such as providing citizens and businesses with online public services and information. Citizens, businesses, other organizations, and even government agencies benefit from e-government because it improves access to government information and service delivery (Mustaf et al., 2020). Malodia et al. (2021) further stated that e-government uses information systems to provide online public service to citizens and businesses.

Like other governments, the Namibia government realized the benefits of transforming public services online. In 2014, the government adopted its first e-Government Strategic Action Plan (Nakale & Chikohora, 2020). Its main aims are to:

- Improve public service delivery to citizens and businesses through the one-stop service portal.
- Reduce spending by government, businesses, and citizens through efficient and effective public service delivery that can be accessed from anywhere, at any time.
- Increase citizen participation in public service efforts by individuals, communities, organisations, and government agencies.

As a result, the government adopted the National One-Stop Portal for the implementation of the e-Government Strategic Action Plan (Ministry of Trade and Industrialisation, 2021).

National One-Stop Portal is a digital innovation that provides access to integrated government services to businesses, citizens, and other government agencies, through a single interface (Scholta et al., 2019). According to Meacham et al. (2019), citizens and businesses can use the National One-Stop Portal to request and receive a variety of services without having to visit government offices. Allowing citizens and businesses to access government services 24/7, from anywhere. Scholta et al. (2019), assert that the successful adoption and usage of the National one-stop portal reduces ambiguity and duplication of effort to improve citizen satisfaction by reducing processing time and mistakes.

Since the adoption of the National one-stop portal, very few services such as business registrations are provided and accessible through the portal (Ministry of Trade and Industrialisation, 2021). However, the majority of government services are still being offered manually by various ministries and agencies. Providing services manually requires citizens and businesses to physically visit the office premises in search of the services. Consequently, this hampers the government's effective and efficient service delivery as such citizens cannot access services from anywhere at their convenience. The National One-Stop Portal requires all public service information systems to be integrated enabling a single gateway for government services (Scholta et al., 2019). Currently, Ministries' and agencies' information systems are not interlinked to the portal.

According to Scholta et al. (2019), having a single gateway enables citizens and businesses to access services from all government offices through a single portal, using a single account. In addition, this reduces the amount of time needed for citizens and businesses to receive public services by streamlining administrative processes, lowering operational costs, and increasing public service accountability (Nguyen et al., 2018).

Hence, this study investigates the challenges faced by the Namibian Government Offices, Ministries, and Agencies when implementing their services on the government's National One-Stop Portal and develops a strategy for the Government Offices, Ministries, and Agencies' systems adoption and usage of the National One-Stop Portal.

2. Literature review

Various governments around the world have implemented e-government projects (Onyango & Ondiek, 2021; Mustaf et al., 2020; Al-Mushayt, 2019; Bakunzibake et al., 2019; Tiika & Tang, 2019; Twizeyimana et al., 2018). According to Al-Mushayt (2019), the European Union have implemented the e-government initiative well more than other regions, followed by USA, Asia, and Africa being the least implementer. Although Africa was rated the least when it comes to e-government implementation, notable achievements are also recorded in the continent. For example in Rwanda, The government has implemented information and communication technology as a means to elevate its status from a least-developed country to a middle-income country as part of its Vision 2030 plan (Twizeyimana et al., 2018). This enabled the government to transform 95% of its services online in 2018 (Twizeyimana & Andersson, 2019). This was achieved through the implementation of the legal and regulatory framework, Smart Rwanda Master Plan and the designing of a basic information and communications infrastructure. In Ghana, the government have implemented various ICT projects including online passport applications, online renewal of driver licenses and change of vehicle ownership systems (Bakon, 2021). Bakon (2021) further reported that the implementation of online services has eradicated corruption in the country. These e-government projects have enabled citizens and businesses to access the services online, eliminating the middlemen's operations in passport application and renewal. In Namibia, Frohlich et al. (2021) indicated that the key characteristics of e-government in Namibia

include ICT knowledge, a positive attitude towards technology, adequate infrastructure, affordable prices, security, and a community-based partnership strategy. Rijarua and Osakwe (2023) stated that the successful implementation of e-government objectives requires political support, government-wide support, adequate infrastructure, skilled personnel, a legitimate legislative framework, data availability, and citizen-centred solutions.

As much as governments have reaped the benefits of e-government implementation. E-government implementation also encounters several challenges, thus hindering its progress. It is reported by Mensah et al. (2020) that lack of budget is one of the challenges facing e-government implementation. Lack of funds hampers the implementation of e-government because insufficient funding for government offices limits the acquisition and development of infrastructures required for e-government.

The Lack of e-government strategies is another barrier to e-government implementation (Twizeyimana et al., 2018), E-government strategies enable the government to set its clear goal in terms of project implementation plan and management (Mensah et al., 2020). In addition, a lack of IT Infrastructure also contributes to e-government failure. Information Technology infrastructure is needed for citizens and businesses to access e-government services, while fast internet speed enables the fast request and response of services between citizens and governments (Mensah et al., 2020). Citizens and businesses in remote areas are facing challenges of limited access to computers and internet connectivity as well as electricity (Twizeyimana et al., 2018).

According to Yera et al. (2020), Governments with larger operational budgets, well-trained IT personnel, and technology infrastructure are more likely to implement their e-Government system successfully. However, Twizeyimana et al. (2018) urge governments that the e-government implementation challenges are not far from each other, as well as their solutions. Countries should learn from one another experiences, successes, and failures.

To improve public service delivery, governments implemented e-government initiatives such as the National one-stop portal (Sahebe et al., 2021; Bakunzibake et al., 2019; Obosi, 2019; Scholta et al., 2019). According to Sahebe et al. (2021), the implementation of the national one-stop portal in Azerbaijan has increased transparency in the government by eradicating congestion in government administration processes. In Ghana, services such as “(birth, marriage, and death), land management, driving licenses, business registration, road traffic, and motor vehicle inspection” are accessible through the National one-stop portal 24/7 (Twizeyimana et al., 2018). In Kenya, Obosi (2019) asserted that the mentality of assisting those whom you know was also eliminated in the government. Thus, offering equal services to the citizens and businesses.

However, the National One-Stop Portal also encounters challenges. According to Yli-Huumo et al. (2018), lack of interoperability and collaboration are some of the national one-stop portal implementation challenges. Government offices are faced with interoperability challenges between different government information systems because proprietary systems are incompatible (Maulana et al., 2020). This hampers the integration of systems from different government offices. The national one-stop portal requires the integration of different government office information systems into a single portal (Meacham et al., 2019). While Collaboration among government offices is also crucial to successfully implementing the national one-stop portal. Bakunzibake et al. (2019) further reported that business process reengineering is another challenge that needs reforming among different government offices. Tackling this challenge can be achieved through cooperation and coordination between the different government offices.

6 Research Methodology

This study used three organisations as cases namely: The Office of the Prime Minister (OPM), the Ministry of Home Affairs, Immigration, Safety and Security (MHAISS), and the Ministry of Industrialisation and Trade (MIT).

OPM was selected as a case because OPM through the Directorate of Public Service Information Technology Management (DPSITM) is the technical advisory unit responsible for driving the e-government initiatives implementation in the government (Office of the Prime Minister, 2014). Therefore, it will be good to understand and hear about the project's success and challenges from them.

The Ministry of Home Affairs, Immigration, Safety and Security is one of the ministries providing a wide range of services to Namibian citizens and most of the services have been automated. Thus, the need to integrate this ministry's systems into the national one-stop portal. While the Ministry of Industrialisation and Trade is selected as a case because the ministry has managed to implement the new system for the statistics subdivision under the Directorate of Industrial Development called DIDEES. The system integrates all the division's functions into a single platform and is accessible online (Ministry of Trade and Industrialisation, 2021). Hence, selecting the ministry to learn from their challenges and success

In this study, a semi-structured interview was employed as a data collection technique. semi-structured interview was used because it allowed the researcher to gather more data from the participants (Gabriel et al., 2020). Data was collected from the employees of the three ministries. Before data collection, the researcher carried out two steps. (1) Firstly the researcher developed data collection questions. The purpose of the data collection question was to guide the researcher and to maintain uniformity during data collection. The data collection questions were extracted from the three research questions.

Secondly, the researcher sought permission from the cases to conduct a study in their environment. To seek permission the researcher submitted a letter of request, proposal and consent form to the executive directors of the organisations. All three cases granted permission for the researcher to conduct the study.

Interviews were conducted face to face from the participant's office. Before the commencement of the interview, the researcher briefed the respondent about the study and what was expected from the participants. All interviews were recorded with a tape recorder. Before recording the researcher asked the participants for their permission to be recorded. Participants were briefed about how confidentiality and privacy will be maintained.

The participants were also presented with the informed consent letter for them to read through, familiarise themselves with what was expected from them and acknowledge their intent to take part in the research by signing the form. Participants from whom data was collected are explained in the tables below.

Table 6: Participants.

Cases	Participants	Reason
Ministry A	Participant 1	The technical expert participant with knowledge of e-government initiatives and information system implementation project experience.
	Participant 4	
Ministry B	Participant 2	
	Participant 3	
Ministry C	Participant 5	Business participant in the leadership position with knowledge of e-government initiatives and information system implementation project experience.

7 Data Analysis

In this study, a content analysis technique is employed for data analysis. According to Suh (2021), content analysis is a method of reducing texts, analysing them, and identifying themes as well as other pertinent information from the qualitative data whilst keeping the main research questions in consideration. Bahariniya et al. (2022) and Suh (2021) stated that in content analysis, the researcher identifies the presence of various themes, concepts, or other meaningful texts and their correlation. The analysis was carried out according to the four (4) stages as depicted in the figure below.



Figure 1: Content analysis process. Kleinheksel et al. (2020)

4.1 Stage1: Identify units of meaning

The data analysis process starts with the researcher first familiarising themselves with the data (Kleinheksel et al., 2020). Hence, the researcher first transcribed the recorded data from interviews. Secondly, the data was cleansed by inserting line numbers to ensure ease of reference. Then, the units of meaning were identified to make sense of the data. Here, the process started with the researcher highlighting the critical concepts from the interview data with a text highlight colour. the highlighted concepts were then inserted into a table indicating the theme, the line number where the theme was extracted, and the new line number. This was done to enable the researcher to label equivalent units with a code in the next exercise. At the end of this exercise, a total of forty-six (46) themes were identified.

4.2 Stage2: Label equivalent units with a code

In the second stage of data analysis, the researcher identified and labelled similar concepts with a code. Once similar concepts were labelled with codes, the codes were then classified, which helped to organise the data into categories. During this process, the researcher was guided by the research questions.

4.3 Stage3: Group Similar Codes into a category

This process started with giving meaning to the categories. At this stage, the researcher grouped similar themes into categories. From the forty-six themes identified in the first stage. The themes were reduced to 15 by grouping themes with similar meanings. The coded themes are indicated in the figure below.

Table 7: 2nd level –15 themes

1.	Online Accessibility	
2.	Insufficient Funds	
3.	Political Support	
4.	Systems Security	
5.	Systems Interoperability	
6.	Lack Of Software Developers	
7.	Standalone Systems	
8.	Ministries Websites	
9.	Ministries Collaboration	
10.	IT Personnel Training	
11.	Ministries Awareness	
12.	System Development Outsourcing	
13.	Top Management Support	
14.	Network Connectivity Challenges	
15.	Obsolete Technology Usage	

Themes were refined further to simplify them. The purpose of further reduction was to better organise a large number of codes with similar meanings. Six categories were merged to reduce the themes to 12 themes as indicated in figure 3 below.

Table 8: 3rd level –12 themes

1.	Ministries online accessibility	
2.	Insufficient Funds	
3.	Management Support	
4.	Systems Security	
5.	Systems Interoperability	
6.	Lack Of Software Developers	
7.	Standalone Systems	
8.	Ministries Collaboration	
9.	IT Personnel Training	
10.	System Development Outsourcing	
11.	Network Connectivity Challenges	
12.	Obsolete Technology Usage	

4.4 Stage4: Describe related categories with a theme

At this stage, the 12 themes/challenges delaying the adoption and usage of the national one-stop portal as shown in stage three are discussed interpretively.

Table 9: the 12 themes

1.	Ministries online accessibility	
2.	Insufficient Funds	
3.	Management Support	
4.	Systems Security	
5.	Systems Interoperability	
6.	Lack Of Software Developers	
7.	Standalone Systems	
8.	Ministries Collaboration	
9.	IT Personnel Training	
10.	System Development Outsourcing	
11.	Network Connectivity Challenges	
12.	Obsolete Technology Usage	

4.4.1. Ministries' Online Accessibility

Citizens and business partners were able to access some of the Ministries' services and products online through their websites. The Ministries' websites represent a platform through which the organisations can market their products and share information about their products. According to one of the participants *"through the Ministries websites, information is readily available to the public and they can access it at any time"* (RS2, pg6, 142-143). At the time of this study, most of the Ministries' websites were not interactive but rather a one-way of communication where the content was pushed from the organisations to the consumers. Most often the citizens accessed the ministry websites for document downloads and processes operations. However, upon completion of the downloaded applications, customers are required to physically visit the Ministries' offices to submit the documents.

The Ministries' websites are developed by the internal IT employees in collaboration with the business unit's employees. However, when the Ministry does not have the internal capacity to develop its website, development help is sought from the Office of The Prime Minister. The development and implementation of the Ministries' websites is an ongoing process. This is primarily because the ministry's business environment changes in terms of new products and services that are developed and new regulations and policies that need to be passed and implemented. Thus the need to keep training the IT employees to manage and maintain websites. A participant shared that *"we train other ministries' IT people to equip them with the necessary skills so they can be able to maintain and improve their websites"* (RS2, pg6, 152-153).

4.4.2. Insufficient fund

Offices, Ministries and Agencies are facing financial challenges to fund the implementation of their IT projects. The ministries' IT projects range from information system, website development and implementation to information system integrations. The insufficient fund has negatively affected the implementation of some projects in the government as some of the information system integration could not be completed as a result systems were operating in silos. A participant stated, *"The Ministry was having financial issues paying their consultants to complete the integration"* (RS1, pg1, 20-21).

Most of the ministries do not have an IT budget allocation. This is because the IT division falls under the general services and Administration department and the budget is allocated to the department. Due to the IT division falling under the department of general services and Administration, this causes some of the IT projects are not to be prioritised. When IT projects are not prioritised it cripples IT capabilities and effective service delivery of the organisation. There is a need for ministries to have a dedicated IT budget that can be used to acquire IT resources and infrastructures necessary to enhance the organisation's operations. One of the participants indicated that *"To improve IT operations, we can start by allocating enough budget toward ICT in all Ministries"* (RS5, pg17, 439-441).

4.4.3. Management Support

The successful implementation of IT projects requires high-level support from ministries' top management to ensure success. The ministerial IT projects are steered by the ministries' Executive Directors, who are responsible for mobilising resources to fund and ensure a successful implementation of the project. The Executive Director is the accounting officer responsible for the administration of the ministry. According to a participant, *"The projects had direct support from top management like the minister because the planning started at the strategic level"* (RS4, pg13, 326). This level of leadership and support is crucial for getting the relevant departments in the Ministry on board and mobilising resources for the Ministry's IT project implementation.

Although, there is top management support most of the ministries' systems are still not integrated. Causing delays in service delivery to the customers. One of the participants stated that *"There is a need for a high-level steering team committee with staff from all the ministries including top management and technical staff"* (RS4, pg14, 362-363).

4.4.4. Systems Security

The security of the ministries' information systems is very crucial for resource protection such as data. The system security aspect includes a high level of security solutions and technologies, comprising digital signatures and credentials, encryption, firewalls, and other advanced techniques that protect system interoperability and online transactions from fraud as well as other security flaws at all levels of the ministry's ICT infrastructure. To prevent unwanted access to personal information users are required to often sign or validate themselves before carrying out any transaction on the systems. Hence, protecting the data is very important because it builds trust between the Ministries, businesses and their customers, it also prevents unwanted or unauthorized access to the Ministries' information. A participant stated, *"They had an issue with the security between the systems. They indicated our data is not secure"* (RS1, pg2, 33-34).

To ensure the security of the systems is not compromised. The Department of Public Service Information Technology Management manages the data centre that hosts most of the ministries' information systems. This helped the ministries to ensure the systems implemented met the security standards set by the Office of the Prime Minister. The ministries have also implemented additional security such as firewalls to prevent access to the ICT network as well as endpoint security to prevent end-user devices from malicious exploitation.

4.4.5. Systems Interoperability

The ministries are faced with interoperability challenges when integrating their information systems. To be interoperable, both systems have to be able to send and receive, process and present the shared data in a way that each system understands the data. At the time of this study, ministries' systems were not integrated because ministries have implemented their systems with different vendors resulting in proprietary systems. A participant stated that *"there is a lack of interoperability between our systems because of different vendors"* (RS5, pg18, 471-472).

The use of proprietary systems can limit the ability of systems in the ministries to interoperate because these systems are not designed to work with other systems and technologies. This can create communication and data exchange obstacles, which makes it difficult or impossible for these systems to collaborate and integrates collectively. Resulting in inconsistent implementations and delays. Hindering the ministries' abilities to integrate and share the information between the systems.

4.4.6. Lack of Software Developers

The ministries are heavily relying on external vendors to develop and implement their information systems. This is mainly caused by the ministries not having software developers within their offices. According to the participant, *"We don't have software developers in our ministry. We only have one analyst programmer who only assists with project management and requirement gathering"* (RS4, pg12, 300). The challenge of not having software developers is causing the ministries to spend a lot of money on consultants because they have to pay for any changes they need on their systems. If the ministry does not have funds, changes will not be implemented, causing customer service delivery delays.

Most of the ministries have analyst programmers that support project management, for example, gathering requirements and making sure the project is completed on time per user needs. A participant shared that *“ministries have analyst programmers but they don't develop systems”* (RS3, pg10, 251-252). The problem with having more analyst programmers than software developers in the ministries is that the ministries will continue relying on external vendors to develop and maintain their systems. Causing the ministries to spend more money on vendors rather than employing more software developers that will develop and maintain the ministries' systems. If the ministries have more software developers their systems will be developed and maintained internally. It will also enable the ministries to implement customer-centric systems.

4.4.7. Standalone Systems

Ministries' systems are operating as standalone systems. These systems are not integrated into each other and operate in silos. This harms service delivery to customers because it limits the sharing of information between systems within an organisation or between organisations. At the time of the study, most of the ministries' systems were not integrated causing delays in service delivery to customers because employees and customers have to access different systems to complete a single task. A participant stated that *“Our systems are not integrated. We have standalone systems, and to make it easier for the public we created links on our ministry website that link to different systems.”* (RS1, pg2, 48). For the individuals to access the services from some of the ministries they have access to multiple systems individually. For example, customers have to create multiple accounts to access these systems and enter their personal information into multiple systems. Thus, creating duplicate data.

Standalone systems have a negative implication on service delivery. As it makes it difficult for ministries to integrate new and existing systems. Limiting ministries' ability to innovate and respond to changing requirements and expectations, resulting in a negative quality of services offered to the public.

4.4.8. Ministries Collaboration

Offices and ministries need to collaborate to attain common goals and strategies. This may include sharing resources, knowledge, and experience to manage problems facing different ministries. Collaboration between the ministries can help the ministries to work together efficiently to serve the needs of the general public. A participant shared that *“In the government, we don't communicate when our departments are implementing the system. When one is stuck with technical work, that's when they contact the IT department.”* (RS1, pg3, 58-59).

Collaboration among ministries is essential because it allows reducing duplicate work and ensures that all ministries are working toward the same goals. It can also assist in identifying and eliminating shortages in systems and policies, as well as ensuring that the ministries are capable of responding efficiently to major challenges that warrant a collective approach. For example, if two ministries are implementing systems, the collaboration between the two ministries can help to ensure that the systems are interoperable. According to a participant, *“the Office of the Prime Minister need to create more awareness for all the ministries of the importance of having a national one-stop portal”* (RS2, pg7, 171-172).

When ministries do not collaborate, it can have a lot of negative consequences. For example, ministries may implement systems that are not compatible with other ministries, which can result in systems operating in silos. According to a participant *“coordination and collaboration are also needed among the government to share information and resources among the ministries”* (RS4, pg14, 171-172). This will help close gaps in service delivery, as all the ministries will work together when implementing related systems.

4.4.9. IT Personnel Training

The ministry IT employees are very important for the development and maintenance of the ministries' online services through the National One-Stop Portal. The IT employees are responsible for developing implementing and maintaining information services in their ministries. Hence, the need to continuously capacitate them with the necessary skills to develop and maintain the information systems. Giving continuous training to employees helps to increase their job experience and satisfaction, which can lead to improved performance and productivity. A participant stated that *"we need to capacitate our ICT staff in terms of hiring more and training the current ones to be able to implement and maintain the systems"* (RS5, pg17, 440-441).

4.4.10. System Development Outsourcing

The lack of software developers in the ministries sees the information systems development and maintenance to be outsourced to external vendors. This process has a negative impact on the ministries as it reduces the control of the systems and their compatibilities with other systems. The use of vendors also creates vendor reliance, which can lead to vendor lock-in of the ministry information systems. According to the participant *"most of the systems were developed by different vendors"* (RS5, pg16, 403).

The use of a multi-vendor information system in the ministries is hampering the system integration in the ministries because of the interoperability of proprietary systems. This has the potential to delay the ministry's digital transformation and hamper its capacity to efficiently leverage technology to enhance its operations and services.

4.4.11. Network Connectivity Challenges

Network connectivity is very essential to ensuring the effective and efficient implementation of the national one-stop portal. Network connectivity enables the ministries' devices to communicate with each other and access information systems through the local area network. For the ministries employees to access the system in real time, the network connectivity needs to be stable and reliable between the different devices on the network. This will allow the ministries to share and transmit data between different offices without any interruption or delays. According to a participant, *"ministry's network capacity and interconnectivity challenges are some of the factors that might impact the integration and usage of the national one-stop portal"* (RS5, pg18, 472).

Network connectivity issues can be caused by a variety of circumstances, such as obsolete or dysfunctional equipment, insufficient network infrastructure, or disturbance from other devices. Hence, the ministries can address these challenges by upgrading their network bandwidth capacity and implementing high-availability network topology to avoid loss of service and minimise systems downtime.

4.4.12. Obsolete Technology Usage

The continuous usage of obsolete technologies not only slows the operation of service delivery to customers but also poses a security threat to the organisation's IT services. Obsolete technology may include old computer hardware that has been replaced by newer versions and software that is no longer supported by their vendors. Ministries' finances are limited, making it difficult to invest in new technologies. A participant shared that *"the ministry continuously uses obsolete technology because of the limited budget ICT budget"* (RS5, Pg18, 472-473).

The use of old and outdated computers and servers can slow down the ministries' productivity because they will be unable to handle the high rate of visitors and transactions of the National One Stop Portal, resulting in user delays and interruptions. Obsolete technology is less secure because they are no longer supported by the vendor putting the national one-stop portal at risk of cyber-attacks, data breaches, and other security risks. Which may compromise the privacy and security of users' personal information. The costs of maintaining old technology are also higher than new technologies because the ministries will need to keep replacing the worn-out parts.

8 Conclusion

The study contributes to both academic and industry sectors. It has identified a range of factors that have implications for the Ministries adopting and using the National One-Stop Portal. Additionally, the study presents a template that can be applied as a source of a guide when implementing the national one-stop portal within government offices, ministries, and agencies in Namibia.

The challenges delaying the adoption and usage of the national one-stop portal have been identified, including non-interactive websites, in-house development capabilities, lack of IT budget, secured infrastructure, obsolete technological infrastructure and one-stop portal awareness challenges. It is essential for government ministries to have a dedicated IT budget when implementing a national one-stop portal, providing regular employee training and hiring additional software developers to develop and maintain ministries systems. This approach could improve the in-house development capabilities of the ministries while decreasing their dependence on external vendors for system development and maintenance.

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A Big Data Oriented Strategic Approach for Decision Support in Organisations

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Abstract

Big data is a new force behind societal and economic development in the world. The world's data collecting is at a turning point that could lead to significant technological advancements that could lead to new approaches to decision-making. The capacity to find value in the data using Big Data Analytics technologies will have the biggest impact, even while data complexity is growing, including data's amount, diversity, velocity, and veracity. The construction of highly scalable algorithms and systems to integrate the data and extract significant hidden values from diverse, complicated, and enormous datasets presents a significant problem in big data analytics. New Big Data Analytics techniques, methodologies, systems, and applications that efficiently and effectively extract important and hidden knowledge from the Big Data are examples of potential breakthroughs. However, big data analytics also needs to be a collaborative endeavor among academic institutions, the government, society, and the industry, as well as academics from a variety of fields, such as computer science and engineering, health, data science, social science, and policy issues. Therefore, this study aimed at developing a big data oriented strategic approach for decision making in organisations. Henceforth, the study used a mixed research methodology, where both primary and secondary data sources were used in forms of interviews and questionnaires/survey through a random sampling.

Keywords: Data, big data, data analytics, techniques, decision-making

1. Introduction

A large amount of data is referred to as "big data" (Chamikara et al., 2020). While the technique managing big data, which is referred to as big data analytics, can be defined as the infrastructure, technologies, equipment, methodologies, procedures, and processes utilized to collect, store, and analyse large amounts of data in order to derive useful conclusions (Lehrer et al. 2018; Mikalef et al. 2018). Big data analytics (BDA) is quickly becoming a popular subject among academics and industry professionals (Wamba et al., 2017).

The creation of viable solutions for obtaining value and knowledge from massive, dynamic datasets is required by the diversity and speed of big data (Joseph, 2018). The efficient extraction of meaningful information from large data, which enables organizations to develop actionable business plans for both present and future commercial possibilities, is a key function of big data analytics today (ProViso Consulting & Ramesh, 2020). Data collection, management, statistical analysis, and presentation are all steps in the data analytics process. To identify crucial information like patterns, correlations, market trends, and client preferences, it requires sorting through a lot of data (Chai et al., 2021).

Currently, not all businesses are aware of the volume of data they generate every day (Hariri, 2019). Transactions are not being recorded in order to collect data that can be analysed to help business processes be improved, potentially saving time and money while maintaining and satisfying customers. Big data is anticipated to play a critical role in the development of new strategic approaches to corporate governance and leadership, according to recent studies. These studies also indicated that big data has the promise of introducing new concepts and practices to organizational sciences (Mazzei & Noble, 2020; Mathias-Kalema & Mokgadi, 2017).

1.1 Problem statement

Some organisations are unable to make real-time data-driven decisions that could bring value to their organisation due to a lack of big data analytics practice (Alsghaier, 2017). This can be as a result of their lack of usage of big data techniques that would help them make wise decisions. An organization must therefore have data-driven plans that incorporate the concept of big data in order to benefit from big data analytics (Mazzei & Noble, 2020). The apparent underutilization of big data analytics by organizations may result in poor communication of the big data vision and objectives at various levels of the organization (Aneato, 2020).

Furthermore, the majority of studies on big data analytics in businesses have focused on its broad advantages (Olavsrud, 2020; Mazzei & Noble, 2020). While current industrial developments and novel technology (Meixner, 2021), such big data analytics, have mostly been examined in industry magazines, some also focused on how it may be sustained (Elragal & Klischewski, 2017). However, several researches have concentrated on how big data analytics can be used in organizations as a system to support decision-making. According to Ayokanmbi and Sabri (2021), the impact of Big data analytics' influence on decision-making, along with industry 4.0 technology, aims to foster a fact-based, data-driven culture that fosters performance excellence. The study showed that a data driven decision support system needs a lot of data and a way to extract information from that data in order for organizational performance to improve. More specifically, Grander, et al. (2020) concentrated on connections between big data and decision support systems, and the authors noted that a significant correlation between "big data," "artificial intelligence," and "decision making" needs to be acknowledged; as a result, they suggested that additional research be done on the aforementioned concepts in order for big data to help business organizations make data-driven decisions. As a result, our study created a big data-focused method for organizational decision support.

1.2. General objective

The main goal of this study is to develop a big data-focused strategy for organisational decision support.

1.3. Related literature

Organisations must have suitable methods for handling big data as a decision support system in a world where technology is developing at an unpredictably quick pace in order to prevent missing out on the opportunity to make wise business decisions in real time. As a result, this chapter concentrated on the study's theoretical foundation. The literature on big data, big data analytics, the advantages and disadvantages of employing big data analytics was also evaluated in this chapter.

1.3.1. Big data

Big data is defined as a group of datasets with large volume, velocity, or diversity that are difficult to manage, store, process, and analyse using standard databases and data processing technologies. In recent years, systems used in information technology, industry, healthcare, the Internet of Things, and other fields have generated exponentially more organized and unstructured data (Bahga & Madisetti, 2016). The current explosion in data generation can be attributed to a number of important factors, including the hundreds of apps, mobile sensors, social networking sites, and other linked devices that are continually collecting data. It is preferable to purchase additional storage space rather than deciding what to delete because storage capacity has improved to the point where acquiring data is now more affordable than it has ever been. Furthermore, in recent years, information retrieval and machine learning technologies have made tremendous advancements, enabling the acquisition of a greater degree of knowledge from data (Jolonek, 2017).

1.3.2. Big data analytics

The development of big data analytics was inspired by the rise of enormous data, which started in the 1990s (Bahga & Madiseti, 2016). Long before the term "big data" was created, corporations employed extensive spreadsheets to analyse data and look for trends during the start of the computer age. The life-cycle of big data analytics starts with data collecting from diverse data sources, even though the use of big data analytics methodologies is necessary to ingest data from different sources (Bahga & Madiseti, 2016). Big data analytics approaches make use of the storage and processing power of a large cluster of devices using distributed and parallel processing architectures (Calzon, 2021).

1.3.3. The advantages of utilising big-data analytics in organisations

Big data analytics has a huge impact on productivity and has the potential to offer organizations effective and efficient value in both operational and strategic approaches. Because they enable you to delve deeper into enormous amounts of data to unearth fresh and insightful information, big data analytics are crucial (Calzon, 2021). This is crucial for enterprises of all sizes, from retail to government, in order to enhance corporate procedures and customer service (Jolonek, 2017). The significance of big data analytics has increased the effort put into gathering, curating, and organizing vast amounts of data (Bahga & Madiseti, 2016).

The use of big data analytics can help businesses better understand their consumers' characteristics, including their purchase habits, and the most effective channels for communication (Calzon, 2021). The time spent gathering, curating, and organizing vast volumes of data has increased as a result of the significance of big data analytics technology, which has led to a rise in demand for big data analytics' ability to analyse unstructured data (Calzon, 2021).

1.3.4. Big data Analytics challenges:

Dealing with data can be a process, but big data management can be even more difficult. The goal of this study is to evaluate the use of big data analytics as a strategy to support data-driven decision-making. However, using big data analytical tools can present a number of challenges, including data storage infrastructure, unpredictability of data management, a lack of professionals who are knowledgeable in big data analytics, synchronization of diverse data sources, security and privacy of data, to name a few (Kumar, 2018).

1.3.5. Security of data

The process of acquiring data could be difficult because important concerns like security shouldn't be overlooked. Therefore, managers and policy makers from various fields, such as public affairs and internet access inequities, should collaborate to address data security challenges, such as the propensity for cybercriminals to steal and harm non-encrypted information (Mergel et al., 2016). Given that big data comes from a variety of sources, another security issue is that some of these sources may have inadequate security levels, a wide range of data formats, and a sizable amount of data (Mergel et al., 2016).

As a result, any security lapses could have a negative impact on several organizations and cause financial losses, necessitating the adoption of suitable countermeasures to such large data security threats. In order to avoid unwanted access, organizations should monitor their data sources and use end-to-end encryption (Smallcombe, 2020). Other security risk factors include the complexity of big data due to its diversity, network perimeter unreliability, social engineering attacks (also known as phishing), which occur when an attacker sends a message that appears legitimate but is actually malicious, carelessness on the part of employees, the creation of fake data, etc (Lizaveta, 2023).

1.3.6. Validation and Uncertainty in Data

A scenario that is confusing generally has knowledge that is either uncertain or partial. Every step of the big data analytics process may contain some level of uncertainty, which can originate from a number of different causes, including idea variance, multimodality, data collection, and variations in ambient circumstances, as well as sampling-related problems (Smallcombe, 2020). Therefore, one of the most important aspects of big data analytics is determining the degree of uncertainty. Despite the fact that there are numerous techniques for analysing huge data, the analysis's accuracy may decrease if the technique itself or data uncertainty are ignored. To provide more accurate and insightful results, big data analytical methods can be augmented with uncertainty models like probability theory, fuzziness, rough set theory, among others (Hariri et al., 2019).

1.3.7. Storage Price/ Infrastructure

Given that data grows quickly and that organisations' data centers and databases are housing an increasing amount of data, keeping an adequate storage capacity is one of the most important yet urgent big data concerns (Olavrud, 2020). Big data analytics will need enormous or large clusters of data storage, yet the data may be both structured and unstructured. Given that very large datasets are not intended for use with conventional relational database models (Alabdullah et al., 2018). Considering the expense associated with data transport, big data storage also comes at a significant cost in terms of processing capacity, infrastructure, and networking expenditures (Widjaya, 2020).

1.3.8. Shortage of Big data skills/ Talent

Since not all organisations are equipped with big data skilled capability, a major problem is the shortage of big data skills. Due to a lack of capabilities, the majority of organizations are unable to use big data analytics (Olavrud, 2020). Additionally, this could result in a lack of big data architecture design, which is the description of the conceptual and physical framework in charge of controlling the intake, processing, storing, management, and access to massive volumes of data. However, this can cause organizations to fall short of the big data analytics high-level objectives (Mergel et al., 2016).

2. Theoretical underpinning of this study

This study adopted two theories to guide the study. The theories are the resource-based view theory and the theory of dynamic capabilities. Both theories guided this research particularly in the area of research methodology putting into consideration the development of the interview protocol and the survey questionnaires. The components of these theories guided the research by enabling questions that assisted the interview respondents or participants and the respondents that answered questions in the survey questionnaire. The theories are explained in details and areas where they guided the research where discussed.

2.1. The Resource-based theory/view

The Resource-based theory promotes resources as a key to improved business performance. The resources should exhibit Value, Rarity, Imitability and Organisation (VRIO) attributes which are used to assess the situation inside the organisation (Kadlecova, 2020). VRIO attributes, thus may enable a firm to gain and sustain competitive advantage (Jurevicius, 2013). The VRIO tool was developed by (Barney 1991; Jurevicius, 2013). According to the VRIO tools analysis, the resource must be valuable, rare, imperfectly imitable and non-substitutable. The supporters argue that organisations should look inside the organisation to find resources instead of looking at competitive environment (Shan et al, 2018).

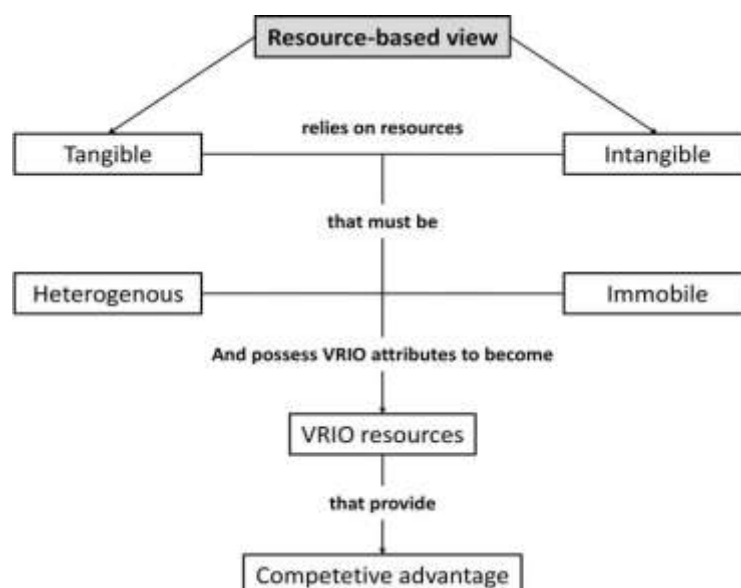


Figure 1: Resource based view (Smętek et al., 2020)

Based on the Resource-based view; the organisation should be able to rely on both tangible and intangible resources which should be of diverse culture, immobile and possess VRIO attributes; hence the resources should hold value, be of rare character, imitability and be part of the organisation 's resources, therefore, enabling the organisation to sustain a competitive advantage using its own resources. The study aimed to focus on the organisation's decision making using the big data approach, the above-mentioned theory was adopted since the organisations' resources are being used for data analysis and extract valuable information to provide guidance for decision making to make real time future decisions using big data approach.

2.2. Theory of Dynamic capabilities

The Dynamic Capability Theory was used and it emphasises that resources are the source of competitive advantage for an organisation to ensure long-term and sustained development. Dynamic-capability is defined as the organisation's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments (Teece, 2017). Dynamic capabilities theory is guided by three dimensions: sensing (the detection and evaluation of an opportunity), seizing (the utilization of resources to take advantage of an opportunity and to maximize value), and transforming (ongoing renewal, reconfiguring the intangible and tangible assets of the business organisation) (Bleady & Abdel., 2018). Dynamic capabilities (DC) theory evolved as a response to the resource-based view's (RBV) incapacity to understand the development and redevelopment of resources and capabilities to handle constantly changing environment. Thus, "dynamic capabilities" are procedures that allow an organisation to adjust its strategy and resource allocation in order to attain long-term competitive advantages and superior performance in fast evolving environments.

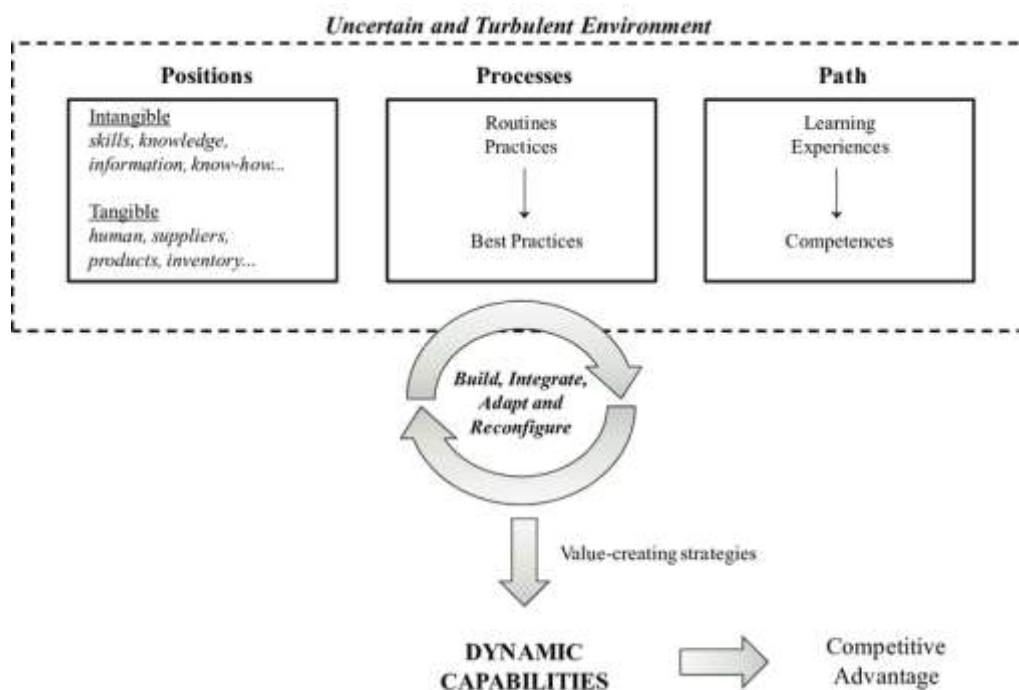


Figure 2: Dynamic capabilities theory (Leiblein, 2011)

As shown in Figure 3, organisational structures and the level of competition influence an organisation's responses to change. When it comes to identifying, seizing, and restructuring the organisation to accommodate changing external conditions, the effects of organisational structure must be aligned with organisational processes. This may result in a more effective, efficient, and adaptive approach, which may lead to a greater flexibility, creativity and responsiveness to change. Organisations may restructure their resource bases in response to growing competitive intensity, deploying dynamic capabilities in the process. By doing this, organisations may benefit by attracting new clients. This places a premium on an organisation's capacity to identify emerging market trends and grasp opportunities before their biggest competitors do. This is achieved by building new capabilities to take advantage of market opportunities, adding new resources, or combining existing ones.

Organisations with similar resources may perform differently and experience different competitive advantages in practice. The continued importance of competitive advantage cannot be entirely explained by a mix of resources. Scholars established the core competence theory by concentrating on the role of capabilities (Yung et al., 2019). According to the dynamic capability model, an organisation's capabilities are a combination of critical skills and tacit knowledge, as well as the resources that an organisation collects over time (Chong et al., 2018). Capabilities are intellectual capital, and other organisations find it difficult to mimic or reproduce them. This hypothesis was presented to help organisations deal with societal growth, new technology, and the growing complexity of the market environment (VU, 2020). The study is aimed to focus on the ever-changing trends of the technology aspect using the organisation's resources with the aim to assess possible opportunities and continuous transformation to improve service delivery by making real time data driven decision.

2.3. The importance of the underpinning theories of this study

The above theories are vital to the current study on the approach of big data analytics in business organisation to enable data driven decisions. Dealing with big data may be quite a complex process, hence,

a validation analysis should be required, and the VRIO tool may be required to meet the study's objectives, such as investigating variables and evaluating strategies in the use of big data analytics within an organisation's intellectual resources. Moreover, the emerging growth of big data and new technology trends may be critical to any organisations thus, the need to adapt the dynamic capability theory to keep up with new technology trends (Teece, 2018).

The technology aspect of the organisation is ever changing and the dynamic capability theory is aimed to enable the organisation to adapt to radical continuous change, by utilising its resources in conjunction with the resource-based theory, by getting the most out of its resources, considering the VRIO attributes to integrate and transform by using data driven decision making.

Moreover, the resource-based theory put more emphasis that resources should be the main source for competitive advantage for organisations and this is done to assure long term and sustainable development (Shan et al., 2018). Considering the valuable, rare, imitable and heterogeneous resources that have to be combined to ensure competitive advantage, the resource-based theory is vital to the study. The study aimed to use the organisations internal resources and acquire insights to develop a big data oriented strategic approach that is specifically customised for the chosen case study. However, according to Shan et al., (2018), other enterprises with resources that are alike may perform differently and experience different competitive advantages in practice.

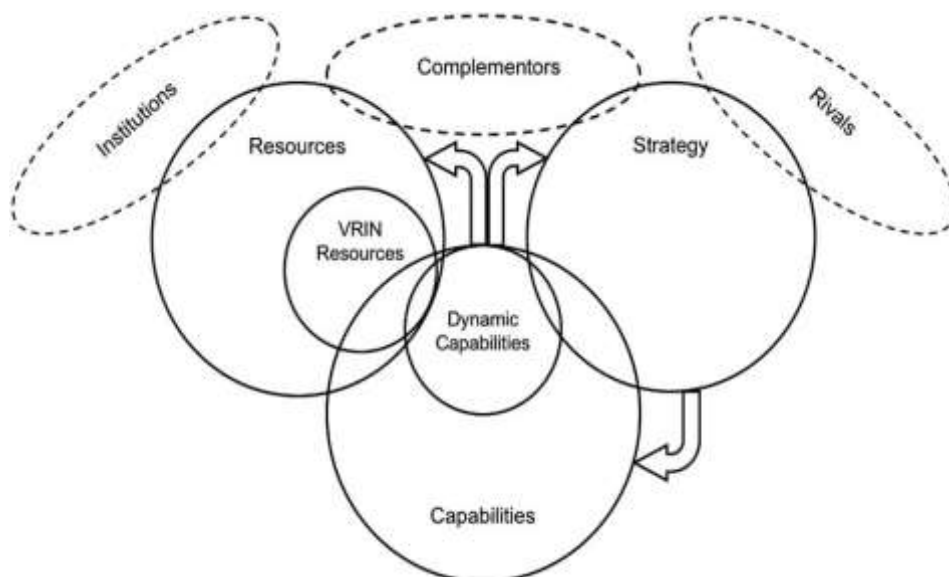


Figure 3: Dynamic capabilities theory incorporated with VRION Resources from Resource based theory (Teece, 2018)

2.4 Research Design

The goal of the research design is to create an adequate framework for the investigation (Jilcha, 2020). As a result, the research techniques employed during the study process are covered in this section. This study used a mixed method strategy, which combines the qualitative and quantitative approaches, to achieve the main research objectives since the qualitative data supports the quantitative data analysis and results (Jilcha, 2020). The data gathered from interviews was analysed using the qualitative approach. It mostly serves to comprehend broad themes in the data and how they are expressed (Bhandari, 2020). While the quantitative

technique was used to statistically analyse the findings of a large number of research and to collect data from surveys in a statistically reliable way (Bhandari, 2020).

The population of the study is made up of employees of an organisation while purposive sampling, a non-probability sampling technique, was used to select middle management to top management who were familiar with the organizations' decision-making processes, therefore representing several directorates from all departments.

Furthermore, a stratified random sample method was chosen to select the survey respondents. 75 survey respondents were thus chosen from a variety of departments, directorates, and divisions. A total of 97 participants were chosen. 22 were chosen for interviews and 75 were chosen for the survey questions.

Data collecting techniques included questionnaires and semi-structured interviews. These data gathering tools were created with the Resource-Based Perspective and the Theory of Dynamic Capability in mind. The components of both theories were considered while crafting the interview and survey questions, which acted as a guide for the creation of the interview protocols and survey questions. Considered as an example of an intangible resource is the organization's knowledge base, while the data collection procedures were directed by the three Dynamics Capabilities which include dimensions of sensing, seizing, and transformation.

3. Analyses/ Discussion of findings

The researcher wants to provide a comprehensive analysis of the full study and a detailed explanation of its findings. The research was expanded upon to look into the numerous decision assistance techniques currently in use in organizations. In addition, criteria required for the use of big data analytics as decision support in organizations were identified through research. The study also sought to uncover organizations' big data analytics utilization plans.

3.1. Interview participants:

3.1.1. Demographic information

Figure 4 illustrates the age group of participants. A breakdown of the results show as follows: 18-25 (0%), 26-35 (9.1), 36-45 (54%), 46-55 (36.4%) and 55-65 (0%). The demographic results show that the age range of 36- 54 dominates the interview questions, which is an indication of middle-aged group, however the age range of 18-25 was not represented, indicating that there are no young adult participants, rather experienced participants, hence followed by the age range of 46-55. Lastly, there are no participants above 55, which may be attributed to the range being the retirement age.

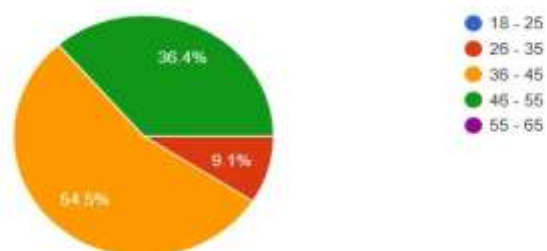


Figure 4: Participants age groups

3.1.2. Gender

Figure 5 below presents the gender distribution, which indicated that more females participated compared to their male counterparts. Females indicate 63.6 % while males indicate 36.4 %. An indication that more

female participants are involved in decision making, compared to their male counterparts, hence their proportion exceeds 50 % of the participants distribution.

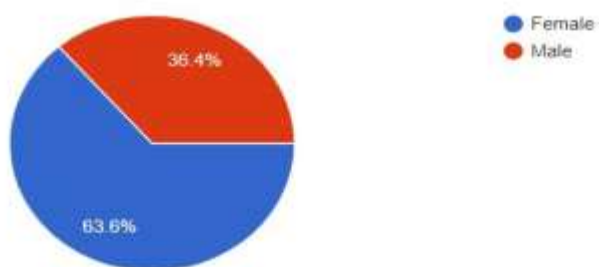


Figure 5: Participants gender

3.1.3. Educational Background

As visible in figure 6, the chart shows the educational background of the participants is as follows: 36.4 % are Bachelor's Degree holders, 18.2 % are Honours Degree holders and 45.5 % are Masters Holders which is quite the highest category among other participants. An indication of highly qualified participants, resulting in an assurance that the study was carried out among formally qualified participants hence questions were handled in a more professional manner and responses were acquired from highly educated participants. Masters holders were followed by Degree holders, lastly followed by Honours Degree which was the least indication, however, from the demographics, most degree holders are upgrading their education.

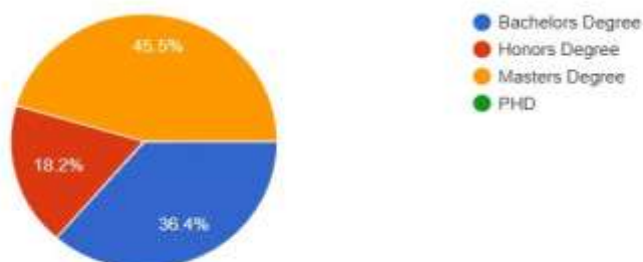


Figure 6: Educational background

3.2. Statistical Presentation

3.2.1 Current data policy adaptation

Participants were asked to rate the current adaptation of the data/ information policy that is already in place. This is based on the consideration that the adaptation of implementation of policy will play a major role when it comes to big data implementation. Figure 7 below illustrates the percentage of participants, 5 participants making up (22.7%), indicated 3/10 adaptation rating, followed by 3 participants (13.6%), who indicated 4/10, while 3 other participants amounting to (13.6 %) indicated 5/10, other participants indicated 1/10, and the rest of the participants indicated "not sure" and "not aware". The highest indication showed a rate of 3/10 and 4/10 adaption rate, which was below 5/10. The least rate was among those who indicated 1/10 until 9/10, which can be interpreted to a need to improve the policy adaption in the organisation. Figure 8 below presents the data policy adaption proportion:

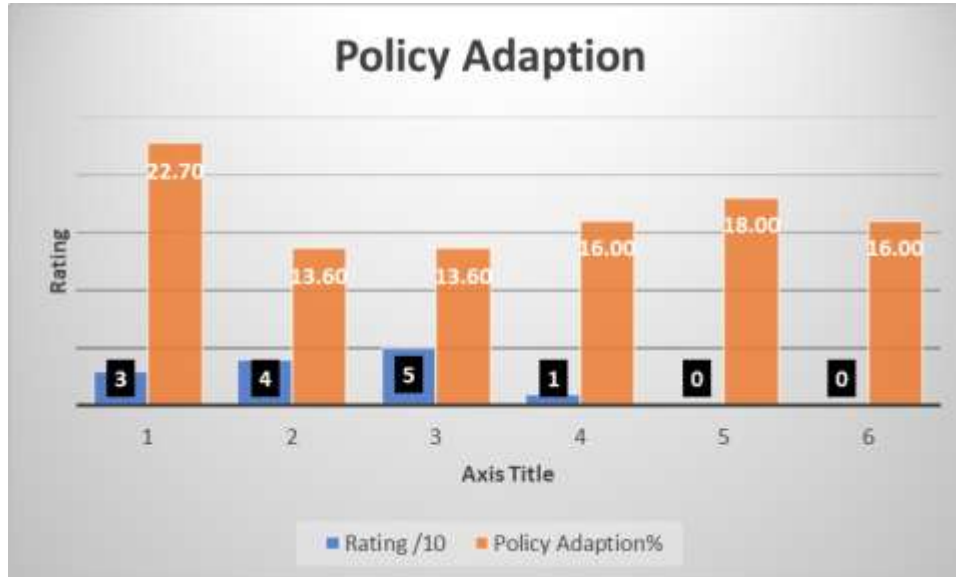


Figure 7: Policy adaption

3.2.2 Big data projects willingness

Figure 8 illustrates the willingness of the participants to partake in big data projects. A question was posed specifically to management to get insight from the management perspective on the big data concept. Participants were asked if they have any interest in big data projects as this may be one of the contributing factors to be considered if participants are keen to participate and support in any big data strategic approach to support decision making. This question in the interview was particularly relevant since the interviews were conducted with management who are key decision makers. The result is that 20 participants indicated yes while one indicated that they need more insights when it comes to big data, while 1 indicated no. Hence, the indication showed a huge interest of the participants in big data initiatives.

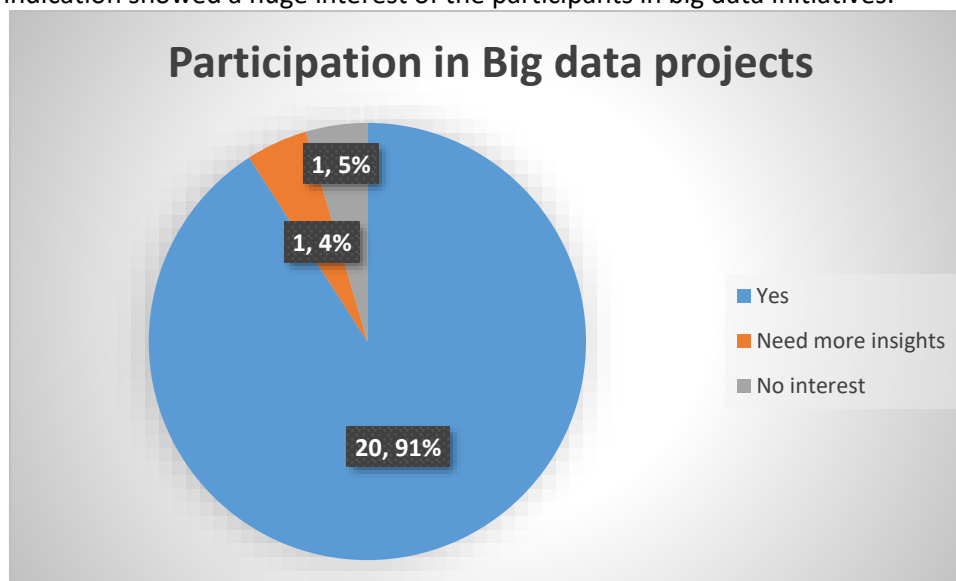


Figure 8: Big data projects

3.2.3 Current frameworks or standards

The participants were asked if there are any frameworks or standards in place to incorporate the use of big data in the near future. This information is very useful to determine the current status of the organisations'

awareness and the factors that are necessary to consider when utilizing big data. As visible in figure 9, the participants' responses show the highest indication of 9.1 % of the population indicating that they are not aware of any frameworks or standards. Others indicated "No", among the least indication is 4.5 % of the population who are uncertain and not aware of any frameworks or standards. Clearly the existence of frameworks and standards to cater for big data is not a usual topic, hence most participants have no idea. Therefore, the organisation needs to introduce big data frameworks or standards to incorporate big data initiatives or strategy. Although few indicated that the frameworks and standards are in existence, it is for the organisation to align with the frameworks or standards.

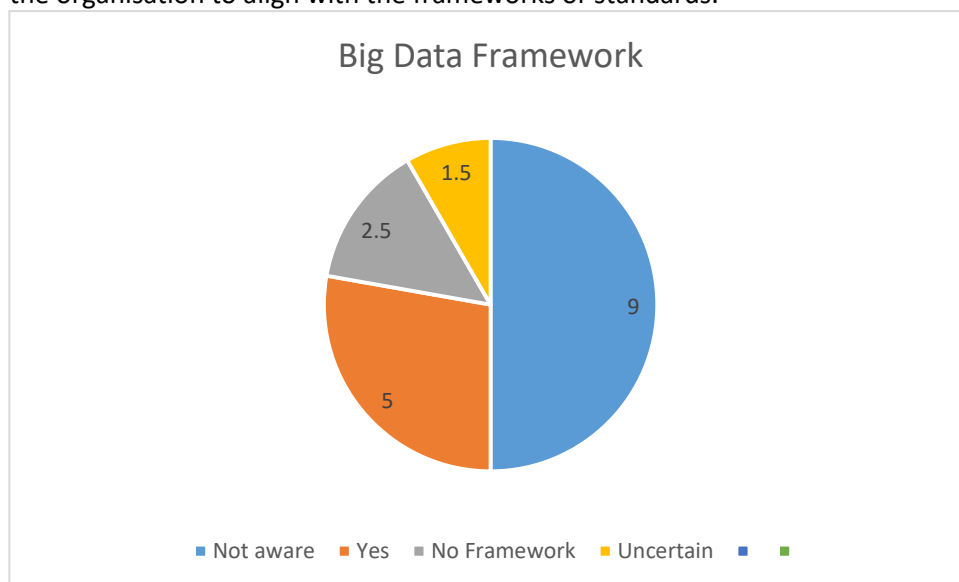


Figure 9: Big data framework

3.3. Questionnaire participants

3.3.1. Demographic Information

Age

As depicted in figure 10, the following is the illustration of the questionnaire participants' age group: 18-25 (1.4%), 26-35 (37%), 36-45 (50.7%), 46-55 (11%) and 55-65 (0%). The age groups are a representation of operational employees, excluding management. The highest indication showed that 50.7% of the participants are among the age range of 36-50 which is a clear indication that there are more middle aged among the participants, followed by 37% which is an age range of 26-35 years old.

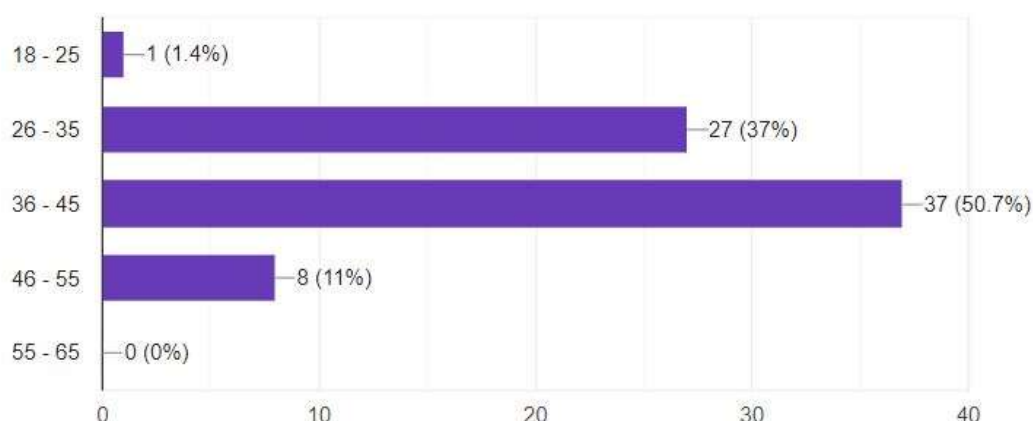


Figure 10: Participants Age

3.3.2. Gender proportion

Figure 11 displays the gender proportion of the participants, which indicated that more females participated compared to their male counterparts. Females indicated 65.8 % while males indicated 34.2 %. The indication showed that more female participants took part in the study.

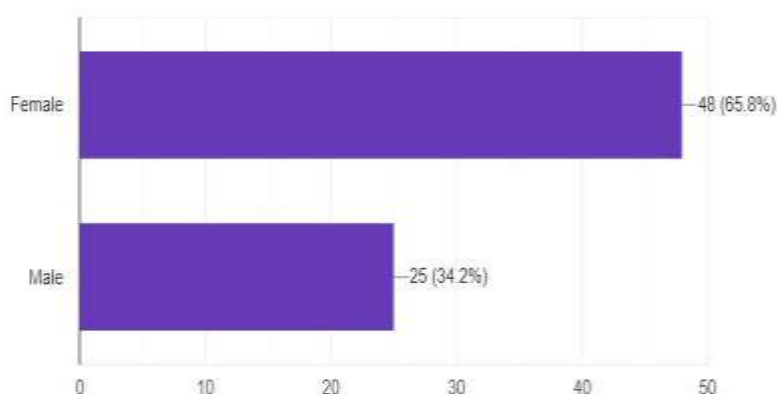


Figure 11: Participants Gender

3.3.3. Educational Background

Figure 12 illustrates the educational background percentage of the participants, which indicated that (49%) are Masters' holders, followed by Postgraduate/ Honors Degree (27%), Bachelor Degree (17%), Diploma (6 %) and Grade 12 (1%). The highest indicators are Masters holders 49%, followed by Honors Degree 17 % showing a high indication of highly educated participants. The lowest indication which is 1% is a grade 12 followed by a Diploma, 6%. Hence, the responses showed that participants are very keen on upgrading their educational qualifications. Therefore, the study responses were acquired from educated and highly qualified participants.

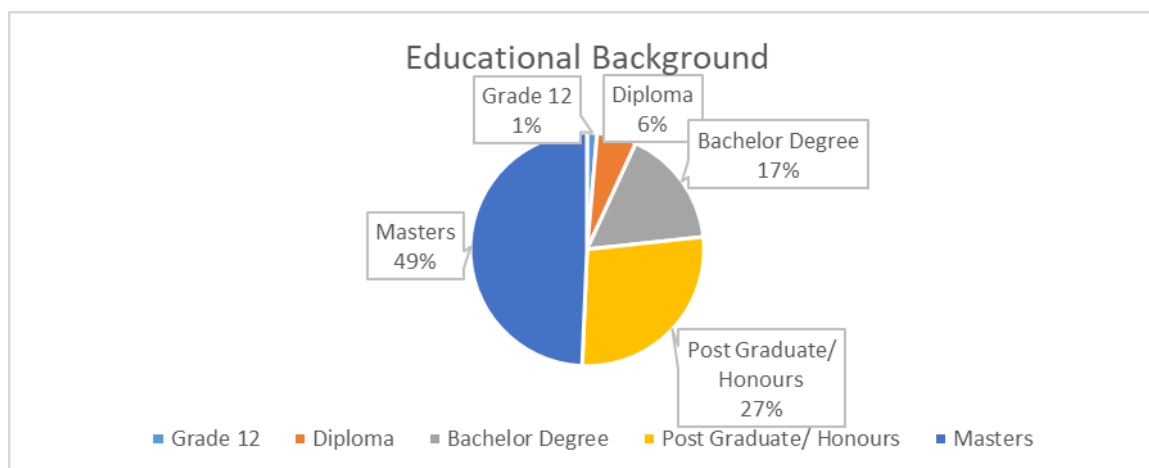


Figure 12: Educational Background

3.4. Statistical presentation on the current status

3.4.1. Computer Literacy

Participants were asked to rate their computer literacy from Fundamental skills to Proficient Computing and Applications. Figure 13 presents the percentage as such: Intermediate computing and applications showed highest with 38.4 %, followed by Advanced Computing Applications 30.1 %, Basic Computing 20.5 %, while the least indicated were: Proficient Computing and Applications 15.1% and Fundamental skills 9.6 %. The responses showed that more participants are computer proficient, hence, less effort/ training may be required to capacitate the participants with big data analytical skills.

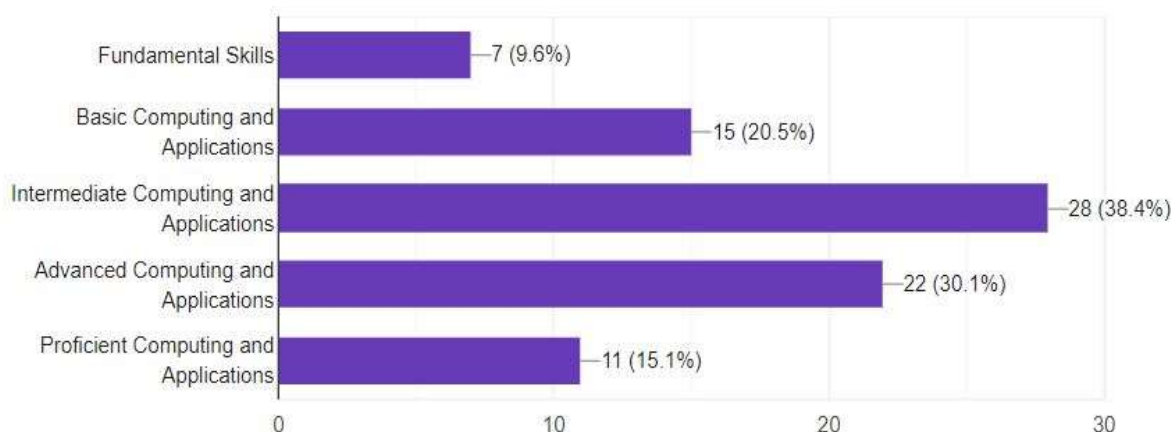


Figure 13: Computer Literacy

3.4.2. Current Big Data Perception Status

For the researcher to get more insight on the current status of the big data perception, the questionnaire was further extended with specific questions that were targeting the IT personnel only. The IT participants were asked to indicate the current perception/ awareness on the use of big data in the organisation. According to figure 14, the participants responses' where as follows: majority indicated "no awareness", few where not sure and opted not to respond and a little percentage indicated "Yes".

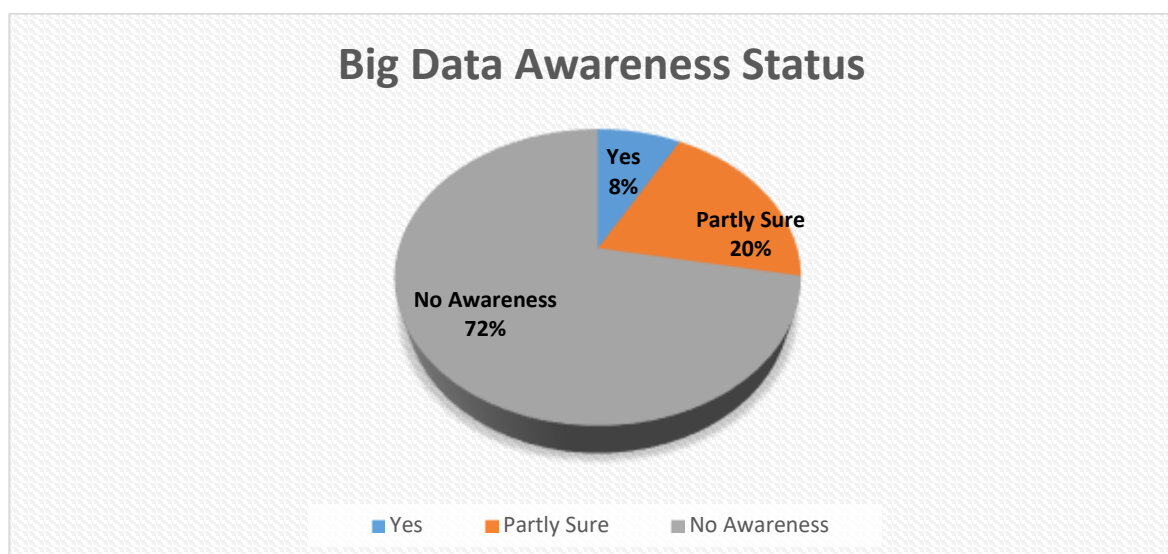


Figure 14: Big Data Awareness

Both the highest indications which were 12% and 8% indicated that there was no awareness on big data. In addition, the least indications which was 4% of the majority have indicated “No awareness”. The results show a clear indication that the big data perception or awareness is not entirely known, considering that the responses are coming from the IT personnel. Henceforth, awareness campaign needs to be part of the big data strategy programme.

3.4.3. Current status on big data skills

The researcher asked the IT participants if there are any IT skills to handle the use of big data. The question was very relevant to establish the current status on the available skills, considering that skills are some of the contributing and driving factors to consider the use of big data to get insights on the use of big data skills. Figure 16 shows the participants responses, where majority indicated “no skills”, followed by some indicating “yes” while few indicated “minimal”, and indicated that “training should take place.”

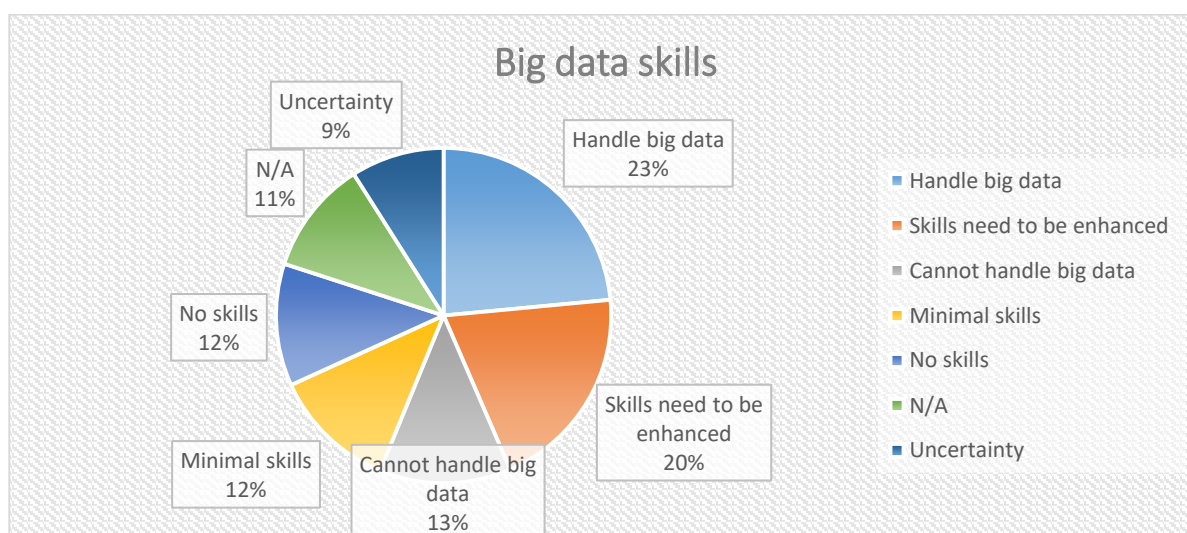


Figure 15: Big data skills

A highest indication of 23.5% indicated that they do have the big data skills, 20% shows that skills need to be enhanced, 13 % indicated that the skills cannot handle big data, while 12 % shows no skills and minimal skills, followed by 11.8% that indicated that there are currently no skills. While the least indication of 9% among respondents have indicated “N/A,” “Not sure, “” Not aware, “which was a clear indication of uncertainty among respondents. Therefore, responses indicated that a fair proportion of IT personnel do believe they don’t have the right skills to handle big data while some are being optimistic that they have the necessary skills. Hence proper assessment and training may be required during the big data strategy rollout.

3.4.4. IT Infrastructure status

The researcher further asked the IT participants if the current infrastructure is able to handle big data projects. The question was very relevant to establish the current status on the available infrastructure, considering the infrastructure as a contributing factor to be considered for the use of big data. A high indication on the current IT infrastructure recorded a positive indication. This showed that few participants do believe that the current IT infrastructure can handle big data initiatives. However, the statistics were followed by a negative indication which showed that the current IT infrastructure cannot handle big data initiatives. Moreover, the least indicator of the participants indicated uncertainty of the current IT Infrastructure, hence thoroughly assessment needs to be done to ensure the current status of IT infrastructure during planning and implementation of the big data strategy. Figure 16 illustrates how the participants’ responded, some indicated “yes”, followed by some indicating “no” while few indicated “not sure”.

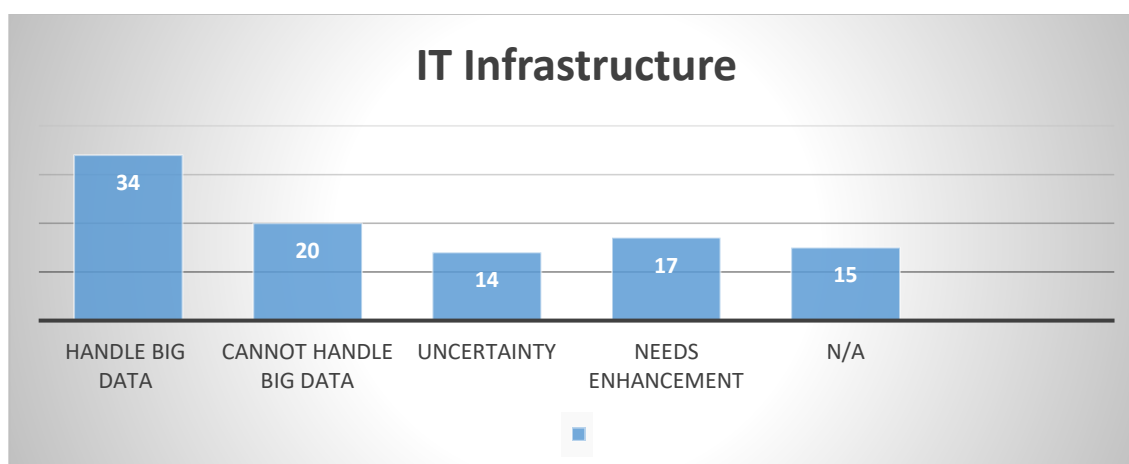


Figure 16: Current Infrastructure

3.4.5. IT Infrastructure maintenance

With regards to the IT Infrastructure maintenance, IT participants were asked to give more insight on the Infrastructure maintenance, to indicate the current maintenance routine. The question was very relevant to establish the current status on the infrastructure maintenance, considering that infrastructure is one of the key factors to be considered for the use of big data. Therefore, Figure 18 shows the participants’ responses on how frequent maintenance of infrastructure takes place, some indicated “monthly”, followed by some indicating “weekly”, “daily”, very few responded “irregular” and others responded after 6 months. A high indication of 10% and 6.7 % was recorded, which indicated “weekly” which showed a positive indication that maintenance does take place weekly. However various participants indicated different results; varying from “6 months,” “ad-hoc”, “daily,” etc., which showed an inconsistency in the maintenance routine, hence there’s a need for consistency in IT maintenance. The statistics of the participants are shown below:

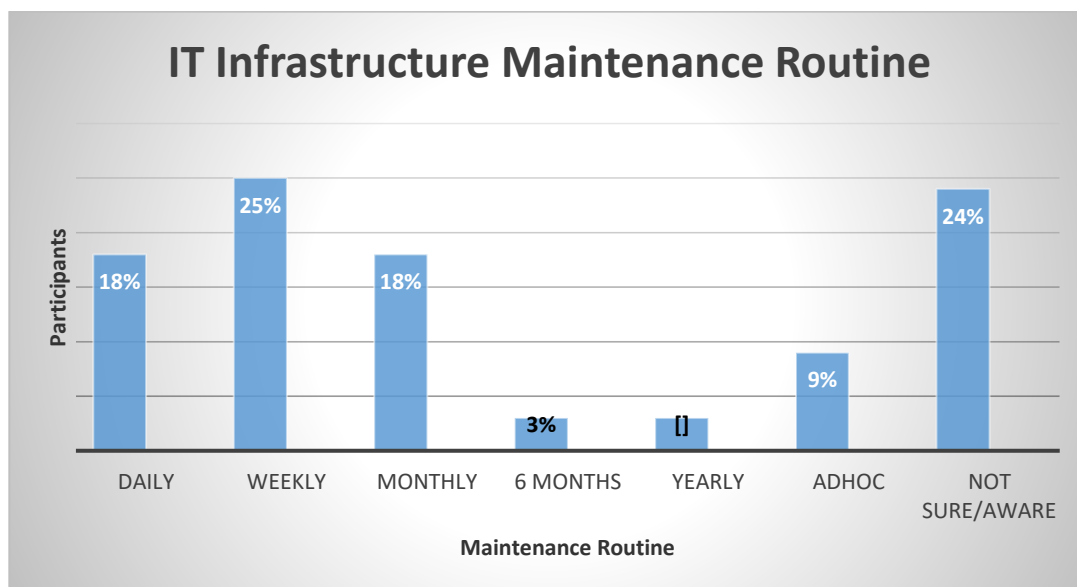


Figure 17: IT Infrastructure maintenance

3.5 Thematic Analysis

After the researcher 's familiarisation process with the data was done, a continuation of the analysis process has resulted in codes and group themes being determined. The process entailed searching for most occurring words and identifying patterns among them, hence coming up with themes. These most occurring keywords were coded and grouped according to their similarity and later extracted into themes. Initially the researcher identified nine (9) themes namely: Strategies, Policies and Guiding methods/ documents, big data awareness and knowledge, current status, organisational structure, big data skills, big data projects readiness, big data projects support and willingness and IT infrastructure maintenance. The themes were reviewed and combined into five (5) themes namely: Policies and Guiding methods/ documents, Big data Awareness and Current Status, Organisational structure and Big data skills, Big data Projects Readiness and Support and IT Infrastructure Maintenance.

The table below shows the final codes and themes that came from the collected data.

Table 1: Codes and Themes

Codes	Themes
Annual plans, Strategic plans, NDP5, Project planning, Performance Management System, IT Policy, Data Protection Policy, Records management policy, E-governance policy, HR Policy, etc.	Policies and Guiding methods/ documents (Strategies)
Large data, next big thing, huge data, complex information, the awareness is partly there, Awareness is minimal, Unsure, very low, no awareness status, no idea, the concept doesn't exist	Big data Awareness and Current Status (Knowledge)
IT structure can be amended or reviewed, the current IT structure can handle it, the need to establish a structure, no provision made yet, Structure is flexible, There are skills to handle big data, current staff would require training, not at the moment, not that I know of, No skills.	Organisational structure and Big data skills
Yes, despite of funds, yes, the budget will dictate Somehow ready, partly ready, not ready, IT infrastructure not ready, Assess the current Infrastructure, upgrade of IT infrastructure	Big data Projects Readiness and Support (Willingness)
Daily, Weekly, Monthly, maintenance schedule, software maintenance	IT Infrastructure Maintenance

3.6 Discussion of Themes

The themes are discussed in details in sub-sections below:

3.6.1 Policies and guiding methods/ documents

Participants were asked to indicate the strategies, planning methods and the policies that are being used for planning and decision making in the organisation. Participants listed the policies and planning documents that are currently in place which are being used as guiding methods for planning and decision making in the organisation. Below are the views which were expressed by some of the participants:

- *“Revised IT Policy for Public Service of the Republic of Namibia, 2017; E-Governance Policy for the Public Service of Namibia, 2005; e-Government strategic Action Plan (2014 - 2018); Web design Standards & Guidelines for the Public service of Namibia 2016. “*
- *“IT policies, e-governance Policies and other policies related to Information Technology. “*
- *“Team work and top down is used for planning and decision making “*
- *“ICT Policy and E-governance policy”*
- *“Strategic plan and annual plans”*
- *“project planning and the use of frameworks”*

- *"LONG-TERM STRATEGIC PLANS (FIVE YEARS); MEDIUM TERM EXPENDITURE FRAMEWORKS, ANNUAL PLANS, AND INDIVIDUAL PERFORMANCE AGREEMENTS "*
- *"Strategic and Operational planning method, HR Policy"*
- *"Strategic Planning "*
- *"I think the IT policy and the draft data protection bill "*
- *"YES, ALL OUR POLICY REVIEWS ARE MAKING PROVISION TO AUTOMATE SOME OF THE COMPONENTS."*
- *"Interoperability Framework"*
- *"yes, the IT policy and innovation policy"*
- *"We are using the Performance Management System as a tool for planning the annual projects. "*
- *"THERE ARE POLICIES AND GUIDELINES"*
- *"Strategic plan and annual plan, key performance indicator"*
- *"the performance management system"*
- *"Traditional way of making decision. "*
- *"Management in consultation with employee make decision"*
- *"5 years strategic plan aligned to vision 2030 and NDPs, Performance agreement aligned to annual plan. "*
- *"I have no idea. "*

3.6.2 Big data Awareness and Current Status

Participants were asked to state the current status of awareness of big data in the organisation and this was done to test their knowledge on the concept of big data. Below are the participants' views, which were expressed by some of the participants:

- *"The awareness is partly there."*
- *"Awareness needs to be enhanced. "*
- *Through e-government projects that are aimed solve public sector services delivery challenges.*
- *Awareness on Big Data is very minimal*
- *"We are aware but still in the infancy stages."*
- *"Nothing"*
- *"Very low, very few staff member have that knowledge. "*
- *"Unsure"*
- *"Average"*
- *"Not aware of anything like using big data"*
- *"This is not known to me, hence awareness must be intensified"*
- *"The Office is trying by its all means to sensitize on the big data practice, as the custodian of Government IT Policies and Infrastructures."*
- *"No awareness"*
- *"Big Data is popular among IT professional but has not been widely articulated organisation-wide, especially down at grassroots levels. "*
- *"Not much awareness in Government on big data."*
- *"we currently don't have big data processing in the organisation"*
- *"the concept does not even exist"*

- *"The organisation is not using big data as of yet."*
- *"It's not highly used due to lack of storage as it requires big system to process it."*
- *"Status: we don't have a system in place to process big data, so we use excel to a level we are able to."*

Most comments above indicate that the awareness is not fully there or it is not there at all. Although some participants feel the big data concept is only among IT professional.

3.6.3 Organisational structure and Big data skills

Participants were asked to indicate if there is provision of the current structure to incorporate a dedicated team responsible for big data projects awareness of big data in the organization. This was done to test their knowledge on the concept of big data. Below are the participants' views:

- *"maybe"*
- *"Not aware"*
- *"Yes, the organisation has the right capacity to govern the project"*
- *"Big Data strategy is simply a must to make well-informed business decisions, improve internal operations and customer experiences, and drastically reduce costs in every business line."*
- *"Yes, there is a provision currently to incorporate a dedicated team to handle big data project in the near future. "*
- *"Yes, our structures in Government makes provisions for working on these types of project"*
- *'yes, vast skilled IT staff"*
- *"Yes, the department of Information and Technology can be used to facilitate a big data project"*
- *"I'm sure our IT department is capable"*
- *yes, employee need to be trained on the important of big date*
- *"Yes"*
- *"Projects such as for big data requires specialist or professional in the targeted area. So, there will be a need for team for this project but we first have to invest in the team in order to have specialists or certified team in-house as outsourcing is costly."*
- *"it can be done but no provision made yet"*
- *"NOT SURE. THIS WILL BE UP TO MANAGEMENT TO CREATE A TEAM TO HANDLE BIG DATA. HOWEVER, OUR TEAM IS PREPARED TO HANDLE BIG DATA PROJECTS PROVIDED THAT WE RECEIVE PROPER TRAINING."*
- *"Our organisational structure is flexible. Meaning it can be adjusted any time, provided that there are funds available."*
- *"There should definitely be or have already been established in our IT division to handle it."*
- *"Yes, it is in the pipeline as outline in NDP5 and HHP2."*
- *"Yes, technical staff members can do. "*
- *"yes, we are ready to handle big data provided that we first receive training on how to handle big data"*
- *"The structure needs to be reviewed to cater for big data projects."*

- *“Partially yes. Provision can be made within the Directorate of Quality Assurance as a start while instituting a fully dedicated team.”*

As evident from their responses, participants feel the provision is there or in-house training can be done to cater for big data projects.

3.6.4 Big data Projects Readiness and Support

Participants were asked to indicate their willingness to work and support the big data projects initiative. The question was further extended for participants to indicate the readiness of the organisation on the big data usage. Below are some participants' views:

- *“Yes”*
- *“Yes, despite lack of funds. But if I had it my way I can't invest into infrastructure that will enable usage of big data. “*
- *“definite yes”*
- *“That is a decision that has to be taken by top management. Depends on the costs and the viability.”*
- *“No”*
- *“No, thanks”*
- *“The willingness is there however the budget will dictate.”*
- *“If that decision comes from the top, yes off course.”*

Above is the compilation of similar responses, hence the list is not too long compared to other responses. Respondents were very optimistic about the big data initiative.

3.6.5. IT Infrastructure Maintenance

Participants from the IT department were asked to shed some light on their recommendations when it comes to the maintenance of the IT infrastructure. Below are some participants' views:

- *“System maintenance schedule. “*
- *None*
- *“Frequent upgrade of IT infrastructure, skills development and documentation of maintenance activity, move to automated processes. “*
- *“Systems Software Updates and Security monitoring tools. “*
- *“Routine system checks up with regards to cybercrime. “*
- *“VPN and able to access some applications from secured public networks.”*
- *“A practical check form to be completed and followed during the checks.”*
- *“Keeping system documentations,”*
- *“Keeping Requirement matrix. “*
- *“Change management”*
- *“Move to automated process, limit equipment downtime and establish a corrective action system for failures. “*
- *“Strongly define the maintenance strategy aligned with DPSITM goal. “*
- *“Get rid of legacy systems. “*
- *“The system upgrade needs to be done periodically. “*
- *“Data analysis tools need to be put in place and be maintained to give accurate information/reports. “*
- *“Monitoring highly critical assets and Emphasize Preventive Maintenance.”*

Clearly the participants do feel there is a lot to be carried out when it comes to IT Infrastructure maintenance. A lot of emphasis is pointed out to do maintenance.

4. Formulation of approach

4.1. Justification for a big data-focused strategic approach

The McKinsey 7-S Model is a method used to determine how well an organization's design is aligned. It does this by analysing the design of an organization by focusing on key internal factors, including structure, systems, strategy, shared values, style, personnel, and skills (Jurevicius, 2022). The researcher was able to identify a few important features that are the factors that need to be considered during the construction of a big data-oriented strategy approach based on the literature review and the data collected and evaluated. Consequently, the McKinsey 7-S Model, a change framework based on the organization's design, was used to steer the development (Malik, 2022).

The gap analysis is conducted using a model to determine how the organisation's present strategy differs from the approach it has to take in order to implement the existing plan successfully (Athuraliya, 2022). The research developed the big data-oriented strategy approach using the steps listed below:

Step 1: Examine the organization's current position.

The internal resources of the organization, including its current skills, IT infrastructure, strategies in place, organizational structure, and policies, as discussed from section 8.2 are the factors needed for big data analytics practice, according to the researcher's analysis of the current situation.

Step 2: Establish the ideal state for the organization

The majority of the elements are not yet in alignment with the suggested big data focused strategic strategy, according to the data gathered from the participants. Findings also indicate that management and employees are open to participating in big data analytics initiatives. However, the current plans, methodologies, and rules need to be updated to include big data projects.

Step 3: Creating a big data approach

In this step, a diagram and a text explanation are used to present the big data-oriented strategic approach. The factors that were discovered and described in sections 8.2 serve as a guide for the development.

Step 4: Periodically review the elements/factors.

A regular evaluation is necessary since components are dynamic and even little changes to one factor can have an impact on others. The elements influencing the big data-oriented strategic approach need to be continually assessed in order for it to stay up with new technological developments and operational changes.

4.2 Process for developing a strategic approach focused on big data.

The development of a big data-oriented strategy approach process should consider the factors required for the use of big data analytics in accordance with the data gathered, analysis, discoveries, and discussions. To accomplish the main goal, it is required for the big data-use-related aspects to be in line with the big data-oriented strategic approach. The following table represents the alignment of the requirements for the use of the big data method from the case study utilized in the organisation and is led by the 7-s Mckinsey model, which focused on the internal resources of the organisation:

5. Development of Big Data Oriented Strategic Approach

During the literature review and data analysis, factors that influence the practice of big data analytics were identified and discussed in the findings. These factors were used as the guide to develop the big data oriented

strategic approach. The proposed big data oriented strategic approach is presented in this chapter. The approach presents the current status of the organisation and the proposed big data approach including factors that influence the utilisation of big data techniques.

5.1 Big data oriented strategic approach justification

The McKinsey 7-S Model is a tool used to identify the effectively alignment of the organisation's design, by analysing the design of an organisational through focusing on key internal elements; structure, systems, strategy, shared values, style, staff and skills, and this is done to allow the organisation to achieve its objectives (Jurevicius, 2022). According to the literature reviewed and the data collected and analysed, the researcher was able to identify few key elements which are the factors that need to be considered during the big data oriented strategic approach development. Therefore, the development was be guided by McKinsey 7-S Model, which is a change framework that is based on the organisation's design (Malik, 2022).

The model can be used to conduct a gap analysis or to identify the difference between the organisation's current strategy and what it needs to adopt in order to effectively implement the current strategy (Athuraliya, 2022). The research followed the steps below to develop the big data oriented strategic approach.

Step 1: Analyse the current situation of the organisation

The researcher has analysed the current situation and identified the factors needed for big data analytics practice and these are the organisation's internal resources, namely: current skills, the current IT infrastructure, the strategies in place, the organisation's structure, policies.

Step 2: Determine the ideal situation of the organisation

According to the data collected from the participants, most of the factors are not yet aligned with the proposed big data oriented strategic approach. Findings also shows that both management and staff members are willing to partake in big data analytics projects. However, big data initiatives need to be incorporated in the current strategies, methods and policies.

Step 3: Development of the big data-oriented strategic approach

During this step, the big data oriented strategic approach is presented in the form of a diagram with an explanation of text. The development is guided by the factors that were identified during data analysis in Chapter 5 and further discussed in Chapter 6, from section 6.2.1 to section 6.2.3.

Step 4: Review the factors/elements from time to time

Considering that the factors are subjected to change, a regular review needs to be done since a single change in one factor may affect other factors. For the big data-oriented strategic approach to keep up with the emerging technology and changes in operations, the factors influencing the big data oriented strategic approach needs to be regularly reviewed.

5.2. Big data oriented strategic approach development process

According to the data collected, analysis and findings and discussions the factors necessary for the use of big data analytics need to be considered during the development of a big data oriented strategic approach process. The factors necessary for the use of big data need to be aligned to the big data oriented strategic approach to achieve the main objective. This is guided by the 7-s Mckinsey model which focused on the internal resources of the organisation therefore, the table below is the alignment representation of the necessary factors for the practice of big data approach from the case study used in the government's office:

Table 2: Big data approach alignment

Factors	Factor description	Alignment:
Strategy (Current strategies, methods in place)	Big data oriented strategic approach	Not aligned
Structure (Organisational Structure)	Complex structure, but no dedicated division for big data	Partly, aligned
Systems (IT Infrastructure)	The IT infrastructure is quite complex, provision for big data initiatives can be made	Partly, aligned
Skills (Big data Skills)	There are computer proficient employees with both technical, programming and analysis skills. However big data specialized skills to manage big data need to be acquired or enhanced.	Partly aligned
Staff (Number of staff and the level of educational qualification)	The organisational structure is flexible; hence provision can be made to cater for big data initiative.	Not aligned
Decision making support (Leadership Style, Strategies, Policies and Plans)	Top managers rely on Annual, Strategic Plans, Policies etc. Bureaucracy No real time data driven decisions support.	Not aligned
Shared values (Vision, Mission mandate))	Team work, Excellence	Not aligned

Table 2 shows that most of the factors are not aligned or partly aligned to the big data approach. However, for a successful big data oriented strategic approach to be developed, a transformation is required for the necessary factors to be aligned to the big data initiative. Hence a transformation is presented in Figure 21 which shows a blueprint illustration for the proposed big data oriented strategic approach transformation process with the ideal future outcome.

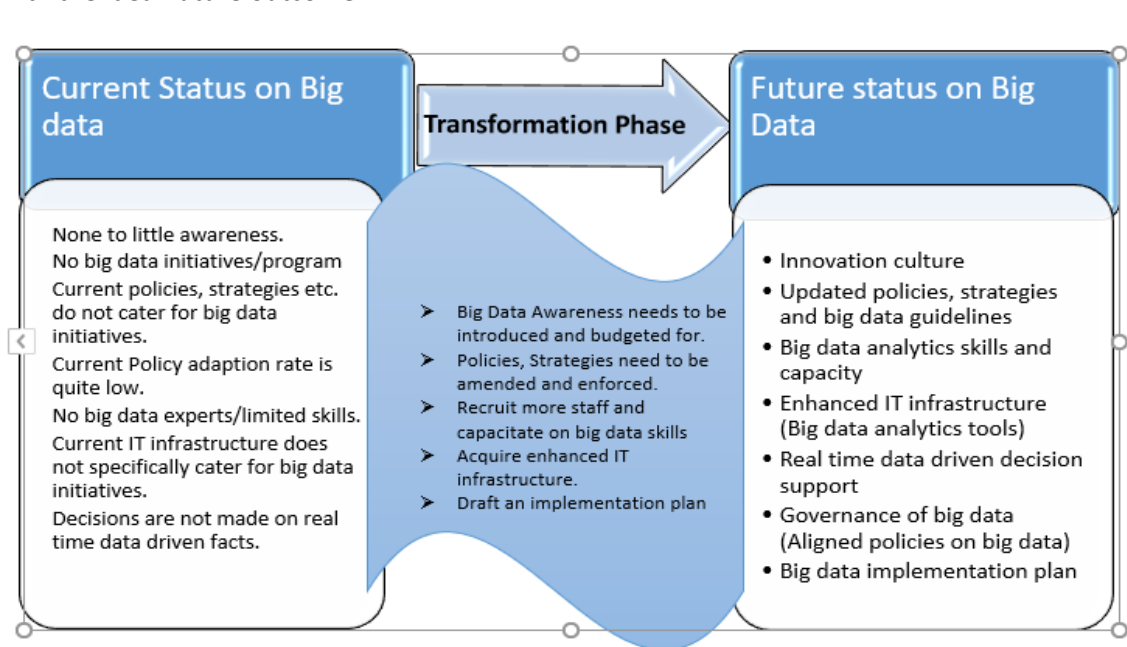
*Figure 18: Big data oriented strategic transformation approach*

Figure 18 presents the transformation process from the current status, the interventions during the transformation phase to the ideal future status. In order to achieve the ideal outcome, the big data concept needs to be introduced and budgeted for, policies, strategies need to be amended and enforced, recruit and capacitate the staff members, acquire enhanced IT infrastructure and come up with a big data oriented strategic approach implementation plan. The outcome is a big data-oriented approach that will support decision making through insights acquired from real time data, resulting in data driven decisions.

5.4 Proposed Big data oriented strategic approach:



Figure 19: Big data oriented strategic approach

Figure 19 is the illustration of the proposed big data-oriented strategic approach, the factors were aligned during the transformation phase and the researcher revised the factors to fit the proposed big data oriented strategic approach for the organisation. The factors are further explained and presented in the following table:

Table 2: Big data oriented strategic approach

Factors	Factor description	Alignment?
Innovation Culture (Big data Strategy)	Adequate funding of ideas Active opportunity management	Yes
Enhanced IT infrastructure	Huge data storage for big data projects, Data analytics capability	Yes
Big data skills and capacity	Data mining, Problem solving, AI, Interpretation and data visualization	Yes
Organisational Structure	Functional reporting structure, Divisional and departments teams	Yes
Big data implementation Plan	Transformation plan, Big data architecture design, Strategic management	Yes
Leadership style: Data driven decision support	Using facts, Metrics, Data targeting, Data-driven strategy	Yes

5.6 Research Limitations

Considering the limitations of the study, it was that it was only carried out in Windhoek, Namibia from the second highest office which is mandated to head the government administration. However not all employees participated in the study, due to time constraints hence a sample was selected for the study. The study 's big data strategic approach was not practically implemented and tested for the mentioned office, resulting in the study being limited to do a complete walkthrough of the implemented approach. Henceforth, the approach's effectiveness is not yet tested in real business operations.

Another limitation regarding some of the interview participants where that, they opted to be interviewed via telephone and this limited the researcher to capture the real expressions of the interview participants. Moreover, some of the interview participants opted to be sent the questions via email and respond there, hence limiting the researcher to ask follow up questions.

5.7 Consideration for Future Research

The study main objective was to develop a big data-oriented approach to aid management in decision making. More research should be carried out in different organisations considering that factors that may influence a big data approach may differ. Furthermore, factors that are necessary for the implementation of a big data approach needs to be assessed to guide with the implementation and development of a customized big data approach for each organisation. In addition, organisations' strategies need to be evaluated to incorporate big data analytics as a programme, considering that we are living in an information era. Furthermore, the proposed big data oriented strategic approach needs to be tested, to ensure validation for future research.

5.8 Research Conclusion

The study evaluated how a big data-oriented approach for decision support can be developed. The study further identified factors that are necessary to develop a big data approach, which where both strategic and operational factors. The study was carried out using two theories as a guiding factor.

The two theories used for the study which are Dynamic-capability theory and Resource-based theory. The resource-based theory/view and the theory of Dynamic Capabilities were used to guide the research. The resource-based theory promotes resources as a key to improved business performance, the resource should exhibit (Value, Rarity, Imitability and Organisation) VRIO Attributes which is used to assess the situation inside the organisation (Kadlecova, 2020). VRIO attributes, thus may enable a firm to gain and sustain competitive advantage (Jurevicius, 2013). The VRIO tool was developed by (Barney 1991; Jurevicius, 2013). According to the VRIO tool's analysis, the resource must be valuable, rare, imperfectly imitable and non-substitutable. The supporters argue that organisations should look inside the organisation to find resources instead of looking at competitive environment (Shan et al, 2018). Hence the researcher opted to use the organisation's resources to assess the internal environment.

However, according to the dynamic capability model, an organisation's capabilities are a combination of critical skills and tacit knowledge, as well as the resources that an organisation collects over time (Chong et al., 2018). Capabilities are intellectual capital, and other organisations find it difficult to mimic or reproduce them. This hypothesis was presented to help organisations deal with societal growth, new technology, and the growing complexity of the market environment (VU, 2020). The study was aimed to focus on the ever-changing trends of the technology aspect using the organisation's resources with the aim to assess possible opportunities and continuous transformation to improve service delivery by making real time data driven decision.

The study collected data from the government's organisation, from different departments using interviews and questionnaires. Therefore, the organisation's internal resources, including the technological resources were analysed to assess how to develop a big data-oriented approach for decision support in organisations. The big data-oriented approach was developed as a result. Furthermore, the study investigated the various methods of decision support in the organisation. Through data interpretation, the study identified factors necessary for big data analytics use as a decision support in organisations and identified organisation's strategies that do not currently cater for big data approaches as a decision support system.

Conclusion

In conclusion, business analytics is all about decision-making, but not the kind of decision-making that was traditionally done, which mainly relied on intuition, experience, and gut feelings, but rather the kind that depends on data, evidence, computer, mathematical, and statistical sciences. Managerial decision-making is undergoing a paradigm shift as a result of the need to make quicker and better data driven decisions in today's fiercely competitive business environment, the availability of large and feature-rich data sources, and advanced computing resources (both on the hardware and software side). In a nutshell, data is very crucial hence there is need to explore the big data approach to get insights to enable decision makers to make real time data driven decisions.

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A Systematic Review for Cyber Security Awareness Platforms: Recent approaches and Research Gaps

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Abstract.

Cybersecurity remains one of the major challenges facing computer systems in the modern age. Traditional hacking methods, reliant on technical intrusion, are being replaced by more human-centric attack vectors (Chang & Coppel, 2020). Consequently, enhancing user awareness has become a crucial defensive measure. The 21st-century surge in remote work and digital transition, exacerbated by the COVID-19 pandemic, amplifies the relevance and urgency for effective cybersecurity awareness platforms. This paper systematically reviews current strategies in this domain, spotlighting: i) Definitions of cyber security awareness platforms, ii) Contemporary Cyber Security Awareness Platform methodologies, iii) Essential components, and iv) Existing research voids.

Keywords: cyber security, Awareness, cyber threats, information security

1. Introduction

As the 21st century unfolds, our profound technological reliance has invariably expanded the cyber threat horizon. Rapid digital adoption, further catalysed by the Covid-19 pandemic, provides both remarkable opportunities and latent risks. While technology revolutionised business and daily life it simultaneously casts a shadow of vulnerability, especially over less tech-savvy users. Consequently, Cybersecurity awareness emerges as a pivotal defense shield, embodying the user's comprehension and readiness to navigate the lurking cyber perils (Corallo et al., 2023). Recent analytical insights from industry stalwarts like (Kaspersky, 2023), (Verizon, 2022), (Deloitte, n.d.) accentuate the increasing trend of cyber adversaries targeting human vulnerabilities, underscoring the human element's pivotal role in the cyber equation. Effective cyber security awareness is no longer a luxury but a necessity. Hansche (2016) posits that a robust security awareness program enlightens users about the significance of information system security, highlighting the repercussions of breaches. Enriching employee knowledge, enhancing skill sets, and fostering vigilant awareness are instrumental in fortifying organisations against the multifaceted threats of the cyber realm (Beuran, Tang & Tan, 2018).

Merely introducing awareness strategies, however, is not sufficient. It is essential to gauge their efficacy in averting threats, mitigating risks, and precluding cyber onslaughts. With an ever-evolving threat landscape, programs run the risk of obsolescence unless they continuously adapt. It is equally vital to discern if such programs resonate across diverse variables like organisational culture, demographic attributes, and educational backgrounds. Many studies, including those by (Aldawood & Skinner, 2019) and (Tsohou et al., 2015), have starkly illustrated the vulnerability of organisations lacking structured awareness initiatives. Designing impactful awareness programs necessitates adopting a range of strategies, from gamification and AI-assisted modules to educational workshops. For a holistic and potent user awareness paradigm, it's crucial to constantly monitor the cyber threat landscape, identifying countermeasures and seamlessly integrating them into the program.

This paper is arranged in the following sections: - The current section i.e., section one is an introduction to the study. Section 2, the methodology explains the methodology used in selecting the appropriate studies for review as well as the analytical process. Section 3 contains the analysis areas of literature review. The

results of the study are presented in section 4. Section 5 provides for conclusion as well as discussion of the findings.

2. Methodology

This study has adopted a Systematic Literature Review (SLR) methodology. SLR provides for a process of collecting relevant evidence on a specific topic that matches a pre-defined eligibility criteria and to answer an articulated research question (Mengist et al., 2020). In the current study context, the SLR was applied to answer the following questions: What are the current approaches used in developing cyber security awareness platforms. Consequently, to achieve the study objectives the analysis was focused on the following key areas: i) Definitions of cyber security awareness platforms, ii) Recent Approaches in Cyber Security Awareness Platform, iii) Components of cyber security awareness platforms and iv) Research gaps.

There are quite a number of approaches towards SLR methodology proposed by various researchers within their studies such as (Lacerda & von Wangenheim, 2018), (Centobelli et al., 2017) and (Yeoh et al., 2022). In particular, the current paper will adopt a model by (Corallo et al., 2022) as presented below for the following reasons a) It is the most suitable model to meet the study objectives and b) It provides a comprehensive breakdown of steps.

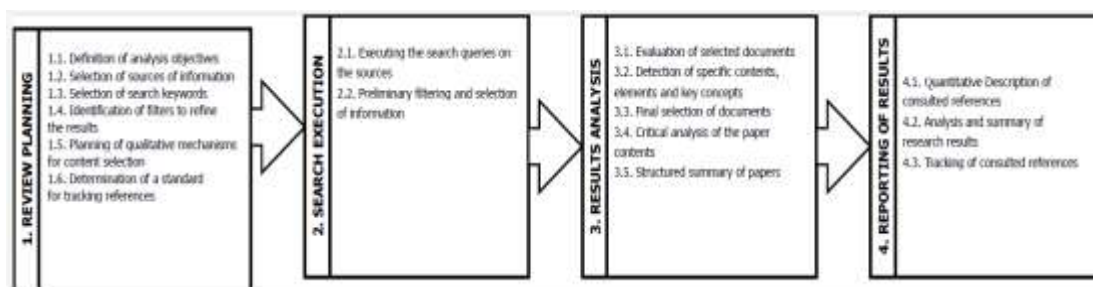


Figure 1: Steps and activities in the SLR method

Source: (Corallo et al., 2022b)

As such, the SLR was carried out in four main stages namely 1. Review Planning, 2. Search Execution, 3. Results Analysis and 4. Reporting of results. Within each step, there are various activities as demonstrated in figure 1.

3. Selection process for literature

Once the study analysis objectives were defined, the search process was performed on Scopus database. Scopus is regarded as a comprehensive source of publication metadata according to (Pranckutė, 2021). The search criteria used the following two keywords: “cybersecurity awareness” and “cybersecurity awareness platforms”. However, the authors are of the view that since the term information security is often used interchangeably with cybersecurity in literature, the key word “information security awareness” was therefore also included. The source was accessed in August 2023.

After the determination of source and keywords, the following search query in figure 2 was formulated.

TITLE-ABS-KEY ("Cybersecurity Awareness") AND (LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "cr") OR LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "sh")) AND (LIMIT-TO (EXACTKEYWORD , "Cybersecurity Awareness" OR "information security awareness" AND "cybersecurity awareness platforms"))

Figure 2: Search Query

The above search query produced 67 articles. The papers were then filtered and selected accordingly to match the study objectives. After filtering them based on the abstract, we were left with 48 articles to consider. We then further screened the 48 based on the title where focus was on the cybersecurity awareness or information security inclusion in the title, which led us to drop 9 articles. This ultimately left us with 39 articles to consider for our review section.

Table1: Filtering results

Source	Filter document language	Filter Type	Document	Selection after topic and abstract analysis	Selection after reading contents of the paper
Scopus	67	67		48	39

4. Analysis areas of literature

The selected papers were evaluated using an excel sheet which records specific metadata about each paper. The following information was recorded for each paper: Title, authors and their affiliations, Source title, publication year, Definitions of cybersecurity awareness platform, method used to create cybersecurity awareness and components of the cybersecurity awareness platform.

Table2: Areas of Analysis

Area	Focus
Definitions of cyber security awareness platforms	Cybersecurity awareness platform
Contemporary Cyber Security Awareness Platform methodologies	Current approaches towards development of cyber security awareness platforms
Essential components	Features of the developed cybersecurity awareness solutions
Existing research voids	Identified research gaps in cyber security awareness research

4.1 Definitions of cyber security awareness platforms

The analysis indicates that none of the selected papers provided an explicit definition of the term cyber security awareness platforms or information security platforms. However, some discuss aspects related to cyber security awareness platforms such as approaches to establishing cybersecurity awareness platforms, evaluation metrics for measuring effectiveness of a cybersecurity platforms and features of an information security awareness platform. The analysis also indicates that there is a correlation between the term

cybersecurity awareness platform and cybersecurity awareness program and the latter is commonly referenced in literature. This prompted a further literature search which focused on finding out the definitions of the terms according to international cyber security standards. The identified two standards also did not provide explicit definitions; however, their definitions of cyber security awareness are found to be comprehensive and contain clauses pertaining to creation of cybersecurity awareness programs in an organisation and hence are highlighted below.

- "The ability of individuals to recognize, understand and respond to cybersecurity risks to organizational operations, assets and individuals." (ISO). Moreover, (ISO 27002:2022) used the term information security awareness and defined it as a "process of informing users about the importance of information security and encouraging them to improve their own computer security habits."
- "Awareness is not training. The purpose of awareness presentations is simply to focus attention on security. Awareness presentations are intended to allow individuals to recognize IT security concerns and respond accordingly." (NIST 800-50)

Although there seem to be differences in terms definitions among the standards, The comparative analysis of these definitions indicates that cybersecurity awareness is created with the common aim to enable individuals to make a secure response towards cybersecurity risks.

4.2 Contemporary Cyber Security Awareness Platform methodologies

After analysing the various definitions of the terms cyber security awareness platforms and information security awareness, an analysis of the contemporary methodologies used in establishing and assessing cybersecurity awareness platforms is done and outlined in this section. Generally, the term "cyber security awareness platform" in the selected papers is referred to using various terms such as systems, models and theoretical frameworks. Below, different sections will present these platforms through the use of terminologies as referred to in selected literature.

4.2.1 Cybersecurity awareness systems

According to (ISO 9000:2015) standard, a system is defined as a set of interrelated or interacting elements of an organization that together contribute to the achievement of its objectives. (Amanowicz, 2020) developed a national distributed cyber security awareness system consisting of four functional system component types, namely Operations Centre System (OCS), Edge System (ES), Management System (MS), and Backbone Network (BN) which has the ability to collect real-time information from multiple systems and provide online security risk analysis and for generation and distribution of early warnings. Similarly, in a separate study (Amanowicz, 2021) presented a technical system that allows collection, processing and sharing of distributed knowledge on hazard events, hence facilitating global cyber threat awareness, and enhancing the process of predicting and assessing cyber risks in order to ensure a near-real-time response.

There is also considerable literature that focuses on using educational measures for cyber security awareness. For instance, a study by (Azzeh et al., 2022) focuses on infusing cybersecurity topics within the students' curriculum to ensure awareness. Their experimental results found significant differences between marks of prior and post-tests for 11 out of 14 infused topics suggesting that universities can implement this approach to ensure cyber security awareness and practices among students. In a more related study, (Peker et al., 2018) developed an interactive module aimed towards increasing cybersecurity awareness among college students that also presents consequences of insecure habits of the user. Furthermore, (Dang-Pham et al., 2020) proposed a network analytic based system that disseminates cybersecurity knowledge, by identifying the influential students from their social networks of online interactions in the online learning systems. The literature on educational based methods indicates that these studies are mostly conducted in educational institutions settings, making it difficult to apply their results to organisational settings. Hence,

this prompts for exploration and development of educational based cyber security awareness methods relevant to organisational and industry scenarios.

Moreover, there are some studies that explored game-based cybersecurity awareness solutions such as (Alqahtani & Kavakli-Thorne, 2020), (Bacud & Mäses, 2021) and (Warasart & Piriyaawong, 2022) and (Fung & Lee, 2022) used a chatbot based solution that acts as an expert of cybersecurity topics. The table below summarises the cybersecurity awareness systems as presented in the analysed literature.

Table 3: Cyber security awareness systems

Name	Description	Category	Year	Reference
National Platform for Cybersecurity (NPC)	A Shared Cybersecurity Awareness Platform	Technical system	2021	(Amanowicz, 2021)
Cybersecurity concepts into curriculum	Adopting the Cybersecurity Concepts into Curriculum: The Potential Effects on Students Cybersecurity Knowledge	Educational	2022	(Azzeh et al., 2022)
Cybersecurity awareness module	Online Cybersecurity Awareness Modules for College and High School Students	Educational	2018	(Peker et al., 2018)
Network analytics	Network Analytics for Improving Students' Cybersecurity Awareness in Online Learning Systems	Technical system	2020	(Dang-Pham et al., 2020)
CybAR	Design and evaluation of an augmented reality game for cybersecurity awareness (CybAR)	Game	2020	(Alqahtani & Kavakli-Thorne, 2020)
online serious games	Game-Based Learning for Cybersecurity Awareness Training Programmes in the Public Sector	Game	2021	(Bacud & Mäses, 2021)
cybersecurity expert chatbot	A Chatbot for Promoting Cybersecurity Awareness	Chatbot	2022	(Fung & Lee, 2022)
Gamified Social Collaboration	Synthesis of Gamified Social Collaboration via Mesh Community of Practice to Enhance Cybersecurity Awareness	Game	2022	(Warasart & Piriyaawong, 2022)

4.2.2 Cybersecurity Awareness Models

In the Merriam-Webster dictionary, A model is defined as "A usually miniature representation of something" or "a pattern of something to be made." Several papers reviewed have established cybersecurity awareness through the use of models. (Wahid et al., 2021a) developed a cybersecurity awareness model based on

Information Security Awareness Model (ISACM) and the Situation Awareness Cybersecurity Education Model (SAOCE). Their model specifically aims to enhance cybersecurity awareness and prevent cyber-attacks among senior citizens. Meanwhile, (Biswal, 2021) proposed a model called Real-time intelligent vishing prediction and awareness model (RIVPAM) specifically for prediction and creating awareness on Social Engineering based attacks. Promptly to the argument of whether cybersecurity awareness predicts compliance with security practices and policies, (Reddy & Rao, 2016) developed a research model that can reflect the relationship between cyber security skills, cybersecurity awareness and compliance. Through the application of Endsley's model, (Thiéry & Fass, 2020) have conducted exploratory research to determine levels of cyber situational awareness of audit processes by evaluating the compliance to the steps within the Endsley's model.

4.2.3 Cybersecurity Awareness Frameworks

Four (4) of the selected literatures have proposed adoption of frameworks as a means to encourage cybersecurity practices and assess cybersecurity awareness. For instance, (Wong et al., 2022) have applied the protection motivation theory (PMT) to understand how employees' perceived cybersecurity awareness influences their actual behaviour towards cyber-attacks. Similarly (Alshaikh & Adamson, 2021) applied psychological attachment theory to argue how cybersecurity awareness influences users' security behaviour. Through the use of Innovation Diffusion Theory (Alshboul & Streff, 2017) have discovered that Information Security Policy awareness leads to improved cyber hygiene practices among employees. Moreover, (Tirumala et al., 2019) proposed a framework that can assist organisations with their implementation process of cybersecurity awareness, whereas (Simonet & Teufel, 2019) investigated the effects of organisational, personal and social determinants of cybersecurity awareness affects the user's behaviour towards information security.

4.2.4 Surveys

A survey is defined by (Leong & Austin, 2005) as a method of collecting information from people for descriptive or predictive purposes. Our review of the literature selected indicated that surveys, particularly through online questionnaires, are the commonly used tools for evaluating the effectiveness of the current security platforms as well as the awareness of users towards cybersecurity. There are eleven (11) literatures among selected papers that used survey methods to conduct studies on cybersecurity awareness. The table below outlines the surveys in reviewed studies.

Table 4: Cybersecurity Awareness surveys

Survey Tool	Paper title	Description	Year	Reference
Interviews and questionnaires	Cybersecurity workforce in railway: its maturity and awareness	Evaluate and estimate the cybersecurity maturity and awareness risk for workforce management in railway transportation by using Railway-Cybersecurity Capability Maturity Model (R-C2M2) and Information Security Awareness Capability Model (ISACM)	2021	(Kour & Karim, 2021)
Online Questionnaire	Assessing the influential factors of cybersecurity	Identification of factors influencing cybersecurity awareness in Malaysia during the COVID-19 Pandemic	2021	(Wahid et al., 2021b)

	awareness in Malaysia during the pandemic outbreak: A structural equation modeling			
*Questionnaire	Measuring awareness of social engineering in the educational sector in the kingdom of Saudi Arabia	Assessing of Social Engineering awareness in Saudi Arabia	2021	(Alsulami et al., 2021)
Online Questionnaire	An assessment of cybersecurity awareness level among Northeastern University students in Nigeria	Identifying the level of cybersecurity awareness of students in Northeastern Nigeria.	2022	(Garba et al., 2022)
Online Questionnaire	Pathways to cybersecurity awareness and protection behaviors in South Korea	Examines two pathways leading to enhanced cybersecurity protection behaviors in relation to cybersecurity awareness and cybersecurity risks.	2023	(Lee & Kim, 2023)
Semi-structured interviews	Understanding parents' perceptions of children's cybersecurity awareness in Norway	Evaluating how parents perceive and address their children's cybersecurity risks.	2021	(Quayyum et al., 2021)
Self-administered questionnaire	Exploring The Correlation between Cyber Security Awareness, Protection Measures and the State of	Examine the awareness of cybersecurity, the measures taken to protect against cyberattacks and the state of victimization among professors at Ambo University.	2021	(Mamade & Dabala, 2021)

	Victimhood: The Case Study of Ambo University's Academic Staffs			
Questionnaire	Exploring The Correlation between Cyber Security Awareness, Protection Measures and the State of Victimhood: The Case Study of Ambo University's Academic Staffs	Examine the awareness of cybersecurity, the measures taken to protect against cyberattacks and the state of victimization among professors at Ambo University.	2021	(Mamade & Dabala, 2021)
Questionnaire	A survey on cybersecurity awareness concerns, practices and conceptual measures	Understanding the cyber security awareness state of internet users	2019	(Tirumala et al., 2019)
Web-based survey and "MyCyberSkills" application	Cybersecurity awareness and skills of senior citizens: a motivation perspective	An investigation study on the set of constructs that contribute to senior citizens' motivation to acquire cybersecurity skills	2021	(Blackwood-Brown et al., 2021)
Questionnaire	A survey on Internet usage and cybersecurity awareness in students	Understanding students' current knowledge on cybersecurity to guide the provision of cybersecurity awareness training.	2016	(Tirumala et al., 2016)

4.3 Essential components

By reviewing the selected studies, it was possible to identify some essential components suggested to be included in the designs and development of cybersecurity awareness systems and models. The following components seem to be regarded as essential in the developed systems and models i) Training, ii) Assessment, iii) Reporting, iv) Personalisation and v) Continuous learning. The observation also indicates that current systems and models components mainly are based on the type of platform or method being used to

create awareness. For instance (Chaudhary et al., 2022) discovers misalignment between posters design and the needs and objectives cybersecurity awareness platforms and hence suggested six main properties namely topic, information quality, message framing, suggestions quality, content presentation, localisation, and style and formatting. In game-based cybersecurity awareness approach, (Bacud & Mases, 2021) emphasized on reinforcing learning content with innovative learning experience and digital technologies as the main attributes that improves users' experience of cybersecurity awareness in the public sector.

4.4 Existing research voids

The analysis results indicate that more research still needs to be conducted. For instance, there is a lack of literature on industry specific cybersecurity awareness platforms as some cybersecurity awareness platforms might be effective in industries with more technical expertise as opposed to industries that are not technical oriented. Furthermore, most cybersecurity awareness platforms evaluation are short-term in nature, it is crucial to also understand if awareness leads to a sustained secure behaviour towards cybersecurity risks.

5. Discussion

Through comparative analysis of cybersecurity systems and methods, it is observed that more studies believe that cybersecurity awareness systems should be related to behavioural factors, suggesting the adoption of various behavioural theories such as PMT and psychological attachment theory. Moreover, there is also an interest in using digital technologies such as serious games and chatbots solutions for cybersecurity awareness. The current widely adopted method to assess users' awareness is surveys mainly implemented through questionnaires. Perhaps a more assertive method such as simulation as adopted by (Daengsi et al., 2022) can be more appropriate to address the difference between users' perceived awareness and actual behaviour (efficacy) towards cybersecurity risks.

6. Conclusion

This study provides a qualitative content analysis of selected literature in the domain of cybersecurity awareness. A comparative evaluation of thematic areas also made it possible to highlight their main contribution towards cybersecurity awareness platforms. The review is arranged into four areas of analysis: (i) Definitions of cyber security awareness platforms; (ii) Contemporary Cyber Security Awareness Platform methodologies; (iii) Essential components; and (iv) Existing research voids. The most relevant evidence for each area of analysis is presented to provide a useful overview to guide future research and management with decisions pertaining to choosing and implementing cybersecurity awareness platforms.

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