A SCHOOL MANAGEMENT SYSTEM INTEROPERABILITY MATURITY (SMSIM) MODEL FOR SCHOOLS IN SOUTH AFRICA

by

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DEDICATION

I want to take this opportunity to dedicate this research to the following people:

My late twin sister, Dineo Maremi, I really could not have done this without you. Even through your passing, I knew you would want me to finish what I had started.

My Husband, Aden Milanzi, thank you so much my love for every sacrifice you made and for running alongside me until I reached the finish line.

Lastly, my parents, Mom: Catherine Maremi and Dad: Ben Maremi, this one is for you.

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My Co-supervisor Prof Adele Botha, who is the strict and harsh one in the team. In my African language, there is a saying: "Le rojwa le sa le metsi" which means you sharpen and groom a person while they are still young. This saying reflects the values a parent instils in their child so they can grow to become respectable adults. This saying truly resonates with Prof Adele's role in my journey through this research. She was brutally honest and scolded me at the very beginning when I was saying words like "I can't, and I don't know". Although I shed a tear and felt extremely hurt by her scolding, it shaped my entire thinking of how I look at this research and I am extremely grateful to have had the privilege of working with her.

My husband really supported me when I put so many of our goals on hold to complete my Masters. He slept many nights and woke up without my presence, but he still understood. The father he became when I still needed to put in late hours working on the dissertation and he had to look after our son alone.

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I want to thank my friend, colleague, and sister, Tumiso Thulare, who really travelled this journey with me. She was there to listen to all my frustrations and concerns. She shared the happy achievements in this journey and helped me understand some of the comments our supervisors provided. Her support is unmeasurable, and I am thankful.

Lastly, I want to thank my late twin sister, who really was proud of me until the very last day of her life. May her beautiful soul Rest in Peace.

DECLARATION

I, Keneilwe Maremi, declare that *A School Management Systems Interoperability Maturity (SMSIM) model for Schools in South Africa*, is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I have not previously submitted this work, or part of it, for examination at UNISA for another qualification or at any other higher education institution.

SIGNATURE DATE

ABSTRACT

This qualitative study applied the exploratory Delphi expert reviews as a strategy through the research onion of Saunders, Lewis and Thornhill (2016) to explore School Management Systems (SMS) and how they can be improved through interoperability. The study followed the research methodology as outlined in chapter 5 to conceptualize the School Management Systems Interoperability Maturity (SMSIM) model that provides guidelines for achieving the next level of interoperability in SMS. To conceptualize the model, literature findings, a combination of Organisational Interoperability Maturity Model (OIM) and Information Systems Interoperability Maturity Model (ISIMM), and experts with over 10 years of experience in various fields participated in the study. Hermeneutics and thematic analysis were used to analyze and interpret the data. After the Delphi expert review results (in two iterations), it was evident that nothing had to be changed or adjusted from the conceptual literature model therefore, the model that emanated from literature was the final model of the study.

Keywords: South African School Administrative Management System (SA-SAMS), School Management Systems (SMS), and Interoperability Maturity Models (IMM).

LIST OF PUBLICATIONS RELATED TO THIS STUDY

Conference proceedings

Maremi, K., Thulare, T. and Herselman, M. 2022. The benefits of digital transformation addressing the hindrances and challenges of e-government services in South Africa: A scoping review. In 2022 IST-Africa Conference (IST-Africa) (pp. 1-8). IEEE. Available at: https://ieeexplore.ieee.org/abstract/document/9845641

Maremi, K., Herselman, M. and Botha, A. 2020. Scoping the aspects and capabilities of South African School Administration and Management Systems (SA-SAMS). In *2020 Conference on Information Communications Technology and Society (ICTAS)* (pp. 1-6). IEEE. Available at: https://ieeexplore.ieee.org/document/9082454

Maremi, K., Herselman, M. and Botha, A. 2020. Interoperability Maturity Models for consideration when using School Management Systems (SMS) in South Africa: A Scoping Review. CICTE 2020: International Conference on Information and Communication Technology in Education, 03-04 September. Prague, Czechia. Available at: https://publications.waset.org/abstracts/search?q=%20interoperability

Herselman, M.E., Botha, A., Maremi, K.J., Dlamini, S.B. and Marais, M.A. 2020. Mobile technology affecting teaching and learning in rural schools. Conference: 16th International Conference on Mobile Learning 2020. Available at: https://doi.org/10.33965/ml2020_202004L003

Botha, A., Herselman, M., Rametse, S. and Maremi, K., 2017, May. Barriers in rural technology integration: A case study from the trenches. In 2017 IST-Africa Week Conference (IST-Africa) (pp. 1-10). IEEE. Available at: https://ieeexplore.ieee.org/document/8102349

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Acronym	Description
ANA	Annual National Assessment
CD	Compact Disc
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
COVID-19	Coronavirus pandemic
DBE	Department of Basic Education
DCDT	Department of Communication and Digital Technologies
EIMM	Enterprise Interoperability Maturity Model
FOSS	Free and Open Source Software
4IR	Fourth Industrial Revolution
GIMM	Government Interoperability Maturity Matrix
ICT	Information Comunication Technologies
IMM	Interoperability Maturity Model
ISIMM	Information Systems Interoperability Maturity Model
IQMS	Integrated Quality Management System
LISI	Levels of Information Systems Interoperability Model
MOE	Ministry of Education
OIM	Organizational Interoperability Maturity Model
SA-SAMS	South African School and Administration Management System
SGB	School Governing Body
SITA	State Information Technology Agency
SMS	School Management Systems
SMSIM	School Management Systems Interoperability Maturity
STEAMIE	Science, Technology, Engineering, Arts, Mathematics, Innovation, and Entrepreneurship
STEM	Science, Technology, Engineering and Mathematics
TV	Television
DDD	Data Driven Districts
ATM	Automatic Teller Machine

CHAPTER 1: SCOPE OF RESEARCH

1.1 INTRODUCTION AND BACKGROUND

School Management Systems (SMS) are large databases that schools utilize to automate their day-to-day administrative operations (Nureni, 2014; Sarker, 2016; Akter, 2018; Ssempala, Kabuunga, Taremwa & Magero, 2018). Multiple users widely utilise SMS, allowing them to be configured independently to address the needs of each school (Sarker, 2016; Akter, 2018). Using SMS assist schools with having to deal with tedious paperwork, they can be easily used, and they work accurately and seamlessly in various scenarios. As a result, these systems save time, increase school management efficiency, and reduce workloads (Sarker, 2016; Akter, 2018).

SMS have gained prominence in recent years as a powerful tool for e-leadership and data-driven decision-making. Teachers, learners, and parents use SMS to communicate and exchange information (Blau & Presser, 2013). As a result, these systems allow schools to easily manage their information, which reduces teachers' workload and creates a centralized database that can be accessed and used by all schools (Wei, Piaw, Kannan & Moulod, 2016). Specifically, the system automates two key functions: academic administration and school administration (Wei *et al.*, 2016).

There are many different SMS that are used in many schools around the world, to mention a few (Arslan, 2013; Al-Hayek, 2016; Kunda & Chama, 2016; Saquin & Marcial, 2016):

- Fedena is used by more than 200 countries, including India, Somalia, Malaysia, Egypt, Saudi Arabia, Nigeria, and many others, and has been implemented in more than 40 000 schools, of which 15 000 are under the Department of Basic Education (DBE) of the Government of Kerala
- South Carolina uses the OPENSIS School Management System to maintain learners' reports, attendance, health records, and practice reports.
- OpenAdmin is a Free and Open-Source Software (FOSS) school management system used in Canada that provides sites for teachers, parents, and administrators.
- E-School, a virtually independent platform that allows any user to access the system from any location through the Internet, was developed in India (Al-Hayek, 2016) and others (for example, SchoolTool, Fekara, OPUS and My School).

- SA-SAMS (South African School and Administration Management System) is used by most schools in South Africa as mandated by the DBE (Gxwati, 2011; Irene, 2013). The smooth operation of a school depends on effective administration and management. To make the administration of schools more effective, the DBE developed SA-SAMS to solve management and administration challenges and streamline data in schools (Molepo, 2015; Muriithi & Masinde, 2016). The DBE has made SA-SAMS freely available to all schools in order to ensure that data is submitted in the correct format (Kuriakose, 2014). There are several forms of financial documentation that schools need to keep on a regular basis: general ledgers, trial balances, cash books, petty cash journals, and bank reconciliations (Hlongoane, 2019). Public schools should align their financial records with SA-SAMS requirements. For this reason, all schools must use SA-SAMS to ensure consistently accurate and complete accounting records (Hlongoane, 2019). SA-SAMS was chosen as the single reporting source in 2008 by the Council of Education Ministers (MEC) representing all provinces (Irene, 2013; Kuriakose, 2014). This decision did not enforce the use of SA-SAMS in schools but outlined how the data's reporting format or structure should be presented to the DBE (Malan, 2014; Van Der Berg, Wills, Selkirk, Adams & Van Wyk, 2019). Each SMS used by schools should easily integrate with SA-SAMS to reduce duplication (Maponya, 2015; Hinds, 2016).

Unfortunately, there has been a lack of technical support and training in some provinces, which has led to SA-SAMS not being adopted as quickly as expected by the public schools (Muriithi & Masinde, 2016). Support requests for schools are often ignored for months due to a lack of support personnel. As a result of these frustrations, schools often abandon SA-SAMS and revert to manual operations (Muriithi & Masinde, 2016). Another challenge is the interoperability of various other types of SMS with SA-SAMS. Through interoperability, data exchange is significantly automated, reducing errors and delivering information to the point of use, enabling more timely actions and a flow of information that can be used effectively in the decision making processes (Cooper, 2014).

The implementation of interoperability can have a great deal of benefits for SMS. An interoperable system allows for continuous information exchange, for example, exchanging data with other systems for performance improvements, creating services, and controlling the processing of information systems and operations (Nsaghurwe, Dwivedi, Ndesanjo, Bamsi,

Busiga, Nyella, Massawe, Smith, Onyejekwe, Metzger & Taylor, 2021). Interoperability can be measured using Interoperability Maturity Models (Awasthy, Flint, Jones & Sankaranarayana, 2018). The maturity model assesses the extent to which key activities and processes are identified, practised, managed, and implemented effectively (Awasthy *et al.*, 2018). Several types of Interoperability Maturity Models (IMM) exist such as the Levels of Information Systems Interoperability Model (LISI), Organizational Interoperability Maturity Model (OIM), Enterprise Interoperability Maturity Model, Information Systems Interoperability Maturity Model (ISIMM), and Government Interoperability Maturity Matrix Model (GIMM). From these models, a combination of OIM and ISIMM will be used to conceptualize a School Management Systems Interoperability Maturity (SMSIM) model to address the purpose of this study, which will be used to measure the level of Interoperability in SMS and provide a guideline that can be used to improve SMS. Section 4.5 discuss the reasons these two models were chosen.

An education system's effectiveness depends on how well its information system supports sharing, storing, categorizing, and using information (Jakimoski, 2016). To determine how interoperability can best benefit SMS, it was necessary to evaluate the interoperability level in SMS and ultimately enhance the system by providing guidelines for advancing to the next level on interoperability in SMS, with the aim of potentially addressing the disadvantages of SMS and ensuring that all SMS can share relevant information according to SA-SAMS requirements.

1.2 PROBLEM STATEMENT

The problem statement of this study lies in the disadvantages of SMS, although SMS offer many advantages to schools, it also comes with many disadvantages such as (Al-Hayek, 2016; Muriithi & Masinde, 2016):

- increased workloads for teachers,
- duplication of work,
- redundancy and errors,
- for schools without internet access there is often delays for the submission of reports to the DBE by schools as the submission is done manually through a CD or mailing system,

- most schools use a free SMS without features like discipline, custom reporting, registration, or inventory. There are some that are narrowed due to space capacity, the number of learners, and storage space,
- often, SMS are installed on a standalone computer, limiting access to the system, which results in tension and stress for administrators working alone during peak demand times, such as when schools must process learner reports at the end of the term, causing delays,
- despite limited access to the system, teachers spend much of their time manually validating learner's marks on paper that is never-ending, which increases the possibility of mistakes,
- the lack of skilled Information Communication Technology (ICT) personnel who can utilize the system. On the government's side, there is an insufficient supply of relevant software, a lack of maintenance culture, as well as an insufficient level of security and purity regarding data,
- can only be accessed within the school's intranet,
- limit learners and parents or guardians from accessing the learners' information.

Despite the DBE's efforts to introduce SMS to simplify the administration in all schools, SMS still lacks in some way or the other as schools without internet access still cannot submit data to the DBE through a click of a button. Furthermore, SMSs are also not communicating nor sharing information, thus lacking interoperability. As a result, schools work in silos, necessitating a SMSIM model that can be used as a guideline that assesses the level of interoperability to improve and support schools with their SMS. The sharing of information must be incompliance to the PoPI Act discussed in chapter 3 of this study. Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include, according to Cooper (2014):

- **Reducing the burden on staff members of the school to enter data:** instead of registering a learner multiple times for the curriculum, the learner can be entered once into the system. This educational benefit can benefit teachers who waste teaching time by repeatedly enter data into the system.
- **Improving data quality:** interoperability improves data quality, as information flows efficiently, and there is a timely action caused by the delivery of information to the point of use, significantly reducing duplication and human errors.

- **Promoting adaptability and promote data sharing:** this means, schools can easily transfer data to the DBE.
- **Supporting data-driven decision making**: accurate and timely data is essential for good decisions.
- **Enhancing efficiency and timeliness:** Information can be delivered to the point of use more rapidly, resulting in more efficient and effective information flow.

These advantages of interoperability can enhance SMS to ensure an improved overall information flow for effective decision making and management of schools.

The SMSIM model will provide guidelines to assess the level of interoperability in SMS that may help improve the disadvantages of SMS. Refer to chapter 4 on how the disadvantages of SMS may be addressed using the SMSIM model.

1.3 PURPOSE OF THE STUDY

The way interoperability can enhance SMS was provided above; therefore, the purpose of the study was to conceptualize a SMSIM model for schools in South Africa. This conceptualized SMSIM model applied a combination of OIM and ISIMM model to assess the level of interoperability in SMS and provided clear guidelines on how SMS can advance to the next level of interoperability to improve. This model may enhance the level of interoperability maturity in SMS and highlight the value of such a model for existing SMS in schools. The SMSIM model is envisaged to enable schools in SA to first measure their maturity levels. Secondly, to acknowledge the growth gained in their maturity levels to realize the potential future of how the systems can improve and evolve and link with SA-SAMS.

1.4 MAIN RESEARCH QUESTION AND SUB-RESEARCH QUESTIONS (SRQS)

The following research questions address the purpose of this study:

Main Research Question: How can a SMSIM model assist schools in improving the interoperability and maturity levels of their current SMS?

- **SRQ1:** What constitutes the components of a model of interoperability maturity for Schools Management Systems?
- **SRQ 2**: What existing models of interoperability maturity can be used to conceptualize a SMSIM model?

- **SRQ 3:** What value will a SMSIM model have for schools using Schools Management Systems?

1.5 THE OBJECTIVES OF THE RESEARCH

To address the purpose of this study (the conceptualization of the SMISM model), the following objectives apply to:

- investigate the existing models of Interoperability Maturity (IM) to determine the levels and components of a model to support interoperability in Schools Management Systems (SMS)
- identify guidelines for achieving interoperability and adapt these for Schools Management Systems
- determine what components the SMISM model should consider and
- identify the value that the SMSIM model can have to support schools with their own SMS.

1.6 THE SCOPE OF THE STUDY

This will focus on interoperability maturity models and how these can benefit SMS to become interoperable with other SMSs to ensure better data integrity. Better data integrity can influence decision making as accurate data can be applied by decision-makers.

1.7 RESEARCH METHODOLOGY AND DESIGN

As this study aimed to conceptualize a SMSIM model, the methodology applied the explorative qualitative design.

The study is grounded in interpretivism as a research philosophy that will follow the research onion process as suggested by Saunders, Lewis and Thornhill (2016:p207). Furthermore, hermeneutic principles was used during the analysis of the data to translate and interpret the text, verbal, and nonverbal communication (Hiller, 2016:p22; Saunders *et al.*, 2016:p182). During the qualitative data collection phase, inductive reasoning was also used to identify essential themes and patterns in the collected data (Leedy & Ormrod, 2021). Various experts with several years of experience in various fields of expertise were consulted to collect data through an explorative Delphi method. The exploratory Delphi design allows data to be collected, the model to be assessed and validated without physical contact, which is more

appropriate for this study since participants have been almost impossible to reach following the COVID-19 pandemic. The following adapted research onion is applied in this study as displayed below:

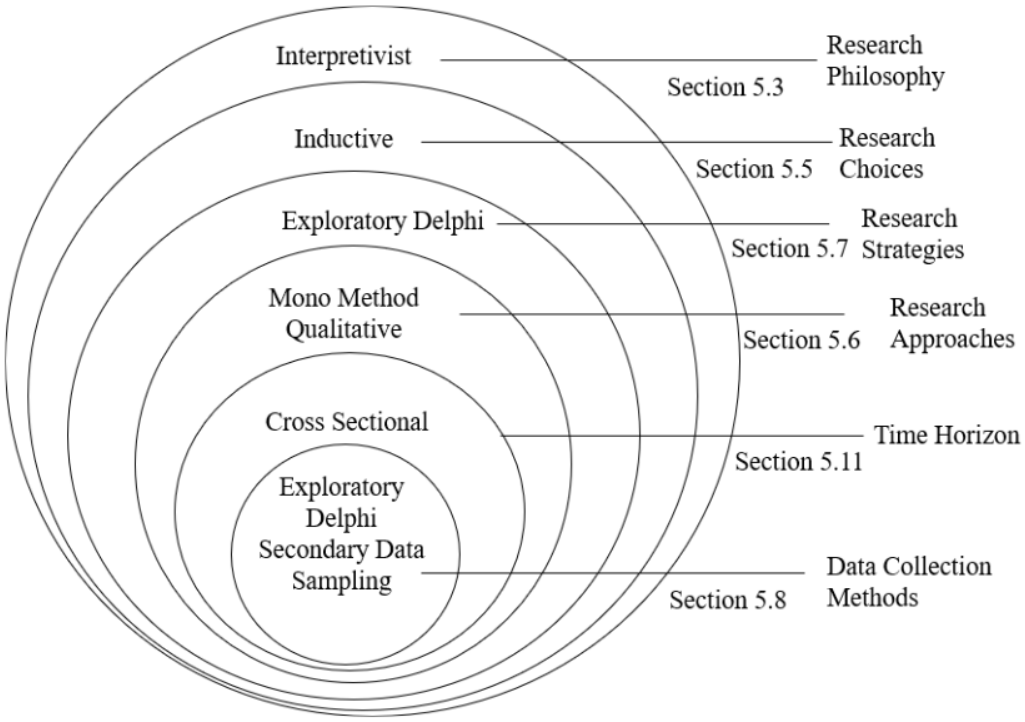


Figure 1-1: Adopted Research Onion ((Saunders et al., 2016))

The research methodology is discussed in more detail in Chapter 5.

1.8 EXPECTED CONTRIBUTIONS OF THIS STUDY

The study is expected to contribute to School Management Systems (SMS) by conceptualizing an Interoperability Maturity Model that can assist in improving interoperable SMSs in schools. A SMSIM model can contribute to literature as there is currently no literature focusing on the interoperability of SMS in schools. SMS is currently not linked with Interoperability Maturity Models. This results in a gap between the two fields of study, and this will open a platform of interoperability in schools and its management systems to simplify management of schools. Section 7.3 provides the detail of the final contributions of the study.

1.9 LIMITATIONS AND CHALLENGES OF THIS STUDY

The limitations of this study are as follows:

- This is an exploratory qualitative study with exploratory Delphi expert reviews that are limited to only experts with over 10 years of expertise in the field of ICT in education, Interoperability, School Management Systems (SMS), ICT4D and Interoperability.
- Furthermore, this study is also limited to SMS that are different from SA-SAMS. The importance of this is to get a clear view of how SA-SAMS and other open and free versions of SMS can be improved from the learnings of the paid versions of SMS. Only schools utilizing a paid version of SMS will be considered for the study because they have a longer period of using and engaging with customized paid-for internationally obtained SMS before the SA-SAMS was developed. They also have an improved knowledge of their own SMS (in many more facets apart from only data), and they do not rely on a free version of SMS.

1.10 ETHICAL CONSIDERATIONS

University of South Africa (UNISA) ethics guidelines were followed for this study to protect the rights of participants and ensure the integrity of the research. Appendix A provides the ethical clearance certificate.

The research adhered to the following:

- The confidentiality and privacy of participants.
- Informed consent.
- Good Research.
- Accountability and voluntary participation.
- Detailed information about ethics can be found in Section 5.11 of Chapter 5.

1.11 THE ORGANIZATION OF THE STUDY

Figure 1-2 shows the organization of the dissertation.

An introduction to the study is provided in Chapter 1 as well as the problem statement, purpose, research questions, scope of the study, and expected contributions and limitations.

Chapter 2 covers the literature review of the study, and it conceptualizes the literature review into two separate chapters, namely Chapters 3, and 4. Chapter 2 discusses ICT and the role of ICT in education, Chapter 3 discusses SMS, and Chapter 4 discusses interoperability as well as interoperability maturity models.

Chapter 5 covers the study's research methodology, which consists of research design and design data collection protocol.

Chapter 6 presents the results of the Delphi questionnaire and the SMSIM model is verified and validated, after analyzing Delphi expert review results.

Chapter 7 draws a conclusion and provides recommendations for future studies. It also answers the MRQ and SRQs and provides a personal reflection.

The following figure summarizes the research process and the structure of the chapters with the associated outcomes:

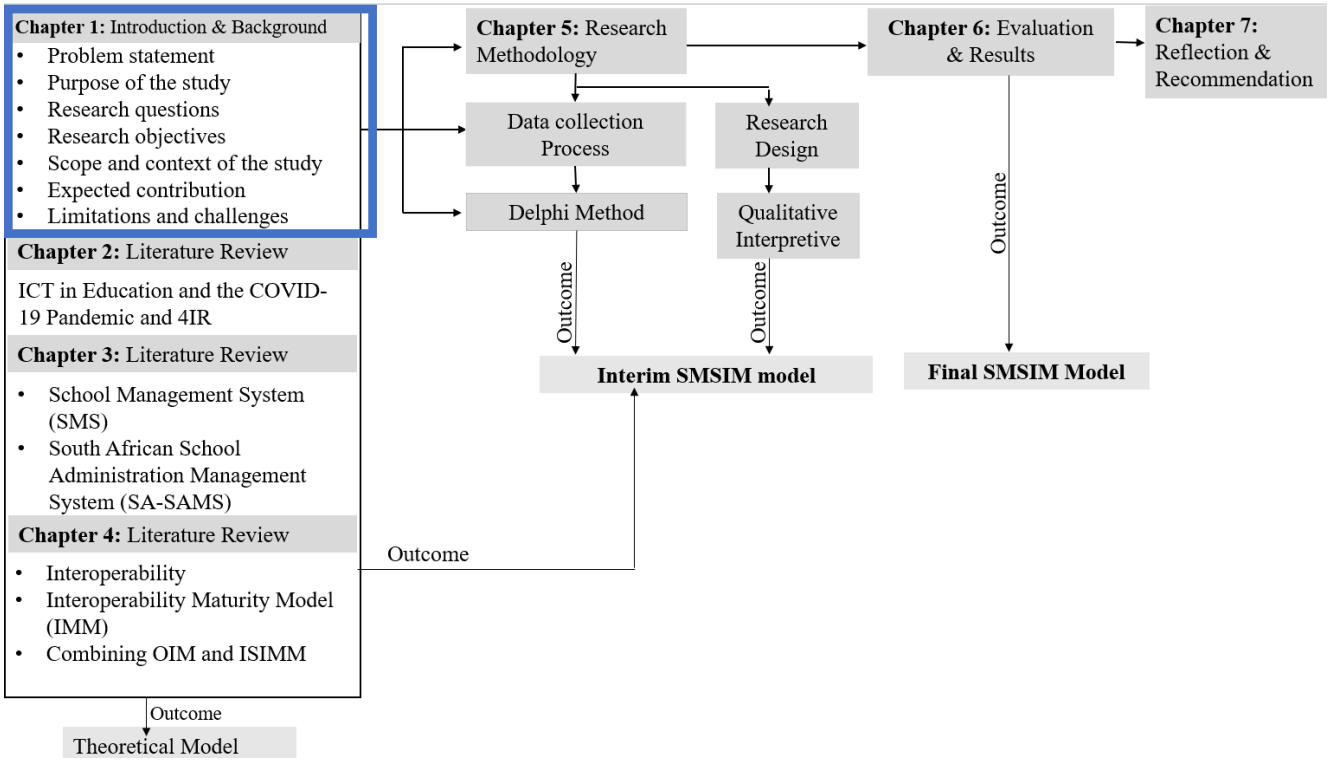


Figure 1-2: Organisation of the dissertation

1.12 SUMMARY

The foundation of the research is laid in this chapter. This chapter introduced the concept of School Management systems (SMS) and discussed the problem statement of this study. The scope was defined, and the research was justified. A general research methodology was outlined (see Figure 1-1). The research methodology and process followed have been provided in Figure 1-1 and the organization of the dissertation has been depicted in Figure 1-2. Chapter 2 will discuss the literature review; this chapter provides insight into ICT and the impact it has

not only on society but also education. Although it will provide a high-level overview of ICT and its impact on society, this chapter will form the basis of other literature studies to follow.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

As per the research process below, this chapter forms part of phase 1 and this chapter aims to highlight the importance of ICT in the education sector and the importance of interoperability when using these ICTs. Firstly, this chapter will provide an overview of what ICT is, then scope it to it's purpose in society and in general. The role of ICT in education will be provided, and then how ICT interoperability can be perceived and the positive and negative effects of ICT interoperability when one assesses it, will be highlighted. It further discusses the COVID-19 pandemic and how online learning assisted society using 4IR technologies. This is very important for the study as it is vital to know the overall impact of ICT in society and the education sector to conceptualize a model that considers all the impacted areas worldwide.

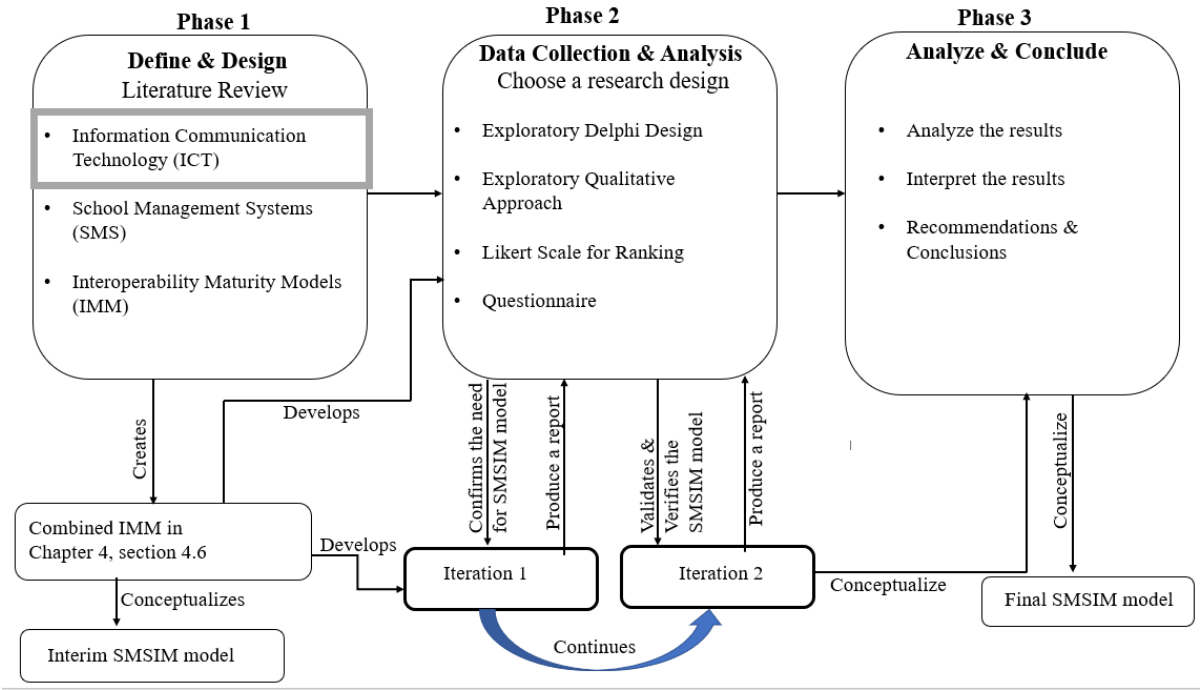


Figure 2-1: Research process of the study highlighting the phases used to develop the SMSIM model

2.2 THE USE OF INFORMATION COMMUNICATION TECHNOLOGY (ICT)

Information and communications technology, also known as ICT, is a common extension of the term "information technology" (IT). ICT integrated communication (wireless and mobile signals), security, audio-visual systems, computers, and middleware allowing business users to

store, send, access, and use information (Ratheeswari, 2018; Hatakka, Thapa & Sæbø, 2020; Suleiman, Zakari, Sani & Ukashatu, 2020). An ICT system enables audio-visual and computer-based communication networks to be linked via a single cable or channel (Nureni, 2014; Ratheeswari, 2020; Suleiman *et al.*, 2020; Adarkwah, 2021).

Based on the description provided above, ICT enables communication and allows people to stay connected. Organisations can do a lot with the power of technology; hence, this study focused on improving the system that is implemented in schools for the daily management and administration of the school. The section below provides the characteristics of information technology.

2.3 THE CHARACTERISTICS OF INFORMATION TECHNOLOGY

The characteristics of Information Technology, according to Ratheeswari (2020), involve:

- Acquiring, storing, distributing, managing, transporting, or obtaining data or information.
- Access to real-time information.
- Easy availability of updated data.
- Providing different types of communication media.

Based on the above characteristics, it is evident why the integration of ICT into education has been considered the primary key to human progress (Veerasamy & De Souza-Daw, 2012) as all these characteristics can support teaching and learning. However, before discussing ICT in education, it is vital to first understand the positive and negative impacts relating to the use of ICT in society. This knowledge assisted as considerations when conceptualizing the School Management Systems Interoperability Maturity (SMSIM) model. These will be discussed in the following two subsections below.

2.4 THE IMPACT OF ICT ON SOCIETY

ICT has an impact on modern society, both positively and negatively. Following are some of these (Nureni, 2014; Fraillon, Ainley, Schulz, Friedman & Duckworth, 2020:5; Imam & Itodo, 2020):

2.4.1 Positive Impacts

The following positive impacts of ICT in society are provided by Nureni (2014); Bhatti, Iqbal, Noreen, Mukhtar and Javed (2021):

- **Faster communication speed:** Prior to the Internet, news used to be published by news providers through newspapers and presented through the Television and Radio only. Anyone can now receive information or news efficiently via the Internet, including business partners, friends, and family members. Due to advancements in Internet connection speed, communication has become fast and inexpensive.
- **Lower communication cost**: It is cheaper and more efficient to communicate using the Internet over other methods, such as courier services, mailing through the post office, or phone calls. Internet access remains a challenge in developing countries as compared to developed countries.
- **Reliable mode of communication:** A computer is a reliable tool. With the Internet, information can be retrieved and accessed from any location. As a result, it is a reliable method of communication.
- **Effective sharing of information:** The advancement of ICT has made it possible for people worldwide to exchange news and information on mailing lists, Internet forums and discussion groups.
- **Paperless environment:** A paper-free environment has been made possible by ICT. Rather than using paper, digital mediums can store and retrieve information. A paperless environment can also be created through online communication, such as emails, online chats, and instant messaging.
- **Borderless communication:** Data can be retrieved instantly, connected, accessible, and a variety of functions can be performed on the Internet. Services and information are now available without regard for geographical boundaries. Through the Internet, communications and information can be exchanged without borders.
- **Create employment:** Even though many employment fields have lost jobs (especially now with COVID-19 spreading), other employment sectors (such as the Healthcare sectors) experienced growth and could create jobs. In businesses, it is necessary to maintain all computers: fix hardware, install software, etc.

Nureni (2014) noted that ICT has proved to be a positive influence on society in reducing manual work and human error, thus schools have implemented ICTs (hardware and software) also reduce manual work and human error thus improving the quality of information. The following section presents the negative effect of using ICT.

2.4.2 The Negative Effects Relating to the use of ICT

The following adverse effects of using ICT are also recorded, according to Nureni (2014):

- **Individualistic and introverted**: Today, people generally prefer online communication over in-person interactions. People are more likely to become introverts and individualistic.
- **Health problems:** Using computers for prolonged periods can harm users as using computers could lead to mental stress, eyestrain, physical stress. Health problems can be solved with ergonomic environments. An ergonomic chair can reduce back pain and screen filters can reduce eye strain.
- **Unemployment:** Some jobs are lost because computers replaced humans, such as in manufacturing, where fully automated fields are now found in many factories. Rather than employing human labour, computer-controlled robots build things. Although robots are expensive to purchase, they save the industry money over time. In addition, robots can operate 24 hours a day without taking a break. Bank Tellers: At first banks used to have a lot of Tellers for depositing and withdrawing money, now tellers are reduced to a few due to the introduction of Automatic Teller Machines (ATMs).

Therefore, it is evident from the above positive and negative impacts that these should be considered when conceptualizing the SMSIM model. The next section will further outline the role ICT plays in education as this study's focussed domain.

2.5 THE ROLE OF ICT IN EDUCATION

ICT has become integral to education worldwide (Bindu, 2016; Arshad, 2020). Educational institutions have increasingly adopted ICT as a part of their environments. The use of ICT in education will become a regular aspect of society, along with technology tools (Arshad, 2020; Ratheeswari, 2020). An increase in the number of students, teachers, and educational institutions influences teaching and learning (Hernandez, 2017). Therefore, ICT is essential in distributing education (Bindu, 2016). The following are the roles that ICT plays in education,

ICT (Sarkar, 2012; Olaore, 2014; Amua-Sekyi & Asare, 2016; Bhattacharjee & Deb, 2016; Ratheeswari, 2018; Agrawal & Alharbe, 2019; Das, 2019; Del Carmen Trillo-Luque, Vilches-Vilela, Quintero-Ordoñez, Fuentes-Gómez & Dauder, 2020:p251; Hatakka *et al.*, 2020; Imam & Itodo, 2020; Khan, 2020; Rana & Rana, 2020; Bhatti *et al.*, 2021):

- Provides educational opportunities such a tablet that can be used to for teaching and learning.
- Assists universities with their education, research, and public service missions.
- Provides a new communication channel between students, teachers, academic staff, and the community.
- Provides access to the syllabus, A student can access the learning program at any time, and they can do so from anywhere.
- Can be utilized to leverage distance learning to bring education to the doorsteps of children living in remote rural areas.
- It helps to stay updated on the latest developments by using various technologies.
- The ICT curriculum enables students to understand the nature of technology, how they can use and manipulate technology, and how ICT impacts individuals and communities.

It is evident that ICT positively impacts the education sector and there are many benefits in utilizing it. Section 2.5.1 below focuses on the role of ICT in administration and management which is the focus of the study. It is essential to understand the role of ICT for administration and management purposes in a school, to conceptualize a model that will be useful and add significant value to the use of SMS in the South African schools.

2.5.1 The Role of ICT in Administration and Management of schools

Malan (2014) posits that the use of the Internet, landlines, and computers in education management and administration have increased in recent years to support school administration's sustainable development. School administrators use ICT administration and management software for various administrative tasks, from data storage to information management (Malan, 2014).

Three main administration groups use ICT daily for administration and management namely (Lin, Xie, Jeng & Wang, 2011; Mwalongo, 2011; Seyal, 2012; Ghavifekr, Afshari, Siraj & Seger, 2013; Marinov & Tsankova, 2015; Qureshi & Qazi Abro, 2016):

- **Administration heads:** Seyal (2012) states that, as administration heads, principals must have the necessary skills to use ICT to perform management and administrative tasks. In both administrative and managerial activities, principals can act as role models regarding information technology because they provide an example that others can follow and are available when needed for help.
- **Administration teachers:** Have administrative responsibilities in addition to their teaching responsibilities such as overseeing all departments and offices.
- **Administration staff:** Administrative employees use ICT to manage their daily tasks. Organizing finances, communicating, maintaining records, processing paperwork, and collecting information for SMS are some of the tasks that administrators do in schools.

When applying ICT to perform administrative tasks, an improvement is detected in the efficiency of the administration and management at every level of the school, from the classroom to the library and throughout the school (Das, 2019). ICT plays a vital role in making administration in a school less burdensome. ICT also offers possibilities that improve and develop administration and strengthen the capability to handle administrative work more effectively (Das, 2019).

The support that ICT can provide to education, in the end, should not be underestimated, as it influences the administration and management of the school. Access to information from various sources is now a possibility. The new opportunities that the fourth industrial revolution (4IR) can provide will also play a role in improving the education sector. The digital technologies which were used in section 2.5.7 during the COVID-19 pandemic are a pure demonstration of the impact technology has to ensuring educational continuity. Teachers and learners accessed new information online during this time than ever before, as this was now the *new normal* for both teachers and learners (Mhlanga & Moloi, 2020).

The following section describes the COVID-19 pandemic and lockdown in South Africa and other parts of the world. Discussing the pandemic and lockdown is essential as this will provide a clear view of the role digital technologies played in ensuring continuity in education.

2.5.2 COVID-19 and Lockdown in South Africa

Sansa (2020) claims that COVID-19 is a novel coronavirus that infects people with severe respiratory illness (SARS-COV-2). The virus first surfaced in China in late 2019 in Wuhan City, and researchers have connected it to a condition known as COVID-19 (Adnan & Anwar, 2020; Arshad, 2020; Sansa, 2020; Durizzo, Asiedu, Van Der Merwe, Van Niekerk & Günther, 2021; Gwenzi & Rzymski, 2021).

COVID-19 emerged at a time when there was a global learning crisis; the High Levels of Learning Poverty were intensified by the Pandemic (Worldbank, 2020). More than 160 countries had to close their schools due to the COVID-19 pandemic. According to the World Bank, 1.6 billion children and youth worldwide were excluded from school due to school closures (Arshad, 2020; Mhlanga & Moloi, 2020; Worldbank, 2020; Durizzo *et al.*, 2021).

The government of South Africa enacted a national lockdown (26 of March 2020), which meant that all educational institutions would be closed. This had an adverse effect on learning. In addition, school closings may have resulted in a loss of skilled human resources and education, which could affect economic growth (Mhlanga & Moloi, 2020; Durizzo *et al.*, 2021).

Due to the COVID-19 pandemic, many companies closed or reconsidered their use of digital technologies (Arshad, 2020). There was no preparation for the lockdown, so universities and public schools without 3IR technology were forced to close. On the continent of Africa, this was a common occurrence due to challenges in infrastructure, protocols, and data costs. The lockdown affected many South African public schools, especially in townships and rural areas, as they were under-resourced and could not provide their learners with ICT access to teaching content. This resulted from the challenging infrastructure in rural areas with no bandwidth or stable Internet access to support learning (Dube, 2020; Mhlanga & Moloi, 2020).

To reduce the size of the academic barrier, some educational institutions transferred some courses to their online platforms (Adnan & Anwar, 2020; Alabbadi & Al-Masaeed, 2020). Primary, secondary, and tertiary education in South Africa had to face the reality of providing only online teaching to their learners during the outbreak of COVID-19 (Mhlanga & Moloi, 2020; Ożadowicz, 2020; Zhong, 2020).

According to Mhlanga and Moloi (2020), the education sector will find it difficult to return to old-school teaching methods in the aftermath of the pandemic, as social distancing will

continue to be an issue to prevent the spread of this virus. When the reality of lockdown struck, education sector corridors were occupied with discussions about online learning and using television and radio for revision. This pandemic motivated the education sector to embrace digital transformation during the lockdown (Alabbadi & Al-Masaeed, 2020; König, Jäger-Biela & Glutsch, 2020; Mhlanga & Moloi, 2020).

It is evident from this section that digital technologies (see section 2.5.5) played a considerable role in the country's functionality during the lockdown. As a result, online teaching and learning became necessary to ensure that learners do not lose out on a whole year of schooling. Sadly, pandemics are natural disasters that occurs without notice, and their effects may not be known until it is too late; however, the use of digital technologies mitigated the impact of the COVID-19 pandemic. In the aftermath of COVID-19, digital technologies were used to maintain school functionality, as many schools had to close and reopen using these technologies (Television, Radio, Social Media platforms such as YouTube). The next section provides an overview of what 4IR is and how it will benefits society. It also explains the technologies that were used in South African Schools to ensure educational continuity during the COVID 19 pandemic.

2.5.3 4IR Technologies in Education

4IR enables individuals to move and connect digital domains through technology to enhance and manage their lives (Kayembe & Nel, 2019). According to Schwab (2016a), 4IR includes genomics, nanotechnology, design and quantum computing, therefore the new revolution goes well beyond the use of computers and technology. The 4IR combines physical, digital, and viral interactions that make it different from previous models (Schwab, 2016a).

Davis (2016) defines 4IR as the advent of cyber-physical systems that allow humans and machines to interact in new ways. Despite these capabilities being grounded in the infrastructure and science of the third industrial revolution (3IR), Davis (2016) further argues that the fourth industrial revolution represents a completely new method of integrating social science with society and even the human body (Davis, 2016; Shava & Hofisi, 2017).

The term "4IR" refers to the fusion of technologies that causes the distinctions between the physical, digital, and biological worlds to become hazier (Davis, 2016; Global, 2018). 4IR impacts almost every aspect of our daily lives, changing how people relate to technology and how and where they work (Global, 2018; Schwab, 2019).

All the definitions of 4IR provided by the four authors Das (2019), Shava and Hofisi (2017), Schwab (2016a), and Kayembe and Nel (2019) are appropriate for this study as they all broaden the definition of 4IR from the technology to the people using it. Section 2.5.5 discuss the technologies that were used to ensure educational continuity and combat the spread of the COVID 19 pandemic during lockdown. The authors identify these technologies as the 4IR technologies, however, literature findings has identified the confusion regarding the understanding of 4IR. Li, Hou and Wu (2017) argue that, the understanding of Cyber Physical Systems (CPSs) causes some confusion about the essence of the 4IR. Furthermore, he states that the developments of digital, physical, and biological technologies are three fundamental technological drivers of the Fourth Industrial Revolution. These three technological drivers can be summarized in Table 2-2.

Table 2-2 Technological drivers for the Fourth Industrial Revolution

Technology drivers	**Fields**
Digital	The Internet of Things (IoT)
	Artificial intelligence and machine learning
	Big data and cloud computing
	Digital platforms
Physical	Autonomous Cars
	3D Printing
Biological	Generic Engineering
	Neurotechnology

As observed from the table above, digital technology is one of the technological drivers for 4IR, and for the purpose of this study, these technologies are the focus as they were used during the COVID-19 pandemic, specifically digital platforms. SMS systems can thus be seen as a digital technology which the model emanating from this study will aim to improve. According

to Schwab (2016b), digital technology is the fundamental driving force for 4IR. Digital power is responsible for nearly all the innovations and advances of the Fourth Industrial Revolution.

The following section discusses the DBE's plan, presented by the Presidential Commission regarding 4IR in South Africa (DCDT, 2020). This is essential information as it indicates the gaps in the education system and how 4IR could help resolve these. A summary of recommendations in the education sector is provided in Table 2-3.

2.5.4 The Future Vision of 4IR for Education in South Africa

Public education in South Africa fails to equip learners with the skills they need to become productive members of society (DCDT, 2020). Private schools' rapid growth results from this underperformance since private schools already have advanced 3IR technologies, such as computers, the Internet, and proper SMS. Although the formal education system faces numerous difficulties and difficult realities, some positive steps have been taken to adapt the current basic education system to the demands of the fourth industrial revolution (DCDT, 2020). A process began in 2015 by the DBE to prepare for 4IR, including a review of the current curriculum (DCDT, 2020).

The four competency categories utilized as a benchmark for 21st-century curricula—critical thinking and problem solving, creativity and innovation, cooperation, teamwork, communication, and digital literacy—were determined to be well addressed by the curriculum. However, these competencies are not fully applied in everyday teaching and learning activities and we do not see the results as a country (DCDT, 2020). As a result, the public education system must begin focusing on developing students' creativity, critical thinking, and problem-solving skills. Science, Technology, Engineering, Arts, Mathematics, Innovation, and Entrepreneurship, or STEAMIE, disciplines are more important today to educate students on 21st-century skills, where the arts and humanities play a crucial part in strengthening STEM learning. When STEM is being introduced to South Africa, there is the opportunity to use STEAMIE approaches from the beginning Table 2-6 discusses how STEM was used to mitigate the COVID-19 pandemic (DCDT, 2020).

There is a universal and urgent need for education and awareness of what 4IR represents at many levels in our society. The DCDT (2020) report recommended the creation of a national online portal to showcase the already-existing 4IR centers of excellence and to educate, inform,

and offer updates on training and other opportunities in the 4IR context. Table 2-3 below summarises recommended solutions to address 4IR in education in South Africa.

Table 2-3: Summary of recommended solutions with areas of interventions to address 4IR in education in South Africa

High-level recommendation (solutions)	Actionable projects / possible areas of intervention
Catalyze Structural Change in the Education System: Efforts must be made to initiate structural changes, as the education system will undoubtedly evolve structurally to reflect the architecture of the 4th industrial revolution over time. The delivery of skills should be enhanced through flexibility, agility, speed of accreditation, integration of learning streams, mobility of learners, remote delivery of content, cognitive flexibility, and technology.	Redesigning and aligning the skills ecosystem to facilitate agility for 4IR learning. • Coordination of the various systems and components within the skill ecosystem must be prioritized to ensure it fits the new skills needs of the 4IR era. • People can enter and leave the learning system multiple times during the lifelong learning process with industry-aligned and stackable micro-credentials. • Introduce relevant technology and devices (comprehension skills, digital literacy. The Human Resource Development Council should facilitate the systemic change process. • Ensure the deliverable is subject to a timeframe, assisted by the 4IR Commission and driven by the Digital and Future Skills Forum. This ecosystem can be linked to a nodal network based on Al that coordinates and streamlines ecosystem components. • Align skills according to the national Digital Skills Strategy, which acts as a framework.

Source: Adapted from (DCDT, 2020)

It is evident from Table 2-3 that the alignment of the skills ecosystem with 4IR is prioritised through various bodies (for example, Digital, and Future skills forum and using the Digital Skills strategy of 2020). The importance of digital literacy skills to be able to operate 4IR technology was also mentioned in the Strategic plan 2020-2025 of the State Information Technology Agency (SITA) (SITA, 2022).

Table 2-4 below provides emerging trends, increasing, and decreasing roles in selected industries. In the DCDT report (2020), the following education sector changes in industry and society are provided in the table below (DCDT, 2020):

Table 2-4: Emerging trends in the Education sector with increasing and decreasing roles in selected industries.

Sectors	Trends Driving Industry Change	Envisioned Future	Increasing Roles	Decreasing Roles
The Education Sector	Globalization: Increasingly more people will be in the middle class within the next ten years, increasing the pressure on the education system; It is critical to recognize that inequality of opportunity leads to disparities in well-being, causing political and social unrest.	Education is the key to economic and social prosperity in an increasingly globalized and connected world.	Designers of learning offer mobile devices Curated knowledge specialists Learning progress analysts	Registration clerk Accounting & bookkeeping Mediocre teachers Librarians Proof-readers

Source: Adapted (DCDT, 2020)

It is thus evident from the DCDT report (2020), published after COVID-19, the focus is on globalizing technology to reach more people and increase the use of mobile devices in teaching. But, unfortunately, before the COVID-19 pandemic, there were limitations in the use of these technologies in South African schools (Ibrahim, 2020). Section 2.5.5 discusses digital transformation towards 4IR in the Education Sector in South Africa.

2.5.5 Digital Transformation Towards 4IR in the Education Sector in South Africa During the Lockdown

This section will provide an overview of the digital technologies used during the COVID-19 pandemic in South Africa. These technologies ensured continuity and showed the impact of technology during the natural state of disaster. Mhlanga and Moloi (2020) identifies these digital technologies as 4IR technologies, however, as seen from the section 2.5.3, there is a confusion regarding 4IR in South Africa.

2.5.5.1 Virtual Learning during the Lockdown

Table 2-5 below shows the digital platforms (Ibrahim, 2020), used by the DBE in South Africa to provide virtual classes during the lockdown that mainly consisted of television and radio. This was a response to the disruption that COVID-19 caused throughout the nation. Lessons were delivered to students via radio, DSTV, and E.TV stations, as stated in the table (König *et al.*, 2020; Mhlanga & Moloi, 2020; Ożadowicz, 2020).

Table 2-5: Virtual classes during the lockdown

Technology Used	Description	Connectivity	Platform	Conditions of Use	Target Group
Television (SABC, DSTV, E.tv)	Teachers delivering lessons live to learners on TV	Offline	Television Desktop	Free (lockdown)	Primary Secondary
Radio (SABC)	Teachers deliver lessons live to learners	Offline	Radio/desktop	Free (lockdown)	Primary Secondary

Source: Adapted from (Mhlanga & Moloi, 2020).

The South African government offered certain online learning options, and several media outlets there backed it. The Department of Communication and Digital Technologies (DCDT) led the initiative. The minister announced that the DCDT and DBE joined forces to ensure this reality through the media (Mhlanga & Moloi, 2020). Schools were closed during lockdown to decrease the impact of COVID-19 (Carvalho, Rossiter, Angrist, Hares & Silverman, 2020). Moreover, the nation's broadcaster built two studios to broadcast virtual classrooms. The teachers presented lessons live in these studios, and E.tv developed a dedicated channel for three months to be displayed on learners' open view (Carvalho *et al.*, 2020). Additionally, courses were provided on several local radio stations across the nation. Thus South Africa can implement virtual classrooms through radio and television, which were during the pandemic, to move the educational system towards the 3IR (Mhlanga & Moloi, 2020).

2.5.5.2 Social media and a digital school used during lockdown

However, the DBE was slow in implementing digital technology during the lockdown. Immediately following the lockdown, the DBE, collaborating with the non-profit coding organisation Africa Teen Geeks, launched a STEM lockdown digital school (Mhlanga & Moloi, 2020). A free science, technology, engineering, and maths (STEM) Lockdown Digital School has been established by the Sasol Foundation through the artificial intelligence-based educational platform Ms Zora (Mhlanga & Moloi, 2020). 34 educators from both public and private schools participated in the program, teaching sessions via DBE's social media pages, including Facebook, Twitter, and Ms. Zora online (Mhlanga & Moloi, 2020). Students could access the recordings on the DBE website at any time and these programs were provided free of charge (Mhlanga & Moloi, 2020). The STEM lockdown digital classroom inspired

authorities to digitise education. In the following table, the technology used, the connectivity type and the target groups are provided:

Table 2-6: Use of Social Media Apps and the Introduction of STEM lockdown digital school (Sasol Foundation (SF) and African Teen Greeks

Technology Used	Description	Connectivity	Platform	Conditions of Use	Target Group
Internet (website), (Ms Zora, SF, Siyavula, DBE)	Teachers in public and private schools offer classes through a live stream	Online	Desktop laptop mobile	Free (Lockdown)	Primary Secondary
Facebook (Ms Zora)	Teachers in public and private schools offer classes through a live stream	Online	Desktop laptop mobile	Free (Lockdown)	Primary Secondary
Twitter (Ms. Zora)	Teachers in public and private schools offer classes through a live stream	Online	Desktop laptop mobile	Free (Lockdown)	Primary Secondary

Source: Adapted from (Mhlanga & Moloi, 2020).

The maintenance of the system following the lockdown is crucial. This could be done after a thorough performance review of these initiatives (Mhlanga & Moloi, 2020).

Universities and other institutions of higher learning were obliged to only provide online courses because of the lockdown extensions in South Africa. Some of the technology used for these institutions are described in Table 2-7.

Table 2-7: Exclusive Online Learning-Remote Learning

Technology Used	Description	Connectivity	Platform	Conditions of Use	Target Group
Internet (website) YouTube (Most universities)	Learners learn on their own at home	Online	Desktop laptop mobile	All rights reserved	Tertiary/ Primary/ Secondary
Microsoft Teams	Used mainly by staff and learners in tertiary institutions to hold discussions	Online	Desktop laptop mobile	Freemium	Tertiary
Skype	Used mainly by staff and learners in tertiary institutions to hold discussions	Online	Desktop laptop mobile	Freemium/ All rights reserved	Tertiary
WhatsApp groups	Used mainly by staff and learners in tertiary institutions to hold discussions	Online	Desktop laptop mobile	All rights reserved	Tertiary
Zoom	Group discussions	Online	Desktop laptop mobile	Freemium	Tertiary

Source: Adapted from (Mhlanga & Moloi, 2020)

Several universities in South Africa have shifted to online learning, even though some institutions did not make the change public. For instance, in order to maintain social isolation, students at the Universities of Johannesburg, Cape Town, and Pretoria were informed that their second semester classes would be conducted online (Mhlanga & Moloi, 2020; Ożadowicz, 2020).

Although schools incorporated the above-mentioned digital technologies to ensure learning continuity, not all schools benefited from it to the fullest extent, particularly schools in rural areas as well as marginalised communities where the Internet is not always accessible (Adnan & Anwar, 2020). However, as discussed in Table 2-5, the government ensured there were educational television (TV) programs and radio station access to information in the country, this shows the critical role of applying digital technologies during the pandemic.

There is still a long way for the education system to use 4IR technologies as these will require a lot of investments, skilled personal and time to eventually evolve to the 4IR era, however the use of digital technologies really benefited the education system as can be observed from the section above. Although there is confusion about the Industrial Revolution era in the education

sector and how far it has evolved, digital technologies still contributed to successfully combating the negative effect of the pandemic.

Furthermore, the COVID-19 pandemic impacted the administration of the school, and the following section discusses some of the challenge encountered during this time.

2.5.6 The Impact on School Related Administration in the Light of COVID-19 Pandemic

The COVID-19 pandemic had a significant impact on every societal sector, including the schools and the school administrations. According to Aytaç (2020) study, half of the 32 school administrators who took part in his study did not have an emergency action plan for the pandemic process and instead followed Ministry of National Education (MoNE) guidelines. Administrators at the schools said that during the pandemic phase, having strong technology leadership and crisis management abilities is crucial (Aytaç, 2020). Another half of the group said that the administrators and their teams developed a comprehensive, long-term plan for handling distance learning during the pandemic, and therefore transparency was essential for making collective decisions (Aytaç, 2020). In Akbaba Altun and Bulut (2023) study, It was found that school administrators' plans were updated due to pandemic conditions that closed educational institutions an extended time. Furthermore, because crisis plans were too formal and prescriptive, they had to be modified to the circumstances. As a result, school administrators said they updated their crisis plans according to the new pandemic circumstances caused by the COVID-19 outbreak. School administrators also felt that the people selected for the crisis response team were not suitable and certain parts of the crisis plan did not work.

The following are the lessons learned during the COVID-19 pandemic as stated by Akbaba Altun and Bulut (2021); and Akbaba Altun and Bulut (2023):

Lessons learned: The Things That Should Be Done Before the Crisis

1. Knowing How to Manage Crises: Before a crisis hits educational organizations, being knowledgeable about the ways to cope with crises beforehand is utmost important.
2. Having a Foresight Regarding the Crisis: School administrators should have a foresight about the crisis before the crisis, should be more open to communication, and anticipate some situations to be experienced.

3. Getting Prepared for Unexpected Situations: School administrators expressed their views that they should be ready for unexpected events and ready for possible problems they may encounter.
4. Preparing a Crisis Plan: The research indicated that development of a crisis plans prior to experiencing a crisis was important. Additionally, plans should contain multiple levels and attempt to cover all contingencies.
5. Building Crisis-Appropriate Schools: It was also found that, besides preparing a crisis plan, school buildings and related infrastructure need to be suitable for unexpected circumstances.
6. Appointing / Being a Competent Administrator: The research also indicated that before a crisis arises, leaders and other people in charge should be capable of administrative tasks and efficient.

Lessons learned: The Things That Should Be Done During the Crisis

1. Preparing and Implementing a Crisis Intervention Program: Effective planning is indispensable during challenging times. School administrators stated that normally there should be a crisis plan, but that the plan should be reviewed in cases of a crisis, revised according to the situation and some planning should be made according to the current conditions.
2. Taking Action: Taking the necessary actions is one of the valuable findings of the study. In other words, being alert and do what is required is crucial during crises. School administrators expressed their views that as soon as the crisis is felt, action should be taken immediately.
3. Supporting: The study also highlighted the importance of supporting the stakeholders. It was stated that they primarily tried to calmly support students and parents.
4. Informing: In the following sentences, school administrators mentioned the importance of immediately informing students, teachers and parents about the situation. They said that to control the situation and to produce the solutions to the problems, the informing process should be accelerated. They also believe that quick information gave chance to analyze the situation and take the necessary actions:
5. Consulting: It was clear from the findings of the study that benefiting from other colleagues' experiences is useful. It was said that administrators should consult other educators to make the right decision in a crisis.

6. Motivating: Motivation became important according to the findings. They should try to maintain their educational activities by keeping their morale high and taking necessary precautions. Administrators should motivate teachers and students positively.
7. Emotion Management: They said that administrators should manage their emotions in case of crisis. It has been stated that school administrators should be calm, pioneering, rational, patient, gathering, prudent, selfless, understanding, empathic, proactive and cool.
8. Process Management: They stated that in times of crisis, school administrators should plan the process well and manage it together with the team in cooperation.
9. Also, it was stated that school administrators should manage the process without departing from reasoning, logic and science in the crisis management process, and do research for better quality process management:
10. Leadership. School administrators emphasized the importance of leadership in times of crisis. They stated that school administrators should be calm, visionary, solution-oriented, responsible and conscious in times of crisis. In addition, it was stated that administrators should know media literacy well and use social media effectively.
11. Organizing. Organizing constitutes a large part of the crisis management and it is necessary to make the organization perfect.
12. Coordination. School administrators have stated that when there is a crisis, school administrators establish a good crisis team, coordinate the teams, and ensure coordinated work at all levels. In this regard, school administrators expressed their opinions.
13. Communication. Communication has been the most emphasized by school administrators in crisis management. It was emphasized that in times of crisis, school administrators should be accessible to all stakeholders, enrich their communication channels and keep these channels open. In addition, it was emphasized that school administrators need to frequently inform parents, teachers and students about the process and establish and maintain an effective communication network.
14. Taking Joint Decisions. The study indicated that involving other stakeholders during decision making process is one of the right things to do while managing the process. School administrators expressed that they make predictive, rational, practical and participatory decisions in times of crisis.

15. Monitoring: School administrators said that they also monitored how remote teaching was carried out
16. Solving the Adaptation Problems: Due to Covid-19 pandemic; several emotional, social, environmental and physical adaptations were immediately necessary. After school administrators started remote teaching, they supported teachers and students who had difficulties adapting to the process.

Apart from explaining the role of ICT in education and the opportunities of the 4IR technologies in education, the next section focuses on ICT and interoperability as it is important to understand how it supports teaching and learning, the flow of information in these and between these systems are still necessary to ensure useful quality information. Therefore, the next section covers the importance of ICT and interoperability.

2.6 ICT AND INTEROPERABILITY

Interoperability in ICT refers to the transmission and distribution of accurate data, information, and other components, such as collaborations, to systems (including organizations or other entities), operations, and components that are often viewed positively as part of ICT programs (Gasser & Palfrey, 2007; Ohwo, 2020). Additionally, interoperability leads to other positive outcomes such as choice, ease of use, and competition (Gasser & Palfrey, 2007). Innovative technology improves the efficiency of systems, reduces user hassles, and provides consumers with a broader range of options (Gasser & Palfrey, 2007; Esmailzadeh, Noori, Aliahmadi, Nouralizadeh & Bogers, 2020).

Information can flow smoothly between education systems, and the data is useful across all systems relevant to education, which is one advantage of interoperability. It is evident from the previous sections that ICT ensures fewer burdens in the school administration and makes teaching and learning easier. It is also apparent that ICT has negative effects on society and the world, such as security and privacy, but integrating ICT and interoperability ensures the overall information flow from one point to another. This section ties ICT and interoperability, which is important for the study. Without interoperability in SMS, information cannot flow seamlessly, and data errors might occur because of inaccurate data, which can hamper effective decision-making. Data interoperability is also crucial for all schools and the education departments of a specific country

Online learning sites promote an additional learning experience where students can interact, collaborate, and take their lessons faster and with their time, as mentioned in the section above (Ali, 2020).

The next section will further outline the benefits and drawbacks of access to ICT interoperability when assessing it. This is important in the context of the purpose of this study because if one can understand the importance of assessing interoperability, it can assist in making interoperability between SMS more meaningful and worth the effort for schools to use when applying the model from this study. Therefore, assessing the drawbacks and benefits of interoperability in ICT is vital for conceptualizing the model. Furthermore, it provides a clear understanding of the possible impact that can be obtained from ICT Interoperability.

2.7 BENEFITS OF ICT INTEROPERABILITY

When assessing ICT interoperability, one must consider its potential benefits and drawbacks as these can assist in conceptualizing the model to ensure it is reliable, secure, and diverse, as indicated by Gasser and Palfrey (2007), and Novakouski and Lewis (2012).

The following benefits of ICT interoperability are highlighted by Gasser and Palfrey (2007), Novakouski and Lewis (2012), and Kerber and Schweitzer (2017):

- **Innovation:** two examples are presented below to illustrate how interoperable systems can and have led to innovation in the ICT space. The Internet is the first interoperable design to which many non-interoperable networks and systems converge. As one of the first applications of the Internet, email proves its importance in this second example. Email protocols or the concept of email were not exclusive, and their designs were generally interoperable.
- **Competition:** competitive markets result in lower prices and provide incentives to design better products and services, which benefit consumers. In general, ICT collaboration promotes innovation by increasing competition.
- **Autonomy, flexibility, and choice:** users' autonomy and flexibility are enhanced when interoperability levels are higher, and all conditions are carefully considered.
- **Openness:** any ICT environment that fosters creativity and growth relies on interoperability if properly developed and maintained.

Potential Drawbacks, according to Gasser and Palfrey (2007), Novakouski and Lewis (2012), Berryman, Yost, Dunn and Edwards (2013), and Van Alsenoy, Coudert, Jasmontaite and Verdoodt (2015), include the following:

- **Security:** Interoperability encourages openness and allows data to flow from one end to another. However, open data access can leave a gap for malicious programs. Furthermore, when policies and infrastructure security are incompatible, the benefits of cooperation disappear quickly.
- **Privacy:** a common question regarding cooperation involves a concern that cooperation might reduce privacy. An increased number of interactions can result in more players gaining access to personal information that is exchanged with the operating system.
- **Reliability:** as ICT systems become more complex, they become less reliable, the more complex processes become, the more difficult they are to rectify quickly.
- **Accountability:** there has been an accountability framework for data protection for more than 30 years. It has been shown that when everyone is responsible, no one is responsible, so when an error is committed, no one takes responsibility. Due to interoperability, transparency of data flow can be a risk to accountability.
- **Accessibility:** given that the use of ICTs entails inherent risks beyond those of reliability and security, there is a chance that such incidents may induce different players to withdraw from the online environment generally.

All SMS should consider the above adverse effects of ICT interoperability as these can reduce the effectiveness of SMS and, if not considered, can hamper the use and trust in the system. The section below presents the key components of the chapter to consider when conceptualizing the SMSIM model.

2.8 KEY COMPONENTS OF THE CHAPTER

Components refer to the essential parts that make up something (Bucherer & Uckelmann, 2011). The table below lists the essential components from this chapter towards conceptualizing the SMSIM model.

Table 2-7: Essential components of the chapter

Components	Section	Key Focus Area	Author
The impact of ICT on society	2.4	Provides an overview of the greater impact on the daily living of individuals for work, communication, and socialization.	(Nureni, 2014), (Fraillon et al., 2020), (Imam & Itodo, 2020)
The role of ICT in education	2.5	This adds to the model by explaining the role of ICT in education. This section cut across the learning, teaching, and administration, which are key to conceptualizing a valid SMSIM model	(Bindu, 2016), (Arshad, 2020), (Del Carmen Trillo-Luque et al., 2020:251), (Hatakka et al., 2020), (Khan, 2020b).

2.9 SUMMARY

This chapter looked at the overall impact of ICT on society and education and the importance of interoperability and integration. Furthermore, this chapter provided support for the conceptualization of the model by showing both the benefits and drawbacks of ICT and how digital technologies were used during the lockdown caused by the COVID-19 pandemic. The SMSIM model will be conceptualized with the consideration of every item in this chapter. Of specific concern from this chapter for the SMSIM model, is to consider the impact of ICT on society. This chapter contributes towards phase 1 (highlighted with a blue block) of creating the model as per the research process below.

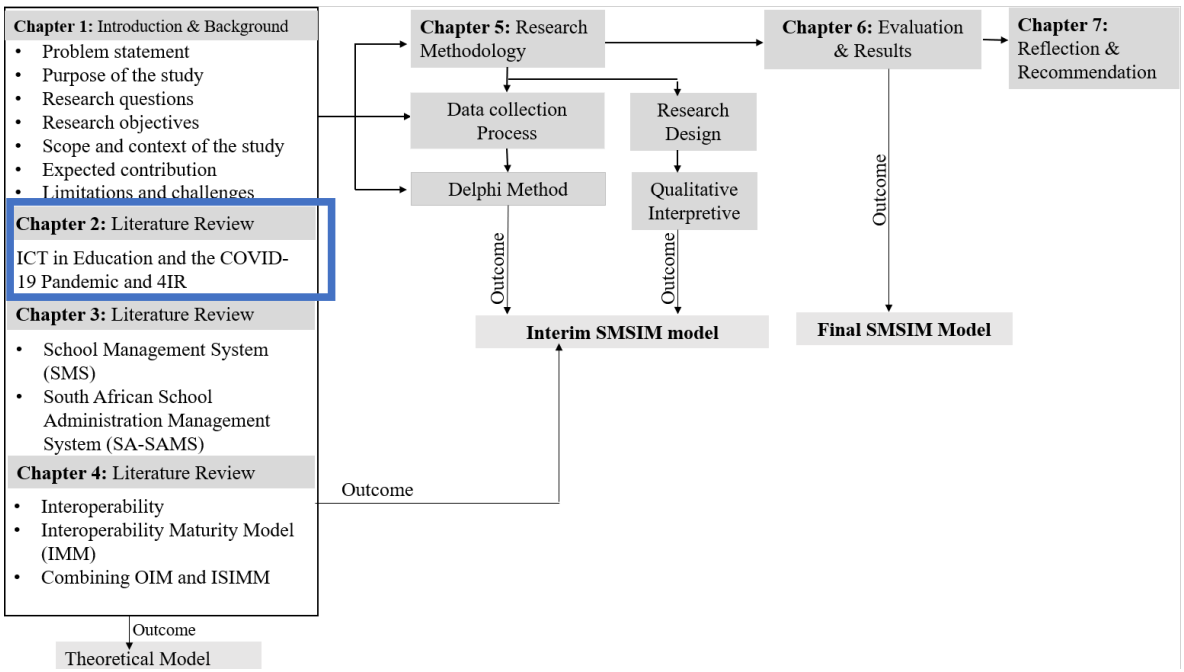


Figure 2-2: Outline of Dissertation

Chapter 3 discusses and outlines SMS; this chapter will discuss in detail what SMS is, the advantages and disadvantages of SMS, and the purpose. The following Chapter 3 is very important for the study as it discusses the main system the model aims to improve.

CHAPTER 3: SCHOOL MANAGEMENT SYSTEMS

3.1 INTRODUCTION

Chapter 2 provided an overview of ICT and its role in the education sector, as well as its role in interoperability. Furthermore, it discussed the impact of COVID-19 in South Africa, concentrating on how the educational sector was affected, and digital technologies that were used in the education sector to mitigate this crisis and ensure school continuity. This chapter provides an overview of School Management Systems (SMS) for South African schools. First, the chapter explains what SMS is, then describes a few SMSs as per literature findings, including SA-SAMS. From Figure 3.1 it is evident that this chapter forms part of Phase one of this study.

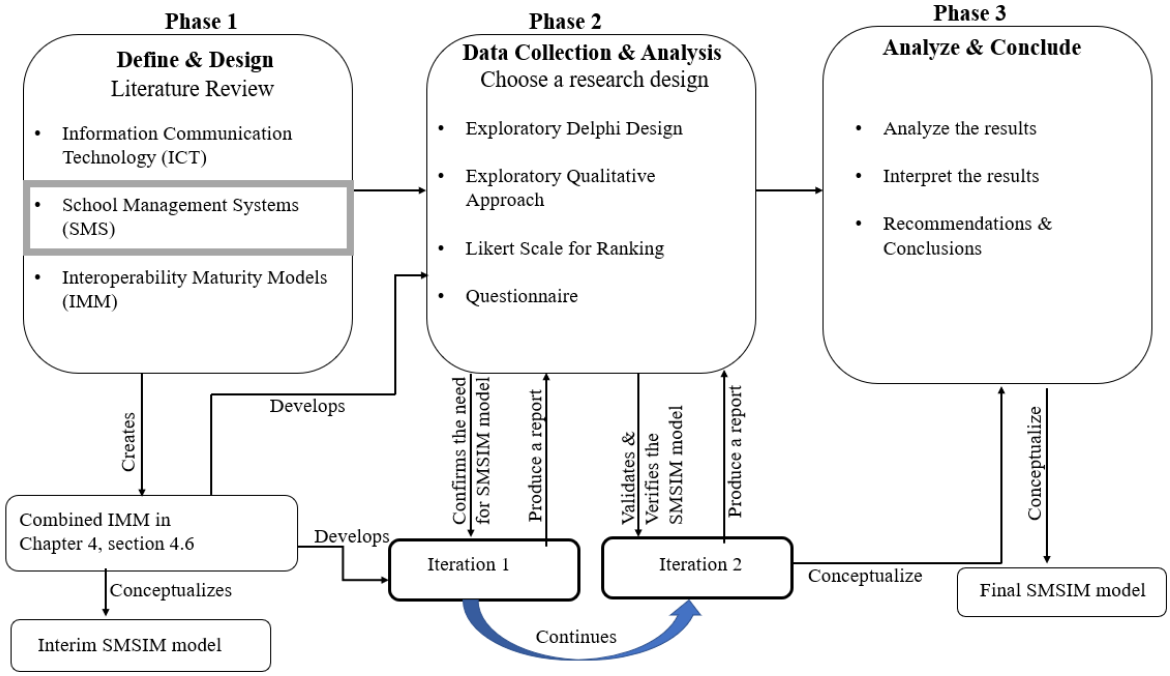


Figure 3-1: The research process highlighting Chapter 3 as part of Phase 1 of the study

In Section 1.1, SMS was introduced, and its history, purpose, and capabilities were discussed. As a continuation of Chapter 1, this chapter explains the advantages SMS offer teachers, administrators, and learners. It also describes the various versions of SMS used by schools, including free and paid versions, and the current state of schools in South Africa. This is vital for this study as some schools already use SMS that differ from SA-SAMS.

Using SMS, schools can innovatively keep track of their records. SMS is a form of Information Management System (MIS) important for schools' smooth operation (Hassan et al., 2014).

Many SMS are typically purchased and owned by individual schools and are located within their premises. Education vendors generally customize SMS to meet the needs of different schools. Some schools purchase servers, desktop computers, and software, such as SMS, software for programming, applications, etc. (Mwangi, 2014). Section 3.2 below discusses advantages of SMS.

3.2 THE ADVANTAGES OF SMS

The advantages of SMS are the following, according to Sarker (2016):

- The school's information and activities can be accessed instantly
- School academic processes and administrative duties will be better managed using SMS
- It runs on desktops and laptops
- School budgets can easily accommodate it, making it affordable.

Apart from these general advantages, there are advantages geared explicitly towards teachers in Section 3.3, and administrators in Section 3.4.

3.3 THE ADVANTAGES FOR TEACHERS

For teachers, SMS can also assist with (Awadallah, 2016):

- Managing the grades of learners.
- Keep their marks up to date.
- Managing leave applications online.
- Registration of learners and teachers.
- Keep track of learners' attendance.
- Assist in the writing of class notes.
- Staff members, learners, and parents can communicate via e-mail with detailed reports and SMS.

Additionally, SMS offers advantages for administrators, as discussed below:

3.4 THE ADMINISTRATIVE ADVANTAGES

The administrative advantages according to Sarker (2016):

- SMS reduces workload of adding, removing, or registering teachers for the administrator. Teachers can add, remove, and register themselves on the system.

The advantages, according to various authors, are thus obvious. Understanding these advantages will help conceptualise the model, as only the problem areas are addressed, and benefits may be enhanced.

Chapter 1 of the study listed a few types of SMS in the introduction section. From the literature findings, only Fedena, MySchool, Ascend SMS, SchoolTool, and Feraka will be discussed in more detail as per the table below. The table defines and provides capabilities of different SMS systems used by schools worldwide (Arslan, 2013; Adebayo, Kanyinsola & David, 2014; Almgren, 2014; Al-Hayek, 2016; Awadallah, 2016; Mythili, Mishtra & Singh, 2018):

Table 3-1: Different SMS and their Capabilities

SMS	Definition	Capabilities
Fedena	It is a flexible school management system that serves all management, administrative, and educational needs in thousands of schools throughout the world.	• Teachers have complete control over how they manage their schools' databases, and it provides various tools for managing educational activities. • In addition, it can be customized so that institutions can make the necessary modifications to it, thereby making it more effective. • There are high-security servers with SSL certificates to provide high-quality data encryption. • By using it, institutions avoid the possibility of their data being accessed by malicious individuals.
My School	In this web-based application, PHP is used to build the web interface and MySQL is used to handle the database backend.	• The ability to manage multiple campuses simultaneously. • Provide schools with an Internet front-end. • Ensure effective communication with parents and other stakeholders • Assist parents, teachers, and students in building and maintaining a community • Zero redundancy in managing administrative records • Optimize resources as much as possible • Management of fees, attendance, and exams are automated. • Dynamic substitutions are managed automatically when creating and regenerating timetables.
Ascend SMS	For Catholic and Independent schools, this is a free, full-featured school administration software program	• It provides parents with smartphone apps, a straightforward discipline reporting system, and a health management system for the school nurse. • Among other features, administrators will find the school vitality, learner performance, and reporting feature particularly attractive.
SchoolTool	This is an open-source cloud-based school administration system designed for schools in developing nations	• Teachers will find it appealing because of its many features. • Teachers may manage their classrooms with daily participation journals, skill assessment documents, grade books, and attendance sheets. They can also easily make report cards and interface with well-known calendar programs like Google Calendar.

SMS	Definition	Capabilities
Fekara	It is an all-around school administration powerhouse with a student population of 50 or less	• It provides all kinds of services, including management and administration of schools, budgets, tests, and assignments. • An app is included for convenient access on the go, which can be used on tablets and smartphones.

Source: Adapted from (Arslan, 2013; Adebayo et al., 2014; Almgren, 2014; Al-Hayek, 2016; Awadallah, 2016; Mythili et al., 2018).

Fedena is designed to be accessible to anyone who needs the SMS. An Internet connection and desktops are all that schools need to implement My School; schools do not need expensive hardware and software. Teachers, students, and parents can all access **MySchool's** system. This keeps learners informed of school activities and grades, and allows parents to contact teachers with complaints, recommendations, or any other issue related to their children's education. Using the system, teachers can communicate with learners and post grades or anything else they want learners to see or receive. The system is under the control of the principals (Awadallah, 2016). According to **Ascend SMS,** schools shouldn't be required to pay outrageous fees for items they require for their success (Awadallah, 2016). The software **SchoolTool** is an excellent starter tool for smaller schools, but it does not provide all the functionality you might need. For example, other applications will have to handle human resources, reporting, and financial management. In addition, the free version of **Fereka** has limits regarding the number of learners, and storage it can handle.

It is evident that different schools use different SMS systems. Depending on affordability and the school's needs, some schools use a free SMS and others use a paid SMS. In the following section, SA-SAMS is discussed in detail.

3.5 SA-SAMS

Having briefly introduced SA-SAMS in Chapter 1, this section aims to provide an in-depth explanation of SA-SAMS, its advantages and disadvantages, the modules it contains and how it is typically set up in schools. A key outcome of this assessment will be to conceptualize a model that assesses the level of interoperability in SMS and then provides guidelines to achieve the next level of interoperability. It is also essential to understand why schools are not using SA-SAMS and rather opting for paid versions, this after the exploratory Delphi expert review findings. The following section provides the background and history of SA-SAMS.

3.5.1 Background and History of SA-SAMS

The South African education sector has a well-established management information systems (Irene, 2013; Shaikjee, 2020). In 2005, the DBE developed and implemented the South African School Administration and Management Systems (SA-SAMS) to gather statistics on the number of students enrolled in schools (Gxwati, 2011; Kuriakose, 2014; Malan, 2014; Pholotho, 2017; Moyo, 2018; Ramazhamba, Mashiane & Dlamini, 2018). Initially, the Free

State Department of Basic Education took the lead on implementing SA-SAMS through advocacy to all stakeholders in 2007; as a result, all public schools in the province are now using SA-SAMS, a fully integrated computer solution encompassing all aspects of school administration (Gxwati, 2011; Shaikjee, 2020). SA-SAMS has been successfully deployed to all public schools where at least one computer has been available for administrative purposes since 2007 (Gxwati, 2011; Shaikjee, 2020). SA-SAMS has significantly improved data quality in schools with electricity. As a part of SA-SAMS implementation, the department employed trainers on contract, one for each district. To ensure that schools are adequately trained to use SA-SAMS, the trainers trained the principals and administrative staff on how to use the system (Gxwati, 2011).

After understanding its history, it is important to explain what SA-SAMS is, and its capabilities, especially from literature found in the Free State Province. Section 3.6.2 below defines SA-SAMS.

3.5.2 Defining SA-SAMS

The table below defines SA-SAMS as per literature findings according to different authors.

Table 3-2: Defining SA-SAMS

	Definition	Author
SA-SAMS	The term "South African School and Administration Management System" is abbreviated as "SA-SAMS." It is a cost-effective, user-friendly, and electronic application designed to support and benefit schools in various ways.	(Molepo, 2015)
	Sibiya (2019) describes South African school administration and management systems as computer programs that assist in school administration, management, and governance.	(Sibiya, 2019)
	Designed, updated, and improved by the DBE, this software solution provides comprehensive school administration and management functions	(Van Wyk, 2021)
	It is a desktop (off-line) system that has been widely used and tested across all provinces (Department of Basic Education, 2013)	(Van Wyk, 2021)
	A comprehensive program that collects information about students, parents, and staff in a school.	(Kuriakose, 2014)
	Free offline (desktop) school management and administration system maintained, enhanced, and created by the National Department of Business Education.	(Van Wyk, Gondwe & De Villiers, 2017)

	It simplifies administrative and management tasks and streamlines principals' governance and management responsibilities in most South African schools.	(Malan, 2014)
	This computer application enables public schools in South Africa to manage, administer, and govern themselves.	(Adam, Butcher, Tusubira, Sibthorpe & Souter, 2011)

Sources: Adapted from (Adam et al., 2011; Kuriakose, 2014; Malan, 2014; Molepo, 2015; Van Wyk et al., 2017; Sibiya, 2019; Van Wyk, 2021)

According to all authors in Table 3-2 above, SA-SAMS is an administrative system used by schools, which is a reasonable definition for this study. The purpose of SA-SAMS is described in the following section. SA-SAMS was introduced to address several problems, as outlined in this section.

3.5.3 The reason for the SA-SAMS design

There are many different reasons why SA-SAMS was designed, and these includes (Irene, 2013; Malan, 2014; Molepo, 2015; Muriithi & Masinde, 2016; Moyo, 2018; Ncanywa & Sibiya, 2020):

- Disadvantaged schools used several applications to accomplish different tasks; for example, financial obligations were handled by a separate application, another handled assessment, and human resources and timetabling were handled by a third application. Consequently, the same data had to be entered into many different applications several times and updated individually whenever changes were made. To meet this need, SA-SAMS was developed as a comprehensive system for school management that includes all aspects of school administration.
- A primary goal of SA-SAMS was to assist school administrators with access to storing information and simplify school life while establishing district, provincial, and national information databases.
- Schools can use SA-SAMS to manage, govern, and administer their operations.

It is evident that SA-SAMS was designed to address problems in the education sector, and to some extent, the system covers all the necessary aspects. Although this system addressed several problems, it still had some shortcomings or disadvantages, which could be improved with a School Management Systems Interoperability Maturity (SMSIM) model that this study

aims to conceptualize. A typical SA-SAMS setup is described in the next section. This is important for the purpose of the study as it adds to the disadvantages of SA-SAMS as per Table 3-3.

3.5.4 Typical Setup of SA-SAMS

The figure below illustrates the architecture of SA-SAMS (Muriithi & Masinde, 2016):

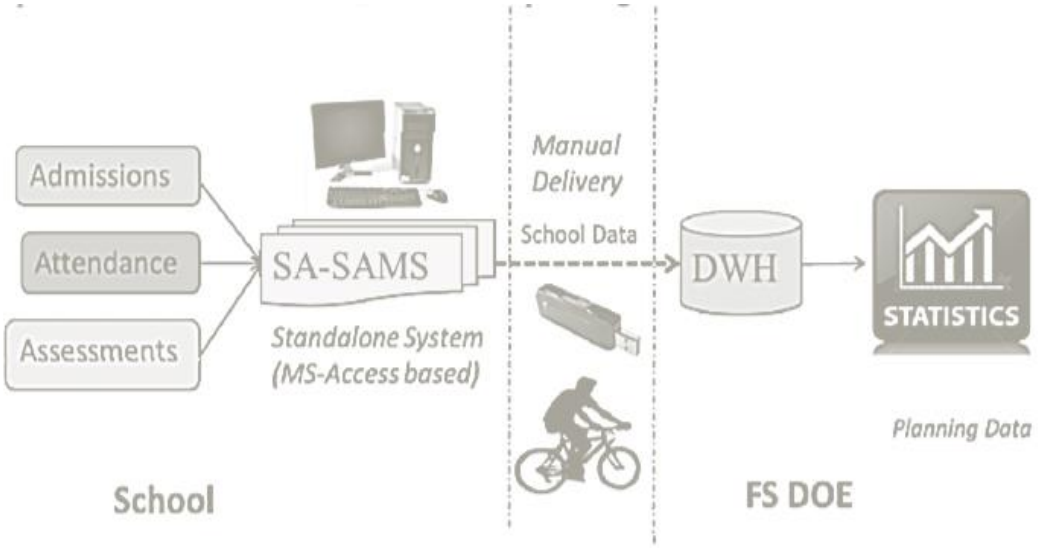


Figure 3-2: The architecture of SA-SAMS (Adapted from Muriithi and Masinde, 2016)

A school administrative clerk or a designated teacher operates SA-SAMS on an independent computer at the school. The school administrator or designated teacher takes care of all data collection tasks, such as processing admissions, recording fees, or capturing learners' performance data. Apart from supporting operational activities at the school, SA-SAMS also serves as the DBE's primary source of school information (Muriithi & Masinde, 2016).

SA-SAMS is typically installed on standalone computers. This causes a lot of problems for school operations as it delays data submissions to the DBE as well as frustrations for the administrators who mostly have access to it, the system limits access; Table 3-3 of this chapter, explains this further under disadvantages. To conceptualize a model that assess the level of interoperability in SMS and provide guidelines to achieve the next level of interoperability in SMS, it is essential to understand these disadvantages and the typical setup of SA-SAMS.

The typical setup of SA-SAMS as per figure 3-2 is only applicable for schools without internet access. Unfortunately, schools without internet access still need to submit data to the DBE through manual means (Post office, CD or USB). Schools with connectivity can submit data to

the DBE electronically through a software product called the Valistractor that is provided by the DBE. Section 3.6.6 of this study discusses the Valistractor in detail. The following section explains the advantages and disadvantages of SA-SAMS.

3.5.5 Advantages and Disadvantages of SA-SAMS

SA-SAMS can provide the following advantages and disadvantages (Reddy, Prinsloo, Netshitangani, Moletsane, Juan & Janse Van Rensburg, 2010; Gxwati, 2011; Irene, 2013; Kuriakose, 2014; Malan, 2014; Molepo, 2015; Muriithi & Masinde, 2016; Pholotho, 2017; Moyo, 2018; Mbuqe, 2020; Ncanywa & Sibiya, 2020; Shaikjee, 2020; Strydom, 2020).

Table 3-3: Advantages and Disadvantages of SA-SAMS

Type of School	Advantages of SA-SAMS	Disadvantages of SA-SAMS
Offline Schools (no internet connection)	It ensures that the most up-to-date information is always available to users.	Due to poor connectivity to high schools with limited resources, the SA-SAMS is not connected to other systems at the DBE.
Offline Schools (no internet connection) And Online Schools (internet access)	By using the system, principals can precisely estimate the impact of adding a staff member on the school's budget. The principal can use this information to make an informed decision about the school's management.	It Fixes bugs that develop over time with patches. Schools must download and install these patches on their own computers, and this can sometimes be a hassle for a busy principal. After a year of using the latest version, principals are required to report any bugs and limitations, and must wait for a year before a compact disc (CD) with the updated and corrected system is available. Generally, it takes about one year for an additional feature to be implemented and fixed.
Offline Schools (no internet connection) & Online Schools (internet access)	Can be used for an inventory of stationery at the school	When a fault has been created at the school level, the school is unable to correct it until the Provincial Office is contacted because the staff members are unskilled to solve the fault.
Offline Schools (no internet connection)	Assists with staff training, leave administration, and absenteeism.	Because SA-SAMS is not connected to schools' systems, submitting data to the DBE is difficult and time-consuming. A school extracts requested data from SA-SAMS, copies it to a CD or flash disk, and physically sends it to the

Type of School	Advantages of SA-SAMS	Disadvantages of SA-SAMS
		DBE. After receiving data from schools, the MOE uploads it to their data warehouse in another lengthy process. School statistics are delayed significantly due to manual submissions.
Offline Schools (no internet connection)	With the use of SA-SAMS, provincial and national departments can quickly and easily access data for annual surveys that will enable effective educational planning.	Despite automating the production of hard-copy records and reports that must go to the district office or be kept at school, the system does not enable online data transfers or file transfers.
Offline Schools (no internet connection) And Online Schools (internet access)	SA-SAMS helps schools put together an annual school survey to send to the DBE.	If a learner is archived during the year and subsequently moved to another school, all the data for that learner from January to June will be lost.
Offline Schools (no internet connection) And Online Schools (internet access)	The academic profiles, behavioral histories, exam scores, parent-guardian information, and other details of students who are enrolled in a class are all kept in the system	SA-SAMS only assists in school administration, which means the information it collects can only be accessed by the school's principal and higher authorities.
Offline Schools (no internet connection) And Online Schools (internet access)	Designed to automatically handle public and school holidays while administering and managing leave. The system offers on-demand details about credits for each person and type of leave.	SA-SAMS fails to share the data it gathers about a student with the educators and parents of the pupils, despite its broad purpose of supporting a principal with administering a school by obtaining information about all students at a school and their activities. The only people who can access records in SA-SAMS are the main and higher authorities.
Offline Schools (no internet connection) And Online Schools (internet access)	The system helps schools to comply with all standards, such as those for Snap Survey or school surveys, and updates can be made periodically in compliance with the most recent policy requirements.	There is a failure to address all stakeholders' needs in the school community, including parents and teachers.

Type of School	Advantages of SA-SAMS	Disadvantages of SA-SAMS
Offline Schools (no internet connection) And Online Schools (internet access)	Ensures learners are placed in the appropriate classes and promoted appropriately.	SA-SAMS suffers from problems common to many software systems. For example, features are only updated annually, and software patches for already existing bugs must be downloaded and installed.
Offline Schools (no internet connection) And Online Schools (internet access)	Develops timetables, relief registers, and consolidated leave reports monthly and quarterly.	

From the tabled advantages of SA-SAMS, it is evident that schools that use it have benefited significantly from it. However, as shown in the above table, the system has several shortfalls that needs to be addressed. Some of these disadvantages are a result of lack of internet access in schools, and others are actual disadvantage of SA-SAMS. The section below presents the software product called Valistractor that is provided by the DBE to enables online schools (with internet access) to electronically submit data to the DBE negating the diagram in figure 3-2.

3.5.6 The Valistractor Software

The New Leaders Foundation, in partnership with the Department of Education, developed the Valistractor – a tool used to authenticate the quality of data submitted by schools to the Data Driven Districts (DDD) Dashboard (Daniel, 2017). This tool validates and extracts school data to display on the DBE Dashboard, it is a key tool in improving the quality of data collected for 21st Century data management (DBE, 2021). The tool is made available to all provinces and to date, more than 7,000 schools are uploading their SA-SAMS data via the Valistractor tool every week, with more than 4,000 users repeatedly accessing the dashboard to augment their decisions. The use of the system drastically improves data accessibility. Importantly, the tool is designed to help district and circuit staff use data to make decisions. Further, the tool assists school management in planning and helps educators identify learners' task-level struggles Kearney (2019).

The above section really provides a solid perspective on the improvements of SA-SAMS. Schools with internet access can realise the full benefits of SA-SAMS using the Valistractor tool. As seen in Kearney (2019) report, over 7000 schools are using this tool and this was documented in 2019, from that time to date, more schools should be using this tool that really

allows SA-SAMS schools to electronically submit data to the DBE. Despite this, there are still some disadvantages of SA-SAMS in which the SMSIM model seeks to address.

SA-SAMS' modules are described in the following section, which illustrates the system's full functionality. Various modules support the management and administration of the school by performing specific tasks.

3.5.7 Modules in SA-SAMS

The following figure provides an outline of the different modules found in SA-SAMS (Strydom, 2020):

Figure 3-3: SA-SAMS Modules

The modules will now be discussed (Mathevula & Uwizeyimana, 2014; Molepo, 2015):

- **General school information:** This module contains details about the school, including names of supporting schools, school cycle information, school terms, classes, demerit codes, subjects offered at the school, and the days of the year that the school is teaching and not teaching. Generally, this module contains the parameters of most managerial functions related to school activities and needs, which must be updated yearly.

- **Human resource information:** This module includes information about teachers, staff members, performance appraisal records, and weekly attendance records. In addition to helping schools record and compare Integrated Quality Management System (IQMS) results, this module helps schools to track their progress.
- **Learner and parent information:** In this section, administrators can store information about current and future learners' enrolment. This module can also include information about parents. The significance of this module lies in its ability to report the number of students per week and the number of students promoted to the next grade at the end of the year. Additionally, it contains grades, schedules, and registration forms for learners. The marks that are captured are automatically converted into percentages and levels. Students' marks are also analyzed according to their subject, gender, and language.
- **Governance information:** This module contains all records related to the school governing body (SGB), such as policies, training records, information about members and training records. The school can use this module to monitor learners' misbehaviour statistics and fees, as these areas require the SGB to make decisions.
- **Financial assistant:** This module provides functions for managing daily finances, including income, petty cash, banking, and cheques. Besides maintaining budgets, the module also helps with bank reconciliations.
- **Standard letters and forms module**: Through this module, a selected group of people can receive new or existing letters. This module allows parents, teachers, and staff to print bank application forms.
- **Export data:** This module is seen as being extremely crucial since the main advantages of utilizing the SA-SAMS program are thought to be the exporting of data from the 10th day and the data from the yearly school survey. All the necessary information about the school, its human resources, and its students are automatically imported into SA-SAMS using the import function. In addition, the survey is filled out automatically, thus reducing the amount of time that schools must spend on the survey and the number of errors they make.
- **Annual national assessments (ANA):** This module includes learning outcomes of Annual National Assessment (ANA), parents' information, human resource information, general school information ANA forms, and governance information.
- **The curriculum module** includes, but is not limited to, recording and reporting student progress. Assigning subjects and placing students in classes is done here. The

evaluation cycle is set up at the end of each semester, which includes tasks required for reporting purposes. A schedule can be printed by subject, class, and year after marks have been captured.

- **The timetabling module** solves planning problems for both high and primary schools.
- **The physical resource module** provides teachers with access to student support materials for school retrieval. Students can print reports showing their grades and class and how many books they have for each topic. A list of fixed school supplies can be created based on specifications and incorporated into the asset management system. Reports can be generated for the school's physical resources that have been captured.

Thus, SA-SAMS serves a wide variety of functions that improve the overall functionality of schools; these functions were considered when conceptualizing the SMSIM model. The cost of SA-SAMS' is described in the following section.

3.5.8 Costs Implications of SA-SAMS

The deployment of SA-SAMS is currently ineffective as schools need to install the system individually and maintain a copy of the updates on their premises. These duplications lead to longer upgrade cycles which can stretch to a year, and higher implementation costs (Kuriakose, 2014). However, this package is provided voluntarily, and schools are not required to use this tool but are allowed to use the School Administration Management System (SMS) of their choice. In addition, SA-SAMS is provided to schools free of charge to give all schools equal access to the computer system (Shaikjee, 2020). Other school management systems used by smaller schools are Microscope and Edupac, which schools have to pay for, while SA-SAMS is free for all public schools (Strydom, 2020).

It is evident from the above that SA-SAMS is offered to schools for free but has cost implications tied to its maintenance. Table 3-1 discussed some different SMS used worldwide and among them is MySchool SMS, an inexpensive web-based SMS. Schools need the Internet only to implement this SMS and therefore some schools are not using SA-SAMS. This is also why private schools have opted for private software to assist with their administrative activities. Further reasons why the usage of SA-SAMS is low will be obtained during data collection and the results are presented in Chapter 6 of this study. The section below provides the key components of the chapter.

3.6 KEY COMPONENTS OF THE CHAPTER

The essential components of this chapter are very important in conceptualizing the SMSIM model.

Table 3-4: Essential components

Components	Section	Key Focus Area	Author
School Management Systems (SMS)	3.1-3.5	The focus is on the free and open versions of SMS. These are key as the data collection will be done on the different versions that will serve as a comparison to improve SMS and conceptualize a SMSIM model	(Awadallah, 2016), (Sarker, 2016), (Mythili *et al.*, 2018), (Al-Hayek, 2016)
SA-SAMS	3.6	This SMS is key for the conceptualization of the model as it is a free and open SMS that was developed, introduced, and deployed to various schools in South Africa by the DBE, comparing the results of the Delphi method against the capabilities of SA-SAMS can help improve this SMS.	(Molepo, 2015), (Sibiya, 2019), (Van Wyk, 2021), (Strydom, 2020), (Shaikjee, 2020), (Kuriakose, 2014), (Muriithi & Masinde, 2016).

3.7 SUMMARY

This chapter discussed SMS and provided a table that summarized some different SMS which exist worldwide. It also provided an in-depth explanation of SA-SAMS. This SMS is essential as it is the focus of the study is the SMSIM model that aims to improve SA-SAMS. The importance of this chapter is that it provides a base for the study that will be conducted in schools in South Africa to conceptualize the model. Of specific concern from this chapter for the model is to consider the SA-SAMS, Cost implications of SA-SAMS, why the system was designed, and why schools are using their own SMS. Like chapter 2, this chapter also contributed towards conceptualizing the model as per the picture below.

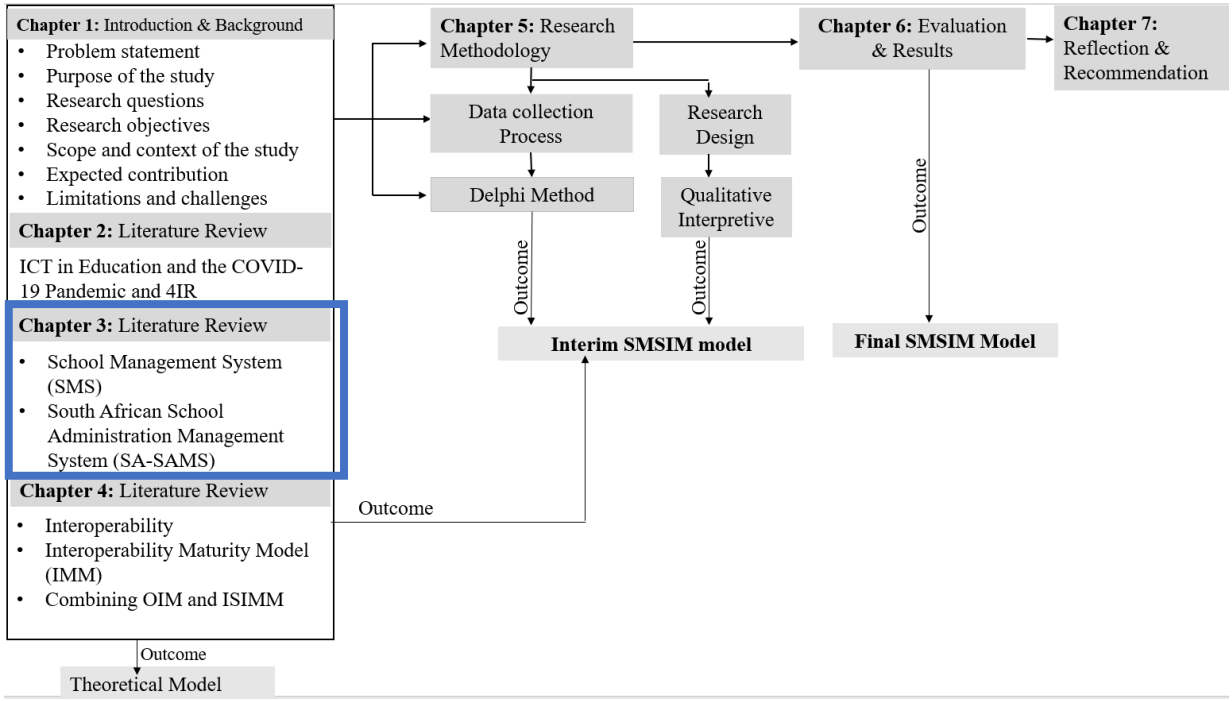


Figure 3-4: The research process that highlights how Chapter 3 contributes to the theoretical framework.

Chapter 4 outlines and discusses the different Interoperability Maturity Models, which were used to conceptualize the SMSIM model.

CHAPTER 4: INTEROPERABILITY MATURITY MODELS

4.1 INTRODUCTION

As per literature findings, Chapter 3 described SMS and listed the different types of SMS available worldwide; however, only a few SMS were discussed in detail. This is the last literature chapter of phase 1 as displayed in the research process below:

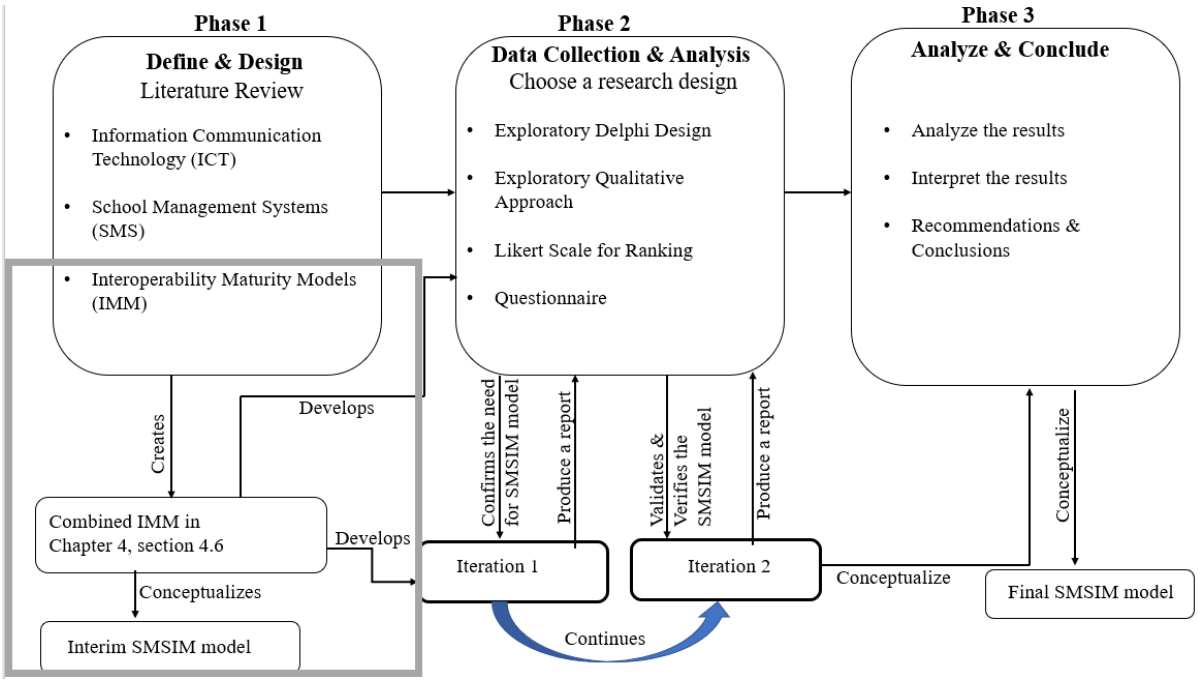


Figure 4-1: The research process of the study highlighting that Chapter 4 is part of Phase 1 of the study.

In this chapter (Chapter 4), the concept of interoperability is introduced, and different Interoperability Maturity Models (IMMs) are described according to literature. Each model is outlined and discussed in more detail. The School Management Systems Interoperability Maturity (SMSIM) model is conceptualized based on two (2) models that were be selected in this chapter.

It might be beneficial, but achieving interoperability is certainly not simple (Brailer, 2005; Zeng, 2019). A clear definition of interoperability does not exist, although it is regarded as a vital success factor (Wozak, Ammenwerth, Hörbst, Sögner, Mair & Schabetsberger, 2008). Without interoperability, utilising technology poses a significant risk (Weber-Jahnke, Peyton & Topaloglou, 2012).

According to literature findings, any organization can benefit from interoperability, but achieving it is not an easy task. Therefore, conceptualizing the SMSIM model was not easy, but it will be beneficial in the end. Therefore, defining interoperability in the following section was essential to understanding the use of interoperability and its potential when SMSIM model was conceptualized.

4.2 DEFINING INTEROPERABILITY

Defining interoperability is key to gaining an insight into interoperability, and how it can benefit the outcome of the study. Table 4-1 defines interoperability.

Table 4-1: Defining Interoperability.

Term	Definition	Author
Interoperability	The concept of interoperability can be viewed as providing a seamless means of exchanging information, for example, automatically personalizing services, so that other systems can use it to improve performance, enable and create services, control operations and process information.	(O'connor, 2017; Sjarov, Kißkalt, Lechler, Selmaier & Franke, 2021)
	Wikipedia defines interoperability as the ability to make systems and organizations work together. In IEEE terms, interoperability is the capability of two or more systems to exchange and use information.	(Elkhodr, Shahrestani & Cheung, 2016)
	In broad terms, interoperability is the ability of various data exchange systems and software applications to work together, exchange accurate, effective, and consistent data, and use the information they exchange.	(Iroju, Soriyan, Gambo & Olaleke, 2013; Zeid, Sundaram, Moghaddam, Kamarthi & Marion, 2019; Sjarov *et al.*, 2021)
	The ability to exchange data and use information between two or more systems or components is called interoperability. As a result of this definition, several challenges arise, such as: Get the information, Exchange data, and Use the information to understand it and process it	(Patel, Patel & Scholar, 2016; Kirpes, Danner, Basmadjian, Meer & Becker, 2019; Zeid *et al.*, 2019; Jaleel, Mahmood, Hassan, Bano & Khurshid, 2020; Sjarov *et al.*, 2021).

The definition in the last row of the table from Patel, Patel and Scholar (2016), Zeid, Sundaram, Moghaddam, Kamarthi and Marion (2019), Kirpes, Danner, Basmadjian, Meer and Becker (2019), Jaleel, Mahmood, Hassan, Bano and Khurshid (2020), and Sjarov, Kißkalt, Lechler, Selmaier and Franke (2021) concord appropriate for this study as it emphasizes the importance of systems communication and seamless information exchange. The following section outlines and discusses different types of Interoperability Maturity Models.

4.3 INTEROPERABILITY MODELS

There have been a lot of study done on interoperability evaluation models. A review of all existing interoperability evaluation models published since 1980 is presented in this section. The Web of Science was searched to identify interoperability evaluation models published between 1980 and 2021. Additionally, Google Scholar was used to supplement the search. Some models for evaluating interoperability are further described considering their significance (Rezaei et al., 2014, Gürdür and Asplund, 2018).

4.3.1 Maturity Models

The maturity model shows a path toward a more organized and systematic manner of conducting business. Maturity models are frequently used to evaluate business processes or specific parts of organizations. With maturity assessments, stakeholders can meaningfully evaluate the existing maturity level of an organization's many elements, highlighting areas for improvement and determining what must be done first to move toward a higher degree of maturity (Proença & Borbinha, 2016).

It is generally understood that "maturity" refers to a state of perfection, readiness, or completion, as well as a progression in the development of a system (Schumacher, Erol & Sihn, 2016). Organisations and processes use maturity models to conceptualize and measure their maturity to achieve specific objectives (Schumacher *et al.*, 2016). As-is situations are assessed, improvement measures are derived and prioritised through maturity models, and progress is tracked. An anticipated, intended, or logical progression from a starting state to maturity is represented by a set of stages in a maturity model (Pöppelbuß & Röglinger, 2011). In maturity models, a certain domain's maturity is evaluated using a wide range of criteria, including competency, capability, and level of sophistication (De Bruin, Rosemann, Freeze & Kaulkarni, 2005). Thus, maturity models are tools for evaluating organisational elements and selecting actions that enhance these elements' maturity (Xavier, Reyes, Aoussat, Luiz & Souza, 2020).

The Maturity Model's ability to identify hurdles, promote initial self-assessment, facilitate best practices for doing so, and plan for ongoing improvement is one of its main goals (Mcleod, Babb & Barlow, 2020). A maturity model is a tool that aids in cooperation planning, decision-making, systematizing transformation programs, and analyzing the efficacy of the actions taken (Silva, Ribeiro, Pinto & Monteiro, 2021).

This study uses all the definitions and purposes of the maturity model defined by all four (4) authors (Schumacher *et al.*, 2016; Mcleod *et al.*, 2020; Xavier *et al.*, 2020; Silva *et al.*, 2021). According to them, maturity is the state of being complete, perfect, and ready, used to evaluate the system as-is and assess its maturity. To ensure that the SMSIM model is complete, perfect, and ready, the 'as-is' process of the organisation is noted and improved, and the maturity of the organisation is assessed, it is essential to ensure the completion of the model is complete, perfect, and ready. The section below also answers the SRQ of the study.

SQR 2: What existing models of interoperability maturity can be used to conceptualize a SMSIM model?

Below are Sections 4.3.2; 4.3.3; 4.3.4; 4.3.5; 4.3.6, and 4.3.7, which discuss various Interoperability Maturity Models (IMM). This section is critical as two (2) IMM models were chosen to help conceptualize the SMSIM model for schools in South Africa. As presented below, the first IMM is the Levels of Information Systems Interoperability (LISI) interoperability maturity model.

4.3.2 Levels of Information Systems Interoperability (LISI)

The Levels of Information Systems Interoperability (LISI) was created in 1998 by the United States (US) Department of Defence C4ISR Working Group. The US Department of Defense uses US intelligence agencies and the defence community's C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) systems (Mingqian & Shuai, 2020). An information system's interoperability can be assessed by using the LISI reference model. This technique establishes, gauges, evaluates, and verifies the level of interoperability that organizations or systems should strive towards (Hendrawan, 2018; Espadinha-Cruz, Grilo, Gonçalves-Coelho & Mourão, 2019; Sjarov *et al.*, 2021). LISI measures the degree of interoperability between systems. Figure 4-2 illustrates the levels of the LISI model. In the LISI model, complexity levels of interoperability are enhanced within the system. Isolated, Connected, Functional, Domain, and Enterprise are among the five degrees of interoperability (0–4), each of which resides inside a specific environment (Guédria, Naudet & Chen, 2008; Rezaei, Chiew, Lee & Aliee, 2014; Jabin, Dimyadi & Amor, 2019b; Luo, Zhang, Mao, Kou & Zhang, 2019; Sjarov *et al.*, 2021).

- **Level 0 - Isolated interoperability** this level has numerous standalone or isolated systems in a manual environment. It is impossible to directly connect to these systems, which have a manual interface. There is an integration and extraction of data manually between multiple systems at this level of interoperability.
- **Level 1 - Connected interoperability** within a peer-to-peer setting: Interoperability between connected systems is based on straightforward electronic data transfer.
- **Level 2 - Functional interoperability** in a distributed environment: This level permits data exchange between systems that are connected by a local network area. Systems share logical data models and provide increasingly sophisticated media exchanges. Functions and systems can share information by combining heterogeneous data in a simple information format.
- **Level 3 - Domain-based interoperability** in a coordinated setting: The domain-based interoperability level allows for the sharing of data across numerous users via wide area networks (WANs). At this level, domain data models are used for information interchange between separate applications. Domain-based interoperability systems facilitate database-to-database interaction through business rules and processes.
- **Level 4 - Enterprise-based interoperability** in a general environment: Through enterprise-based interoperability, systems can access global data across several domains. At this level, multiple users can access the data concurrently, and both the programs and the data are equally shared and distributed. This level also allows for advanced collaboration. All common data formats are interpreted in the same way across the entire enterprise.

The visualization of the LISI model is provided below.

<table>
<tr><td colspan="3" rowspan="2">LEVEL
(Environment)</td><td colspan="4">Interoperability Attributes</td></tr>
<tr><td>Procedures</td><td>Applications</td><td>Infrastructure</td><td>Data</td></tr>
<tr><td rowspan="3">Enterprise Level
(Universal)</td><td rowspan="3">4</td><td>c</td><td>Multi-National Enterprises</td><td rowspan="2">Interactive (cross applications)</td><td rowspan="3">Multi-Dimentional Topologies</td><td rowspan="2">Cross-Enterprise Models</td></tr>
<tr><td>b</td><td>Cross Government Enterprise</td></tr>
<tr><td>a</td><td>DoD Enterprise</td><td>Full Object Cut & Paste</td><td>Enterprise Model</td></tr>
<tr><td rowspan="3">Domain Level
(Integrated)</td><td rowspan="3">3</td><td>c</td><td rowspan="3">Domain Service/Agency Doctrine, Procedures, Training, etc.</td><td>Shared Data (Situation Displays Direct DB Exchanges)</td><td rowspan="3">WAN</td><td>DBMS</td></tr>
<tr><td>b</td><td>Group Collaboration (White Boards, VTC)</td><td rowspan="2">Domain Models</td></tr>
<tr><td>a</td><td>Full Text Cut & Paste</td></tr>
<tr><td rowspan="3">Functional Level
(Distributed)</td><td rowspan="3">2</td><td>c</td><td rowspan="2">Common Operating Environment (DII-COE Level 5) Compliance</td><td>Web Browser</td><td rowspan="2">LAN</td><td rowspan="3">Program Models & Advanced Data Formats</td></tr>
<tr><td>b</td><td>Basic Operations (Documents, Maps,Briefings, Pictures Spreadsheets, Data)</td></tr>
<tr><td>a</td><td>Program Standard Procedures, Training, etc.</td><td>Adv. Messaging (Parsers, E-Mail+)</td><td>Network</td></tr>
<tr><td rowspan="4">Connected Level
(Peer-to-Peer)</td><td rowspan="4">1</td><td>d</td><td rowspan="2">Standards Complaint (JTA, IEEE)</td><td>Basic Messaging (Plain Text, E-mail w/oattachments)</td><td rowspan="3">Two Way</td><td rowspan="4">Basic Data Formats</td></tr>
<tr><td>c</td><td>Data File Transfer</td></tr>
<tr><td>b</td><td rowspan="2">Security Profile</td><td rowspan="2">Simple Interaction (Text Chatter, Voice, Fax, Remote, Access,Telemetry)</td></tr>
<tr><td>a</td><td>One Way</td></tr>
<tr><td rowspan="5">Isolated Level
(Manual)</td><td rowspan="5">0</td><td>d</td><td colspan="2">Media Exchange Procedures</td><td rowspan="4">N/A</td><td>Removable Media</td><td>Media Formats</td></tr>
<tr><td>c</td><td rowspan="3">Manual Access Controls</td><td>NATO Level 3</td><td rowspan="3">Manual Re-entry</td><td rowspan="3">Private Data</td></tr>
<tr><td>b</td><td>NATO Level 2</td></tr>
<tr><td>a</td><td>NATO Level 1</td></tr>
<tr><td>0</td><td colspan="5">NO KNOWN INTEROPERABILITY</td></tr>
</table>

Figure 4-2: The LISI Model (Ostadzadeh, Shams & Badie, 2015; Gürdür & Asplund, 2018)

The LISI process is built on the LISI Reference Model. The attributes of the LISI Reference Model can be seen in the rows and columns of the five LISI interoperability levels as Procedures, Applications, Infrastructure, and Data (PAID). The essential specialized capabilities are made possible by the broad categorisation of level/attribute intersections. As a

result, the LISI divides interoperability aspects into four uniform properties (Rezaei *et al.*, 2014; Gürdür & Asplund, 2018; Hendrawan, 2018; Luo *et al.*, 2019):

- **Procedure attributes** include various forms of operational controls and documented guidance that impact the integration, development, and operation of systems. Further, standards, policies, and procedures are addressed in the procedure attributes to facilitate the exchange of information between systems.
- **Application attributes** include the system mission, the primary reason for creating the system, and functional process attributes—which include a variety of operational controls and documentation—have an impact on all facets of system development, integration, and operation. The procedural qualities contain architectural rules, standards, policies, and procedures that permit information interchange between systems. The primary objective of system development, the system mission, and the functionality requirements are examples of application qualities. These characteristics point to programs that provide processing, exchange, and manipulation.
- **Infrastructure attributes** establish and maintain a connection between applications and systems. Among these attributes are the systems, networks, and hardware that enable the interaction.
- **Data attributes** describe the system's information processes, encompassing both its format (syntax) and content (semantics). Among the data attributes of interoperability are protocols and formats that enable the exchange of data and information.

The LISI Model offers the valuable feature of expressing the results in interoperability metrics to assess interoperability. The level of system interoperability is measured by the LISI metric. The Interoperability Questionnaire and the LISI Capabilities Model act as data aggregators and measurement templates to assess the level of interoperability (Rezaei *et al.*, 2014; Gürdür & Asplund, 2018).

Based on the Interoperability Maturity Model above, it is evident that LISI provides a process for assessing an information system's interoperability, focusing on enhancing its interoperability levels of complexity. However, this model will not be considered for the study as it was extended by the Organisational Interoperability Maturity Model (OIM) (discussed below) that assesses the non-technical and human activity level to interoperate with other organisations (Maremi, Herselman & Botha, 2020). The following section describes OIM.

4.3.3 Organizational Interoperability Maturity Model (OIM)

This concept extends the LISI by adding a more amorphous layer of command-and-control functionality. This model defines five levels of organisational maturity to describe interoperability. Table 4-2 provides a detailed illustration of the organizational interoperability maturity model (Haghighinasab & Khosravi, 2011; Rezaei *et al.*, 2014; Gürdür & Asplund, 2018; Jabin *et al.*, 2019b; Sjarov *et al.*, 2021).

The Organizational Interoperability Maturity (OIM) model was created in 1998 by the Australian Defence Science and Technology Organization to evaluate the interoperability of organizations (OIM). The objective of OIM is to assess an organization's ability to interoperate with another by looking at nontechnical or human-activity aspects. In addition to four organizational interoperability qualities, it has levels equivalent to LISI (independent, cooperative, collaborative, combined, and unified) (preparation, understanding, command style, and ethos) (Guédria *et al.*, 2008; Haghighinasab & Khosravi, 2011; Rezaei *et al.*, 2014; Gürdür & Asplund, 2018; Mcdaniel, 2020). The four enabling traits in OIM are preparedness, understanding, command style, and ethos and are characterized as follows (Mcdaniel, 2020):

- **Preparedness:** This attribute indicates how prepared an organization is to interoperate. Furthermore, it focuses on training, experience, and doctrine that enables different organizations to work together.
- **The understanding** attribute measures understanding of how information and knowledge are shared within the organization and how they are used. Necessary levels of information and knowledge-sharing are considered in the attribute.
- **Command style:** This attribute describes the way decisions are made, how roles and responsibilities are assigned, and how the organisation is managed. As part of this process, roles and responsibilities are examined both delegated and shared.
- **Ethos:** This attribute refers to the objectives, values, culture, and trust of an organization. Since its introduction, the organisational interoperability maturity model has been reviewed by several researchers.

Then, on a scale of 0 to 4, these four characteristics are evaluated across five stages of increasing interoperability: independent, cooperative, collaborative, combined, and unified.

Table 4-2: Organizational Interoperability Maturity Model (OIM)

	Preparedness	**Understanding**	**Command Style**	**Ethos**
Level 4 Unified	Complete-normal day-to-day working	Shared	Homogenous	Uniform
Level 3 Combined	Detailed doctrine and experience in using it	Shared comms and shared knowledge	One chain of command and interaction with home org	Shared ethos but with influence from home org
Level 2 Collaborative	General doctrine in place and some experience	Shared comms and shared knowledge about specific topics	Separate reporting lines of responsibility overlaid with a single command chain	Shared purpose: goals, value system significantly influenced by home org
Level 1 Ad hoc	General guidelines	Electronic comms and shared information	Separate reporting lines of responsibility	Shared purpose
Level 0 Independent	No preparedness	Communication via phone etc	No interaction	Limited shared purpose

Source adapted from: (Lane & Valerdi, 2011)

4.3.4 Levels of conceptual Interoperability

To address the need for conceptual interoperability that extends across technical models like LISI, conceptual interoperability model tiers were proposed. The paradigm views interoperability as a conceptual challenge rather than a technical one, and it seeks to integrate conceptual and technical design. The levels are (Gürdür & Asplund, 2018; Jabin *et al.*, 2019b; Leal, Guédria & Panetto, 2019):

- **Level 0 - Independent:** At this level of interoperability, interactions between autonomous organizations are detailed. Organizations operate at this degree of interoperability with only personal interactions. Organizations on this level may not share common goals or purposes but may have to interoperate in scenarios with no precedent. Interoperability at this level leads to unexpected and unplanned arrangements. Despite this level's absence of formal frameworks, communication occurs through meetings, faxes, and telephone calls.

- **Level 1 - Adhoc:** Few organizational frameworks can support ad hoc arrangements at this level of interoperability. Guidelines explain interoperability, but specific arrangements have not been finalized. Overarching goals are shared at this level of organizational interoperability. Despite this, organizations continue to exist as independent entities because of individual, organizational goals.
- **Level 2 - Collaborative:** To achieve this level of interoperability, recognized frameworks must be prepared, and common objectives must be determined. Moreover, roles and responsibilities are assigned based on ongoing responsibilities, although the organizations remain distinct. The level of organizational interoperability is where knowledge exchange and training take place as the last stage.
- **Level 3 - Integrated:** There is a common understanding, shared goals, and readiness to interoperate at this level of interoperability. Using it as a detailed doctrine has a significant amount of experience. The frameworks at the integrated level of organizational interoperability have been prepared and tested, despite any remaining ties to a home organization.
- **Level 4 - Unified:** At this degree of interoperability, organizational objectives, value systems, command structures, and knowledge bases are shared. Organizational interoperability is continuous at the unified level. There are no impediments to complete full interoperability in the organizational framework at this level. However, it is likely that only very homogeneous organizations will achieve a unified level of interoperability.

OIM evaluates humans' ability to interact with the system and other organizations. The LISI model is extended by this model. Thus, OIM was chosen to conceptualize the SMSIM model for schools in South Africa. It is important to understand how SMS users interact with SMS and their shortfalls; this model (OIM) does that. However, this model is unable to look at the technical elements of SMS to ensure interoperability and thus, this model was combined with Information Systems Interoperability Maturity Model (ISIMM), which focuses on the system itself as per Section 4.3.7 (Maremi *et al.*, 2020). The following section lists and outlines the Enterprise Interoperability Maturity Model (EIMM).

4.3.5 Enterprise Interoperability Maturity Model (EIMM)

The enterprise interoperability maturity model was created by the European Commission through the ATHENA IP (Advanced Technologies for interoperability of Heterogeneous Enterprise Networks and their Applications Integrated Project). There are identified maturity levels and areas of concern in the enterprise interoperability maturity model (See Figure. 4-3). Interoperability and collaboration issues would be defined by specific objectives and goals for each area of concern. The interoperability and collaboration maturity levels are defined depending on the existence or absence of maturity indicators. Each indicator must meet the threshold conditions or reach the level required for each maturity level (Guédria *et al.*, 2008; Rezaei *et al.*, 2014; Ostadzadeh *et al.*, 2015).

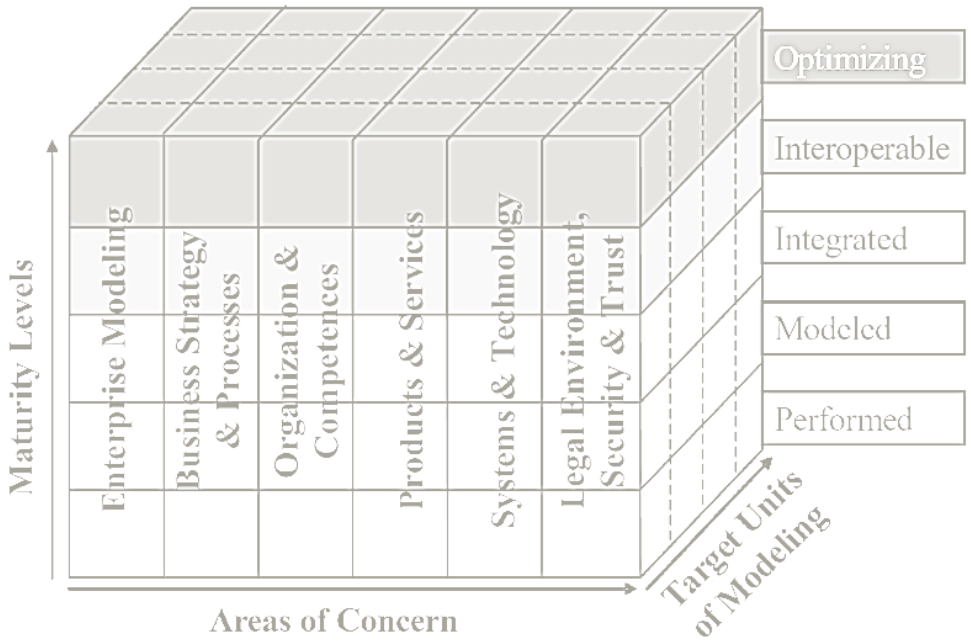


Figure 4-3: Enterprise Interoperability Maturity Model (EIMM) (Ostadzadeh et al., 2015)

The following section lists and explains the maturity levels in EIMM:

- **Business strategy and processes:** The area of business strategy and processes is concerned with defining, identifying, and executing company strategy and procedures. It pursues and necessitates strengthening the cooperation procedures for various organizational units in addition to the external entities to attain interoperability in this area of concern.

- **Organization and competencies:** This area of concern deals with improving, enacting, specifying, and identifying organizational structures containing the skills and knowledge of the identified players. Identifying the external entities to collaborate with, specifying the networked organization topology, and improving and deploying it to achieve interoperability in this area is necessary.
- **Products and services:** This area focuses on the design, specification, identification, and lifecycle strategy of an organization's products and services, as well as its quality characteristics. Finding new opportunities and specifying the same components for products and e-services that use networked technologies to achieve interoperability in this area is necessary.
- **Systems and technology:** This area of concern includes improving, maintaining, operating, acquiring/constructing, designing, specifying, and identifying enterprise systems. Ideally, this involves developing links to enterprise models and tracing them back. Innovative technologies that foster interoperability must be researched and evolved to achieve interoperability in this area of concern.
- **Legal environment, security, and trust:** This area of concern focuses on recognizing the requirements for trust, security, and the law, working with outside parties to manage these issues, and offering solutions to do so because they are essential to interoperability.
- **Enterprise modelling:** An all-encompassing sixth area of concern directly affects all the previously identified areas. Enterprise Modelling refers to improvements, applications, constructions, and specifications for enterprise models. For enterprise modelling, the specification identifies the proper languages, meta-models, infrastructure, techniques, organization (skills and people), and related activities. Additionally, it emphasizes the compatibility of corporate models.

The following are the five stages of the enterprise interoperability maturity model (Rezaei *et al.*, 2014):

- **Performed:** Enterprise modelling and collaboration are performed ad hoc at the Performed maturity level. Organizations collaborate with external entities (customers, administration, suppliers), but the relationships are not planned carefully. It is common for collaborative processes and tasks to exceed budgets and schedules at this level.

Aside from that, they cannot repeat their past success and are not utilizing the technology to its full potential.

- **Modelled:** Enterprise modelling and collaboration are carried out similarly at the Modelled maturity level, and the method has proved to be useful. The application of the described techniques and meta-models occurs at this level. Furthermore, roles are clearly defined, and everyone is aware of the business model's implementation. To promote collaboration, network technologies are also used.
- **Integrated:** Enterprise modelling has been formally documented, communicated, and applied consistently at the Integrated maturity level. This level involves organizations using a defined framework and methodology for enterprise modelling, integrating the various dimensions, and tracing the model back to the enterprise IT infrastructure. Models are improved using a knowledge base. As part of the enterprise model, interoperability technologies, standards, and externalisation facilitate business collaboration.
- **Interoperable:** At the Interoperable maturity level, enterprise models offer dynamic interoperability, changeability, and external entity evolution. At this level, the enterprise model smoothly incorporates the workplace of the employees. Results and process metrics are the foundation of continuous improvement for the individuals and organizations involved.
- **Optimizing:** To achieve the Optimizing maturity level, an organization must be able to adapt and react to changes in the business environment quickly, efficiently, and with agility. This level aims to integrate enterprise systems with enterprise models and improve interoperability by researching and applying innovative technologies. Enterprise modelling could be utilized at the Optimizing maturity level to fulfil the overall goals of the associated business, people, or unit.

This model will not be considered for the study as it focuses on the enterprise's interoperability maturity model. This model will be used when the study's main focus starts assessing SMS as an enterprise (Maremi *et al.*, 2020). The following section discusses the Government Interoperability Maturity Matrix (GIMM).

4.3.6 Government Interoperability Maturity Matrix (GIMM)

Figure 4-4 illustrates the government interoperability maturity matrix (GIMM) that was presented by Sarantis, Charalabidis and Psarras (2008).

Figure 4-4: Government Interoperability Maturity Model (GIMM)

With the model, administrations can perform a simple self-evaluation to assess their status in relation to e-Government interoperability as well as what steps need to be taken to improve their positioning when it comes to implementing e-Government systems and providing services to citizens and businesses. The European Interoperability Framework's (EIF) interoperability types are expanded by this maturity model, which also identifies several interoperability attributes that must be considered when assessing each organization's situation regarding e-Government interoperability. The GIMM is depicted in Figure 4-4 as being composed of a number of levels, each of which corresponds to a distinct interoperability level for a collection of interoperability qualities (IA) (Guédria *et al.*, 2008; Rezaei *et al.*, 2014; Cestari, Loures & Santos, 2018; Fernandes, Neto & Santos, 2018; Jabin *et al.*, 2019b; Jabin, Dimyadi & Amor, 2019a; Almeida Prado Cestari, Loures, Santos & Panetto, 2020).

4.3.6.1 Five levels of maturity are defined in the GIMM

The GIMM have the following five levels (Guédria et al., 2008; Rezaei et al., 2014; Cestari et al., 2018; Fernandes et al., 2018; Gürdür & Asplund, 2018; Jabin et al., 2019a, 2019b; Almeida Prado Cestari et al., 2020):

- **Level 1 - Independent:** The connection between independent groups is discussed at the independent level.
- **Level 2 - Adhoc:** Ad hoc arrangements can be supported only with minimal organizational frameworks.
- **Level 3 - Collaborative:** There are recognized mechanisms in place to promote interoperability at this level. Even when shared goals are determined and roles and tasks are allocated, organizations maintain their individuality.
- **Level 4 - Integrated:** This degree of interoperability calls for a common concept of interoperability with other organizations, as well as common goals and value systems.
- **Level 5 - Unified:** At this degree of interoperability, organizations share knowledge bases, organizational goals, organizational structure, and values.

4.3.6.2 Three main interoperability dimensions in the GIMM

The following three interoperability dimensions are defined in the GIMM (Rezaei et al., 2014):

- **Organisational interoperability:** The organizational interoperability component entails creating collaborations between organizations that share information and may have various internal structures and processes, as well as formulating business objectives and structuring business processes. Organizational interoperability also attempts to satisfy the needs of the user community by making certain that services are user-friendly, accessible, clearly identified, and quickly available.
- **Semantic interoperability:** This dimension ensures that any application can understand the precise meaning of information exchanged, regardless of its original purpose. Combined with other information resources, this dimension facilitates systems' ability to process information meaningfully. A multilingual front-end delivery of services is, therefore, a prerequisite of semantic interoperability.
- **Technical interoperability:** Technical interoperability connects computer systems and services. Security, accessibility, data display, data interchange, middleware and data integration, and connectivity services are among the services included in this dimension.

GIMM defines several Interoperability Attributes classified into three interoperability dimensions using a parametric score matrix. Hence, a vector containing the GIMM Interoperability Attributes is a good representation of the interoperability state. Lastly, the

Government Interoperability Maturity Matrix provides mathematical formulations and patterns to consider when transitioning a government organization to an interoperability state (Rezaei *et al.*, 2014; Gürdür & Asplund, 2018).

In addition to assessing the state of the administrations in terms of e-Government interoperability, this model also identifies the steps that need to be taken to improve system implementation. Due to the advanced nature of this model, which focuses specifically on e-governance, it was not considered when the SMSIM model of the study was conceptualized. The SMSs in the education sector is used by both private and public institutions that must submit data to the DBE, therefore the GIMM model narrows the focus to e-government and does not consider private sectors. Moreover, the study focused on schools in South Africa that uses different SMS to conceptualize the SMSIM model (Maremi *et al.*, 2020).

4.3.7 Information Systems Interoperability Maturity Model (ISIMM)

To evaluate the interoperability maturity of information systems, the Information Systems Interoperability Maturity Model (ISIMM) was created. The LISI and GIMM theories served as the foundation for the ISIMM, which primarily focuses on the technical components of interoperability that would enable data sharing and exchange in an information systems environment (Van Staden & Mbale, 2012; Campos, Chalmeta, Grangel & Poler, 2013; Anggoro, Hubeis & Sailah, 2018; Almeida Prado Cestari *et al.*, 2020).

ISIMM in Figure 4-5 specifically outlines the stages and levels of interoperability sophistication that an organization's information systems will go through. Information system interoperability maturity (ISIMM) provides a standardized and systematic approach to analyzing and measuring. The construction of an interoperable systems environment within the government will be made easier by ISIMM's provision of the means to gain a deeper understanding of interoperability in information systems, which goes beyond investigating interoperability's intricacies (Van Staden & Mbale, 2012; Ostadzadeh *et al.*, 2015; Anggoro *et al.*, 2018; Almeida Prado Cestari *et al.*, 2020).

Figure 4-5: Information Systems Interoperability Maturity Model (ISIMM)(Rezaei et al., 2014).

The following areas are where the ISIMM focuses on the technical interoperability of information systems (Van Staden & Mbale, 2012; Campos *et al.*, 2013; Ostadzadeh *et al.*, 2015):

- **Data interoperability:** The ability of various software applications from heterogeneous systems to comprehend the syntactical and semantic meaning of data obtained from various data models by using common data models, mappings, and structures is referred to as data interoperability.
- **Software interoperability:** This is described as the ability of diverse software organizations to exchange and share data by solving their differences.
- **Communication interoperability:** User systems can communicate and connect through standard protocols to provide interoperability.
- **Physical Interoperability:** This refers to the ability of computer hardware, network devices, and peripherals to interact with one another.

Figure 4-6 illustrates the maturity interoperability computing environment tiers of ISIMM (Van Staden & Mbale, 2012; Campos *et al.*, 2013; Ostadzadeh *et al.*, 2015):

- **Level 1 - Manual:** There are no connections between information systems, and data is shared manually between systems.
- **Level 2 - Adhoc:** The basic sharing of non-standardized data takes place electronically with other organizations. Databases and applications are separated, and data is not shared between organizations. Instead, data is exchanged between systems in a point-to-point manner on an ad-hoc basis.
- **Level 3 - Collaborative:** This level enables broader connections with legacy systems. In a distributed setting, basic collaboration is achieved between independent

applications. Logical data models are shared and used in the data exchange process. However, minimal standard functions exist, applications and databases are separated, and data is not shared.

- **Level 4 - Integrated:** Data in the integrated stage are shared to some extent, and data is exchanged between independent applications using shared domain-based data models. Collaboration is at an advanced domain level. Integration of services or systems is being implemented between organisations.
- **Level 5 - Unified:** At this stage, data and applications can be fully shared and distributed between organizations. Organizations are interoperating continuously through high-quality services at this level of enterprise collaboration. There is a common interpretation of data, and it is based on a standard exchange model. There is full interoperability between front-end and back-end systems. The processes at this level are also automated.

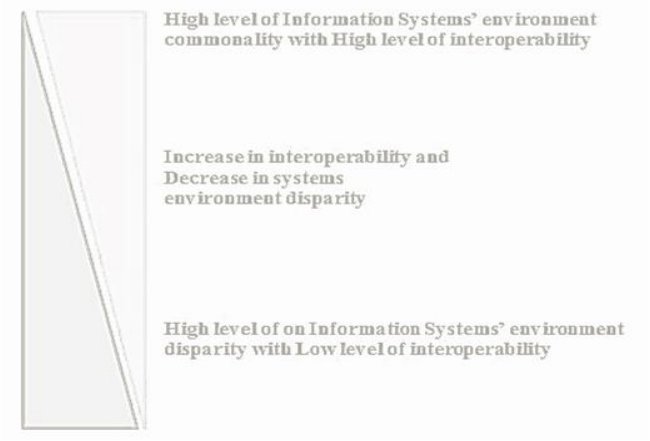


Figure 4-6: information systems' interoperability maturity transition (Campos et al., 2013, Van Staden and Mbale, 2012)

The transition of an interoperable environment from a very disparate information systems environment to a highly common integrated and shared information systems environment, as indicated in Figure 4-6, is defined by the interoperability maturity stages of ISIMM. This classifies a change in the interoperability of the information systems environment from a low level to a high level (Van Staden & Mbale, 2012; Campos *et al.*, 2013; Ostadzadeh *et al.*, 2015).

It is evident from the section above that ISIMM focuses on the technical aspect of interoperability of the system; this makes it a good model to combine with OIM, which focuses on the human aspect to ensure a valuable model is conceptualized. For an organization to

operate effectively, it is important to evaluate how the organization's system supports its day-to-day operations and how the people interact with the systems put in place. In other words, the users of SMS and SMS are equally important in the school's operation (Maremi *et al.*, 2020).

4.4 CONCEPTUALIZING THE INTERIM SCHOOL MANAGEMENT SYSTEMS INTEROPERABILITY MATURITY (SMSIM) MODEL

Chapters 2, 3, & 4 of the literature review assisted in the conceptualization of the School Management Systems Interoperability Maturity (SMSIM) model. Figure 4-7 below outlines how each chapter contributed to conceptualizing the SMSIM model across different literature review sections.

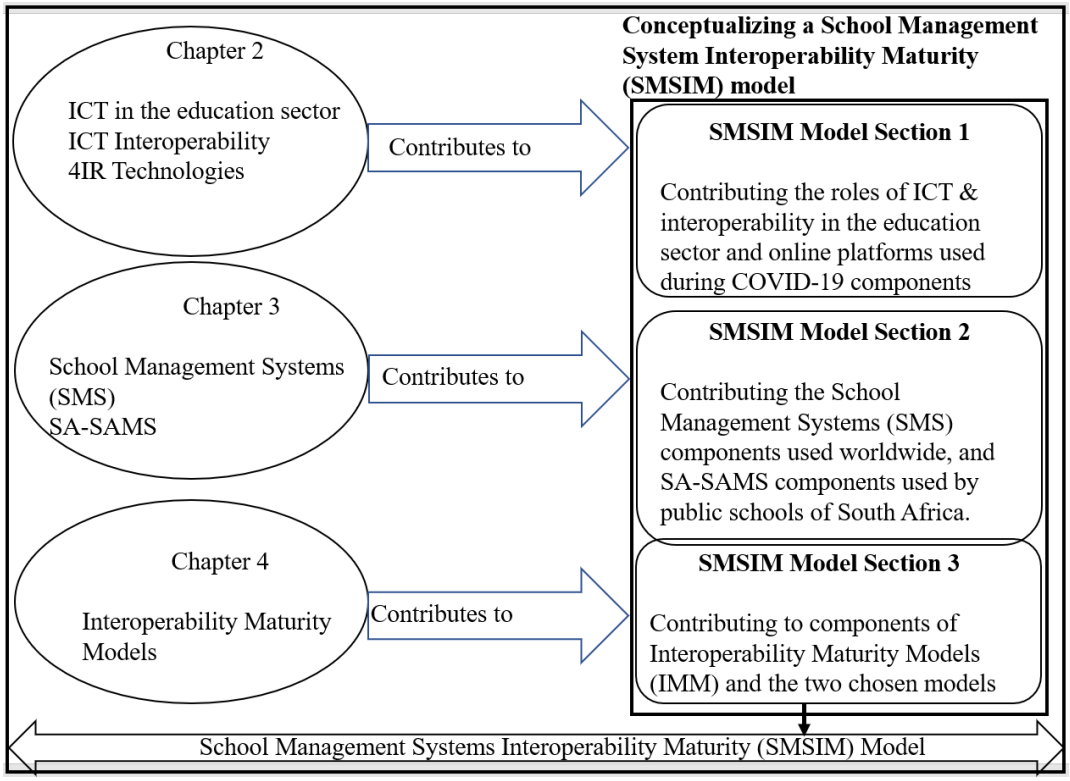


Figure 4-7: Conceptualizing the School Management Systems Interoperability Maturity (SMSIM) model

It is evident from this figure that Chapter 2 focussed on ICT aspects, Chapter 3 on school management systems and Chapter 4 on interoperability maturity models. Concepts from these literature chapters will be applied to conceptualize the model.

4.5 CHOOSING OIM AND ISIMM

To conceptualize a model that is effective, reliable, and efficient, Interoperability Maturity Models (IMM) were outlined and discussed in the following sections: 4.3.2 - 4.3.7. From those IMMs, Organization Interoperability Maturity Model (OIM) and Information System Interoperability Maturity (ISIMM) Models were chosen for conceptualizing the initial SMSIM model before the data collection process.

These models were chosen because:

- The OIM concept builds on the LISI architecture and emphasizes interoperability. This model focusses on the ability organisation to interoperate. The model also focus on employees in the organisations and how they interact with the changes in the organisation. See Section 4.3.3 for more information on how this model evaluates non-technical or human activity and an organization's capacity for collaboration.
- The ISIMM assesses the level of interoperability between information systems; this is important as it will give a clear picture of interoperability in the SMS. As information exchange is the main goal of interoperability, ISIMM also concentrates on the more intricate technological elements that enable data to be shared and exchanged within an information systems environment. With this maturity model, a deeper comprehension of information systems will be gained, which is essential for SMS, see Section 4.3.7.

Both models were created as extensions of the LISI model, and they are quite complementary to one another. It is crucial to comprehend the SMS's level of interoperability so that it may be enhanced, and it is only marginally significant to predict how users will interact with the system. From system to organizational adaptation, these two theories offer a comprehensive perspective.

Since the LISI Model resembles the ISIMM more, it is not considered in this context. The LISI model extends the ISMM and OIM model and measures the degree of interoperability between systems (see sections 4.3.2, 4.3.3 and 4.3.7). When interoperability has been incorporated into SMS, GIMM can be used to conduct a self-evaluation that evaluates the administrations' current position regarding e-government interoperability and the steps necessary to improve their posture with relation to system implementation. Future uses of the GIMM model can be considered (see Section 4.3.6). Because EIMM is a high-level maturity model that focuses on

the enterprise, see Section 4.3.5, it is not considered. The two (2) models were combined in the next part are (OIM & ISIMM).

4.6 COMBINING OIM AND ISIMM

Section 4.3 discussed different Interoperability Maturity Models (IMM) which exist. Section 4.5 of this study chose two (2) IMM from the list that were discussed and justified why only two (ISIMM & OIM) models were chosen to conceptualize the interim SMSIM model. In this section, Table 4-3 below, combines the two models chosen to conceptualize the interim SMSIM model for schools in South Africa. The interim SMSIM model will be given to experts for evaluation based on determining the worth, significance, validity, and value of the model for SMS. These results will be documented in Chapter 6.

Table 4-3: Combining OIM & ISIMM

Organizational Interoperability Model (OIM)			**Information Systems Interoperability Maturity Model (ISIMM)**		
Level 4 unified	Complete normal day-to-day working	Shared understanding	information is interpreted the same. Systems are fully interoperable.	Complete data sharing	Level 5 Unified
Level 3 Integrated	The same level of understanding and preparedness to interoperate	common goals and value systems	There is a higher level of collaboration and services integration	There is data that is shared to a certain extent in the integrated stage	Level 4 Integrated
Level 2 Collaborative	frameworks and common goals	Shared Comms and shared knowledge	Least shared functions exist	There is a broader connection to legacy systems	Level 3 Collaborative
Level 1 Ad hoc	Guidelines	Shared Purposes	No data that is shared among organizations	There is a separation of applications and databases	Level 2 Ad-Hoc
Level 0 Independent	No Preparedness	No Interaction	No sharing of data	No connection of Information Systems	Level 1 Manual

This table combined ISMIM (4.3.7) and OIM (4.3.3) models, the components and levels in these models are discussed in their respective sections (4.3.7, 4.3.3). These models will serve as the main guideless for achieving interoperability in SMS. These models cover two crucial areas: how users interact with the system and the interoperability of SMS as a digital technology. The expert review Delphi questionnaires are mostly derived from this combined table to conceptualize the SMSIM model that cuts across SMS from the system's perspective to the user. The output of the findings during data collection was used to further refine the conceptualized SMSIM model of this study.

A combination of OIM and ISMIM also answers the sub-research question 1 of the research questions.

SQR 1: What constitutes the components of a model of interoperability maturity for Schools Management Systems?

The following section was derived from Table 4-3 above and was verified and validated through the expert review results. In Chapter 6, this did not change but ed-admin was assessed using this model. This section presents the interim SMSIM model conceptualized based on the current state of SA-SAMS and different SMS according to literature and the two combined maturity models in Table 4-3.

4.7 THE INTERIM SCHOOL MANAGEMENT SYSTEMS INTEROPERABILITY MATURITY (SMSIM) MODEL

The School Management Systems Interoperability Maturity (SMSIM) model is a feeder model that assesses the level of interoperability in the SMS and continuously provides guidelines to improve the current level of interoperability in SMS. This model consists of five phases: the foundation, primary, intermediate, secondary phase, and tertiary phases. The SMSIM model uses the tested, verified, and approved Interoperability Maturity Models (IMM) which are a combination of Information System Interoperability Maturity Model (ISIMM) and Organizational Interoperability Maturity Model (OIM) to assess and provide guidelines for improving SMS. A feeder at each phase goes into each level of ISIMM and OIM to assess interoperability at each level and provide guidelines for the next level.

From the model, it is evident that on the left side, one finds the ISIMM with its interoperability levels with the same number of levels with different names as the OIM on the right side of the

model that focuses more on the organizational maturity to provide interoperability. Both has five levels of interoperability maturity. OIM has levels 0-4 and ISIMM has levels 1-5. Only the names of the first level in each differ (ISIMM has a manual level because at this low level, information systems are not connected, and data is shared manually). The OIM refers to this level as independent because there is no preparedness in the organisation to have interoperability at this level.

The second level in both models uses the phrase Adhoc to refer to a level where only basic data is shared (ISIMM) and in the OIM the organization's preparedness has guidelines and the understanding is shared with a specific purpose.

Moving to the third level in both one sees the use of the same name (Collaboration) as at this level in ISIMM there is collaboration regarding a broader connectedness to legacy systems with basic collaborations. In the OIM there is collaboration regarding the sharing of knowledge and experience.

At the fourth level, the ISIMM focuses on integrating data interoperability in information systems and OIM a combination level in the OIM where there is more detail and depth in the understanding and preparedness of the organization.

Level five of both (ISIMM & OIM) models is called the Unified level, in ISIMM, this level is reached when data is fully distributed between organizations and collaboration is at an advanced enterprise level.

The interim model that is conceptualized from literature in Figure 4-8, will go through a Delphi expert review and the consensus will determine how many rounds will be required (see Chapter 6 for the number of rounds that occurred in the study).

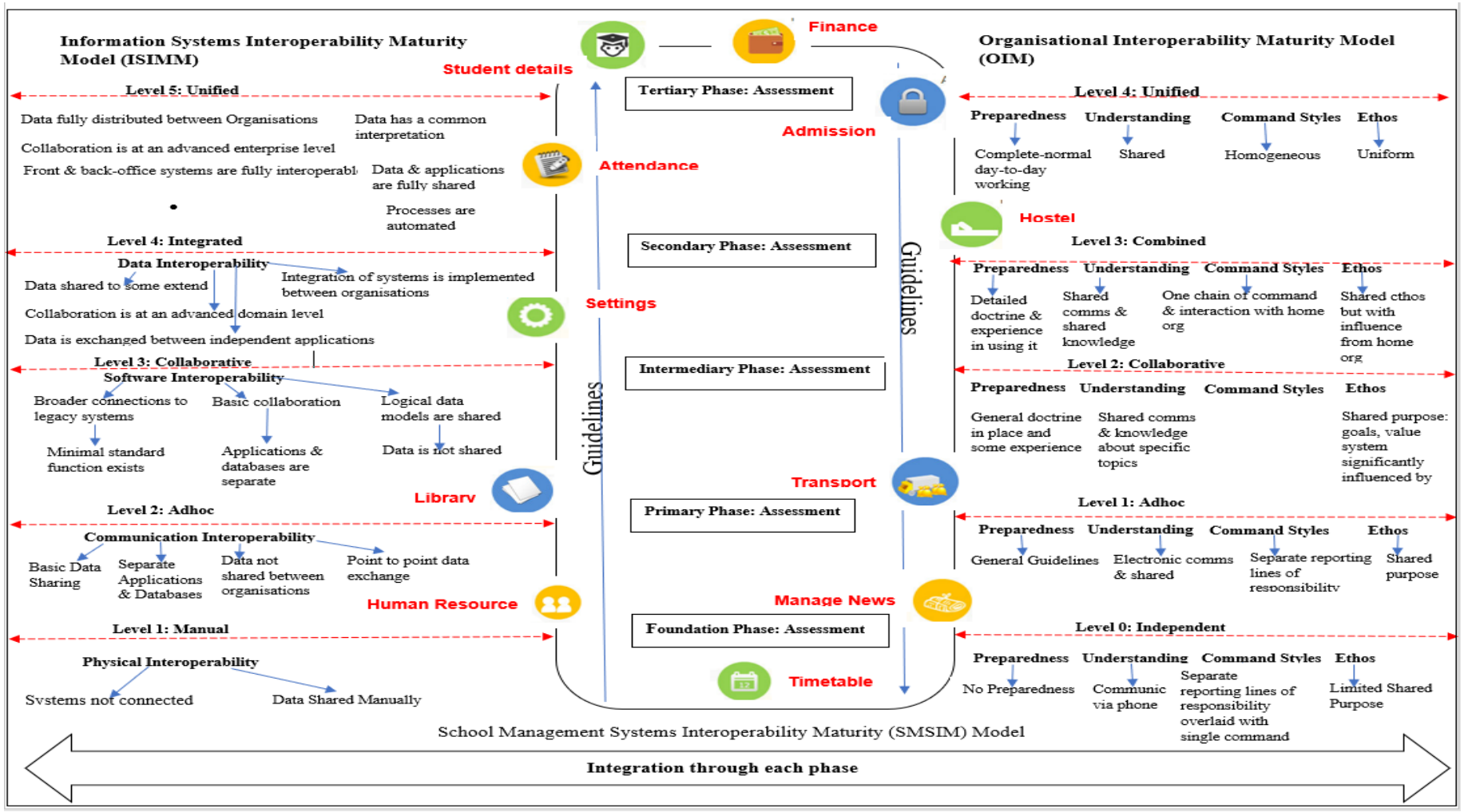


Figure 4-8: School Management Systems Interoperability Maturity (SMSIM) model

The icons in the centre represents a typical SMS, this can differ from one SMS to another depending on the icons each SMS has to represent different types of features of the system.

The arrow indicates that guidelines will be provided for the entire SMS.

The red dotted bidirectional arrow represents the process of feeding into the OIM & ISIMM to assess the level of interoperability of SMS.

The following section describes each level and further provides guidelines to move to the next level.

Foundation phase (bottom middle of Figure 4-8): At this level, a feeder is sent into Information Systems Interoperability Maturity Model (ISIMM) and Organizational Interoperability Maturity Model (OIM) manual or independent level in parallel to assess the required level of interoperability. The outcome of the level serves as a guideline for the next level: Systems are not connected in this interoperability level, and data is shared manually through the post office. Schools are normally unprepared for interoperability to occur, they only communicate via phones among staff members and other schools, there is no interaction with other schools except through communicating via manual means (digital platforms are not used), and there is a limited shared purpose. For schools to get to the adhoc level, they need basic data sharing and general guidelines for interoperability and some electronic means of communicating and sharing information. This can be as simple as using email to communicate with other schools and each other.

At this phase, teachers have increased workloads. There is duplication of work as marks and administrative tasks are done manually (no digital technologies), there is a lot of redundancy and errors because of fatigue and human error, and submission of reports to the DoE is always delayed. However, according to literature, most schools, especially in the private sector, have passed this stage, specifically regarding manual communication and data sharing. Interoperability can reduce the burden on staff members of the schools by introducing systems that will improve data quality and enhance efficiency.

Primary phase (second phase in the middle of Figure 4-8): At this level, a feeder is sent into **ISIMM and OIM Adhoc level** in parallel to assess the required level of interoperability, the outcome of the level serves as a guideline for the next level**.** In this level of interoperability, the school has separate reporting lines of responsibility, general guidelines to achieve

interoperability, and a shared purpose with other schools, there is basic data sharing, applications and databases are separate, data is not shared with other schools, and data is exchanged through systems in a point-to-point manner. For schools to get to the collaborative level, they need to have a shared logical data model, basic collaboration with other schools, and general doctrine to support interoperability and some experience in interoperability.

Schools in this level of interoperability have improved decimally compared to the schools in the foundation phase of interoperability. However, the improvement is minimal, and a lot of work must be implemented to realise the full benefits of interoperability. It is observed that, at this level, school administrator is still burdened with entering data into the systems of the schools as databases and applications are separate, and data is shared in a point-to-point manner. There is limited access to system and only the system administrator can enter data into the system, this opens room for errors, duplicates, redundancy and compromising the integrity of the data between the back-and-forth communication of the systems. By using a SMSIM model as a guideline model to help improve SMS, the requirements of the next level will be obtained and with slow progress, this type of school will run smoothly.

Intermediary phase: At this level, a feeder is sent into **ISIMM and OIM collaborative level** parallelly to assess the required level of interoperability, the outcome of the level serves as a guideline for the next level**:** In the collaborative level of interoperability. There are broader connections to legacy systems. Although minimal standard functions exist, applications and databases are still separate at this level. There is basic data collaboration with other schools, and data is still not shared. Schools can share communications and knowledge about specific topics with other schools. The general doctrine is put in place to support interoperability and some experience, reporting lines are still separate, and the school shares goals, purpose, and value systems with other schools. Schools must exchange data between independent applications for getting to the integrative level.

Unfortunately, legacy systems are outdated computing software and hardware that are still being used. These systems meet the needs they were originally designed for but don't allow for growth. Although these systems present a major investment and, for the most part, they cannot be abandoned. Interoperability connects these types of legacy systems with the new systems. With this advantage of interoperability, information is never lost and there is room for growth. However, most of the disadvantages of SMS are still not entirely solved in this phase as data

is still not shared and there are still silos in the schools even though some communication between schools can occur. Schools in this phase must work on getting to the next phase to fully realise the benefits of interoperability. Many schools in South Africa are in this phase of interoperability, and they know the benefit of interoperability and measures are put in place to support interoperability. However, data is still not shared, and applications and databases are still separate. Unfortunately, there is still too much strain on the staff members of the schools to enter data into different systems.

When interoperability is applied correctly in the school, there should be seamless information exchange between the systems, by a click of a button, other departments, such as the finance department and administrative departments, must be able to retrieve information without the need to re-enter what was already entered by another staff member from another department. Paid SMSs can do this to some degree. Ed-admin, which was mentioned by one of the experts during the round 1 questionnaire of the Delphi study, has 40 different modules which can be accessed from anywhere at any time. To some degree, thesis SMS is interoperable, it is also able to integrate with other systems. However, it, unfortunately, still works in silos with other schools and other applications not included in the system. Also, there is no evidence of such an SMS integrating with legacy systems.

Secondary phase: At this level, a feeder is sent into **ISIMM and OIM Integrative or combined level** in parallel to assess the required level of interoperability. The outcome of the level serves as a guideline for the next level**.** At this level of interoperability, schools need to have detailed policies & experience in using digital technologies as well as the ability to communicate, sharing knowledge, and interact with other schools through the use of digital platforms and SMS. On a technical level, data is shared and exchanged between independent applications, and systems are integrated between organizations. To get to the unified level, they need to have interoperability completely implemented in the school, both on a technical level and the human activity level.

Schools that qualify to be on this level have implemented interoperability effectively, meaning there are systems integrations from one organization to another. Schools can communicate and seamlessly share information without compromising security and privacy. However, most schools have not reached this stage of interoperability. To get to the next level of

interoperability, schools must be completely interoperable with other schools on a day-to-day basis.

Tertiary phase: At this level, a feeder is sent into **ISIMM and OIM's unified level** parallelly to assess the required level of interoperability. The outcome of the level serves as a guideline for the next level. At this level, schools have a shared understanding with other schools, and are completely interoperable with other schools on a day-to-day basis. In addition, the school's data is fully distributed between organizations with a common interpretation on a technical level. At this level, schools are continuously interoperating, data and applications are fully shared, processes are completely automated, and front and back-office systems are fully interoperable. This is the last level of interoperability, and schools would have reached the ultimate level of interoperability by getting to this level. This level usually is easy to achieve for schools of the same kind, for example, a school that is branched out into different arears.

Schools needs to be interoperable to promote data sharing, however there must be compliance with the PoPi Act. When a learner changes schools, they must provide a report card or transfer letter to be admitted. If schools were interoperable, the report card could be verified by clicking a button through their SMS, and to transfer a learner's history from one school to another, the learner or parent (if the learner is underage) would need to provide consent. Also application to a new school requires documentation such as birth certificates, Immunisation etc., this information can be accessed through the SMS as it is required learner admission (Education, 2021). Schools are responsible for protecting the privacy of children's information (Elizabeth, 2021). POPIA provides that the personal information of children may only be processed in limited circumstances and even then, should never be processed unless sufficient guarantees are provided for to ensure that the processing does not adversely affect the individual privacy of the child (Rakhee & Era, 2021). People do not need to be interoperable however they will be affected by the interoperable school and or system therefore, they need to be skilled on how to utilise these systems and how to protect the school, parents and the child’s personal information by ensuring compliance with the PoPi act.

The figure below provides a more refined interim SMSIM model to show the simplicity of how the model feeds into each level to assess interoperability and provide guidelines required for the next level of interoperability. This figure also shows what is assessed at each level:

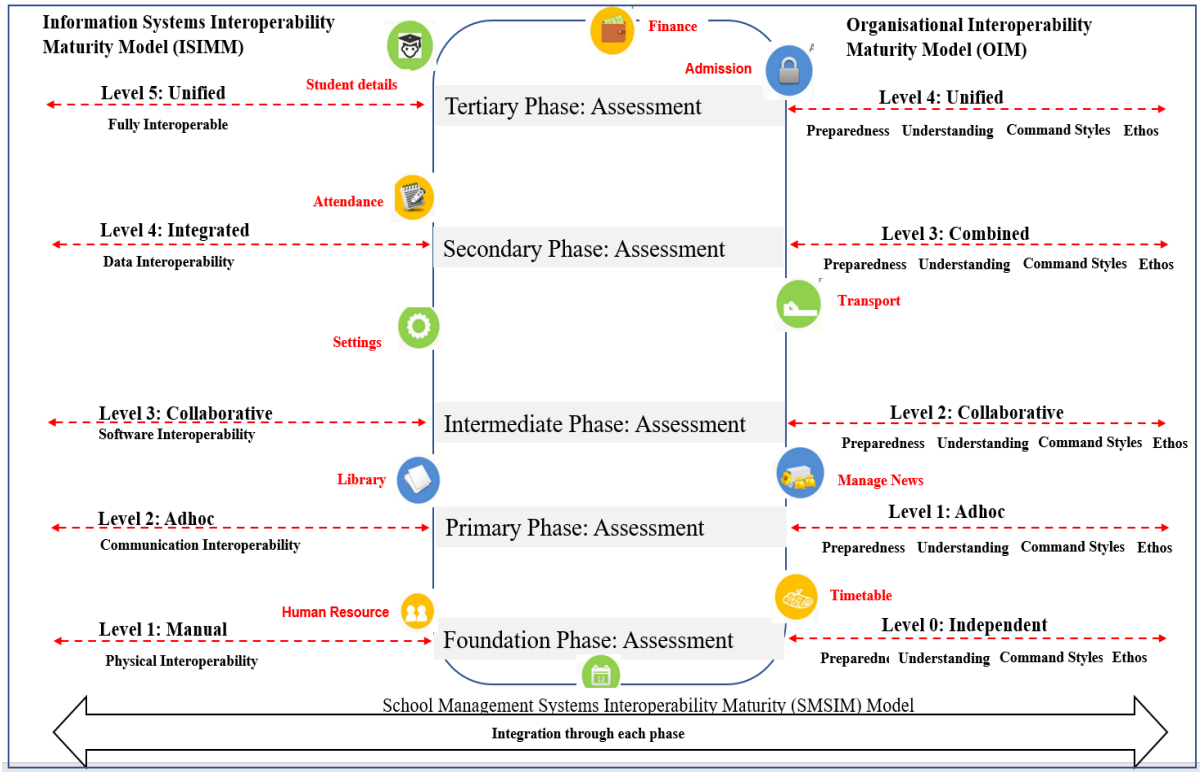


Figure 4-9: Refined Interim SMSIM *model*

4.8 KEY COMPONENTS OF THE CHAPTER

The following section shows the key components from this chapter that were essential to consider for the model, the essential components in the table below are the two chosen models that were combined in Section 4.6 to conceptualize a SMSIM model:

Table 4-4: Essential components of the chapter

Components	Section	Key Focus Area	Author
Interoperability	4.2	By defining and explaining interoperability, this component allows a broad understanding when conceptualizing SMSIM model	O'Connor (2017), Sjarov et al. (2021), Elkhodr et al. (2016), Zeid et al. (2019), Kirpes et al. (2019), Jaleel et al. (2020).
Organizational Interoperability Maturity Model (OIM)	4.3.3	This model focuses on the organization and the human aspect in the organization, this is essential as it balances the conceptualization of SMSIM model.	Gürdür and Asplund (2018), Sjarov et al. (2021), Jabin et al. (2019), McDaniel (2020).
Information System Interoperability Maturity Model (ISIMM)	4.3.6	This model is key as it focuses on the technology aspect of the organization, this completes the SMSIM model	Anggoro et al. (2018), Almeida Prado Cestari et al. (2020), Ostadzadeh et al. (2015).
Combining OIM & ISIMM	4.6	By combining OIM & ISIMM model, a clear picture can be observed to conceptualize the model	

4.9 SUMMARY

This chapter briefly introduced interoperability and described Maturity Models. It then listed and discussed different existing Interoperability Maturity Models. Two (2) models were chosen from the identified models to help conceptualize the theoretical model of this study, namely OIM and ISIMM. These were the most important models to consider. This chapter further combines the chosen models to ensure they are ready for data collection and analysis that will form Chapter 6. Finally, this chapter conceptualizes a SMSIM model, which will be improved and refined after data collection and data analysis.

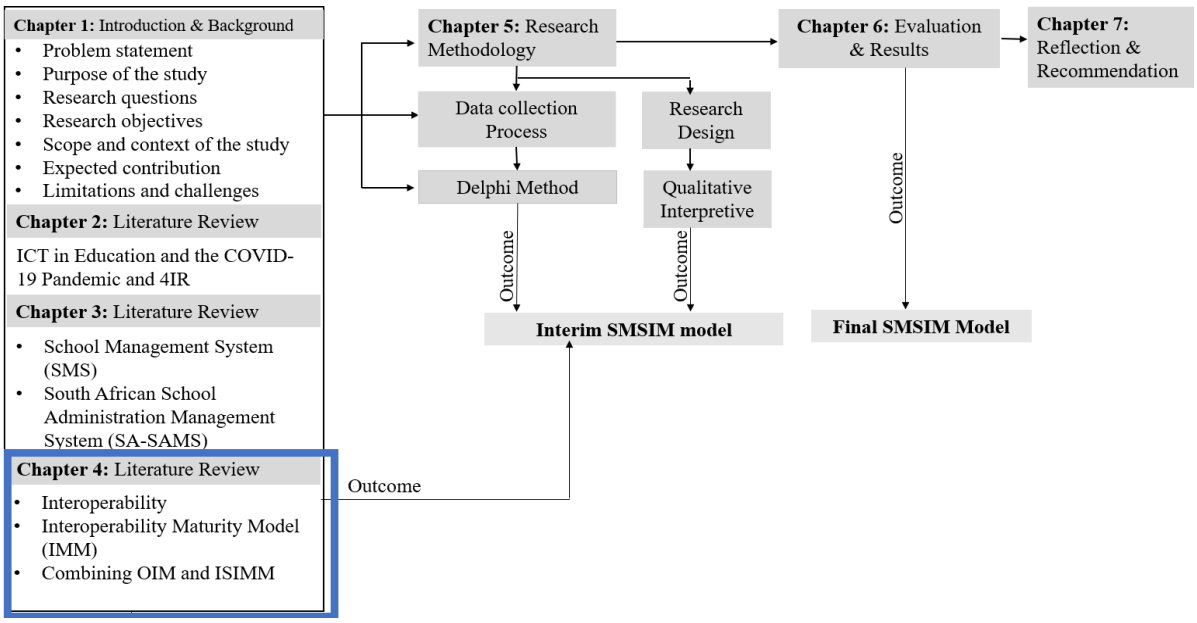


Figure 4-10: Chapter overview

From the above figure, it is evident that this chapter concluded Phase 1 of the study.

CHAPTER 5: RESEARCH METHODOLOGY

5.1 INTRODUCTION

This chapter describes the methodology that underpins the study. In order to study a phenomenon of interest, researchers gather, examine and deduce evidence (Leedy & Ormrod, 2021). For a problem to be solved, appropriate data must be collected (Leedy & Ormrod, 2021). The research methodology guides the research process in terms of designing, determining effort, and achieving results. In many cases, the research statement determines the research questions as well as the subject discipline (Herselman, 2011). Research methodology refers to how research should be done. It contains an understanding of the research question and a set of assumptions that guide the methods of investigation (Melnikovas, 2018). As an integral part of a dissertation or thesis, a methodology ensures consistency between selected tools, techniques, and underlying philosophy (Melnikovas, 2018).

For the purpose of this study, Leedy and Ormrod (2021) definition will be used as they emphasize that the research methodology is an essential part of the research that guides how the research will be undertaken and conducted.

This is a qualitative exploratory research study with exploratory Delphi expert reviews, and the research design and methodology used in this study are outlined in this chapter. This chapter details the research process adopted for this study and explains the data collection process undertaken by the researcher as well as reasons for choosing each method. The purpose of this study is achieved by following the research process as illustrated in Figure 5-1.

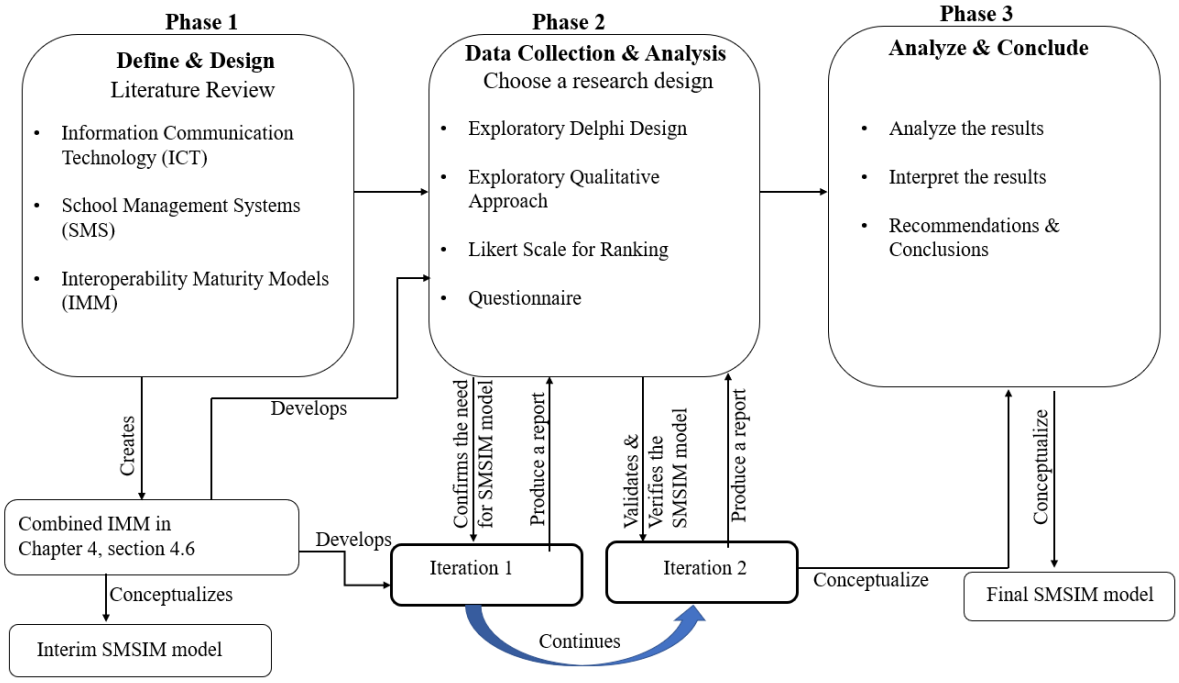


Figure 5-1: Research Process to conduct the research

The completion of each phase allows for the next phase to start.

- Phase 1: The literature review aimed to answer the second SRQ by exploring existing Interoperability Maturity Models (Chapter 4, Section 4.3). The identified Interoperability Maturity Models (IMM) assisted in creating a combined Interoperability Maturity Model (OIM & ISMIM) in Section 4.6 that can be used to assess the level of interoperability of SMS in schools of South Africa, thus achieving the outcome of the first phase.
- Phase 2: Delphi Method consists of a series of questionnaires distributed to selected experts under a survey coordinator's supervision (Hirschhorn, 2019). The survey coordinator gives participants anonymous feedback on the panellists' responses after the first round of questions and before any new ones are asked. Upon reviewing this feedback, participants may reconsider their opinions when responding to subsequent questionnaires (Hirschhorn, 2019). This technique, which incorporates surveys and monitored opinion responses in a safe, anonymous setting, is a potent tool for exposing and articulating differing viewpoints and advancing knowledge (Hirschhorn, 2019). The literature study in phase 1 (Chapters 2 and 3) provided a combined Interoperability Maturity Model (OIM & ISMIM) that can be used to assess and conceptualize the School Management Systems Interoperability Maturity (SMSIM) model for schools in South Africa. Experts will go through iterations of questions to validate the model until

a consensus is reached. This will be done to ensure that the final output is credible, accurate and relevant. At the end of round 1, the results reaffirmed the problem statement of the study and the need to conceptualize a SMSIM model that can improve SMS in South Africa as it can assist schools to measure the interoperability maturity level of their SMS and to use the guidelines to improve their SMS.

- Phase 3: The result of the Delphi Method in phase 2, using the combined model in phase 1, will assist in verifying if the interim SMSIM model (Chapter 2, 3 and 4) is validated for the purpose of the study, thus conceptualizing a final SMSIM model for schools to use in SA (Chapter 4). Thus, answering the main research question. This model will be validated through expert reviews as discussed in Chapter 6, and conclusions, as well as recommendations, will be provided in Chapter 7.

Phase 2 of Figure 5-1 is discussed in more detail below and forms the basis of this chapter.

5.2 OVERVIEW OF THE RESEARCH DESIGN

Saunders and Lewis (2017) research onion is shown in Figures 5-2 and 5-3. Layers are used to depict the research design. The path of the investigation is determined by the outer layers, which in turn influences the interior levels (Saunders & Lewis, 2017).

The research onion below illustrates the different research designs which exist. For this study, all the research designs/ techniques will be discussed in detail and only the design which will be chosen by the researcher will be justified.

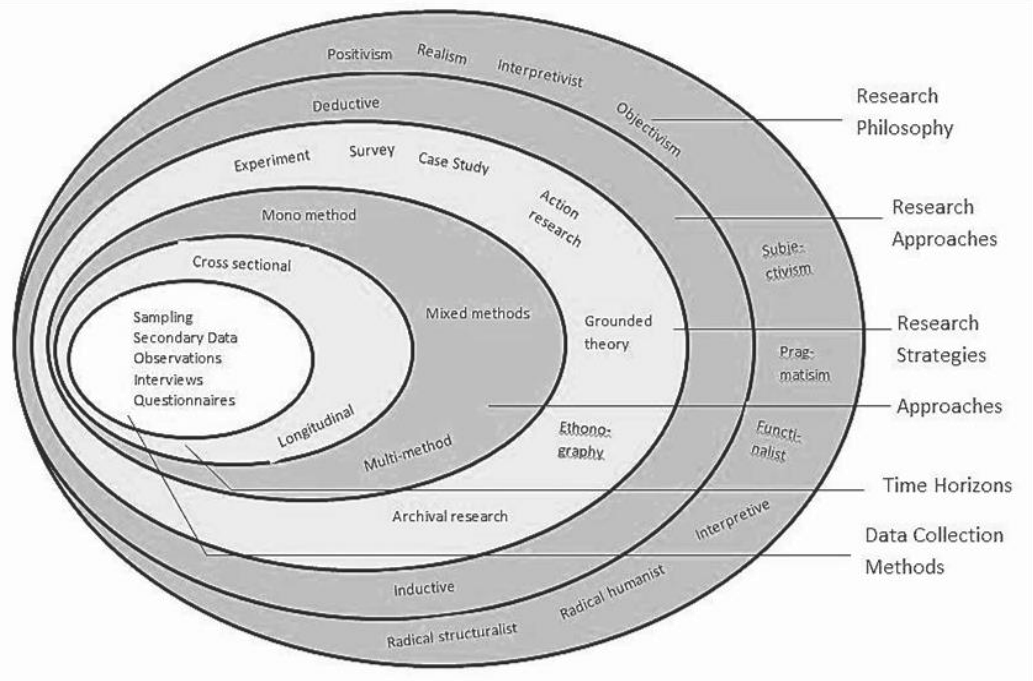


Figure 5-2:Research Process to conduct the research

According to Melnikovas (2018), the research onion has six main layers::

- **Research philosophy in a study** describes the reality, knowledge, and values of the study by defining ontology – what exists, epistemology – how we know what exists, and axiology – what is true.
- **Approach to theory development** usually includes: deduction – which is implied by the research philosophy at the previous level – an existing theory is used as a starting point, followed by a question or hypothesis and data collection for confirmation or rejection; induction – observation and data collection are followed by description and analysis to develop a theory; abduction – observation of empirical phenomena is followed by research that draws a best guess or conclusion from the available data. Inductive approaches are used to develop theories in fields with little research, whereas deductive approaches are commonly used to analyze existing theories. A surprising fact is usually used as the starting point for the abductive approach, followed by induction and deduction to determine the most likely explanation.
- **Methodological choice** determines whether quantitative and qualitative methods will be used or a combination of both.

- **A strategy** involves planning how data will be collected and analyzed: case studies, experiments, action research, surveys, narrative inquiries, archival research, ethnographies, grounded theories, etc.
- **Time horizons** involve planning how data will be collected and analyzed: experiments, surveys, archival research, case studies, ethnographies, action research, grounded theories, narrative inquiries, etc.

The Figure below summarizes the research onion with the identified components at each level that were applied in this study.

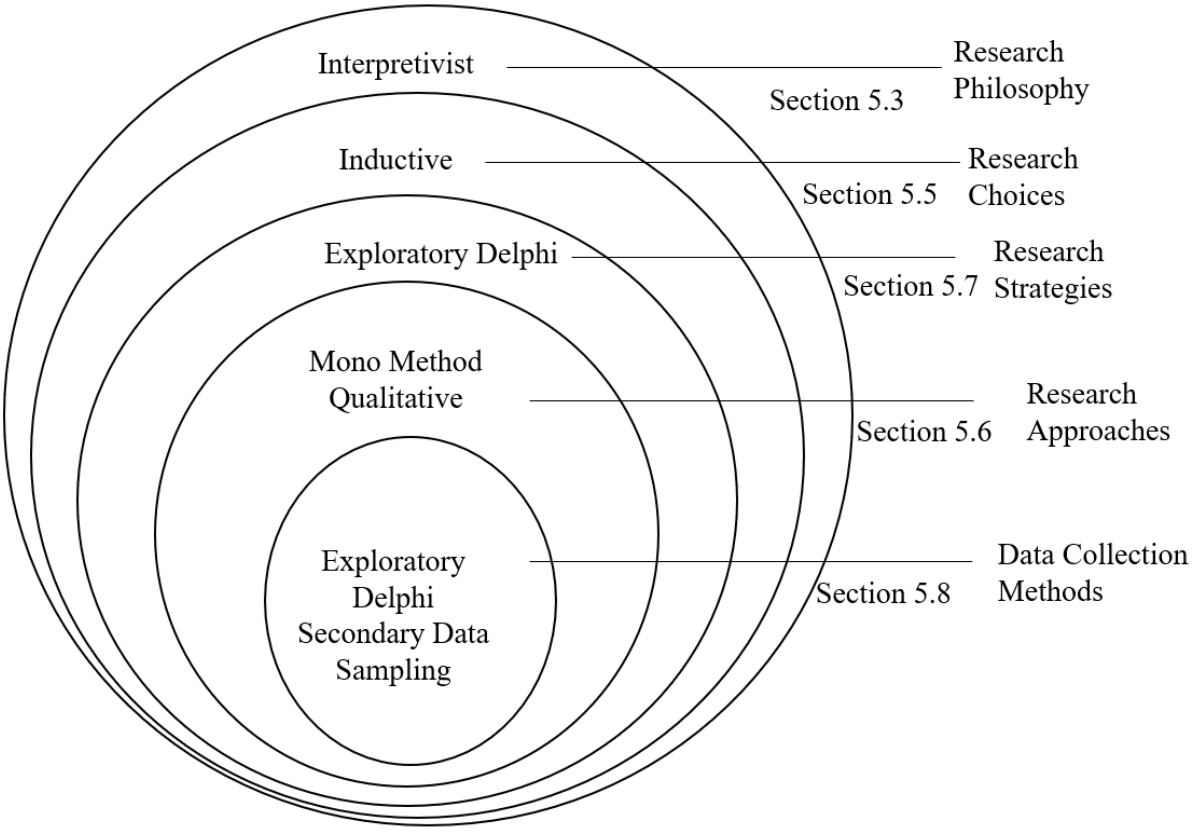


Figure 5-3: Adapted Research Onion applicable to this study ((Saunders et al., 2016))

The specific chosen aspects applicable to this study, in each layer will now be further discussed.

5.3 RESEARCH PHILOSOPHY

The job of a researcher is to understand and articulate beliefs about the nature of reality, what can be known about it, and how to gain that knowledge and this is also known as research paradigms (Rehman & Alharthi, 2016; Saunders *et al.*, 2016:p130). Paradigms are theoretical frameworks containing assumptions about the methodology, ontology, epistemology, and

methods. Basically, it is a way to understand and study the world as it is. Four types of research paradigm exist and include (Guba & Lincoln, 1994; Wahyuni, 2012; Hussain, Elyas & Nasseef, 2013; Rehman & Alharthi, 2016; Saunders *et al.*, 2016:p177; 178; Creswell & Creswell, 2018:p54; 58):

- **Positivism.** Because of the writings of French philosopher Auguste Comte, the area of philosophy known as positivism rose to popularity in the early nineteenth century. A Positivist believes that reality is independent of humans. The positivist strives to understand the social world in the same way as the natural world. A large part of positivist thought is based on experimentation.
- **Critical realism.** A group of twentieth-century authors affiliated with the Institute of Social Research at the University of Frankfurt gave rise to critical theory. Critical theorists hold a historical realist ontological position. The nature of reality cannot be denied, but it has been shaped by cultural, political, and religious factors. Research using the critical method consists of dialogic and dialectical interactions; the researcher works with the subjects in order to change their attitudes towards social systems that are preventing them from meeting their intellectual and social requirements.
- **Interpretivism.** Interpretivism responds to positivism's dominance. Interpretivism rejects the idea that there is a single, verifiable reality. To understand their subjects, researchers put themselves in their subjects' shoes and look through their eyes. The constructivist theory asserts that knowledge and understanding are derived from interpretation rather than assumptions regarding facts.
- **Pragmatism.** A pragmatic approach evolved from using what worked best in each situation. A pragmatic researcher uses a variety of methods to understand existence by focusing on the research problem.

The research philosophy applicable to this study is the interpretive research philosophy. This approach will be used to better understand people and their experiences when they evaluate and validate the conceptualized model and its components. Interpretivism is a philosophy that emphasizes the researchers' need to understand humans' role as social actors (Saunders *et al.*, 2016:p181). Interpretivism takes a particular context as the focus of understanding, and the central belief of this paradigm is that reality is socially constructed (Hiller, 2016:p22; Saunders *et al.*, 2016:p181). As part of the interpretation process, qualitative researchers compare the results with the literature, present the overall results, discuss a personal viewpoint, and state

limitations and future directions (Creswell & Creswell, 2018:p313). Furthermore, it is important to understand the theoretical lens through which the research is conducted, and the section below elaborates on that.

5.3.1 Theoretical Lens

This section discusses the theoretical framework that guides the research.

5.3.1.1 Institutional Theory

In studying the role that SMS and interoperability can play in supporting the administrative burden for schools, it is vital to comprehend the broader educational context and how this influences its functioning. For this reason, this research makes use of the Institutional Theory. According to Raynard, Johnson and Greenwood (2015), organizations are a collection of controlled activities that operate within a complex network. However, there is growing recognition of the parallels between formal organizational structures and institutions, which has influenced how they are operated. To ensure that the model is in line with the broader educational context, this research uses Institutional theory.

Organizations embed institutional norms to establish industry standards for guiding operations. Furthermore, Institutional Theory believes that external and internal pressures influence how organizations operate (Alkalbani, Deng, Kam & Zhang, 2016). This refers to the notion that organizational structures are designed to reflect and adhere to established norms, while their needs are deferred (Othman, 2016).

Through the Institutional Theory, the researcher could unpack the varying factors contributing to the education ecosystem where SMS needs to function. This theory also assisted the researcher in confronting the issues related to the fragmentation of SMS and how a conceptual model that applies interoperability and maturity levels can be designed to better assist schools in using SMS.

5.3.1.2 Theoretical Grounding

The researcher will further use hermeneutics to translate and interpret the text of the experts, verbal and nonverbal communication. Hermeneutics relates to vocal and non-vocal communication and refers to the interpretation and conversion of the script (typically ancient scriptures) (Friston & Frith, 2015). It is mainly used during data analysis. When deciding when

an interpretation is correct, the main issue of hermeneutics is to focus on evolving measures. This issue is not limited to clarifying ancient scripts (Jardine, 2015). Although it does not offer a method, hermeneutics gives academics a sense of how human understanding functions in the real world (Jardine, 2015).

Following the hermeneutic circle (Klein & Myers, 1999) as explained in Section 5.4, understanding the meaning and importance of individual texts depends on understanding the whole body of relevant literature (built up through understanding individual texts). Therefore, the hermeneutic circle can assist in surveying relevant literature (Boell & Cecez-Kecmanovic, 2010). The hermeneutic circle serves as a tool for evaluating our understanding of a particular text (Warnke, 2011).

The following section discusses the hermeneutic circle, which will be used during data analysis.

5.4 THE HERMENEUTIC CIRCLE

Researchers and participants interpret phenomena as part of an iterative process in the continuing hermeneutic circle. The hermeneutic circle helps interpret data and fosters communication between the researcher and participants (Craig, 2017). Additionally, the hermeneutic circle method of analysis enables the researcher to examine the data through a continuous process of assessing the whole and specifics of the information gathered (Harper, 2018). It was crucial to understand the findings from the expert evaluations and how they contributed to this research after the data was collected through the Delphi expert review. hermeneutics was utilized to analyze and interpret the consensus of rounds 1 and 2. With the goal of comprehending multiple components that contribute to the functions of a whole, hermeneutics is grounded in the interpretive paradigm (Herselman and Botha, 2016). Hermeneutics functioned as a valuable analysis approach to gain an in-depth understanding of problems in SMS.

Table 5-1 summarizes the principle for interpretive field research and how it was applied for this study.

Table 5-1: Summary of principles for interpretive field research

Fundamental Principle	Summary of Principles for Interpretive Field Research
Hermeneutic Circle	This principle was applied throughout the research and mostly in this chapter (6) to gain human understanding by iterating between the interdependent meaning of parts and the whole they form.
Contextualization	The context of this principle focused on the SMSIM model that was conceptualized to address the problems in School Management Systems (SMS).
Interaction Between the Researchers and the Subjects	The interaction of these principles occurred in two (2) phases, the first phase is when the researcher interacted with the literature review and then developed questionnaires to pose to experts, and the second phase is the interaction between experts and the researcher. First, interactions between the experts and the researcher occurred when expert reviews were administered. The results are reflected in section 6.4 of chapter 6.
Abstraction and Generalization	The conceptualized SMSIM model presented in section 6.5.2.2 can be used by Schools in South Africa and can potentially solve problems in SA-SAMS.
Dialogical Reasoning	The theoretical foundation developed by the literature findings in Chapters 3 to 5 and the contributions from the expert reviewers served as the basis for the interpretation in this study (results presented in section 6.5).
Multiple Interpretations	The supervisors' helpful criticism was considered and interpreted to properly document the results that were obtained. The researcher was also sensitive in interpreting the data collected from experts' reviews of round 1 to round 2 Delphi questionnaires.
Suspicion	Multiple sources were used throughout the research to reaffirm and provide context to the problem statement, particularly the literature chapters (3,4,5). In addition, the experts mentioned in sections 5.7.3 of this chapter and 6.3.1 of chapter 6 took part in the study. The findings from iteration 1 of the expert review are presented in section 6.3 of chapter 6, and those from iteration 2 are presented in section 6.5. The information, sources and participants were treated with sensitivity to ensure reliability and credibility.

Source: Adapted from (Klein & Myers, 1999)

Hermeneutics was also applied during the data analysis to support thematic analysis (Section 5.9). The section below outlines the approach to theory development.

5.5 APPROACH TO THEORY DEVELOPMENT

Two main choices can be used by the researcher, namely inductive or deductive approaches (Johnson-Laird, 2010; Matzel & Sauce, 2017).

- Inductive reasoning is a logical procedure whereby several premises, which are all generally accepted to be true or found to be true, are integrated to arrive at a conclusion or to provide evidence for the validity of a conclusion.
- Inductive thinking differs from deductive reasoning in that the degree of certainty is dependent on the strength (or consistency) of the evidence, whereas the conclusion of a deductive inference is certain, the truth of an inductive inference's conclusion is only probable.
- Deductive reasoning is the mental process of making logical inferences. It is just one type of reasoning.

The approach chosen by the researcher for this study is the inductive reasoning because this approach will allow essential themes and patterns to be selected from data during the qualitative data collection process. The information provided by people are examples or incidences from where conclusions can be drawn (Leedy & Ormrod, 2015). The following section presents the research approach chosen for the study.

5.6 THE RESEARCH APPROACH

Research approaches are strategies and tactics that cover everything from general hypotheses to specific techniques for gathering, analyzing, and interpreting data. This plan involves several decisions that a researcher should take to make sense of the results (Creswell & Creswell, 2018:p51).

There are mainly three different types of research approaches (Creswell & Creswell, 2018:p51):

- **Qualitative research:** Is a method for examining and determining the relevancy that different people or groups assign to social or human problems. The research process entails developing questions and collecting data that typically takes place in the participant's environment, inductive analysis that progresses from specifics to broad

themes, and the researcher's interpretation of the significance of the data. As a result, the final report's structure is adaptable.

- **Quantitative research:** Is a method for evaluating the relationships between variables to test objective theories. So that numbered data may be examined using statistical techniques, these variables can be measured, often using instruments. An introduction, literature and theory, methodology, findings, and discussions are all included in the final written version of the report.
- **Mixed methods research:** Is a procedure for investigating that includes acquiring both quantitative and qualitative data, fusing the two, and using a variety of designs that may contain theoretical underpinnings and philosophical presumptions. The underlying assumption of this kind of research is that using both qualitative and quantitative methods combined results in a deeper understanding of a studied subject than using simply one or the other.

The research approach applicable to this study is the qualitative approach, as it can help explain everyday life in new and intriguing ways (Mayan, 2016:p11). Qualitative inquiry is inductive, interpretive, and primarily collected in natural settings (Creswell, 2007:p53; Mayan, 2016:p12). Qualitative researchers try to understand or interpret the meaning people create from their experiences by studying naturally occurring phenomena (Mayan, 2016:p13). The Delphi technique is a qualitative approach that can be used in a qualitative exploratory study (Al-Busaidi, 2014; Habibi, Sarafrazi & Izadyar, 2014). The qualitative Delphi technique was adapted for the study as presented in Section 5.7 as a research strategy and used during data collection.

To help people, understand their worlds collectively, qualitative researchers love living and learning with them. Humanness is, therefore a crucial component of qualitative research (Mayan, 2016:p13). A diversity of approaches to improve the cogency and trustworthiness hereafter the credibility of the data they gather is used by qualitative researchers (Leedy & Ormrod, 2015), which is why this approach is best suited for this research study.

An interpretative paradigm, which stresses personal experiences and their significance to a particular person, is what distinguishes qualitative research. Therefore, the researcher's subjective perceptions of the circumstance is a key factor in the study's findings (Starman, 2013). Qualitative research also stresses an individual's viewpoint on the situation, process, and

relationships under investigation using an idiographic approach (Starman, 2013). The specific data collection instruments chosen to conceptualize the model further were coupled with this approach.

5.7 RESEARCH STRATEGIES

A research strategy outlines how the researcher intends to answer the research questions (Lewis & Saunders, 2018). The following is a brief description of the different types of strategies, as described by Lewis and Saunders (2018) and Creswell (2007:p53-73):

- In **case studies,** research questions are addressed within a real-life context, using various sources of evidence (data).
- In **ethnographic research**, first-hand experiences in the field are used to describe and interpret the social world.
- In **experiments**, a hypothesis is defined, samples are selected from known populations, they are assigned to different experimental groups, some variables are changed, and others are controlled.
- A **grounded theory** develops a theory based on observations and interviews using inductive inquiry.
- In **archival research,** administrative records and documents are analyzed as primary data sources.

- **Surveys** are structured research strategies that collect data from a large population through structured interviews or questionnaires; and
- An **action research** strategy aims to manage change and involves close collaboration between practitioners and researchers.

According to Habibi *et al.* (2014) a Delphi technique is a group method for acquiring knowledge and making qualitative decisions. Furthermore, Habibi *et al.* (2014) state that the Delphi approach is appropriate for exploratory qualitative research that seeks to understand the nature and essential components of occurrences. Therefore, the Delphi method will be applied for the purpose of this study. Delphi derives its name from the antiquity of the ancient oracle of Delphi, which provided guidance for Greeks and Romans seeking answers to crucial questions in their lives (Avella, 2016; Beiderbeck, Frevel, Heiko, Schmidt & Schweitzer, 2021).

A wide range of disciplines has utilized the Delphi method since it was developed and has undergone several expansions since its creation. Thus, this technique is considered an effective way to obtain expert consensus about a complex problem or forecast the future of a given field (Massaroli, Martini, Lino, Spenassato & Massaroli, 2018).

A Delphi method is a technique that, when applied, allows a team of experts (i.e., the Delphi Panel) to gather structured and systematic information about a particular subject through the use of questionnaires (Flostrand, 2017). When applied to communication processes, Delphi is a technique that helps group members effectively work together to provide a consensus on a problem (Turoff, 1970; Mukherjee, Sutherland, Khan, Berger, Schmitz, Dahdouh-Guebas & Koedam, 2014; Asghari, Nassiri, Monazzam, Golbabaei, Arabalibeik, Shamsipour & Allahverdy, 2017). Even when experts are not located in the same geographic area, the Delphi method enables them to provide insight and opinions (Dalkey & Helmer, 1963; Yeh, Van Hoof & Fischer, 2016).

There are many circumstances in which the Delphi method is necessary, including when group dynamics prevent effective communication (for example, time differences, distance, and personality conflicts) (Beiderbeck, Frevel, Von Der Gracht, Schmidt & Schweitzer, 2021). Experts who consented to participate are asked to complete the questionnaires in iterative rounds. Before each new round begins, the panel receives the responses from the previous round. After reviewing the answers provided by the other panellists, each participant can re-evaluate their original responses. Typically, 3 or 4 rounds are required to reach a consensus or stabilize the questionnaire answers (Linstone & Turoff, 1975; Yeh *et al.*, 2016). In this study, two iterations were applied to reach a consensus among experts when evaluating the model's components and validating the model.

Therefore, the Delphi method lends itself to the effective validation of subject matter integrity without physical access to domain experts, and it is suitable for use when one needs to do so. With the COVID-19 pandemic spreading, it became impossible to access schools or any research organization. Moreover, targeted participants and their staff tried to adjust to the virus' impact, making it even harder to gain access to participants for research (Daniel, 2020). Restoring normality is not a simple one-time process, schools, teachers, and students had to seek flexible methods to manage the difficulties caused by COVID-19's interruptions to learning (Daniel, 2020). As a result, the Delphi method was the best solution for the purpose

of this study, as it focused only on the experts to validate the purpose of this study. Skulmoski, Hartman and Krahn (2007) further allude that for graduate students completing master's and PhD research, the Delphi method is an attractive option to use when collecting data. Furthermore, the table below presents studies that applied the Delphi technique in the education field, this table reaffirms the choice of using the Delphi technique as the research strategy in this study.

Table 5-2: Studies that applied the Delphi Technique

Article	Purpose	Year	Author
Curriculum development through Delphi	The application of the Delphi method for curriculum creation in higher education is discussed in this article.	1978	(Reeves & Jauch, 1978)
Validating Teaching Competencies for Faculty Members in Higher Education: A National Study Using the Delphi Method	The teaching abilities of faculty members in higher education were assessed in this study using the Delphi Method.	1995	(Smith & Simpson, 1995)
The Delphi Method for Graduate Research	Used to successfully explore novel ideas both inside and beyond the body of knowledge for information systems in the University of Calgary program.	2007	(Skulmoski *et al.*, 2007)
Using the Delphi Technique in Educational Technology Research	The Delphi Technique is examined in this article along with its advantages and potential uses for educational technology researchers.	2011	(Nworie, 2011)
Development of ICT Competency Standard Using the Delphi Technique	In order to create a legitimate and trustworthy ICT (Information & Communication Technology) competency standard for teachers, the goal of this article is to explain the use of the Delphi technique in the research design.	2013	(Fong, Ch'ng & Por, 2013)
Using the Delphi technique to support curriculum development	This paper's goal is to advance the body of knowledge regarding the use of the Delphi technique for updating business course curricula by providing an analysis of its use to support curriculum development.	2015	(Sitlington & Coetzer, 2015)
The Delphi method: characterization and potentialities for educational research	The Delphi method is introduced in this article, along with its uses in education.	2018	(Marques & De Freitas, 2018)
Technological aspect factors of E-learning readiness in higher education institutions: Delphi technique	This paper's goal is to review the technological aspects of eLearning readiness using the Delphi technique and to create a preliminary model for these features in higher education institutions.	2019	(Al-Araibi, Mahrin & Yusoff, 2019)
Adopting a modified Delphi technique for revisiting the curriculum: a useful approach during the COVID-19 pandemic	In order to successfully transition academic endeavors during and beyond the COVID era, this study will describe a participatory qualitative research project employing the Delphi consensus technique and Internet technologies.	2020	(Rajhans, Rege, Memon

Article	Purpose	Year	Author
			& Shinde, 2020)
A Research Study by Delphi Technique in School Counselling	The Delphi technique, which a researcher can use to study school counseling, is examined in this conceptual article, along with the many processes that implement the technique to meet the study's goals.	2020	(Sivalingam, 2020)
Developing an empathy educational model (EEM) for undergraduate nursing students: A Delphi Technique	The Delphi technique was employed in this study to create an instructional model that teaches empathy to undergraduate nursing students.	2021	(Zhu, Yang, Zhang & Chen, 2021)
Application of the Delphi Technique to Determine the Technological Competencies of a Faculty Member	By using the technology of independent expert assessments—the Delphi method—the study aims to ascertain the current level of manifestation of technological competencies as well as generalized prospects for development and improvement of the identified level within the chosen group of freelance teachers.	2021	(Sosnytskyi, Sikorskyi, Bezborodykh, Morozova & Moroz, 2021)
The current situation of information literacy education and curriculum design in Pakistan: a discovery using the Delphi method	The current study used the Delphi procedure in developing nations as a unique research lens to examine information literacy education. The study's main goal is to provide a framework for information literacy in higher education.	2021	(Batool, Ur Rehman & Sulehri, 2021)
Exploring hospitality graduates' competencies in Malaysia for future employability using Delphi method: a study of Competency-Based Education	This study examines the hospitality competences required by higher education graduates for their employability in the sector in the future using competency-based education.	2022	(Shariff & Abd Razak, 2022)

It is evident from the table above that Delphi has been applied in the education sector, more specifically when conducting exploratory qualitative research. Section 5.7.1 discusses the advantages of the Delphi technique.

5.7.1 Advantages of the Delphi technique

The following presents advantages of the Delphi technique (Lilja, Laakso & Palomäki, 2011; Avella, 2016; Asghari *et al.*, 2017; Kallia & Sentance, 2017; Massaroli *et al.*, 2018):

- **Consensus:** In cases when there is uncertainty or where there is no clear cause, consensus can be reached. In this study the iterations continued until a consensus was reached among experts.
- **Flexibility and simplicity:** Designing a Delphi study can be quite simple and flexible, and evaluating the conceptualized components of the model is straightforward, and the design will be flexible enough to allow for valuable inputs to refine the final model.
- **Knowledge sharing:** One aspect of Delphi designs that isn't frequently discussed is on how diverse disciplines can exchange knowledge, generate innovative thinking, and advance the understanding of other panel members by applying to the panel's objective. In this study, the panel consisted of experts from various backgrounds (IT network specialists, administrators, principals, and teachers). This allows them to expand their knowledge base on SMS.
- **Cost effectiveness:** Following a Delphi design is quite cost-effective, unless the researcher wishes to incorporate an instrument that involves a "charge for usage." The main expense is time, both that of the researcher and that of the participants (who are all volunteers). Other than time, the study's specific costs are not significant. It utilizes currently existing resources and tools. This technique was valuable during data collection as access to schools was prevented due to CODIV-19 regulations and restrictions.
- **Freedom of expression:** The anonymity that is necessary for all Delphi panels directly results in freedom of expression. It provides panellists with a great deal of freedom in how they express their ideas and may allow them to share various viewpoints with others without worrying about being attacked. Therefore, the experts in this study had to express their views anonymously.
- **Anonymity:** This eliminates participants who are afraid to express their ideas and positions. Knowing who said what prevents other panellists from openly evaluating each other's comments. Experts could not judge each other as anonymity protected them in using this technique.

- **Ease of communications:** The Delphi Method's early iterations relied heavily on physical artifacts (papers that had to be typed, mailed, or faxed), which significantly reduced panel operations' efficiency and made it impossible for participants from other countries to participate. Although the accessibility and simplicity of electronic communications have greatly reduced these problems, they have also brought forth new ones, particularly for researchers. This is especially true when it comes to protecting participant anonymity. Consequently, all interactions between the researcher and each panellist should remain private. In this study, these communications did occur on a one-to-one basis.
- **Membership variations:** It is not necessary for the panel to consist of the same number of members for every round of the study. It can vary in several ways, including, but not limited to, members dropping out or skipping a round and coming back to it later or skipping the first round but joining the next. Maintaining the number of groups, ensuring that membership is balanced among the groups, and ensuring that the membership standards are upheld are all important considerations for researchers. In this study, the researcher did see that variations occurred as in the last iteration, the number declined, although valuable insights were collected.
- **Lack of geographical limitations based on electronic communications:** Geographical boundaries that affected the design of the physical artifact in Delphi investigations have almost entirely been eliminated by electronic communications. Therefore, researchers are no longer constrained by geography when seeking out participants or tackling pressing global concerns. In this study, the experts were not all from one province, and this allowed for a broader reach.

It is evident from the above advantages of the Delphi Technique that it is straightforward and effective at data collection. It also assures accuracy and does not need to physically meet participants to validate the outcome of this study. Similarly, the Delphi technique has disadvantages that need to be considered to have an effective model. The following section presents the disadvantages of the Delphi Technique.

5.7.2 Disadvantages of the Delphi method

Delphi has weaknesses like most research designs do, but the researcher causes those errors, not the design, as is the case with most research designs. Deficiencies in the researcher or

panellists can cause flaws to manifest. The following are some typical examples of the disadvantages when using the Delphi method (Shariff, 2015; Kallia & Sentance, 2017; Fink-Hafner, Dagen, Doušak, Novak & Hafner-Fink, 2019; Singh, Nicely, Cai & Day, 2021):

- **Researcher bias:** Because of the researcher's dominant strength and impact, bias may even enter the process unintentionally. The formulation of the question(s) and the selection of participants can be used to support the researcher's positions. Another manner in which a researcher can show bias is by choosing panel members who have predetermined opinions on the issue. Researcher bias was addressed in this study as the supervisors assisted in the selection of experts to ensure the trustworthiness of the data.
- **Researcher shortcomings:** A possible drawback of researchers forcing their views on respondents is evident, particularly in the case of a modified design where Round 1's literature review was created by the researcher. Another example would be a bad summary of the panellists' comments. The earlier discussion of modified Delphi designs stated that no matter how initiating material was generated, panel members should never be prevented from adding to the generated alternatives. Researchers need to recognize that their role is not one of the contributors but rather of facilitator. In this study, the researcher did facilitate the process and did not contribute to the study; and
- **Panel member anonymity and petulance:** A panel member could withdraw at any time and for any reason. In this study, all ten participants completed the two Delphi iterations.

These disadvantages presented what may go wrong when implementing the Delphi method. It is thus important to consider these disadvantages when selecting the experts and when verifying and analyzing the feedback from responses. Therefore, the next section discusses how to select experts.

5.7.3 Selecting experts

In qualitative research, sampling is when specific data sources are selected and gathered to meet the research objectives (Gentles, Charles, Ploeg & Mckibbon, 2015). Purposive sampling was used in this study as one selects purposive sampling for a specific purpose (Leedy & Ormrod, 2021). Expertise is the capacity for competence, or the exertion required to display extraordinarily high levels of performance on a specific task or within a given topic. An individual who reaches this level is referred to as an expert (Bourne Jr, Kole & Healy, 2014).

A list of the expert's knowledge, skills, desires, plans, and accomplishments is necessary for a description of competence (Bourne Jr *et al.*, 2014). Furthermore, expert opinions can assist in highlighting any vulnerabilities that might exist with respect to the topic being evaluated (Jansen & Hak, 2005; Jahoor, 2019).

There are several recommendations for choosing an expert group. Even though every circumstance for choosing from the pool of specialists is different (Manakandan, Rosnah, Mohd & Priya, 2017; Engelman, Fuller & Steer, 2018). Rowe and Wright (2001) summarize the following principles for choosing expert opinion in applications of Delphi (Jolson & Rossow, 1971; Rowe, Wright & Bolger, 1991; Rowe & Wright, 2001; Grime & Wright, 2016; Manakandan *et al.*, 2017; Hohmann, Cote & Brand, 2018; Ahmad & Wong, 2019):

- Use between 5 and 20 experts.
- Use experts with relevant fields of expertise.
- Make use of diverse experts.
- Provide the panel's mean or median estimate along with each panellist’s justifications for their estimations for Delphi feedback.
- Delphi polling should continue until the results become stable. Usually, two formal rounds are sufficient.
- Calculate the final projection by adding up and evenly distributing the expert forecasts.

In this study, the researcher ensured that these principles guided the selection of experts as displayed in Table 5-3 below.

For a Delphi panel, a qualified expert should be (Lilja *et al.*, 2011):

- The best in her/his field of expertise in a technical or scientific discipline.
- Has a broad interest in learning about everything, not only what is in their field but also what is in the world.
- Able to recognize linkages between many scientific domains and between existing and future development on a national and worldwide level.
- Able to look at problems from a variety of angles, even some that are unfamiliar and risky.
- A desire to produce new things.

Table 5-3 presents experts who were selected to participate in the study, the selection criteria were guided by Section 5.7.3 above.

Table 5-3: Expert Reviewers

Domain/Expert Reviewer	Years of experience	Role	Field of Expertise
Expert Reviewer 1	17	IT Manager and Support	ICT in Education
Expert Reviewer 2	30	IT Manager	ICT in Education
Expert Reviewer 3	12	Industry experts focusing on interoperability	Interoperability
Expert Reviewer 4	13	ICT manager working with various schools and their SMS	ICT4D, Interoperability, SMS
Expert Reviewer 5	30	Deputy principal	School Management Systems (SMS)
Expert Reviewer 6	11	IT manager of school system	ICT in Education
Expert Reviewer 7	16	ICT Coordinator	School Management Systems (SMS)
Expert Reviewer 8	12	Interoperability manager	Interoperability
Expert Reviewer 9	15	System Administrator	School Management Systems (SMS)
Expert Reviewr 10	20	ICT Coordinator	ICT4D, Interoperability

The study was originally supposed to include 21 participants, which included teachers, ICT coordinators, principals, system administrators, and experts, but only ten (10) experts participated in the study due to a lack of access to schools. The COVID-19 pandemic and the possibility of infection from face-to-face contact have contributed to the lack of participation. Despite lifting restrictions and removing masks, schools are still recovering from the effects of the COVID-19 pandemic, so the Delphi method was used to conduct the study. Ten (10) experts validated the model's quality, efficiency, and relevance. Following the literature review, the interim model was adapted (Figure 4-7) using empirical evidence to provide the final model.

In this study the researcher did address these suggestions during the selection of the experts. The above section is very important for the success of the study, only experts will participate in the study and thus, how they are selected is vital. The following section lists and summaries different Delphi Designs.

5.7.4 Different Delphi designs

The Delphi method is included in the broad category of "consensus development procedures," which is itself included in the broad category of action research methodologies (Vernon, 2009; Avella, 2016). There are two main Delphi designs, the conventional Delphi, and the modified Delphi (Kallia & Sentance, 2017). Table 5-4 below summarizes other Delphi designs as per the literature.

Table 5-4: Summary of Delphi Designs (adapted from Fisher, Erasmus & Viljoen, 2020)

Form of Delphi	Description	References
Exploratory-/Conventional-/ Classical Delphi	To gather trustworthy data about potential trends relating to a certain problem or topic, a panel of experts is assembled.	(Ekström, 2020), (De Soria, Durán, Morrás, González & Varela, 2018).
Modified Delphi	The conventional Delphi method is altered, for instance, by enabling some experts to debate in-person even at the end of the process, recognizing the importance of in-person interactions for exchanging ideas, identifying the causes of differences, and resolving ambiguities.	(Griffey, Schneider, Adler, Capp, Carpenter, Farmer, Groner, Hodkins, Mccammon & Powell, 2020), (Bleijlevens, Wagner, Capezuti, Hamers & Workgroup, 2016).
Spatial Delphi	This is valid for decisions involving spatial location that are made after consultations. Expert contributions are mapped geographically, and the convergence of their views is denoted using basic geometric forms (circles or rectangles).	(Di Zio, 2018), (Di Zio & Pacinelli, 2011).
Policy-/ Focus-/ Decision Delphi	Used to examine several policy solutions with the most significant benefits and drawbacks for each policy resolution based on the assessments, viewpoints, and experiences of experts.	(Kattirtzi & Winskel, 2020), (Paraskevas & Saunders, 2012).
Real-time-/Consensus Conference-/ Normative Delphi	This is a system for asynchronous online conferences that is computer-mediated and ensures anonymity.	(Linstone & Turoff, 2011), (Yousuf, 2007).
E-Delphi (eDelphi), Technological-/ Online- / Argument Delphi	A modified e-Delphi survey is conducted online.	(Taylor, Feltbower, Aslam, Raine, Whelan & Gibson, 2016), (Hasson & Keeney, 2011).
Disaggregating Policy Delphi	This format assumes that expert communication cannot lead to consensus and will thus elicit several schools of thought because experts will	(Tapio, Paloniemi, Varho & Vinnari, 2011).

Form of Delphi	Description	References
	congregate around the competing claims that receive the most support.	
Problem Solving Delphi	This kind is employed for group judgment by gathering participant rankings or paired comparisons.	(Linstone & Turoff, 2011).
The Fuzzy Delphi Method (FDM)	In contrast to traditional deterministic approaches, which express information as a single value, fuzzy numbers are used instead.	(Manoliadis, 2018).
Ranking -type Delphi	The most applicable for IS research is probably Ranking-type Delphi. It focuses on typical areas of interest in information systems research, such as the identification and ranking of Critical Success Factors (CSF), the breakdown of research frameworks, and the prioritizing of selection criteria.	(Kobus & Westner, 2016).

Fisher, Erasmus and Viljoen (2020) tabled different Delphi forms for this study. The exploratory Delphi design will be explained in detail in the section below.

5.7.5 Exploratory Delphi

An exploratory Delphi attempts to predict a future or series of events (Battersby, 1982). This method is a forum for establishing facts about a specific situation or topic (Franklin & Hart, 2007; Fisher *et al.*, 2020). According to Dalkey and Helmer (1963), exploratory Delphi is a method of obtaining consensus from an expert panel by means of questionnaires and controlled feedback. A consensus is generally reached after three iterations in this design. It is possible, however, to reach consensus, theoretical saturation, or to uncover sufficient information with fewer rounds of analysis in a homogenous sample (Skulmoski *et al.*, 2007; Fisher *et al.*, 2020). Stopping the rounds at the right time is crucial. Results may not be meaningful if they are terminated too early, while too many rounds can lead to sample fatigue and resource waste (Hasson, Keeney & Mckenna, 2000; Fisher *et al.*, 2020). Whenever a subsequent round is necessary, there should be a good reason for it (Landeta & Barrutia, 2011). Regardless of the nature of the response, the number of rounds depends largely on when stability in the responses is achieved (Linstone & Turoff, 2011). Consensus is more easily determined through this method than by calculating percentages (Hasson *et al.*, 2000). In many cases, the third round is a repetition of the second round, except that the second-round results are provided to the panellists. In this study, a consensus was reached after two (2) iterations and the results are presented in Chapter 6.

The first step in exploratory Delphi is to choose a knowledge base from which to identify the various fields, relevant institutions, works of literature, and legal frameworks. After that, the first questionnaire (round one) serves as a plan for generating ideas to identify the problems in the study area (Ibiyemi, Adnan & Daud, 2016). In round one, the participants—referred to as panellists—should address as many relevant topics as they can. A second questionnaire that asks opinions on the topics raised complements the feedback provided from round one responses (Ibiyemi *et al.*, 2016). The subsequent rounds include each panellist's (expert's) response as well as those of the other panellists. In light of the comments from the other panellists, each expert is invited to re-evaluate their response (Ibiyemi *et al.*, 2016). The input process continues through several rounds until a consensus is reached. The process is best characterized as multi-staged, with each stage building on the results of the previous one (Nworie, 2011; Green, 2014). Somerville (2008) and Lang (1995) provide the list of the process as follows:

- The participation of experts.
- The panel's size.
- Two or more Delphi rounds
- Heterogeneity.
- Anonymity.
- Feedbacks from each run that are under control and include some textual and statistical data.
- Analysis of data and
- Consensus.

Exploratory Delphi meets the purpose of this study because it allows experts to reach a consensus from an expert panel by means of questionnaires and controlled feedback which is how data was collected in this study. This method establishes facts about a specific topic, and SMS as well IMM was the main topic for this study. The first iteration stated facts about SMS and validated the need for a SMSIM model that can be used to evaluate interoperability level in SMS, and a consensus at 70% was reached necessitating the second iteration that validates the SMSIM model. The following section tables different scaling techniques that can be used and adapted when using the Delphi method. The importance of this table is to provide a different insight into how the interactions with the experts can be structured and ranked.

5.7.6 Scaling techniques

The scaling technique involves assigning participants to continue a progressive adjustment in the previously given values or numbers based on the characteristics of a certain object in accordance with the established regulations (Triantafyllidis & Samaras, 2015; Badr, Abdul Salam, Almotairi & Ahmed, 2021). All the scaling techniques are based on four pillars, i.e., order, description, distance, and origin. There are many scaling techniques used for Delphi ranking presented in Table 5-5 and Table 5-6 below (Calil, Reguero, Zamora, Losada & Méndez, 2017; El-Khoueiry, Sangro, Yau, Crocenzi, Kudo, Hsu, Kim, Choo, Trojan & Welling 3rd, 2017; Wu & Leung, 2017; Chyung, Swanson, Roberts & Hankinson, 2018; Hill, Lettington & Schmidt, 2018; Varatharajan, Manogaran, Priyan, Balaş & Barna, 2018; Nasrabadi, Dehnokhalaji, Korhonen & Wallenius, 2019; Taherdoost, 2019; Javaheri, Mirzaei & Lukowicz, 2020; Holmberg, Wolf, Eide, Großschädl, Schüttengruber, Patel & Heckemann, 2021; Suparji, Nugroho & Martiningsih, 2021; Manisera & Zuccolotto, 2022).

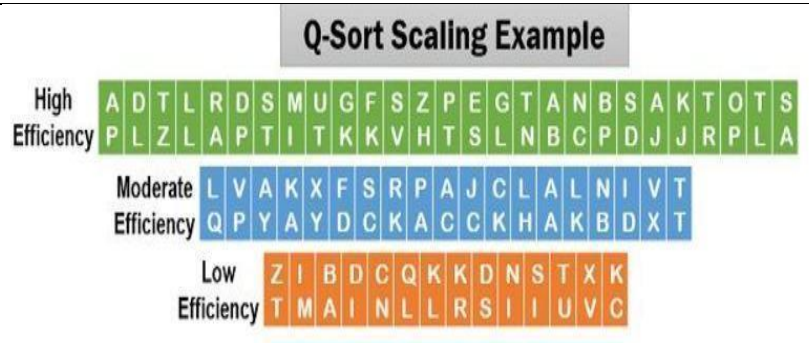
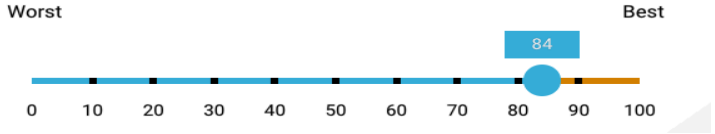
Table 5-5: Primary Delphi Scaling Techniques

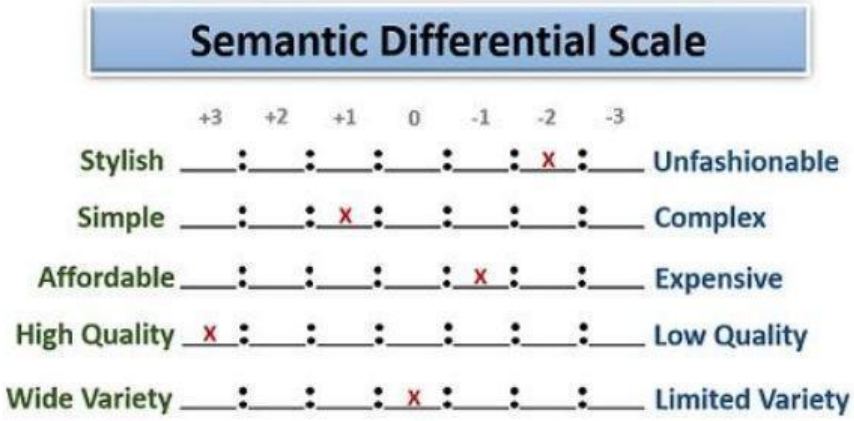
Scaling Technique	Description	Ranking
Nominal Scale Types:	For non-quantitative variables that are distinct from one another and do not have a numerical consequence, nominal scales are used.	
Dichotomous	Dichotomous means there are only two labels on a nominal scale.	Yes or No
Nominal with Order	"Nominal with order" refers to labels on a nominal scale that are placed in either ascending or descending order.	Excellent, Good, Average, Poor, Worst
Nominal without Order	The term "nominal without order" refers to such a nominal scale that lacks a sequence.	Black, White
Ordinal scale	The ordinal scale is founded on the idea that things or labels are positioned relative to one another according to a person's preferences or choices.	The ratings so provided are as follows: 5 Star – Excellent 4 Star – Good 3 Star – Average 2 Star – Poor 1 Star – Worst
Interval scale	The numerical labeling with the same difference between successive measurement units is known as an interval scale, sometimes known as a cardinal scale. Researchers can compare the objects more effectively by using this scaling technique.	1, 2, 3, 4, 5, 6
Ration scale	A ratio scale is an abstract number system, just like an interval scale. It has the additional feature of starting from a set zero point and enables measurement at the appropriate intervals, as well as order, classification, and	If a business wishes to determine the prevalence of obesity in a specific area, select a category to which your weight belongs to: Less than 40 kilograms 40-59 Kilograms

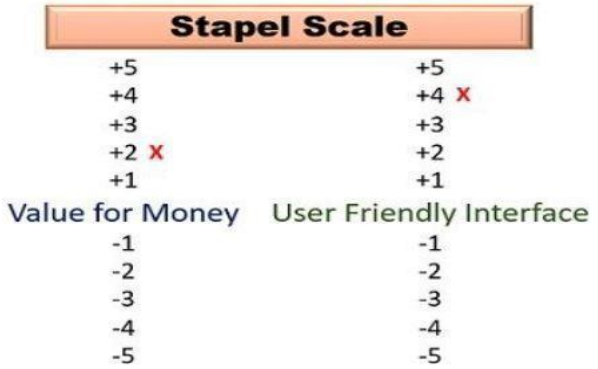
	distance. In this case, the acquired ratio can be used to make the comparison.	60-79 Kilograms 80-99 Kilograms 100-119 Kilograms 120 Kilograms and more

Table 5-6: Other Comparative Scaling Techniques

Comparative scale types:	**Description**	**Ranking**
Paired comparison	The respondents utilize a comparative scale when comparing two or more factors. The respondent must choose one of two variables represented by a paired comparison. This method is mostly employed during product testing to enable customers to compare the two key products available on the market.	Ranking For instance, a market study was done to determine whether consumers preferred brands A and B of network service providers. The survey's findings are as follows: Brand ‘A’ = 57% Brand ‘B’ = 43% Thus, it is visible that the consumers prefer brand 'A', over brand 'B'.
Rank Order	In rank order scaling, the respondent must rank or arrange the supplied objects in the order of their choice.	For example, a soap production company used rank order scaling to determine the consumers' preferred order. It asked the respondents to rank the following brands in the sequence of their choice: Soap Brand Rank Brand V 4 Brand X 2 Brand Y 1 Brand Z 3 The above scaling shows that soap 'Y' is the most preferred brand, followed by soap 'X', then soap 'Z' and the least preferred one is the soap 'V'.

Comparative scale types:	**Description**	**Ranking**
Constant Sum	It is a scaling approach in which the respondents rate the merits, qualities, and significance of a certain good or service using a running total of units such as dollars, points, chits, chips, etc.	For example, the respondents from three distinct segments were asked to provide the following cosmetic product characteristic (P) 50 points: Attributes Segment1 Segment 2 Segment 3 Finish 11 8 9 Skin Friendly 11 12 12 Fragrance 7 11 8 Packaging 9 8 10 Price 12 11 11 From the above constant sum scaling analysis, we can see that: Segment 1 considers product 'P' due to its competitive price as a major factor. But segment 2 and segment 3, prefers the product because it is skin-friendly.
Q-Sort Scaling	Q-sort scaling is a method for selecting the best objects from a large set of provided variables. It places emphasis on sorting the provided objects into similar piles in decreasing order according to predetermined characteristics. It is appropriate when there are at least 60 and no more than 140 objects, with 60 to 90 being the most optimal number of objects.	
Non-comparative scale types:	To evaluate a product or object's performance across various parameters, a non-comparative scale is utilized.	
Continuous Rating Scales	The respondents can position the object on the graphical rating scale however they like. A place that falls	

Comparative scale types:	Description	Ranking
	between two extreme requirements, either vertically or horizontally, is chosen and marked.	
Itemized Rating Scale	Another crucial method for non-comparative scales is the itemized scale. It places emphasis on selecting a specific category from the range of ones provided by the respondents. The researchers briefly define each class to facilitate such selection.	
Likert Scale	The researcher presents various statements to the respondents and asks them to indicate how much they agree or disagree with each one by choosing one of the five options available on the Likert scale.	1 – Strongly Disagree 2 – Disagree 3 – Neither Agree Nor Disagree 4 – Agree 5 – Strongly Agree
Semantic Differential Scale	For each of the specified properties of the object, the respondent may select any one of the seven points on a bi-polar, seven-point non-comparative rating scale. demonstrating the respondent's attitude or view of the object.	 From the above diagram, we can analyze that the customer finds the product of superior quality; however, the brand needs to focus more on the styling of its watches.

Comparative scale types:	**Description**	**Ranking**
Stapel Scale	A Stapel scale is an itemized rating scale that uses a unipolar rating to gauge respondents' reactions, perceptions, or attitudes toward a certain object. A Stapel scale can only go from -5 to +5, removing 0, and is therefore limited to 10 units.	For example, a tour operator requested respondents to score their vacation package according to its affordability and user-friendliness using the following criteria:  With the help of the above scale, we can say that the company needs to improve its package in terms of value for money. However, the decisive point is that the interface is user-friendly for the customers.

The Likert Scale will be further discussed as it will be used for ranking during the evaluation of the components and for ranking these in this study during an iteration of questionnaires with the experts.

5.7.6.1 Likert Scale

The Likert-scale is the most common instrument used to measure affective factors, including motivation and self-efficacy, as they make it very simple for researchers to collect significant amounts of data (Nemoto & Beglar, 2014; Chyung *et al.*, 2018; Matas, 2018). An initial 5-point psychometric scale for evaluating several propositions connected to attitudes was developed in the 1930s by American social psychologist Rensis Likert (Likert, 1932; Alan & Kabasakal, 2020). The wording used in the initial Likert scale was: Strongly Approve, Approve, Un-decided, Disapprove, and Strongly Disapprove. Over time, the wording changed from Approve to Agree, which resulted in the Likert scale we know today: Strongly Agree and Agree on one side, and Disagree and Strongly Disagree on the other side, with a midpoint in the middle.

The conventional Likert scale evolved into other Likert-type scale modifications because of its ease of use and popularity. These are commonly used in survey instruments designed for (Ryan, 1980; Garland, 1991; Raaijmakers, Van Hoof, T Hart, Verbogt & Vollebergh, 2000; Boone & Boone, 2012; Kulas & Stachowski, 2013; Purdey, 2013; Chyung *et al.*, 2018; Claveria, 2021):

- Evaluating how well employees do at work.
- Research on communications.
- Marketing research.
- Psychometric research
- Political opinion research.

Debates over validity arise from the variations in Likert-type scales in the context of these applications, such as the impacts of using the following formats (Chyung *et al.*, 2018):

- Including or not including a midpoint in the scale:
    - Strongly disagree, disagree, neutral, agree, strongly agree.
    - Strongly disagree, disagree, agree, strongly agree.
- Using descending order vs ascending order of the scale opinions:
    - Strongly agree, agree, neutral, disagree, strongly disagree.
    - Strongly disagree, disagree, neutral, agree, strongly agree.

Measuring positively and negatively stated survey items with the Likert scale

- The objectives were clear:
    - Strongly disagree, disagree, neutral, agree, strongly agree.
- The objectives were unclear:
    - Strongly disagree, disagree, neutral, agree, strongly agree.
- The objectives were not clear
    - Strongly disagree, disagree, neutral, agree, strongly agree.

5.7.6.2 The Likert scale as a measurement method

Another American psychologist, Stanley Smith Stevens, developed the nominal, ordinal, interval, and ratio scales as four different sorts (levels) of measurement in the 1940s (Stevens, 1946; Kuhlmann, Dantlgraber & Reips, 2017). The ordinal scale has levels that are ranked in sequence (for example, performance ratings such as Poor, Fair, and Good). The interval scale has levels with consistent spacing between them (for example, a scale consisting of –2, –1, 0, 1, and 2). Finally, the ratio scale has levels with proportionate ratios and a meaningful zero value (for example, test scores of zero to 100). The middle point, or "neutrality," on the Likert scale's five points (or "anchors"), is used to measure attitudes. As illustrated in Figure 5-4, the lengths between successive points on the scale must be equal for the Likert scale to qualify as an interval scale. To put it another way, the distance between Strongly Disagree and Disagree (the length of "a" in Figure 5-5) is the same as the distance between Disagree and Neutral ("d"), which is the same as the distance between Neutral and Agree ("b"), as well as the distance between Agree and Strongly Agree ("c") (Sullivan & Artino, 2013; Chyung, Roberts, Swanson & Hankinson, 2017).

- Using Likert-type scales or slider scales
    - Completely Dissatisfied 0 1 2 3 4 5 6 7 8 9 10
    - Completely Satisfied A slider scale as shown in Figure 5-4

Figure 5-4: A Slider Scale

In this study, the Likert scale is used as a measurement method, the following section describes the Likert scale as a measurement method.

Figure 5-5: The Five-point Likert scale as an ordinal scale

There may also be a difference in the distances between the Likert scale's "a," "b," "c," and "d" points as seen in Figure 5-5. As a result, the Likert scale cannot be used as an interval scale and is instead classified as an ordinal scale. Furthermore, it's crucial to word a midpoint correctly. As a midpoint, Neutral (or Neither Agree Nor Disagree) denotes a level of opinion that is neutral. However, if Undecided is chosen as the midpoint, it is debatable whether it represents a point of view that lies halfway between disagreement and agreement or whether it should instead be viewed as an absence of opinion (Sullivan & Artino, 2013; Chyung *et al.*, 2017).

In the latter situation, as shown in Figure 5-6, the Likert scale resembles a 4-point ordinal scale with Undecided as a separate option off the scale. Other perspectives, such as I don't know or it depends on, should not be labelled as a midpoint but instead should be offered as response options off the scale to capture data that is more likely to be interval than ordinal in nature (Chyung *et al.*, 2017).

Figure 5-6: The Four-point ordinal Likert scale with undecided as a separate option

This study only used the five-point Likert type ranging from 1= strongly disagree to 5 = strongly agree (Dönmez & Toker, 2017). The experts were given questions through two (2) iterations, and they chose either of the options below:

1 – Strongly Disagree
2 – Disagree
3 – Neither Agree nor Disagree
4 – Agree
5 – Strongly Agree

Table 5-5 and 5-6 above provides different scaling techniques that can be used for ranking in the Delphi method. For the purpose of this study, Likert scale was adopted as it allows facts from literature and the experts input. This scale complements the modified Delphi design and hence it is adapted for this study. The process of the Delphi technique that was followed in this study is outlined in the figure below:

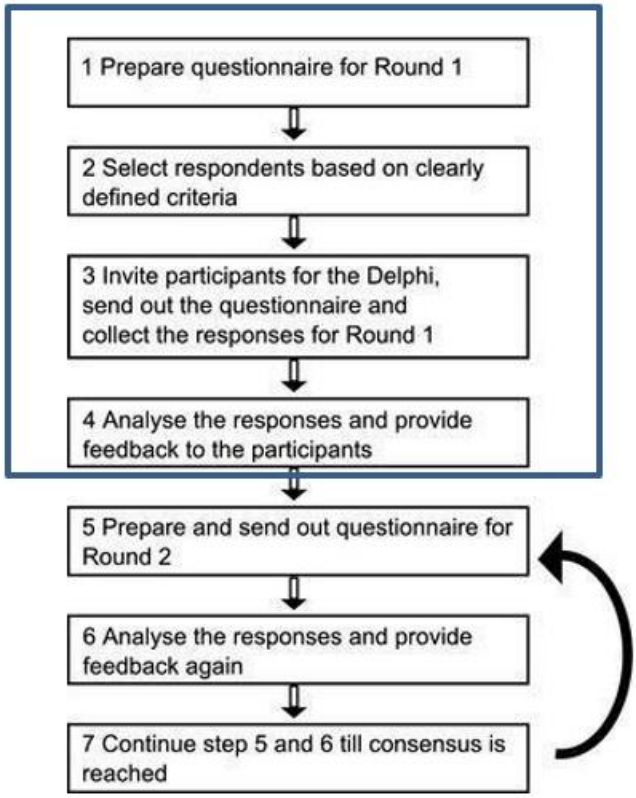


Figure 5-7: Delphi Method 1st iteration (John-Matthews et al., 2017; Mukherjee et al., 2014)

In round one, the first four steps in the above process were followed. During this round, questionnaires were prepared to identify relevant experts. In section 5.7.3, Table 5-3, presents the selection criteria of experts and only experts that meet the criteria were selected to participate in the study. The first questionnaire was drafted from the literature findings. This is important to solidify the knowledge and experience in this field. The selected experts were invited to participate in the study.

Round 2 only began after the first round was complete. The questionnaire from round 2 were developed based on the feedback from round 1, the pre-conceptualized SMSIM model was provided to the experts in round 2 based on the feedback they provided in round 1, and this started the discussions of validating the model. The process repeated itself in two (2) iterations until a consensus was reached. Anonymity is key in this process, and all the experts anonymously received a copy of the results.

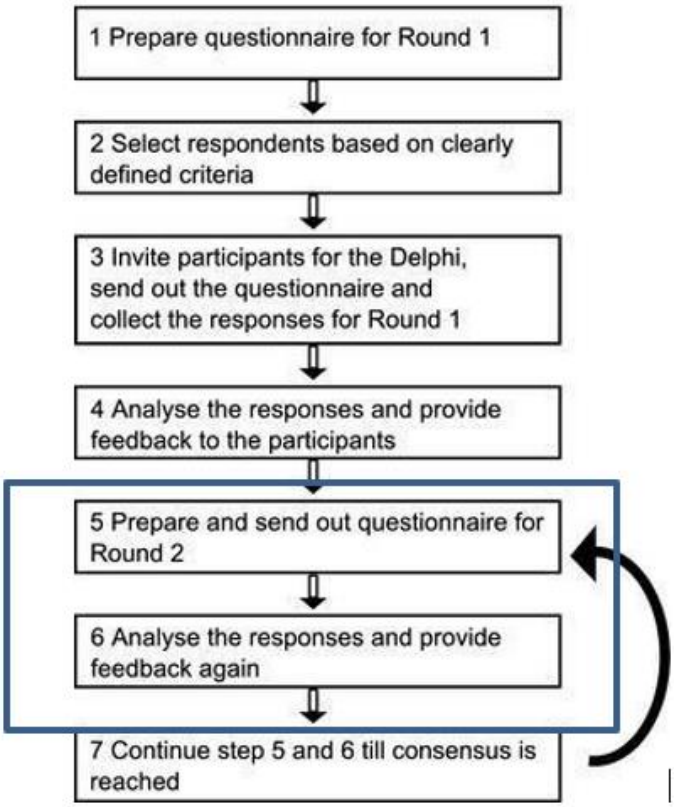


Figure 5-8: Delphi Method 2nd iteration (John-Matthews et al., 2017; Mukherjee et al., 2014)

Round 2 followed the above process and until the last step was reached (see Figure 5-8). Each round consisted of verifications and analysis of the feedback obtained. Section 5.4 of the hermeneutics circle determined the relevancy of the questions that were prepared for the next round. The following section discusses the data collection methods (Appendix C and D provide the detail of what was asked during the two Delphi rounds).

5.8 THE DATA COLLECTION METHODS

In order to answer specific research questions, test hypotheses, and assess results, data collection is the act of acquiring and analyzing information on relevant variables in a planned, methodical manner (Kabir, 2016). All academic disciplines, including the humanities, social sciences, business, and natural and applied sciences, share the data collection component of research. Although techniques differ depending on the profession, the importance of ensuring accurate and truthful collection does not change. The objective of collecting data is to obtain high-quality data that can be used for rich data analysis and to create responses to posted questions that are convincing and believable (Kabir, 2016). This study applied questionnaires (online), and document analysis as its data collection methods.

5.8.1 Questionnaires

Any text-based tool that provides users with a series of questions to answer or statements to respond to by marking a page, writing a number, or checking a box on paper or online is referred to as a questionnaire (Roopa & Rani, 2012; Young, 2015). For less experienced researchers, such as students working on dissertation projects, questionnaires look particularly alluring. This may be the case for the following reasons (Roopa & Rani, 2012; Young, 2015):

- They are simple to build, or at least it may seem that way.
- Many of the currently used questionnaires can be used or modified for usage, and they are frequently freely accessible to researchers.
- They are moveable or can be bought online.
- They can be utilized to swiftly compile massive datasets through direct contact, mail, the Internet, or email.
- In contrast to spoken data, which must be recorded and transcribed before analysis, the information they collect can be processed and analyzed rather fast.

Since interviews were not possible because of the unavailability of participants who were willing to go through the traditional interview process, a Delphi study was chosen and questionnaires were prepared for data collection. The following five important strategies were used during the qualitative data collection phase (Leedy & Ormrod, 2021):

- The researcher used self-reflection/reflexivity to identify individual, communal, and political prejudices that could negatively affect the capability to interpret data collected.

- Triangulation was used to find inconsistencies or consistencies among the data that was collected in multiple forms related to the same research question.
- Clearly distinguishing between data and memos helped the researcher's interpretations.
- Seeking exceptions and contradictory evidence.

Questionnaires were developed using the Likert scaling technique and provided online through Lime survey to experts to respond to in two iterations of the exploratory Delphi study until a consensus was reached. This provided a holistic view of how each person with a different role interacting with the system responds to the common question. A perception was then formed based on analysing the results from different trends of participants. Questionnaires were used throughout the process of verifying and validating the model to ensure that there is a difference, relevance, efficiency, and credibility to the newly conceptualized model.

5.8.2 Document Analysis

In document analysis, a type of qualitative research, the subject of the study is given voice and meaning by the researcher's interpretation of the documents (Bowen, 2009). One must follow a systematic process called document analysis to evaluate or assess printed and electronic (computer-based and Internet-transmitted) documents (Bowen, 2009; Wach & Ward, 2013). Like other analytical methods in qualitative research, document analysis requires that data be examined and interpreted to elicit meaning, gain understanding, and develop empirical knowledge (Bowen, 2009).

There are many different types of documents used for systematic examination as part of a study and these include manuals, diaries, letters and memorandums, advertisements, background papers, agendas, program proposals, attendance records, newspapers, and meeting minutes, scripts for radio and television programs, printed event programs, brochures, and journals, printed event programs, charts, press releases, application forms, institutional or organization reports, maps, survey information, books, and various public records were among them (Bowen, 2009).

5.8.2.1 Advantages and limitations of document analysis

The following are the advantages and limitations of document analysis, according to Bowen (2009):

- **Efficient method:** In comparison to other research techniques, document analysis takes less time and is therefore, more effective. Instead of data collection, it requires data selection.
- **Availability**: Since the invention of the Internet, many documents have been in the public domain and are accessible without the creators' consent.
- **Cost-effectiveness:** When new data gathering is not practical, document analysis is frequently the method of choice because it is less expensive than other research techniques. The information (included in the documents) has already been acquired; the documents' content and quality evaluation is now necessary.
- **Lack of obtrusiveness and reactivity:** Documents are "non-reactive" and "unobtrusive," meaning that the research process has no effect on them. (Previous research mentioned in documents is not considered here.
- **Stability:** Documents are stable because they are non-reactive. No changes are made to the study because of the researcher's participation (Merriam, 1988). In this way, documents are appropriate for further scrutiny.
- **Exactness:** Documents are useful in the research process because they contain precise names, references, and event information (Yin, 1994).
- **Coverage:** Documents offer comprehensive coverage; they span a long time, several events, and numerous settings (Yin, 1994). Analysis of documents is not always beneficial. Below are a few restrictions that documents naturally have.
- **Insufficient detail:** Documents are made outside of a research objective and are produced for a purpose other than research. As a result, they frequently don't offer enough information to address a research topic.
- **Low retrievability:** Sometimes retrieving documentation is impossible or very difficult. It's possible to purposefully restrict access to papers, as demonstrated by Yin (1994).
- **Biased selectivity:** A deficient collection of documents raises concerns about "biased selectivity" (Yin, 1994, p. 80). The available (chosen) documents in an organizational setting are probably going to be in line with corporate rules and procedures and the objectives of the organization's principals. However, they may also reflect the organizational unit's emphasis on record-keeping (for example, Human Resources).

Given its efficiency and cost-effectiveness, document analysis offers advantages that clearly outweigh the limitations.

For this study document analysis was not used, Chapters 2, 3 and 4 of this study focused on the literature findings. The next section describes the methodology used for literature findings.

5.8.3 Scoping Reviews

The literature was obtained through scoping reviews. The purpose was to better understand the available literature conducted by other authors prior to this study, and how this literature contributed to interoperability, interoperability maturity models (IMM) and SMS. According to Nakano and Muniz (2018, p.1), researchers contribute to meaningful research based on prior knowledge that they have developed through a "collective and cumulative endeavour".

A scoping review is a valuable tool in the arsenal of evidence synthesis techniques that continue to grow. Scoping reviews are now considered a valid alternative when systematic reviews are not adequate to meet the users' needs. A scoping review clearly indicates the volume and nature of the literature and studies on a given topic (Munn, Peters, Stern, Tufanaru, Mcarthur & Aromataris, 2018). It also describes the focus of the literature and studies. Generally, scoping reviews aim at identifying and mapping the evidence available (Munn *et al.*, 2018). Therefore, each literature chapter identifies interoperability, IMM and SMS themes.

5.8.3.1 The objective of scoping reviews

The following section outlines the rationale that enforces the scoping review approach. Among the reasons researchers may be more inclined to use scoping reviews, Arksey and O'Malley (2005) identify the following:

- Research findings are not presented in detail, but rather a range of information is consolidated.
- The mapping of literature may form the basis of a full systematic review.
- Summarizing research findings in a specific area, aiming to provide an overview of the information found.
- Finding gaps in literature where there has been minimal or no research.

In the context of this study, the scoping review was used to determine what has been covered about ICT, SMS and IMM, the main objective was to find literature that could support the problem statement of the study.

5.9 DATA ANALYSIS

Data analysis is a creative and dynamic process. Researchers attempt to increase a profound understanding of what they have studied and continually refine their interpretations throughout the analysis process (Taylor, Bogdan & Devault, 2015). Creswell and Creswell (2018:p376) define data analysis as when a researcher organizes and tries to make meaningful conclusions from collected data. Researchers draw first-hand experience with settings, informants, or documents on their data analysis to interpret their data (Taylor *et al.*, 2015). In qualitative research, data analysis is probably the most difficult aspect of communicating with others or teaching (Taylor *et al.*, 2015). The preliminary coding scheme will be adapted and refined during the study.

The qualitative data that was using the questionnaires was available as text data. Data analysis will also be done using Microsoft Excel and software analysis tools such as open coding to guide the analysis phase with Nvivo 12 (Nvivo, 2021). To improve data analysis, Creswell and Creswell (2018:p307) recommend developing code inside the primary documents. The Nvivo software lets you annotate, link, search, code, query, and visually represent qualitative data (Creswell & Creswell, 2018:p307). The analysis will be guided by hermeneutics, as was discussed in Section 5.4. The ability to explain written scripts is referred to as hermeneutics (Friston & Frith, 2015). The practical operation that provides knowledge in the sense of familiarity with something, the sort of understanding by which we integrate facts into a meaningful whole, is hermeneutics or interpretation (Zimmermann, 2015). Data analysis was conducted based on the feedback from the various experts in each round to ensure that the literature study trends match the empirical data.

5.9.1 Thematic Analysis

A component of the qualitative research methodology is thematic analysis. It is a technique used for examining data collections to find and document any established patterns that could exist (Saunders *et al.*, 2016:p651). It is also a useful method for creating connected themes and codes in academic research. In contrast to grounded theory or hermeneutic phenomenology, which demand a higher level of interpretive complexity, the use of theme analysis is

appropriate for researchers who prefer to apply a relatively modest level of interpretation. Thematic analysis is primarily defined as a strategy for detecting, interpreting, and reporting patterns (themes) within data as an independent qualitative descriptive approach (Vaismoradi, Turunen & Bondas, 2013; Castleberry & Nolen, 2018; Neuendorf, 2018:13; Braun & Clarke, 2019). Finding and identifying recurring themes in data is done through thematic analysis (Desantis & Ugarriza, 2000; Neuendorf, 2018:13; Kiger & Varpio, 2020). Thematic analysis can be conducted within both realist/essentialist and constructionist paradigms, although the outcome and focus will be different for each (Braun & Clarke, 2006). The systematic aspect of content analysis that thematic analysis may provide allows the researcher to integrate meaning analysis with context analysis (Kiger & Varpio, 2020). Thematic analysis evaluates several facets of the study by applying minimum description to data sets (Braun & Clarke, 2006; Vaismoradi *et al.*, 2013; Kiger & Varpio, 2020). In this study, thematic analysis was used to identify possible themes presented in Table 5-7. The Table below outlines the processes of data analysis in thematic analysis that was followed.

Table 5-7: Processes of data analysis in thematic analysis (Braun & Clarke, 2019; Kiger & Varpio, 2020).

Thematic Analysis	**Descriptions**
Familiarising with data	To obtain themes as presented in Table 5-8, a lot of reading occurred while noting down ideas. The Nvivo 12 was used to visually present qualitative data.
Generating initial codes	Analyzed the data, systematically identified its most interesting features, and collated relevant data.
Searching for themes	Identified potential themes, and collected all relevant data related to each potential theme
Data Organization	This involved using different folders to separate themes and group related themes based on the focus area. This ensured that the correct theme was utilized when required to build the outcome of the study.
Interpreting Data	To establish meaning in a broader sense, it was important to make sense of the code and themes.
Reviewing themes	The selected themes were checked if they work in relation to the data sets.
Defining and naming themes	Clear definitions and names for each theme were generated, as in Table 5-8 through an ongoing analysis process.
Producing the report	The outcome of this process is documented throughout this study. Chapter 2, 3 and 4 discuss these themes in more detail to form a base for the components of the SMSIM model.

The most important part of the study is to answer the main research question: How can a SMSIM model assist schools in improving their current SMS's interoperability and maturity levels? And to achieve this, the main research question was broken down into manageable sub questions to determine the bounds of what is already covered in literature and themes were extracted in this study across various literature chapters (Chapters 2, 3 and 4), as presented in the table below:

Table 5-8: Themes

Chapter	Relevant SRQ	Extracted Themes	Definition
Chapter 2	What constitutes the components of a model of interoperability maturity for Schools Management Systems?	Theme 1: Information and Communication Technology (ICT)	ICT Communication and information technologies can be thought of as a set of tools and resources that facilitate communication and the creation, dissemination, storage, and management of information.
Chapter 3	What value will a SMSIM model have for schools using Schools Management Systems?	Theme 2: School Management Systems (SMS)	The Interoperability Maturity Levels of SMS will be assessed and guidelines will be provided to improve the level of interoperability in SMS.
Chapter 4	What existing models of interoperability maturity can be used to conceptualize a SMSIM model?	Theme 3: Interoperability Maturity Model (IMM)	IMM is a model that measures interoperability in a specific domain.

These themes ensured the researcher kept track of the purpose of the study and ensured there was no SRQ that was not covered through literature as presented in the table above. This section was extremely important as it streamlined the focus area of the study and excluded all irrelevant literature findings that did not focus on the themes to answer the SRQs. Overall, the literature considered for review was organized and classified into folders based on the research's themes, including ICT, SMS, and IMM literature. After reviewing the literature, concepts associated with these were analyzed. The codes were then used to determine which concepts were more prevalent throughout the literature reviewed based on their frequency of occurrence. The results are shown in Figure 5-9.

Figure 5-9: Most frequently used words across the selected literature

Several themes were generated using Nvivo 12, through the theoretical foundation in Chapter 2,3 and 4 of literature review. Word cloud shows the commonly used concepts found in literature chapters as displayed in Figure 5-9 above, which contributed to themes that form a foundation for conceptualizing the SMSIM model. This figure shows how the most prominent words are aligned with the theoretical basis of the research as well as the aspects that comprise the research themes.

5.10 TRUSTWORTHINESS

A study is considered trustworthy if the research report's reader believes it to be so (Gunawan, 2015). Trustworthiness has been further divided into credibility, which corresponds roughly with the positivist concept of internal validity; dependability, which relates more to reliability and transferability, which is a form of external validity; and confirmability, which is largely an

issue of presentation (Gunawan, 2015). The aspect of trustworthiness will now be further discussed below.

5.10.1 Credibility

Credibility is a degree of honesty, character, also faith in an entity. Credibility may result from personal and independent mechanisms relating to the services and goods given by the entity. Credibility is constructed over time by customers' single experiences and others participating in viable transactions with the entity (Stibel, Stibel, Hackett, Kazerani & Loeb, 2015). To guarantee that the data is precise, to corroborate the findings and enrich their validity, data triangulation was used (Yin, 2009; Herselman, 2011):

- data triangulation contains the utilisation of a diversity of data sources in a study. This study involved the experts, documents relevant to the study, and SMS as explained in the literature reviews.

It is evident from the definition and the discussion provided above that credibility is an important aspect of trustworthiness. The two ensure that the research is not compromised in any way and that the outcome of the research is credible. Thus, this research will be trustworthy and credible. The section below discusses the ethical considerations of the study.

5.11 ETHICAL CONSIDERATIONS

David and Resnik (2011) define ethics as the difference between acceptable and unacceptable behaviour. Furthermore, David and Resnik (2011) define ethics as a point of view, a step-by-step process, or techniques for logically understanding difficult issues and problems. This research will follow ethical guidelines laid down by the University of South Africa (UNISA) and the DBE to protect the rights of all participants and ensure good research is conducted fairly.

The researcher will not expose research participants, and their rights and privacy will be highly respected. The findings will be reported wholly and truthfully, excluding twisting what was done by the participants (Leedy & Ormrod, 2021). A consent form detailing the purpose of the project and the rights and privacy of the participants during this research was provided to the participants to sign before applying the data collection methods (provided in Appendix C &D). Evidence of the ethical clearance from UNISA is available in Appendix A.

5.12 SUMMARY

This chapter provided an overview of the applicable research methodology for this study. The research onion outlined the layers involving the research philosophy in Section 5.3 with the theoretical lens and the hermeneutic circle in Section 5.4. The research approach and using the Delphi technique in this exploratory qualitative study were discussed together with the advantages and disadvantages of applying the Delphi technique. The data collection methods (questionnaires and scoping literature reviews), the data analysis (hermeneutics and thematic analysis) and trustworthiness were outlined and finally the ethical considerations were provided.

From Chapter 5 it was evident that this is an exploratory qualitative study that applied the Delphi expert reviews as a strategy to focus on SMS at schools. The following chapter focuses on the results of the Delphi study.

CHAPTER 6: ASSESSMENT AND VALIDATION OF THE SMSIM MODEL

6.1 INTRODUCTION

In Chapter 5, the research approach was covered. The findings of the assessment and evaluation of the Delphi expert reviews are presented in this chapter (6). This chapter covers phases two and three of the research procedure described below.

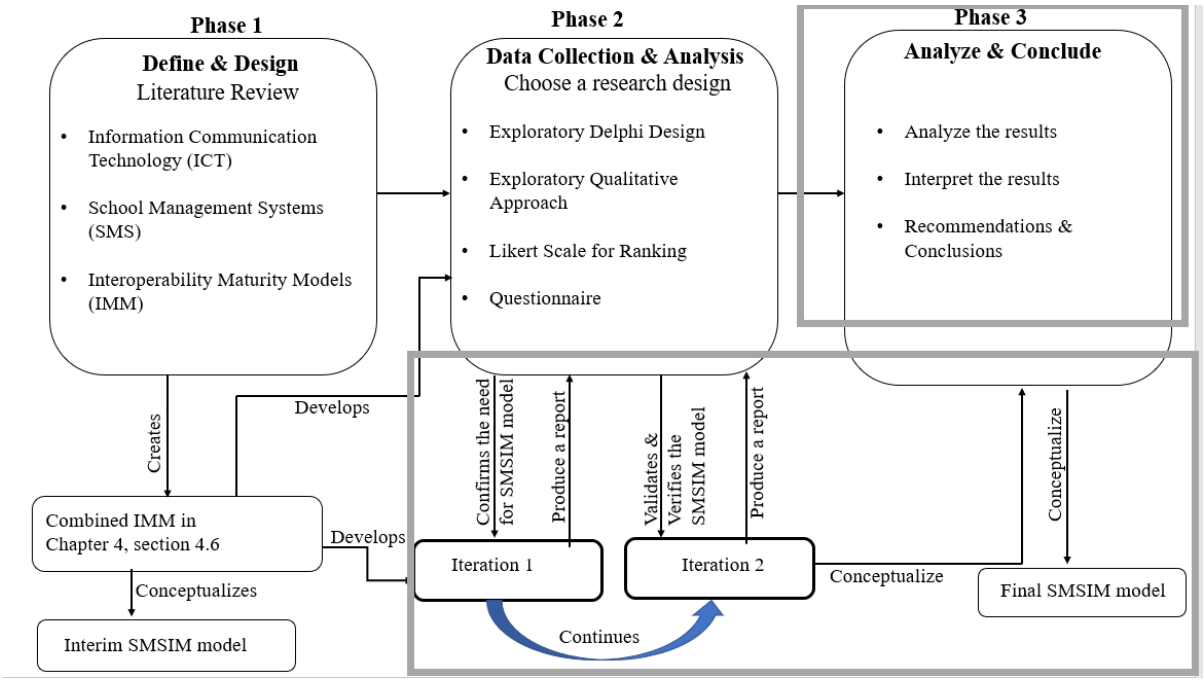


Figure 6-1: The research process and how Chapter 6 covers phases 2 and 3

The Delphi Method is important as it was used to collect data from experts, as explained in Chapter 5, Section 5.7 (Research strategies). With this approach, getting a group of carefully chosen experts to agree on a position is the primary goal (Deveci, Özcan, John, Covrig & Pamucar, 2020). Due to these reasons, Chapter 6 conceptualize the School Management Systems Interoperability Maturity (SMSIM) model and discusses expert assessments and evaluation of the Delphi study's findings.

A consensus was reached after two rounds of the Delphi Study, the first round focussed on basic knowledge of School Management Systems (SMS) to validate the problem statement in Chapter 1 of the study, ascertain the need for a SMSIM model, and assess the level of understanding from the experts in the subject matter. According to David and Roberta (2020),

the questions for each round are based in part of the findings of the previous one, allowing the study to evolve over time in response to earlier findings. In the first round a 70% consensus was reached that necessitated the second round that will verifying and validating the SMSIM model (Etikan, Musa & Alkassim, 2016). The section below presents the findings from round 1 of the Delphi Study.

First, the process of conducting the evaluation will be explained, followed by the analysis of the data and finally the considerations of the experts with the results in each round will finalise this chapter.

6.2 THE PROCESS OF CONDUCTING THE EVALUATION

Determining merit, worth, value, or relevance through a methodical process is called evaluation (Picciotto, 2011; Wanzer, 2021). Furthermore, evaluation is defined by Preskill and Russ-Eft (2015:448) as a type of research that seeks to answer important questions about the effectiveness of a program, process, product, system, or organization. Most of the time, it is carried out for decision-making, and diverse stakeholders should use the results (Wager, Lee & Glaser, 2017).

An evaluation was conducted throughout the study to determine the merit, worth, value and significance of the SMSIM model. The focus was on ensuring the conceptualized SMSIM model addressed the study's problem statement in Chapter 1, Section 1.2. Throughout the process of conceptualizing the SMSIM model, questionnaires for the first round of the Delphi study were evaluated to ensure they appropriately aligned and addressed the problem statement. A fundamental question in the expert review process is answering the question, "who is an expert?" (Vesper, Reeves & Herrington, 2011). Thus, it was important to carefully select experts based on their years of experience, level of understanding, knowledge and expertise in the field, willingness to partake in the study, and availability. Purposive sampling was utilized to choose the experts who would participate in this research (Chapter 5, Section 5.7.3). Purposive sampling is a non-probability, judgmental sampling technique that carefully selects study participants (Etikan et al., 2016). Experts responded on the model’s validity and efficiency, which validated the merit, worth, value and significance of the SMSIM model.

6.3 EXPERT REVIEW RESULTS FROM ITERATION 1

The conclusions of the evaluation carried out through expert reviews are outlined in the following sections to determine the findings' significance, they are interpreted.

6.3.1 Expert Review Demographic Information

As stated in Chapter 5, Section 5.7, the Delphi method/technique was used, in which chosen experts (participants) were requested to respond anonymously and individually to questionnaires. The panellists are given the chance to alter their responses considering the opinions of other panel members after the moderator summarizes all the responses from the panel at the conclusion of each round. The procedure is repeated until a predetermined degree of stability or answer saturation is obtained. The Delphi questionnaires were structured using a Likert Scale. See Appendix C for the questionnaires. The researcher presented certain statements to the participants and asked them to indicate how much they agreed or disagreed with each one by choosing one of the five options from the Likert scale.

In addition, a questionnaire was composed of general knowledge statements to assess not only the level of knowledge and understanding of SMS from experts but also the need for a SMSIM model.

The target group was six (6) experts; however, a total of ten (10) heterogenous experts in various fields of expertise as was presented in Table 5-3, participated in the study. Figure 6-2 below presents experts who participated in the study and their fields of expertise are School Management Systems (SMS), ICT in Education, and Interoperability.

Field of Expertise		
Answer	**Count**	**Percentage**
ICT in Education (A1)	3	42.86%
School Management Systems (SMS) (A2)	2	28.57%
Interoperability (A3)	2	28.57%
ICT4D, Interoperability (A4)	0	0.00%
No answer	0	0.00%

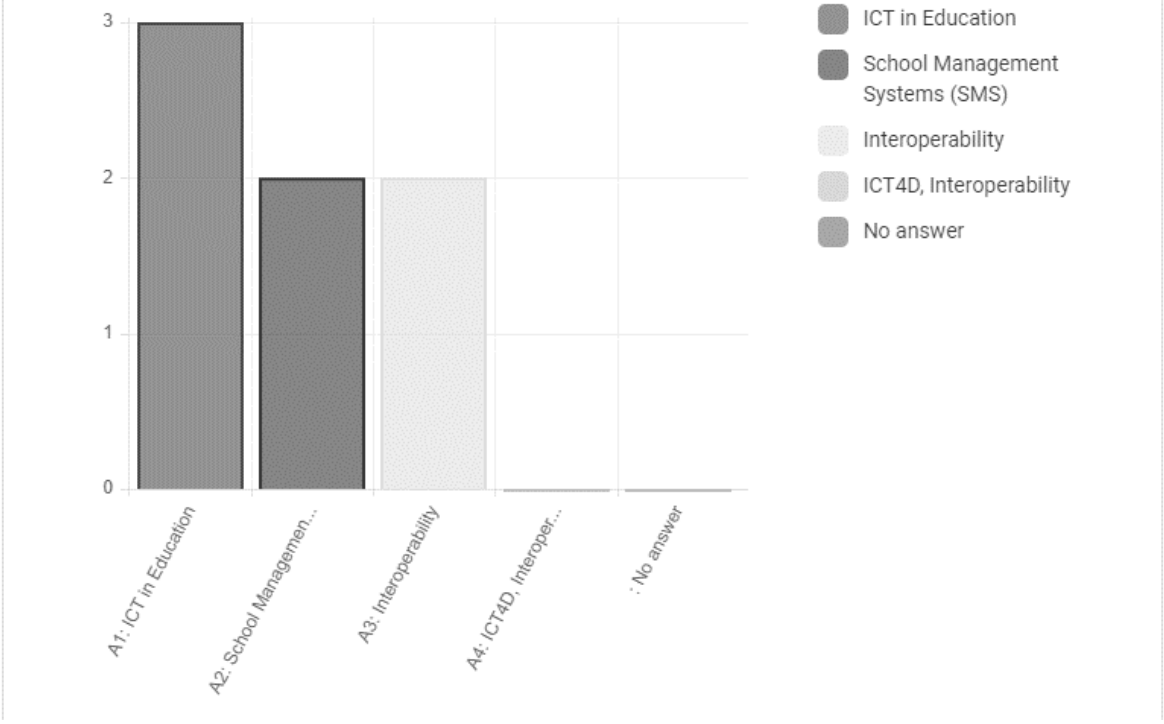


Figure 6-2: Experts who participated in the study.

6.3.2 Results of the Delphi Iteration 1

6.3.2.1 Round 1 Delphi Questionnaires

The section below presents the first Delphi questionnaires, and the result of the questionnaires are further articulated.

- *School Management Systems (SMS) are large repositories that schools use to manage the day-to-day administrative activities of the school.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	2	20.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	5	50.00%
No answer	0	0.00%

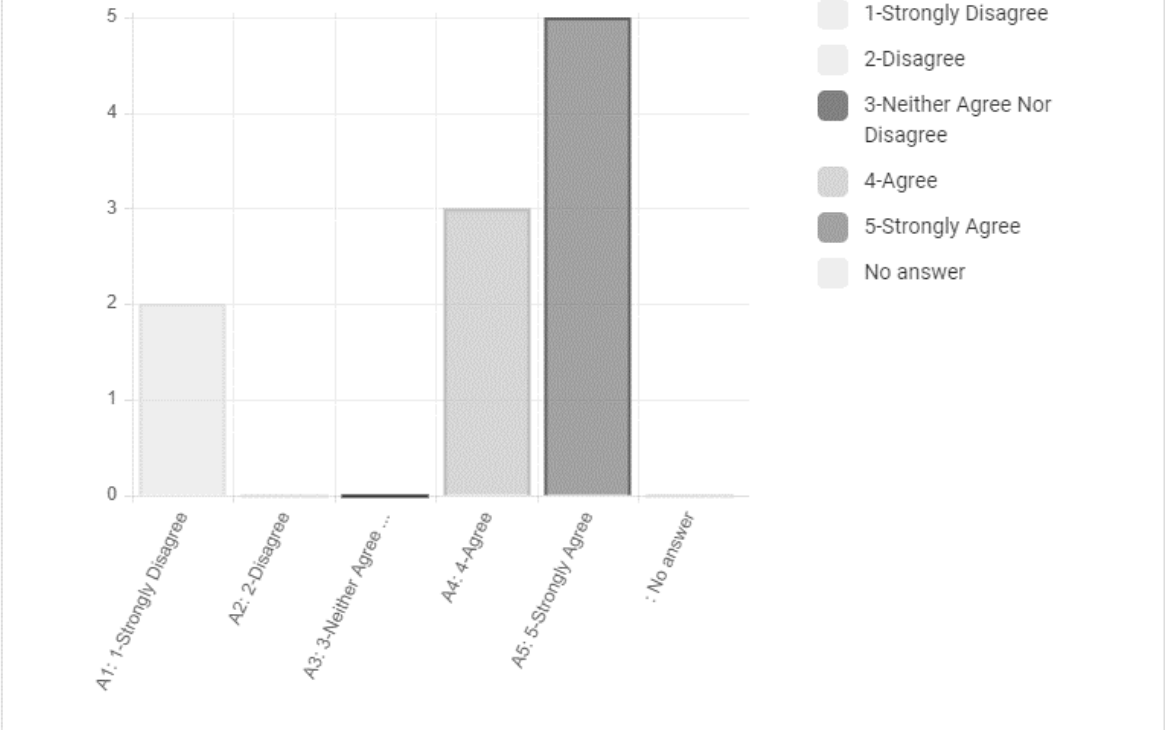


Figure 6-3: Q1 Delphi Round 1 Questionnaire

Figure 6-3 above shows that 50% of the experts strongly agreed, 30% agreed, and just 20% strongly disagreed with the posed statement. After considering the 50% of experts who strongly agreed, together with the 30% who agreed, 80% of experts agreed with the statement. Thus, the results reaffirm the literature findings where Sarker (2016) defined School Management Systems as large repositories that schools use to manage the school's daily administrative activities. The 20% of experts who disagreed with the statement could result from not fully understanding the system, not directly interacting with the system, or not fully understanding the statement. Despite the 20% of experts who disagreed with the statement, it is evident from

the high percentage of experts agreeing that both experts and literature support that SMS are big repositories used for daily management of the school's administrative activities.

- *Multiple users use SMS, and these can be configured to meet the needs of each school independently*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	2	20.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

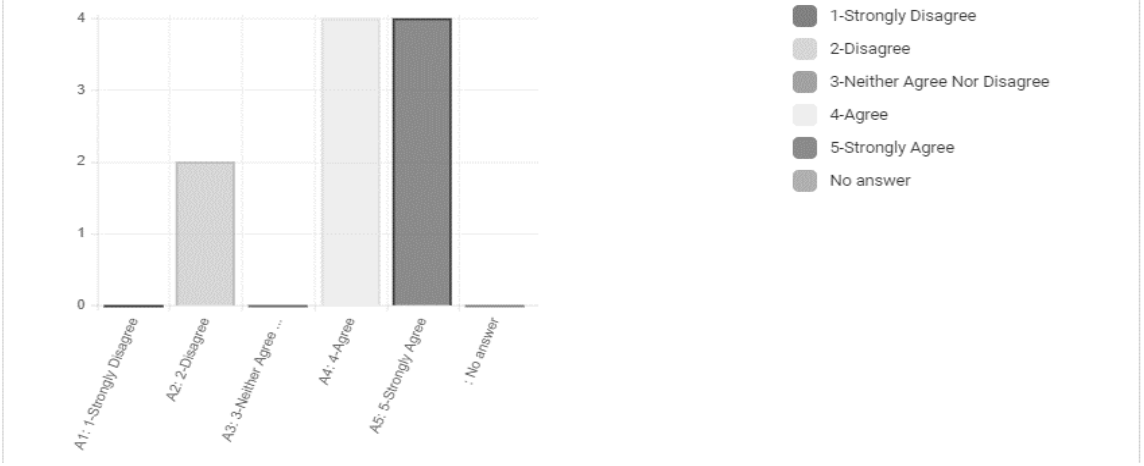


Figure 6-4: Q2 Delphi Round 1 Questionnaire

Based on Figure 6-4, 40% of experts strongly agreed, 40% of experts agreed, and 20% of experts disagreed. Thus, 80% of the experts agreed with this statement. The result of this statement solidifies what has been obtained from literature as Sarker (2016), and Akter (2018) indicated that they have also found that multiple users use SMS systems for different purposes and they configure these systems as they go along. Therefore, it is evident that both literature and experts' results support the fact that multiple users use SMS and configure these systems.

- *SMS help to overcome monotonous paperwork in schools, are very easy to use, and can work accurately and smoothly in different scenarios. SMS reduce workload, increase efficiency in school management, and save time.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	5	50.00%
No answer	0	0.00%

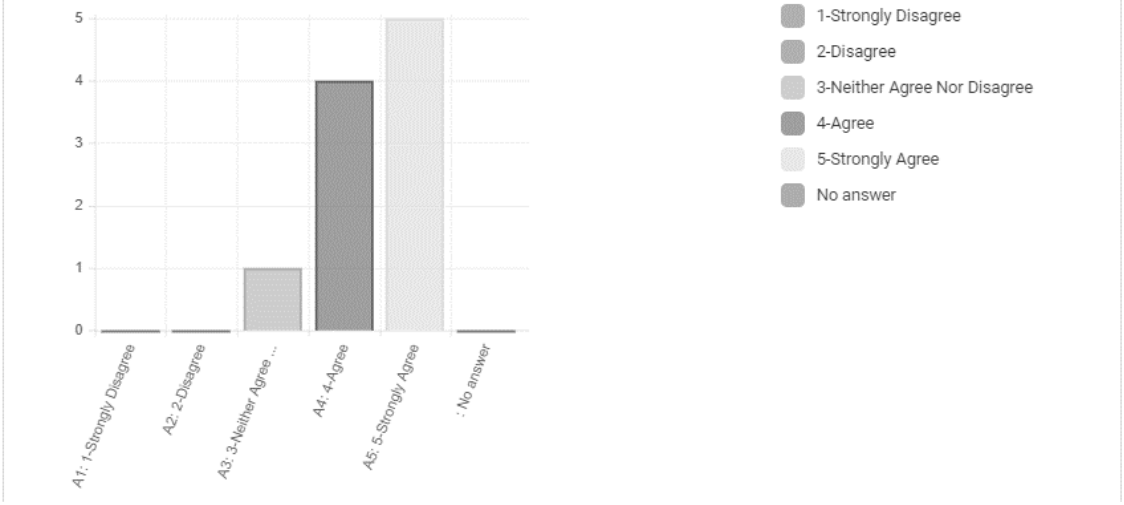


Figure 6-5: Q3 Delphi Round 1 Questionnaire

The statement above was derived from literature, Sarker (2016) argued that SMS helps to overcome monotonous paperwork, they are easy to use, reduce workloads, increase efficiency in management and save time, whereas 50% of experts strongly agreed, 40% of the experts agreed and only 10% of experts neither agreed nor disagreed to Sarker's statement. Other authors, also agreed with Sarker's statement (Ramazhamba *et al.*, 2018; Ncanywa & Sibiya, 2020; Ndaba, 2021). This resulted in 90% of the experts supporting the statement. Figure 6-5 has a higher percentage of experts supporting this statement, this advantage of SMS seems to be applicable for both paid, open, and free versions of SMS. It is thus evident from literature and these results that SMS overcome tedious paperwork, making these easy-to-use systems that can accurately and smoothly work in different scenarios, significantly reducing workloads, saving time, and increasing efficiency in school management.

- *Many schools in South Africa use a specific SMS called SA-SAMS (South African School and Administration Management System) as mandated by the South African Department of Basic Education.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	2	20.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	3	30.00%
No answer	0	0.00%

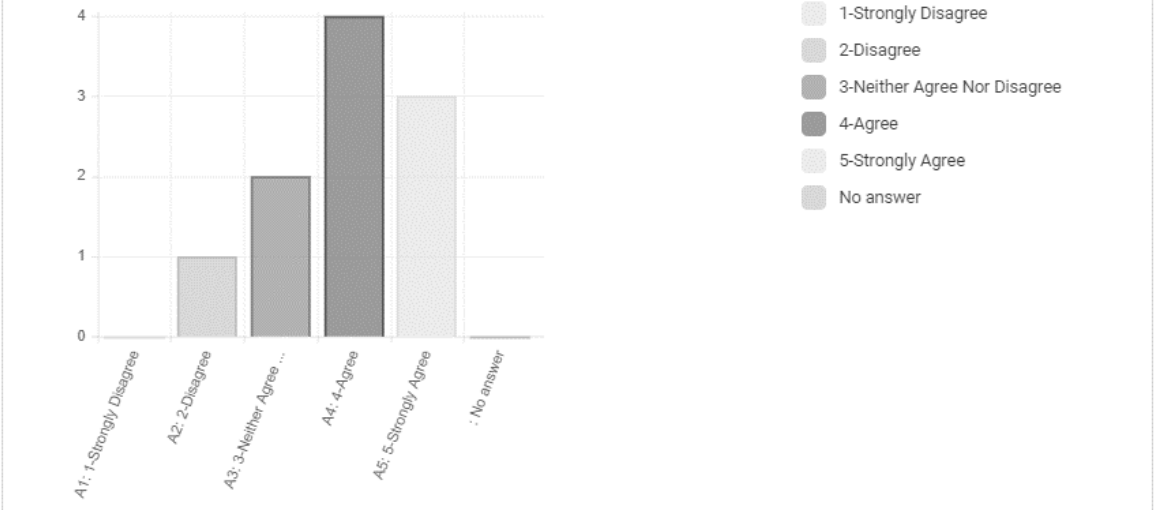


Figure 6-6: Q4 Delphi Round 1 Questionnaire

According to Figure 6-6 above, 30% of experts strongly agreed, 40% agreed, 20% neither agreed nor disagreed and only 10% disagreed; the result was 70% in favour of the statement. The 70% of the experts who responded in favour of the statement may use SA-SAMS for reporting purpose, for example, importing the school reports into SA-SAMS. Also, they could have knowledge that supports this statement. 20% of experts could not really support or go against the statement. Gxwati (2011) and Ramazhamba *et al.* (2018) alluded that many schools use SA-SAMS, and the DBE mandates this. As per literature findings, the DBE in seven provinces collects data from all schools quarterly from the SA-SAMS administrative data system (Van Der Berg, Van Wyk, Selkirk, Rich & Deghaye, 2019). Thus, literature and expert results support the use of SA-SAMS by many schools as mandated by the Department of Basic Education of South Africa.

- *To make the administration of schools more effective, the DBE developed SA-SAMS to solve not only management and administration challenges but also to streamline data in schools.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

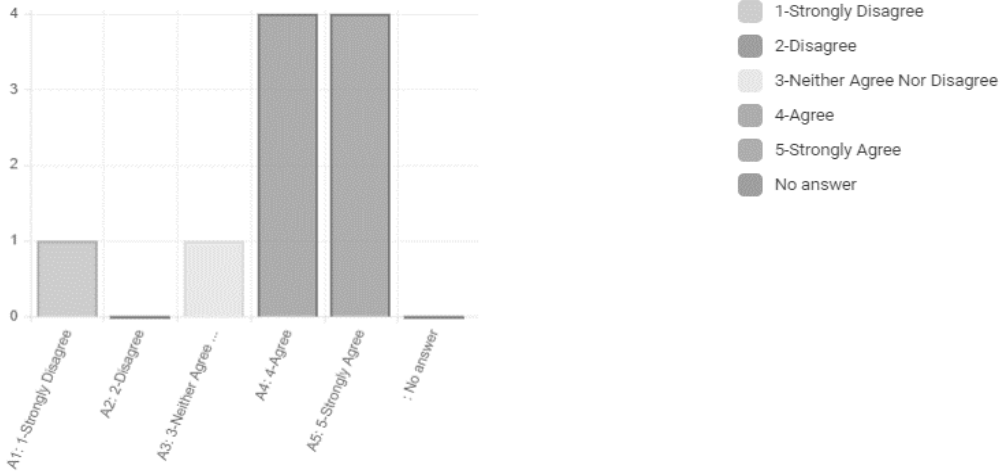


Figure 6-7: Q5 Delphi Round 1 Questionnaire

The statement above was derived from literature, and a total of 80% of experts agreed with the statement, 80% including the 40% who strongly agreed and 40% who agreed. This question aimed to assess the knowledge the experts have on the background of SA-SAMS. However, not all the experts could confidently respond to this question as 10% chose neither to agree nor disagree, and 10% of the experts strongly disagreed with the statement. Muriithi and Masinde (2016) indicate that the DBE developed SA-SAMS to solve management and administration challenges and to streamline data in schools, thus making the administration of the schools more effective. The results of literature and expert reviews solidify that the DBE developed SA-SAMS to make the school's administration more effective in solving management and administration challenges and streamline data in schools.

- *Not all schools in South Africa are using SA-SAMS, but their SMS should easily integrate with SA-SAMS to reduce duplicate work.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	3	30.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	3	30.00%
No answer	1	10.00%

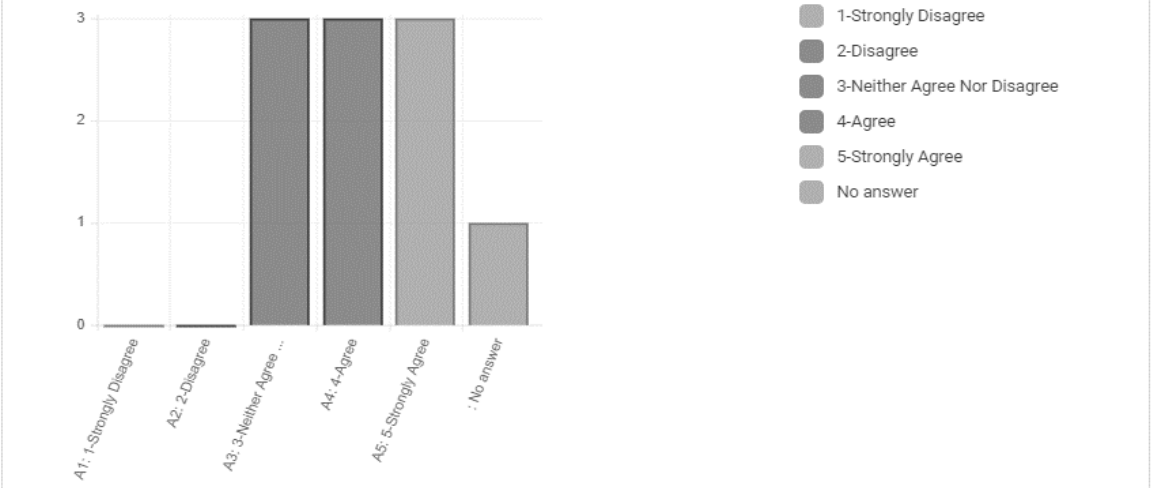


Figure 6-8: Q6 Delphi Round 1 Questionnaire

10% of the experts chose not to respond to the statement, 30% strongly agreed, 30% agreed, and 30% neither agreed nor disagreed with it, a total of 60% agreed to the statement. Compared to previous statements, this statement seems to have received a lower percentage of support, and this may be because the SA-SAMS system is used by schools in South Africa more for reporting purposes than as the main SMS system. Muriithi and Masinde (2016) indicate the disadvantage of SA-SAMS at that it cannot connect with other systems in the DBE, which creates manual means of report submissions. Literature findings has identified that manual means are only applicable to offline schools (no Internet), schools with internet access allows online report submission to the DBE using the Valistractor software (See section 3.5.6).

So far, there is no evidence of schools that have SMS that can integrate with SA-SAMS, therefore, reporting is still done manually by exporting the report from one system to another instead of clicking a button (Muriithi & Masinde, 2016). This validates the need to have a

SMSIM model that can assess the level of interoperability in SMS and then provide guidelines on how interoperability of the next level can be achieved.

In the comment section of this statement, experts expressed that "SA-SAMS is inherently flawed and unstable. Schools must spend a lot of money and time every time the DBE change the goalposts for data needed for SA-SAMS". Kuriakose (2014) also indicates that SA-SAMS provides patches or fixes for the bugs that crop up over time. Each school must download and install these patches onto the system, which may sometimes be a hassle to achieve. There is no stability or consistency in what the DBE is trying to achieve using SA-SAMS. Mbuqe (2020) indicates that system problems in SA-SAMS result in the unreliability of the information produced. There are three-term and four-quarter schools, which causes issues with deadlines and data availability. Others mentioned that "SA-SAMS is probably the worst SMS system in use in South Africa. It is not user-friendly, and the support is lacking. Every time data must be entered into SA-SAMS, the DBE changes the format of the database and what they need. This causes the schools to spend a lot of money to pay for development to be able to export data in the format the DBE requires".

It is evident from the results provided by experts and literature findings that SA-SAMS really needs improvement. Integrating with this system is not feasible right now as it is flawed. There is a lot of cost implication for the schools when importing data into SA-SAMS, which also causes many delays. The SMSIM model provides guidelines for achieving interoperability for schools in South Africa. This finding has validated the importance of interoperability in education systems and the need for integrating these systems. Experts also indicated that "Ed-Admin is a great School Management System, and experts who use this SMS feels it is the best system in the world as it is interoperable and can be accessed from anywhere in the world".

- *Although SMS offer many advantages to schools, it also comes with many disadvantages, such as:*

  - Increased workloads for teachers

Answer	Count	Percentage
1-Strongly Disagree (A1)	2	20.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	5	50.00%
5-Strongly Agree (A5)	2	20.00%
No answer	0	0.00%

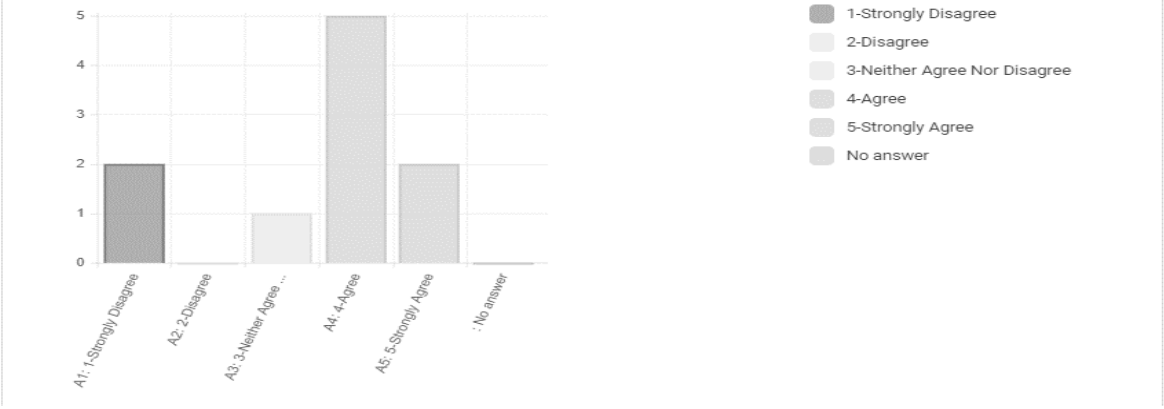


Figure 6-9: Q7 Delphi Round 1 Questionnaire

Figure 6-9 resulted that 20% strongly agree with the statement, 50% agree, 10% neither agree nor disagree and 20% strongly disagree. This totalled 70% in support of the statement. It is clearly observed that despite paid and free versions of SMS in schools, the workload is still a big problem for teachers in the education sector. For SA-SAMS, this is a disadvantage because SA-SAMS is installed on a standalone computer which limits access to users (Muriithi & Masinde, 2016; Pillay, 2020). Only the school administrator has access to this system, and teachers are forced to manually record masks and submit them to the administrator to input into SA-SAMS (Muriithi & Masinde, 2016; Pillay, 2020). The administrator is often frustrated with the amount of work they must do and the limited time they must report the data to the provincial department (Muriithi & Masinde, 2016). A SMSIM model can help guide how this disadvantage can be reduced by assessing the level of interoperability the SMS of the school is currently on and providing guidelines to get to the next phase.

Experts who use Ed-Admin felt that all these disadvantages mentioned above only apply to SA-SAMS, as they do not have any issues using Ed-Admin. Ed-Admin is available worldwide, and staff and parents can access it 24 hours daily (Walsh, 2022). It works incredibly well and hardly duplicates work if the staff member uses the system as intended.

- Duplication of Work

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	3	30.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	3	30.00%
No answer	0	0.00%

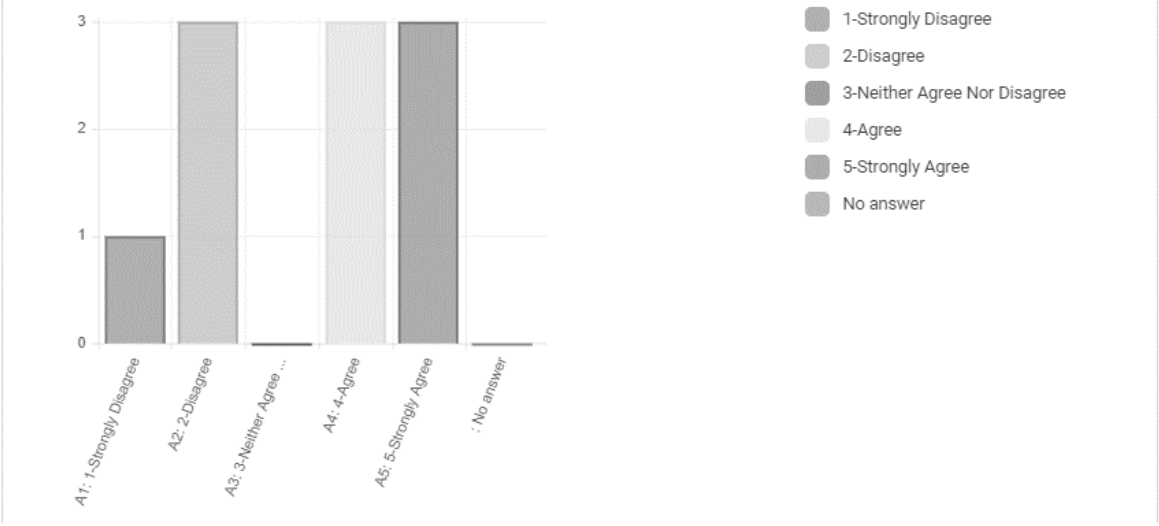


Figure 6-10: Q8 Delphi Round 1 Questionnaire

As per the Figure 6-10 above, it is evident from the feedback that 60% of the experts agreed to this disadvantage of SMS. However, 40% of the experts disagreed with the statement, which could result from their SMS catering for this disadvantage. What is essential to observe from this finding is that paid SMS have fewer disadvantages than open and free SMS. This disadvantage results from SA-SAMS being installed and accessed on a standalone computer (Muriithi & Masinde, 2016). According to Maremi *et al.* (2020), all SMS used by schools should easily integrate with SA-SAMS to reduce duplicating work.

- Redundancy and errors

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	2	20.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	3	30.00%
No answer	0	0.00%

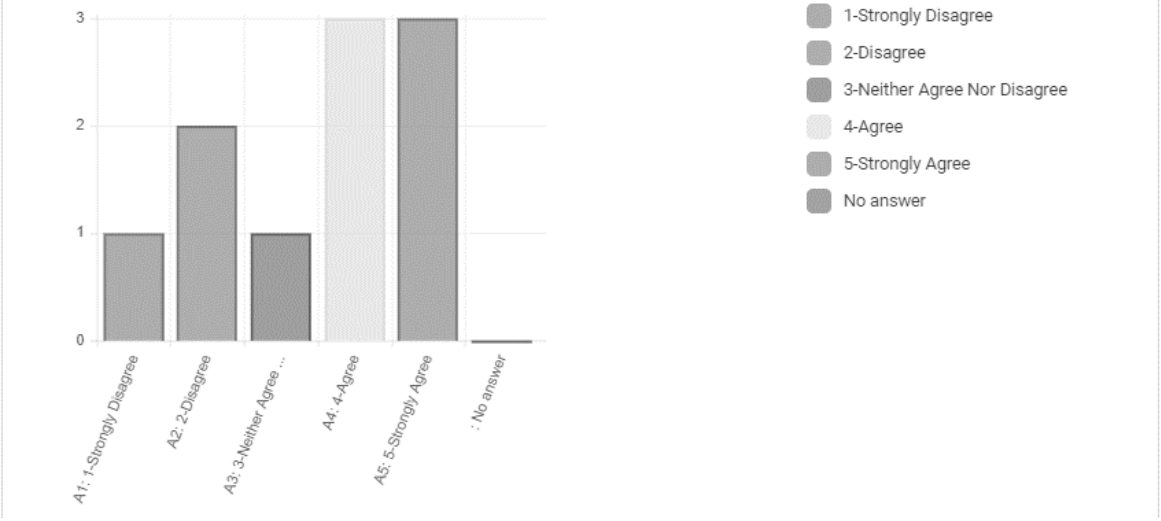


Figure 6-11: Q9 Delphi Round 1 Questionnaire

A total of 60% support the statement, with 10% neither agreeing nor disagreeing and 20% disagreeing and 10% strongly disagreeing. This can be influenced by the different SMS used in the schools, as different experts indicated who participated in the study. 10% of the experts strongly disagreed, which could be that the SMS used solved this disadvantage identified by literature for open and free versions of SMS. Unfortunately, there are schools without internet connectivity, and they cannot fully realise the benefits of SMS as submission to the DBE is still done manually using CDs and USBs.

- Delays for the submission of reports to the DBE by schools

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	5	50.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

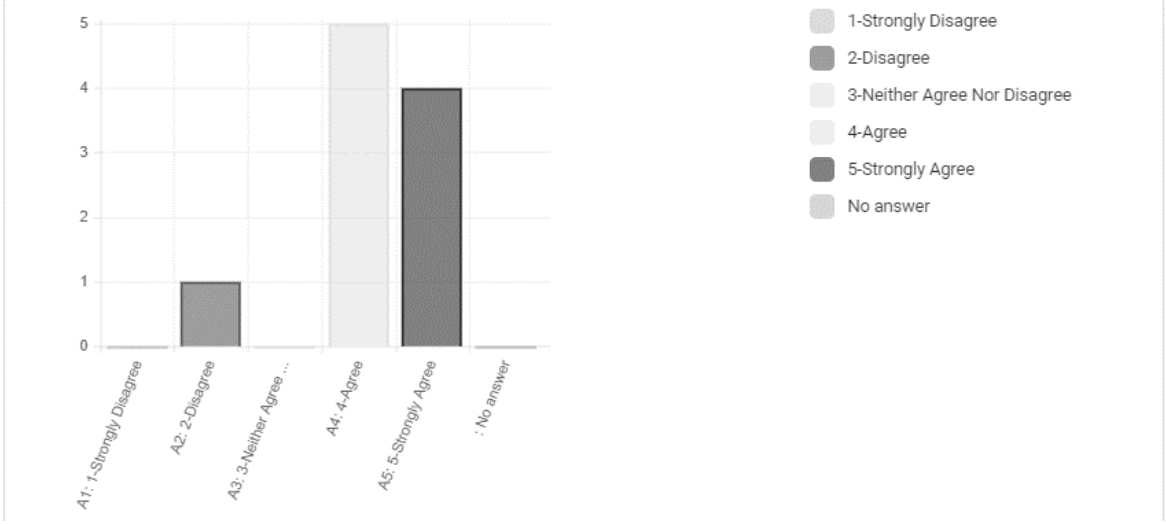


Figure 6-12: Q10 Delphi Round 1 Questionnaire

90% of the experts supported this statement, with only 10% disagreeing. Although private schools use a paid version of SMS, which is more technologically advanced and can be accessed anywhere, these SMS are still not integrated with the DBE SA-SAMS SMS. Unfortunately, this means submitting reports is still made manually by either exporting data into SA-SAMS or mailing the reports to the DBE (Muriithi & Masinde, 2016). The SMSIM model aims to assess the maturity level of interoperability in SMS and provide guidelines on how to get to the next level (Maremi *et al.*, 2020). As evident from both literature findings and expert results, delays in submitting reports to the DBE are still a problem. Guidelines from the SMSIM model can benefit even advanced SMS used in South Africa by schools.

- *Most schools use a free version of SMS which often lacks features such as discipline, custom reports, registration, and inventory. Some are narrowed by space, the number of learners, and storage.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	2	20.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	3	30.00%
No answer	0	0.00%

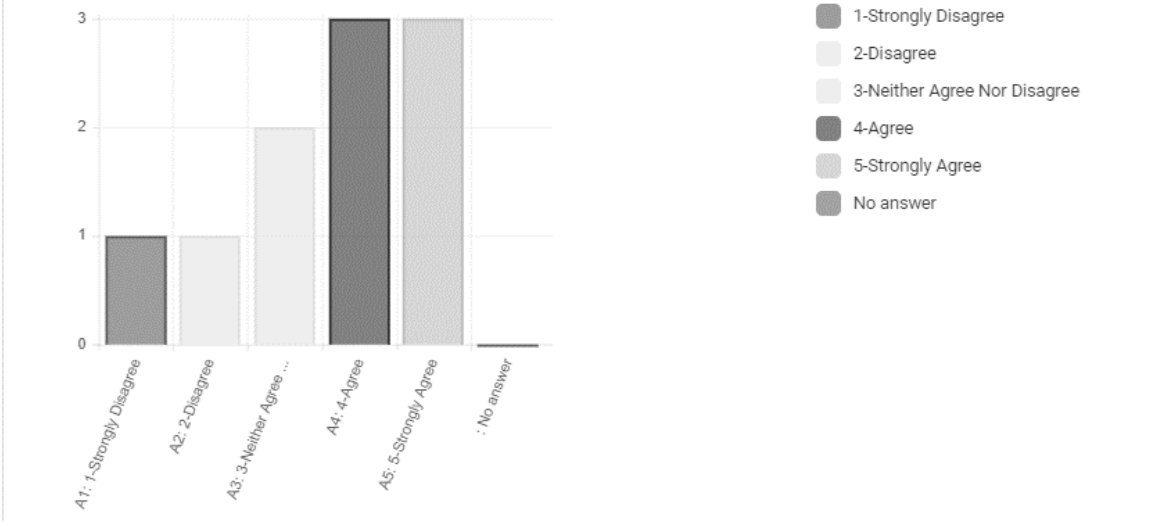


Figure 6-13: Q11 Delphi Round 1 Questionnaire

60% of the participants agreed with this statement and 20% disagreed, whereas 20% neither agreed nor disagreed. This result could be a because of experts who are using a paid version of SMS or knowledge of some schools that use a free version of SMS. According to Saadi (2017), there are various features that the open-source version is missing as compared to the commercial version, including inventory, custom reports, registration, and discipline. It is evident from both literature and expert results that many schools in South Africa use an open and free version of SMS. This open-source version often lacks some features and is narrowed by space capacity, storage, and the number of learners.

- *SMS are frequently installed on a single solitary computer, which restricts access, puts a lot of strain on the administrator working alone, and is the only resource accessible during periods of high demand, like the end of the term when schools must process learner reports. This causes inconvenient delays.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	2	20.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	2	20.00%
No answer	0	0.00%

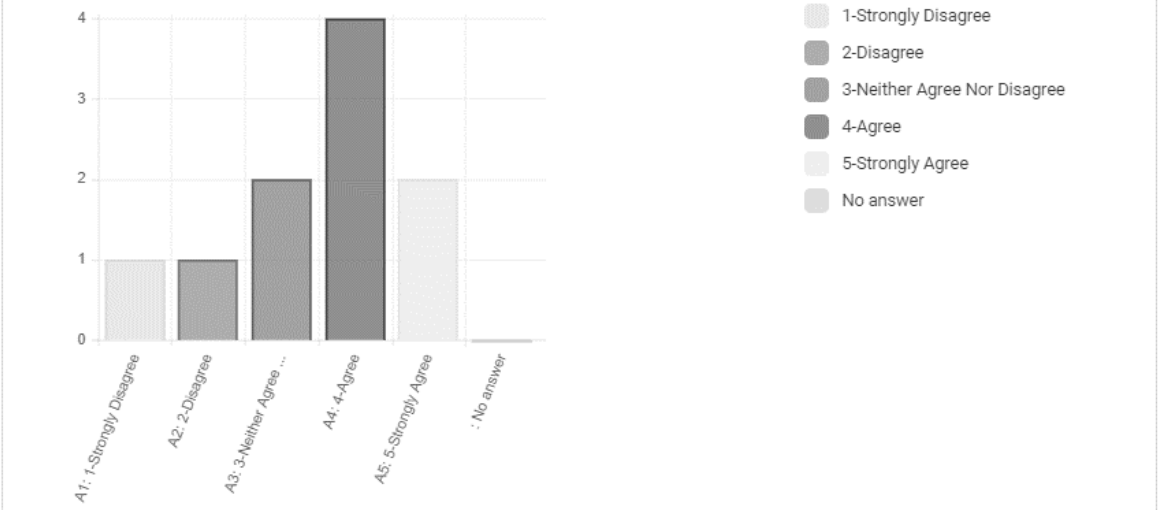


Figure 6-14: Q12 Delphi Round 1 Questionnaire

Unfortunately, SMSs are not completely interoperable and cannot be accessed anywhere hence 60% of the participants agreed with this statement. There is a lot of room for improvement in SMS hence the proposed SMSIM model can add a lot of value to schools (Maremi et al., 2020).

- *Teachers spend most of the teaching time manually capturing students' marks on never-ending sheets of paper, which increases the likelihood of mistakes, and have limited access to the system to accomplish simple activities like recording marks.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	3	30.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	1	10.00%
No answer	1	10.00%

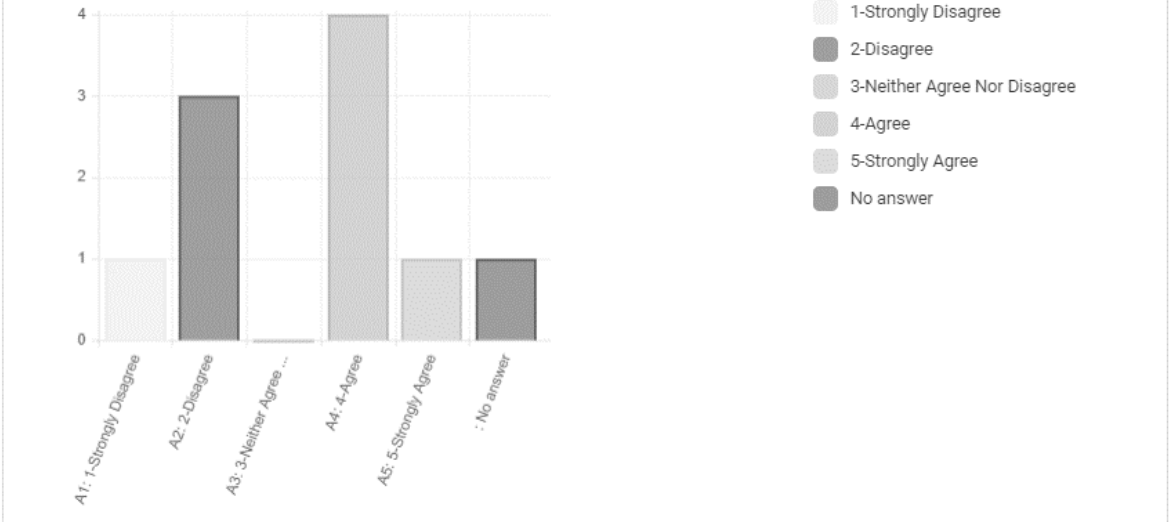


Figure 6-15: Q13 Delphi Round 1 Questionnaire

Not all the paid versions of SMS can be accessed from anywhere, which can be observed from the responded percentage of this statement. If you look at Ed-Admin, an SMS mentioned by some experts during the data collection process in round 1, Ed-Amin can be accessed by all users from anywhere through apps and the Internet. Ed-Admin is very interoperable (Walsh, 2022), which thoroughly delineates this disadvantage of SMS. The 10% of participants who strongly disagreed could have used Ed-admin as their SMS. Similarly, the 30% that disagreed could be that their SMS allows them to access the system from anywhere at any time. The SMSIM model can assess all SMS and evaluate what is needed to reach the next level.

- *Non-availability of skilled ICT personnel who can utilise the system. On the government's end, there is a lack of maintenance culture, appropriate and adequate availability of relevant software, data security, and impurity.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	2	20.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	2	20.00%
No answer	0	0.00%

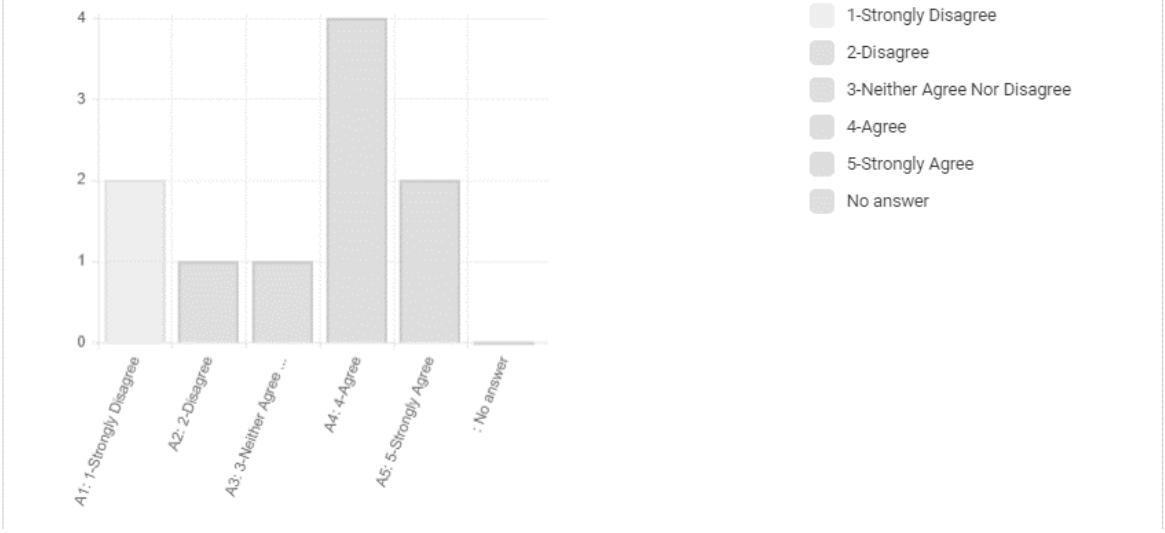


Figure 6-16: Q14 Delphi Round 1 Questionnaire

Looking at the outcome of this statement, 20% strongly disagreed, and this is subject to the type of SMS currently installed in the school. However, despite 20% of participants who strongly disagreed and 10% who disagreed, 60% of the participants agreed with the statement. This is still a high number of schools needing an improvement of their SMS.

- *SMS can only be accessed within the school's intranet.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	3	30.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	2	20.00%
No answer	0	0.00%

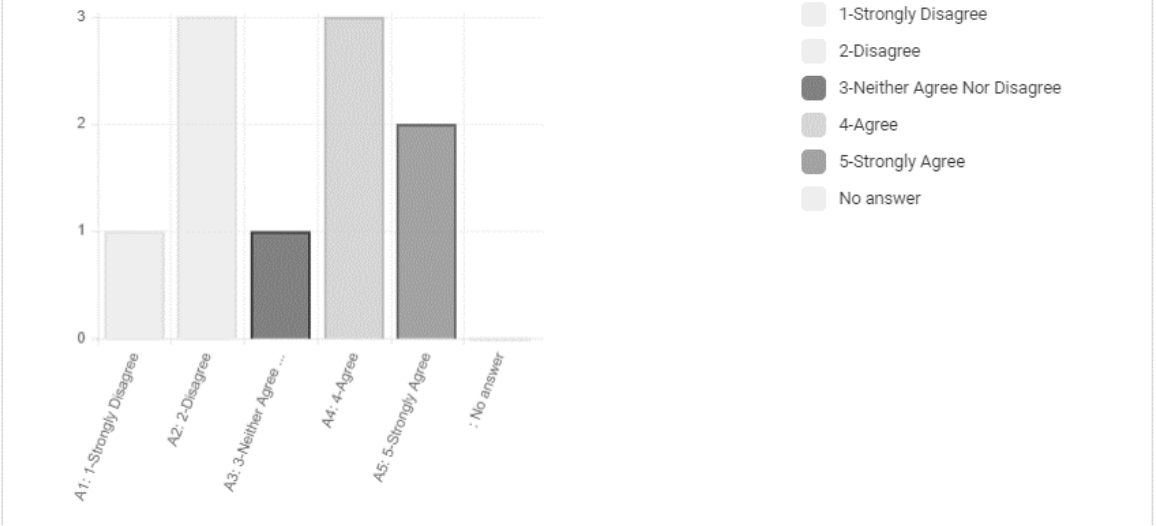


Figure 6-17: Q15 Delphi Round 1 Questionnaire

The outcome of this statement is subject to how SMS is accessed in schools. As per the results, 30% of the participants disagreed, this can be because the school uses Ed-admin or other SMS, which does not connect only to the school's intranet. Thwala (2019) and Kuriakose (2014) indicate that most open and free SMS are accessed through the intranet in the school premises. A total of 50% of participants agreed with the statement of SMS being accessible in the school premises through the intranet. It can be observed from the results that both literature and experts confirm that SMS are mostly accessed through the intranet of the school.

- *Limit learners and parents or guardians from accessing the learners' information*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	2	20.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	1	10.00%
No answer	1	10.00%

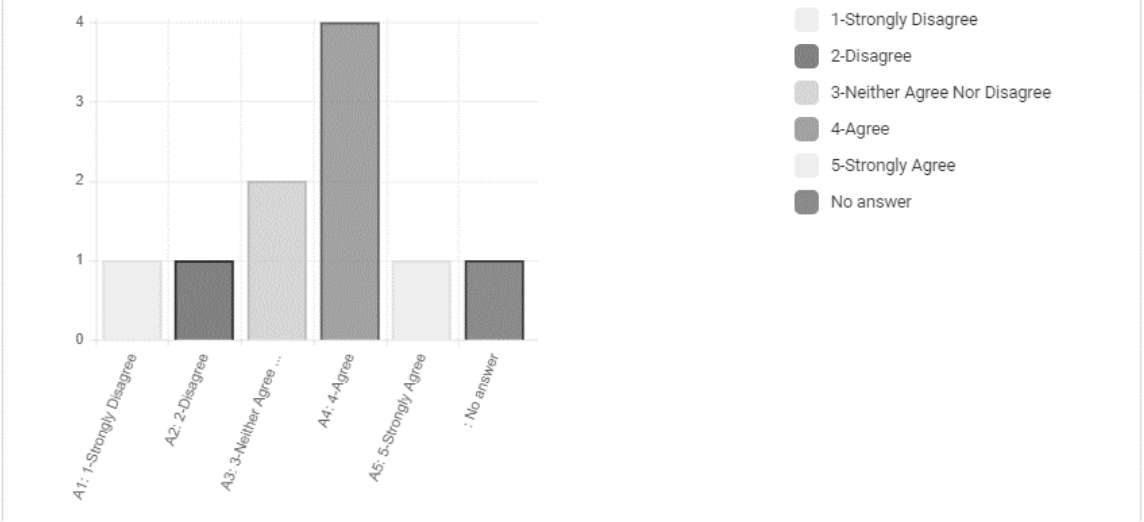


Figure 6-18: Q16 Delphi Round 1 Questionnaire

A total of 50% of experts or participants agreed with the statement, 20% neither agreed nor disagreed and a total of 20% disagreed. According to Muriithi and Masinde (2016), SMS that are installed on a standalone computer, limit access to information for learners, guardians and parents. It is, therefore, evident from the literature findings and the experts' results that SMS limits access to information for learners, guardians, and parents.

Experts who use Ed-Admin felt that it is probably the best thing to have happened to their school as it is accessible from anywhere in the world, and parents can access their child's information through a portal. In addition, termly reports can be obtained through the system, saving money (Walsh, 2022). SA-SAMS does not have any of these benefits, and literature finding supports this statement.

- *SMS has room for improvement due to its disadvantages*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	6	60.00%
No answer	0	0.00%

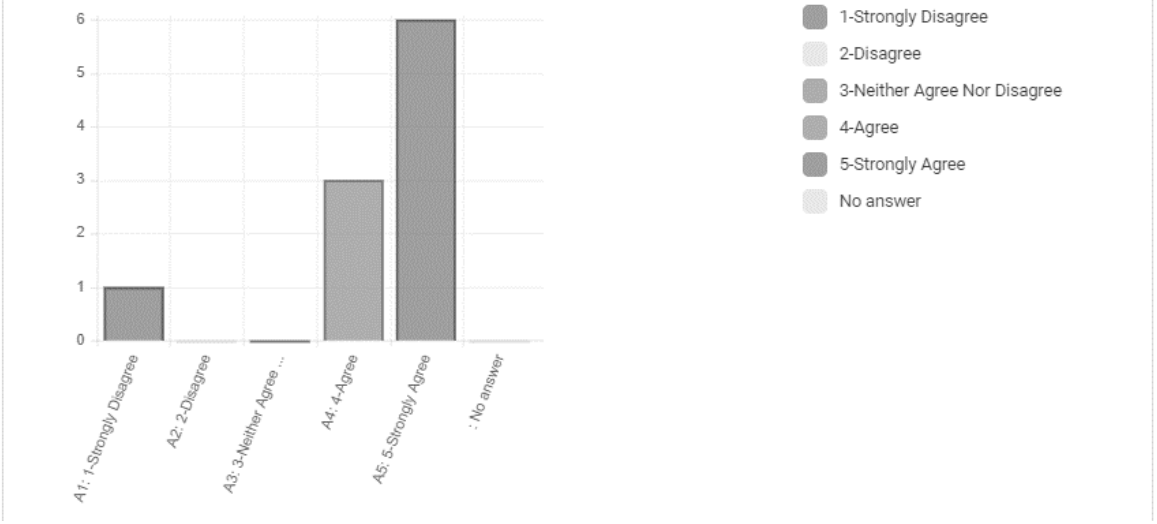


Figure 6-19: Q17 Delphi Round 1 Questionnaire

90% of participants agreed that SMS has room for improvement. The reality is that SMSs different from SA-SAMS are not integrated with the DBE, and interoperability must be implemented to integrate these systems for a seamless information flow from one entity to another (Muriithi & Masinde, 2016).

- *Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include:*

- Reducing the burden on staff members of the school to enter data

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	5	50.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

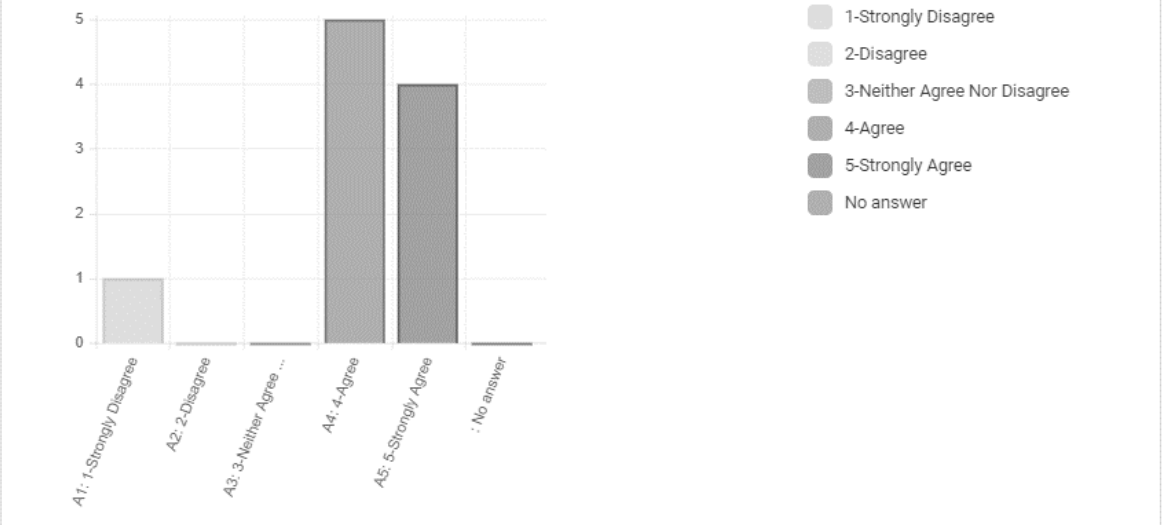


Figure 6-20: Q18 Delphi Round 1 Questionnaire

90% of participants agreed with the statement with interoperability, the burden on staff members of the school to enter data can be significantly reduced. Other experts in the comment section of this Likert statement, indicated that the burden on school staff members to enter data could only be significantly reduced if the SMS is a system that can be used at any time and is not limited by the disadvantages of the old version. Ed-Admin can be accessed from anywhere and anytime as per their website and experts' responses (Walsh, 2022). However, there is no evidence that this system is not limited by the disadvantages of the old version or legacy systems.

Cooper (2014) indicated that interoperability has educational benefits that can help address the disadvantages of SMS, thus reducing the burden on staff members to enter data. The literature and experts' results solidify the importance of interoperability in significantly reducing the burden on staff members to enter data.

- Improving data quality

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	3	30.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	2	20.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

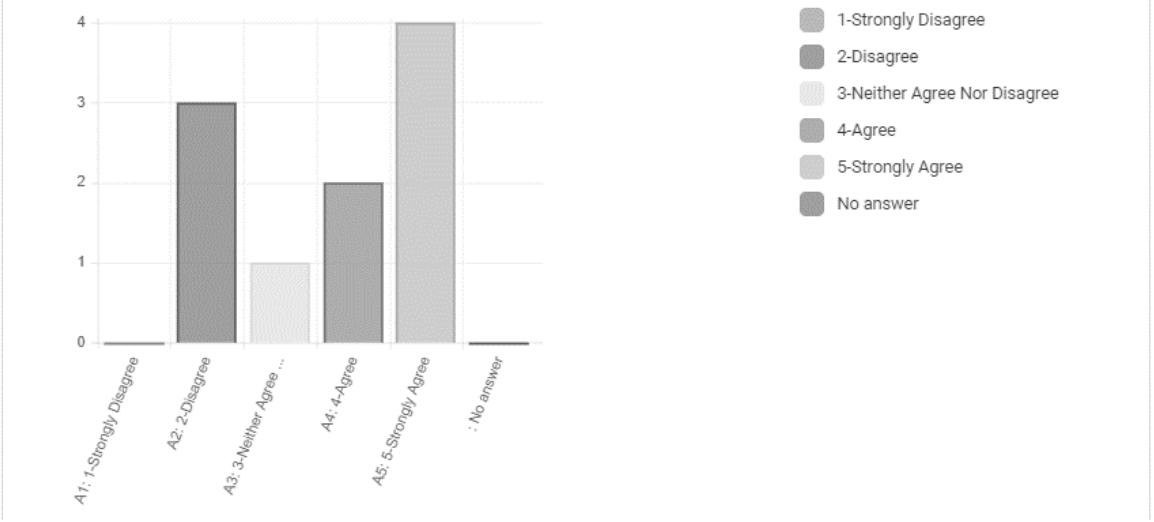


Figure 6-21: Q19 Delphi Round 1 Questionnaire

40% disagreed that interoperability can improve data quality. Despite that outcome, 60% of the participants support the statement. Cooper (2014) further identified another educational interoperability benefit: it improves data quality. Therefore, it is evident from the high percentage of experts who agreed with the statement and literature finding that interoperability can enhance data quality.

- Promoting adaptability and promote data sharing

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	3	30.00%
4-Agree (A4)	1	10.00%
5-Strongly Agree (A5)	6	60.00%
No answer	0	0.00%

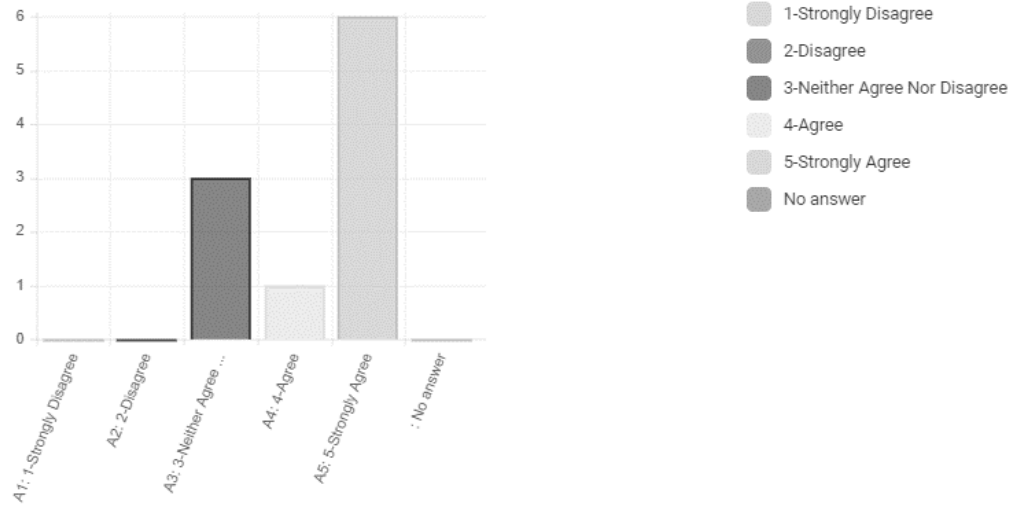


Figure 6-22: Q20 Delphi Round 1 Questionnaire

70% of participants who understand how interoperability works and the benefits it provides support the statement. However, 30% of participants opted to neither agree nor disagree. With interoperability, systems can communicate and exchange data seamlessly. Rajkumar, Muzoora and Thun (2022) indicate that the benefits of interoperability are endless and further identify information sharing and adaptability (the capacity to be modified for a new use or purpose) as some of the benefits of interoperability. Both literature and expert results confirm that interoperability can benefit education by promoting adaptability and data sharing.

- Supporting data-driven decision making

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	2	20.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

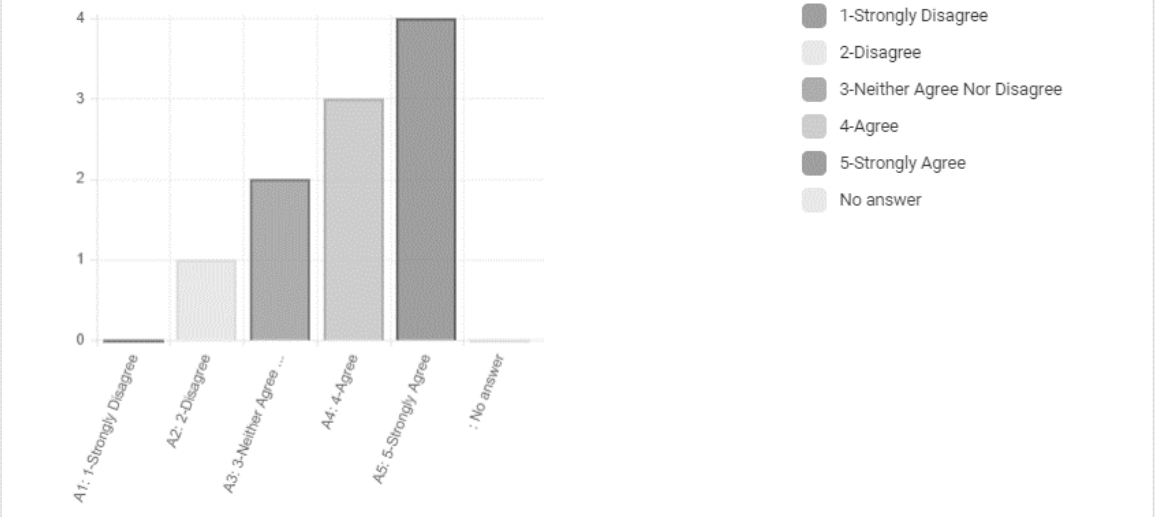


Figure 6-23: Q21 Delphi Round 1 Questionnaire

A total of 70% of participants support the benefit of interoperability. However, 30% disagreed or did not provide an answer to the statement. Rajkumar *et al.* (2022) further indicate that interoperability supports data-driven decision-making. The results showed that 20% of the participants neither agreed nor disagreed with the statement. This suggests that perhaps not everyone is aware of the benefits of interoperability in the education system and awareness must be made to enlighten people. Despite that, it is evident that both literature and expert results support the educational benefit of interoperability of data-driven decision-making.

- Enhancing efficiency and timeliness

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	2	20.00%
5-Strongly Agree (A5)	7	70.00%
No answer	0	0.00%

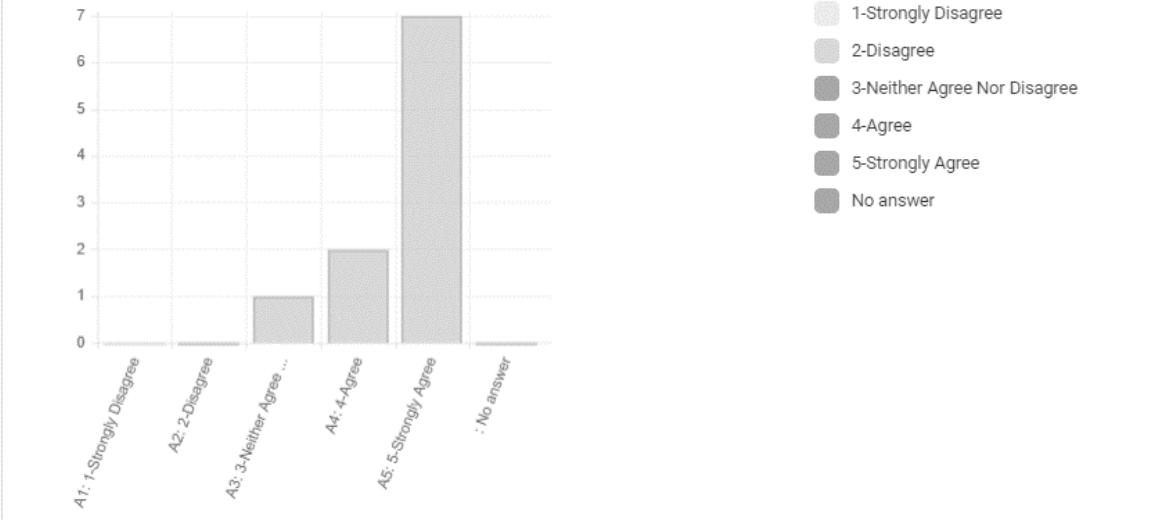


Figure 6-24: Q22 Delphi Round 1 Questionnaire

A total of 90% of the participants supported this statement. However, 10% neither agreed nor disagreed. The comments section in the questionnaire, indicated that interoperability exists in SMSs different from SA-SAMS, especially in Ed-Admin. Among the many benefits of interoperability mentioned by Rajkumar et al. (2022), enhancing efficiency and timeliness is one of them. The literature and expert results confirm the usefulness of interoperability in the education sector, enhancing efficiency and timelessness.

- *These advantages of interoperability can enhance SMS to ensure an improved overall information flow for effective decision-making and management of schools*

Answer	Count	Percentage
1-Strongly Disagree (A1)	1	10.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	2	20.00%
4-Agree (A4)	2	20.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

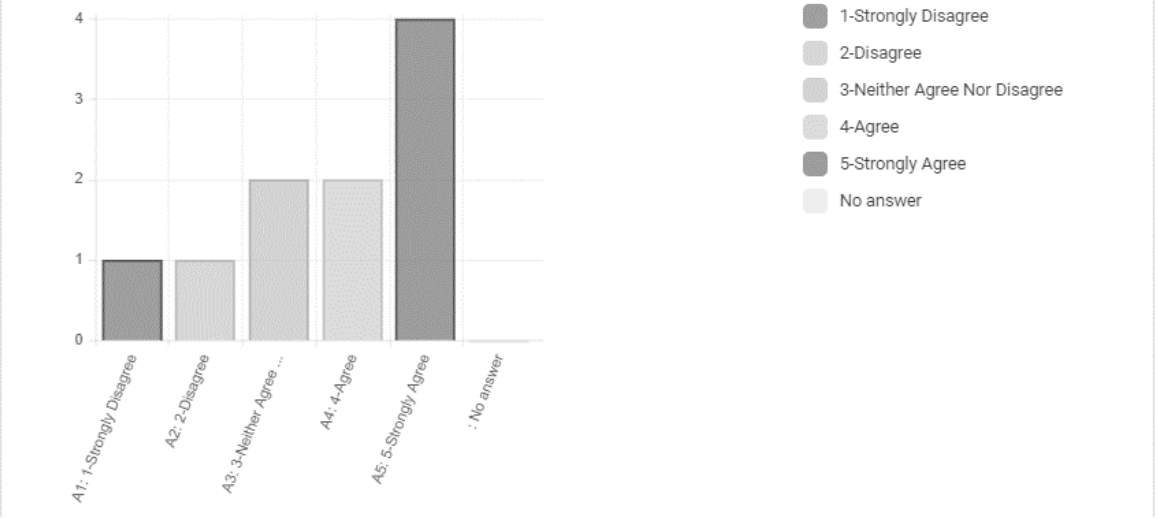


Figure 6-25: Q23 Delphi Round 1 Questionnaire

This question was very tricky to answer especially when experts do not fully understand the benefits of interoperability. Nonetheless, 60% of participants supported the statement, 20% neither agreed nor disagreed, and 20% disagreed with the statement.

- *Interoperability is the platform that provides continuous information exchange, for example, exchanging information that other systems can use to improve the performance, create services, control the processing of information systems and operations*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	2	20.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	2	20.00%
5-Strongly Agree (A5)	5	50.00%
No answer	0	0.00%

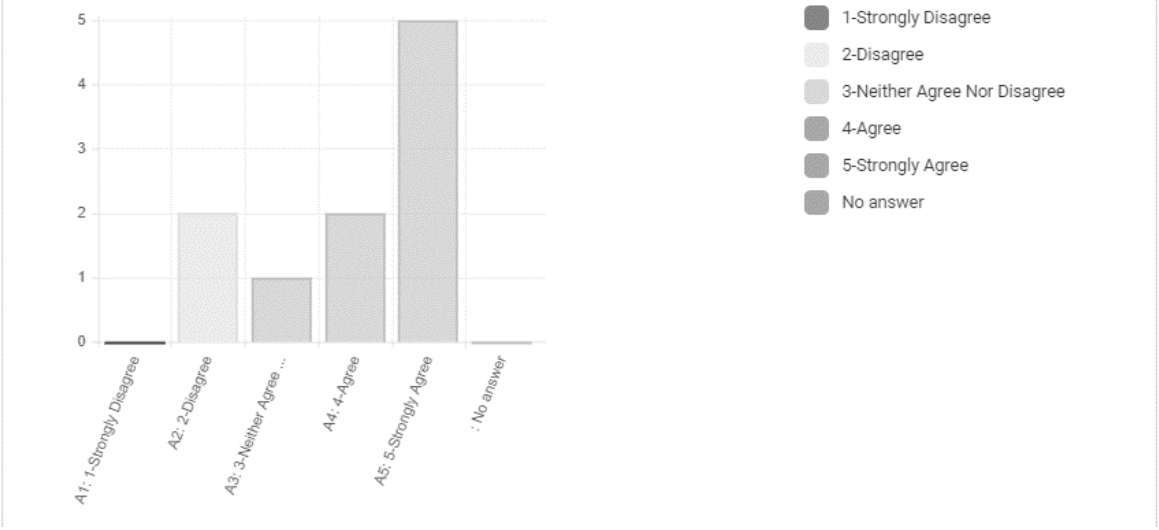


Figure 6-26: Q24 Delphi Round 1 Questionnaire

A total of 70% of experts supported the statement, the benefits of interoperability are evident and are realised by many experts in the education department. The SMSIM model uses a combination of the Organizational Interoperability Maturity Model (OIM) and Information System Interoperability Maturity Model (ISIMM) to assess the level of interoperability in SMS and provide guidelines to get to the level (Maremi *et al.*, 2020). However, getting to the next level requires budget and commitment from the school to invest in what is needed to reach the suggested level of interoperability with their SMS.

- *There is a need to conceptualize a model that will bring together interoperability in SMS*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	2	20.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	4	40.00%
No answer	0	0.00%

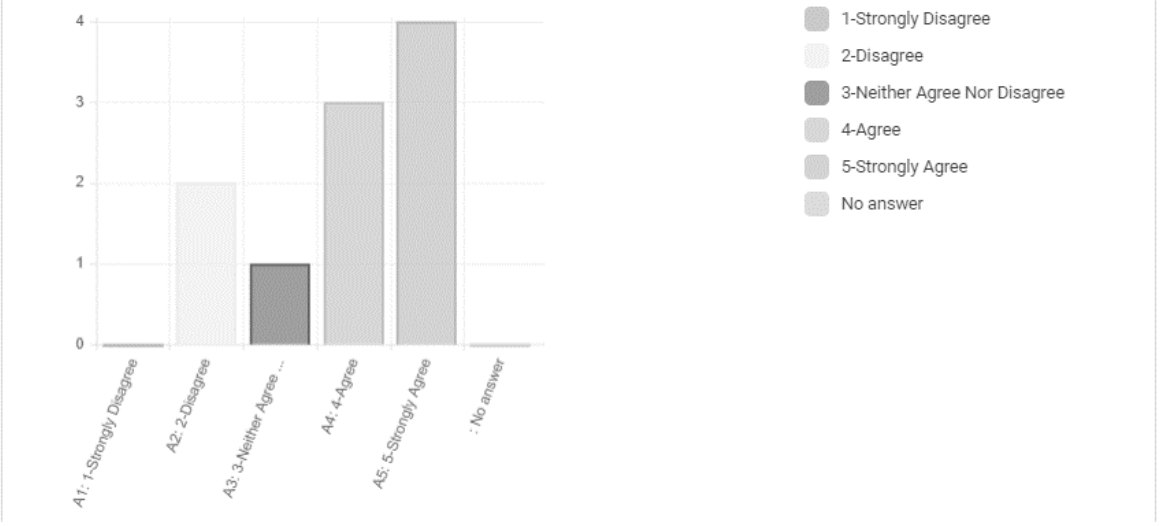


Figure 6-27: Q25 Delphi Round 1 Questionnaire

70% of participants agreed there is a need to conceptualize a model that will bring interoperability in SMS, and this is because interoperability is crucial for integrating all the systems. Unfortunately, interoperability also means the organization must allow access to their system from one department to the other and other departments prefers to work in silos to maintain privacy. This statement resulted in 20% disagreeing with it. This can be based on the disadvantages of interoperability, or the participants being delighted with the current SMS in use that they feel there is no need for improvements or SMS can be improved.

Experts who use Ed-Admin in the comment section of the questionnaire, indicated that interoperability educational benefit exists in Ed-Admin and not in SA-SAMS, as per their perception. This result motivated the need to test the validity, accuracy, and efficiency of the SMSIM model by assessing the level of interoperability in SMS.

Measures of central tendency (means, medians, and modes) as well as measures of dispersion, are the main statistics employed in Delphi studies (standard deviations and interquartile ranges)

(Hasson *et al.*, 2000; Hsu & Sandford, 2007). The use of Likert-type scores, based on median scores, is highly recommended in the literature (Hill & Fowles, 1975; Hsu & Sandford, 2007). According to estimates, the Delphi consensus varies between 55 and 100%, with 70% being the norm (Vernon, 2009; Avella, 2016). Means and standard deviations were calculated to quantify the level of agreement among experts. The mean of a data set represents its central tendency. In the analysis of a set of data, central tendency identifies the central position of the data within the set (Chakrabarty, 2021). The standard deviation measures how skewed the data are in relation to the mean. The values are near to the mean or expected value when the standard deviation is low. However, a high standard deviation suggests that the results are spread out over a wider range (Hargrave, 2022). Based on the mean and standard deviation, participants' perceptions were analyzed and grouped according to their Likert-scale scores.

The main purpose of the first round was to verify the problems of SMS and validate the need for a SMSIM model that can help improve SMS. The themes were converted into statements and questions and a Likert scale was used to rank these themes which developed a questionnaire, and the set agreement consensus was set at 55%. As observed from the figure below, questions about the disadvantages of SMS have a higher percentage than the set agreement consensus, and this validated the need for round 2 which will introduce a SMSIM model to experts for evaluation. As can be observed from the figure below, 70% of experts agreed that there is a need to conceptualize a model that will bring together interoperability in SMS, the overall feedback from the questionnaire also validated the need to for the SMSIM model and this made provision for the second iteration.

Furthermore, based on the std deviation of this figure, most experts favoured the “Strongly agree” and “Agree” ranks rather than the rest as it resonated more with their field of expertise and reality.

Table 6-1: Iteration 1: Descriptive statistics

Questionnaires	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	No Answer	Mean	stdDeve	Percentage
School Management Systems (SMS) are large repositories that schools use to manage the day-to-day administrative activities of the school	5	3	0	0	2	0	1.666667	2.065591	80%
Multiple users use SMS, and these can be configured to meet the needs of each school independently	4	4	0	2	0	0	1.666667	1.966384	80%
SMS help to overcome monotonous paperwork in schools, are very easy to use, and can work accurately and smoothly in different scenarios. SMS reduce workload, increases efficiency in school management, and saves time	5	4	1	0		0	1.666667	2.250926	90%
Many schools in South Africa use a SMS called SA-SAMS (South African School and Administration Management System) as mandated by the South African Department of Education	3	4	2	1	0	0	1.666667	1.632993	70%
To make the administration of schools more effective, the DBE developed SA-SAMS to solve not only management and administration challenges but also to streamline data in schools.	4	4	1	0	1	0	1.666667	1.861899	80%
Not all schools in South Africa are using SA-SAMS, but their SMS should easily integrate with SA-SAMS to reduce duplicate work	3	3	3	0	0	1	1.666667	1.505545	60%
Disadvantages of SMS includes: Increased workloads for teachers	2	5	1	0	2	0	1.666667	1.861899	70%
Disadvantages of SMS includes: Duplication of Work	3	3	0	3	1	0	1.666667	1.505545	60%
Disadvantages of SMS includes: Redundancy and errors	3	3	1	2	1	0	1.666667	1.21106	60%
Disadvantages of SMS includes: Delays for the submission of reports to the DBE by schools	4	5	0	1	0	0	1.666667	2.250926	90%
Most schools use a free version of SMS which often lacks features such as discipline, custom reports, registration, and inventory. Some are narrowed by space capacity, the number of learners, and storage.	3	3	2	1	1	0	1.666667	1.21106	60%
SMS are often installed on one standalone computer, which limits access, which causes substantial tension and stress on the administrator working alone and is the only resource available during peak demand times such as the end of the term when schools are required to process learner reports. This mostly results in annoying delays.	2	4	2	1	1	0	1.666667	1.36626	60%
Teachers have a small amount of access to the system for performing simple tasks like capturing marks and mostly consume teaching time by manually validating learners' marks on paper that are never-ending, increasing the chances of errors.	1	4	0	3	1	1	1.666667	1.505545	50%
Non-availability of skilled ICT personnel who can utilise the system. There is a lack of specific and inadequate availability of relevant software, lack of maintenance culture, and lack of data security and impurity on the government's side.	2	4	1	1	2	0	1.666667	1.36626	60%
SMS can only be accessed within the school's intranet.	2	3	1	3	1	0	1.666667	1.21106	50%
Limit learners and parents or guardians from accessing the learners' information	1	4	2	1	1	1	1.666667	1.21106	50%
SMS has room for improvement due to its disadvantages	6	3	0	0	1	0	1.666667	2.42212	90%
Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include: Reducing the burden on staff members of the school to enter data	4	5	0	0	1	0	1.666667	2.250926	90%
Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include: Improving data quality	4	2	1	3	0	0	1.666667	1.632993	60%
Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include: Promoting adaptability and promote data sharing	6	1	3	0	0	0	1.666667	2.42212	70%
Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include: Supporting data-driven decision making	4	3	2	1	0	0	1.666667	1.30384	70%
Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include: Enhancing efficiency and timeliness	7	2	1	0	0	0	1.666667	2.73252	90%
These advantages of interoperability can enhance SMS to ensure an improved overall information flow for effective decision-making and management of schools	4	2	2	1	1	0	1.666667	1.36626	60%
Interoperability is the platform that provides continuous information exchange, for example, exchanging information that other systems can use to improve the performance, create services, control the processing of information systems and operations	5	2	1	2	0	0	1.666667	1.861899	70%
There is a need to conceptualize a model that will bring together interoperability in SMS	4	3	1	2	0	0	1.666667	1.632993	70%

6.3.2.2 Ed-Admin

During the first round of the Delphi questionnaire, various experts highly mentioned Ed-Admin as a School Management System (SMS) that is interoperable and 100% better than SA-SAMS. Based on this response, the researcher felt the need to investigate this SMS further. It was also important to use the SMSIM model to assess the level of interoperability in the Ed-Admin, which aimed to evaluate if the SMSIM model is accurate, is of quality and its ability to deliver what it intends to achieve. The following section discusses a summary of the Ed-Admin based on the information provided on the Ed-Admin website, a complete reflection of what the system can do can only be provided by the company to the client.

Ed-Admin is an all-in-one School Management Software. It is a powerful and intuitive learning management software, that offers a complete package for schools. Schools, Higher Education Institutions and Government, can use it as their core goal is to help institutions grow (Göpper, 2020; Walsh, 2022). This management software is designed to scale with the needs of universities and colleges. This one-platform design allows the school's information to always be at your fingertips. In addition, Ed-admin, as SMS, will enable institutions to coordinate and network effectively. Every element, from student performance to principal reports, is traceable and customizable to suit the school's needs.

With Ed-Admin, all the resources required to manage funds are kept in one location. At your fingertips are everything from customer records and employee payroll to tuition and application fees. Batch payments, automatic statements, and payment gateways are tooling the school can employ to save time and please parents, clients, and suppliers. By integrating the school's admission module with Ed-website, Admin's the admission process may be easily handled from inquiry to enrolment, and automated procedures from enrolment to re-enrolment to online fee collection can be enjoyed. Additionally, it gives the institution the chance to use analytics to expand its academy. With comprehensive analytics monitoring, schools can pinpoint their pupils' strengths and problems.

- More than 40 Modules: More than 40 modules make up Ed-Admin, which covers every area of managing education, from finances and academic resources to personnel administration and communication. Figure 6-8 shows the 40 modules of Ed-Admin.

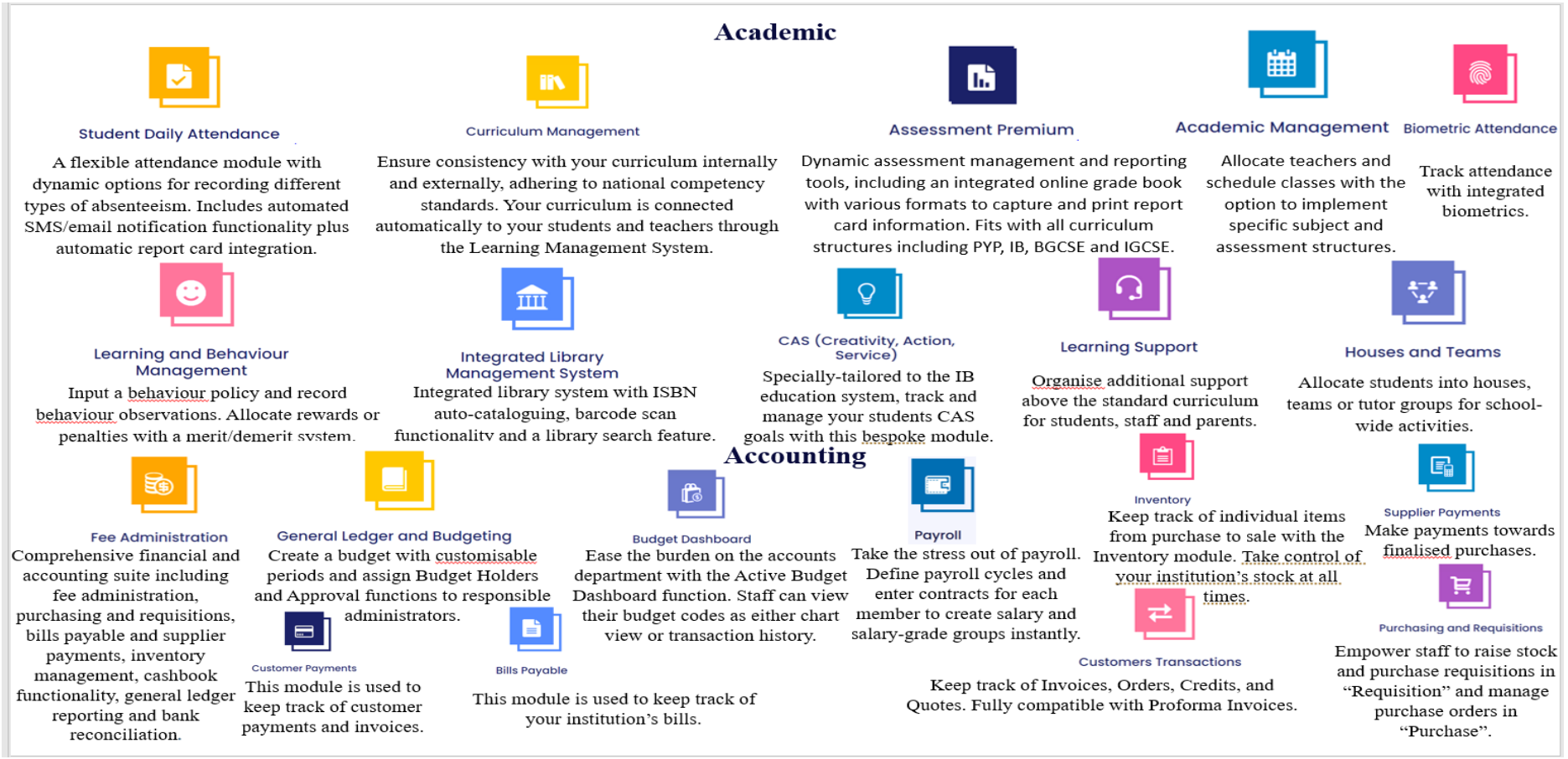

Academic
Student Daily Attendance
A flexible attendance module with dynamic options for recording different types of absenteeism. Includes automated SMS/email notification functionality plus automatic report card integration.
Curriculum Management
Ensure consistency with your curriculum internally and externally, adhering to national competency standards. Your curriculum is connected automatically to your students and teachers through the Learning Management System.
Assessment Premium
Dynamic assessment management and reporting tools, including an integrated online grade book with various formats to capture and print report card information. Fits with all curriculum structures including PYP, IB, BGCSE and IGCSE.
Academic Management
Allocate teachers and schedule classes with the option to implement specific subject and assessment structures.
Biometric Attendance
Track attendance with integrated biometrics.
Learning and Behaviour Management
Input a behaviour policy and record behaviour observations. Allocate rewards or penalties with a merit/demerit system.
Integrated Library Management System
Integrated library system with ISBN auto-cataloguing, barcode scan functionality and a library search feature.
CAS (Creativity, Action, Service)
Specially-tailored to the IB education system, track and manage your students CAS goals with this bespoke module.
Learning Support
Organise additional support above the standard curriculum for students, staff and parents.
Houses and Teams
Allocate students into houses, teams or tutor groups for school-wide activities.
Accounting
Fee Administration
Comprehensive financial and accounting suite including fee administration, purchasing and requisitions, bills payable and supplier payments, inventory management, cashbook functionality, general ledger reporting and bank reconciliation.
General Ledger and Budgeting
Create a budget with customisable periods and assign Budget Holders and Approval functions to responsible administrators.
Budget Dashboard
Ease the burden on the accounts department with the Active Budget Dashboard function. Staff can view their budget codes as either chart view or transaction history.
Payroll
Take the stress out of payroll. Define payroll cycles and enter contracts for each member to create salary and salary-grade groups instantly.
Inventory
Keep track of individual items from purchase to sale with the Inventory module. Take control of your institution's stock at all times.
Supplier Payments
Make payments towards finalised purchases.
Customer Payments
This module is used to keep track of customer payments and invoices.
Bills Payable
This module is used to keep track of your institution's bills.
Customers Transactions
Keep track of Invoices, Orders, Credits, and Quotes. Fully compatible with Proforma Invoices.
Purchasing and Requisitions
Empower staff to raise stock and purchase requisitions in "Requisition" and manage purchase orders in "Purchase".

Figure 6-28: Modules of Ed-Admin

- Why Choose Ed-Admin Learning

The figure below provides valuable reasons why schools should choose to buy Ed-Admin as a SMS:

Figure 6-29: *Why choose Ed-Admin*

From Figure 6-29, it is evident that this SMS presents the other systems and applications Ed-Admin is integrated with.

Figure 6-29: Ed-Admin represents other systems and applications – therefore it was selected

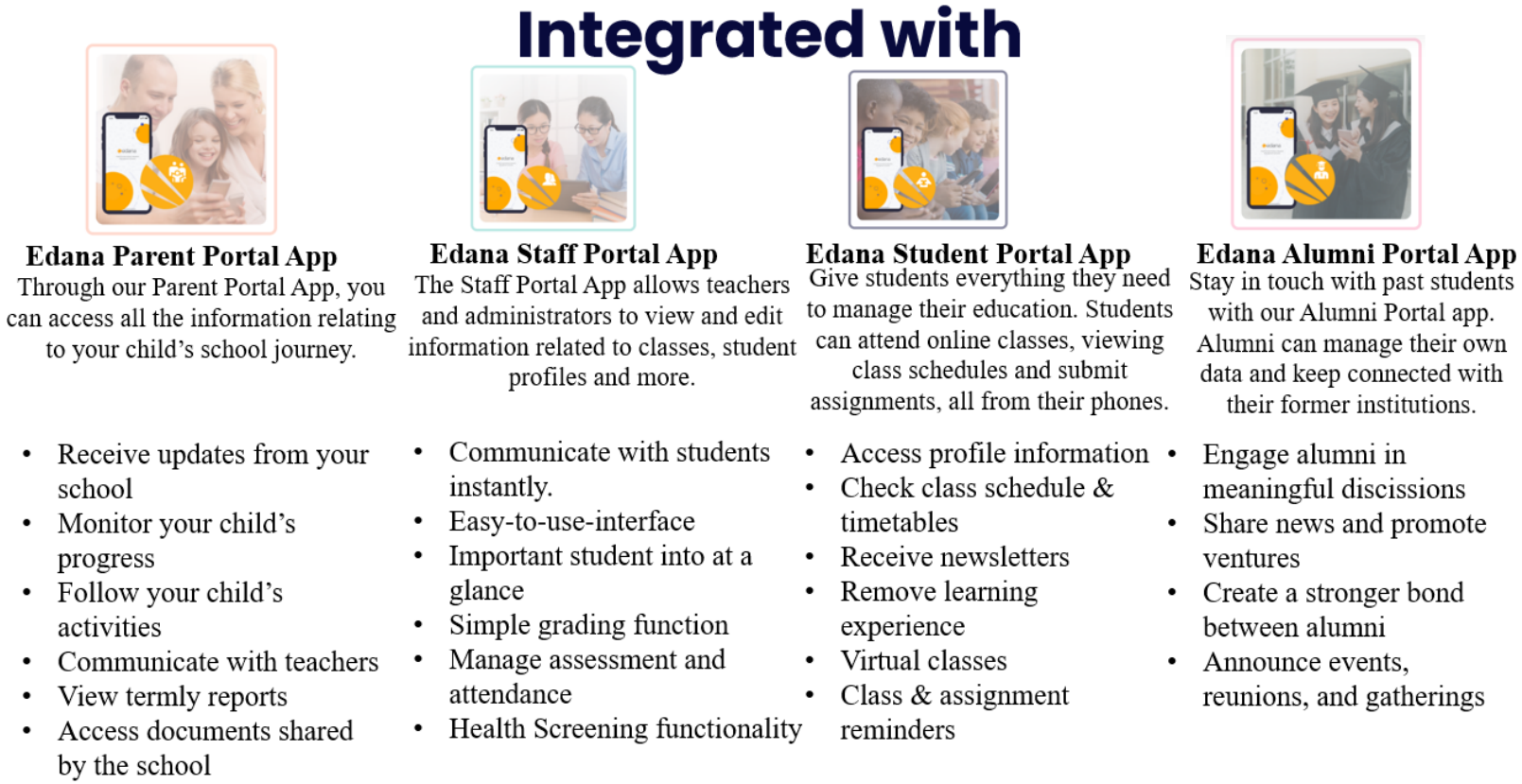


Figure 6-30: System Integrating with Ed-Admin

Ed-admin is integrating with other systems as seen in Figure 6-30, these systems allow Ed-Admin to be accessible using mobile apps from anywhere and at any time. Figure 6-31 below shows more systems integrating with Ed-Admin to enhance and better the School Management System (SMS).

Figure 6-31: Systems Integrating with Ed-Admin

Systems and applications in Figures 6-32 are included in Ed-Admin by request. This makes Ed-Admin customisable to schools as needed.

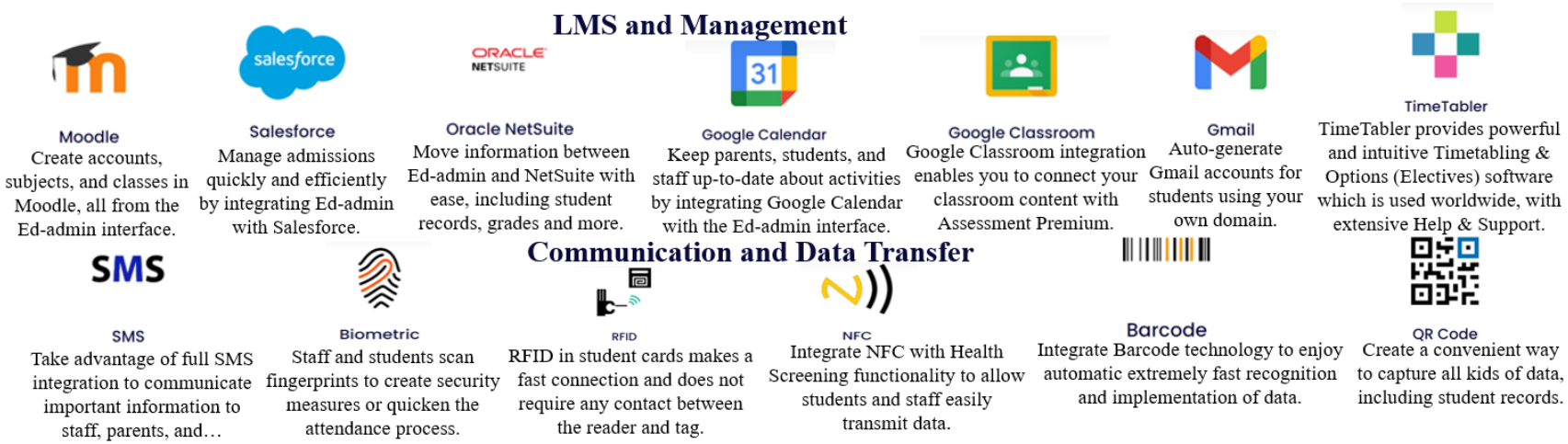


Figure 6-32: Integration

Integrations allow users to use all their favourite tools right from the Ed-admin interface. Streamline, sync, and even automate their tasks to make school management easier than ever.

More information about Ed-Admin can be obtained on their website (Ed-Admin, 2022).

Another SMS used by other schools is Saspac, another School Management System mentioned by some of the experts who participated in the study. The Saspac ERP for schools is created, maintained, and supported by Saspac, a company founded in 1979. Saspac ERP offers schools a comprehensive solution for both business and educational administration needs because it is both robust and simple to use (Göpper, 2020). This SMS is also not integrated with SA-SAMS. However, they export what is needed for the department into SA-SAMS. The section below presents the round 2 Delphi questionnaire.

6.4 USING THE SMSIM MODEL TO ASSESS ED-ADMIN

The results of the qualitative Delphi method in iteration one, identified Ed-Admin as a fully interoperable SMS that address disadvantages that other SMS have. This necessitated testing the SMSIM model for accuracy, validity, worth and efficiency. To do this, the SMSIM model was used to test Ed-Admin to identify the level of interoperability in the SMS and to provide guidelines on achieving the next level of interoperability. The section below, presents Ed-Admin and its level of interoperability. The accuracy of this section relies on the information provided on Ed-Admin website and can be further adjusted when implemented in schools based on the needs.

Chapter 4 detailed the SMSIM model and the steps that occur in this level. Section 6.5.1.2 of this chapter shows the final SMSIM model. According to the levels in the model, Ed Admin falls on the Intermediate level of interoperability. There is no evidence on the website that identifies and discusses the use of Ed-Admin to communicate with other schools. Ed-Admin is mostly used for school management rather than communication, thus this SMS is assessed and identified on the intermediate phase of the SMSIM model.

In the intermediate level, databases and applications are separate. Although there is basic data collaboration with other schools, no data is shared, and logical data models are shared. Communicating with other schools and sharing knowledge on specific topics is possible. The Ed-Admin website makes mention of how it can help institutions coordinate and network more efficiently. In contrast, it does not mention how institutions can coordinate and collaborate. Ed admin does not qualify in the secondary phase as this phase requires system integration between organizations. The tertiary phase is a long-term goal for many organizations worldwide, requiring full interoperability. Below is a picture view of where Ed-Admin lies in the SMSIM model.

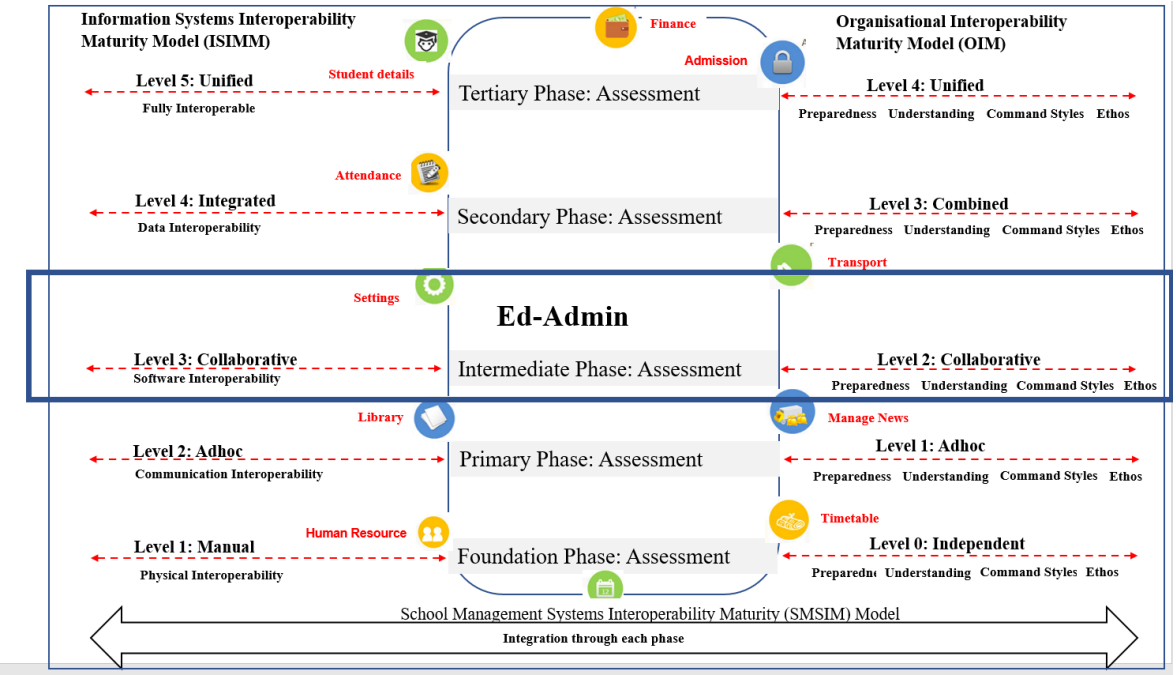


Figure 6-33: Level of interoperability in Ed-Admin

After the first round of Exploratory Delphi questionnaires a report was prepared and anonymously provided to the experts to reflect and change or adjust their initial responses if required and from this report, all experts did not need to change their initial responses, instead all experts were happy with the report and their initial response and all reached a consensus that round 2 that evaluate the SMSIM model is required. The report is attached in appendix E.

6.5 EXPERTS' RESULTS IN ITERATION 2

The section below presents the Delphi round 2 questionnaire questions with the results:

6.5.1 Round 2 of the Delphi Questionnaires

The first round of the Delphi study reached a 70% consensus that necessitated round 2 that eill focus on verifying and validating the SMSIM model (see Appendix E). The statements and questions in this section focus on the practical expertise of the subject matter experts, this section aims to unpack problems in SMS and how it can be improved using interoperability. When statements and questions were developed in this questionnaire, it was important to ensure that the round 1 questionnaires informed the round 2 questionnaire statements and an evaluation of the literature finding was conducted throughout the research to verify and validate the model based on determining the merit, worth, value, or significance. The section below presents the statements and questions of the Delphi round 2 questionnaires.

- *No doctrines are put in place that enables SMS to cooperate with other SMS.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	7	70.00%
5-Strongly Agree (A5)	3	30.00%
No answer	0	0.00%

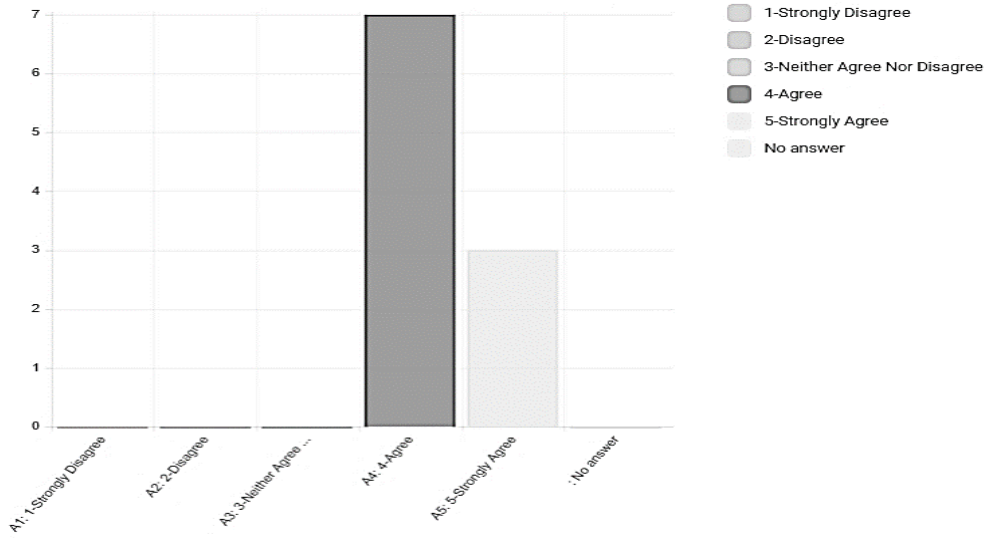


Figure 6-34: Q1 Delphi Round 2 Questionnaire

The main purpose of this statement was to confirm the lack of interoperability in SMS across schools. As per the results, 70% of the experts agreed with the statement, while the other 30% strongly agreed with the statement. The reality is that, although some schools in South Africa have a good SMS that is interoperable and can be accessed from anywhere in the world, and this was confirmed with round 1 questionnaires, access is still restricted to only the members of the school. Any other organization does not have a way rather than manual means to communicate with feeder schools or other schools. In this case, the SMSIM model places most schools in the foundation phase of interoperability, where systems are not connected, and communication is done partially manually, as in today's world, emails and telephones are used for communication.

- *Schools cannot use SMS to share information and communicate, importing data into SA-SAMS is done manually.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	4	40.00%
5-Strongly Agree (A5)	6	60.00%
No answer	0	0.00%

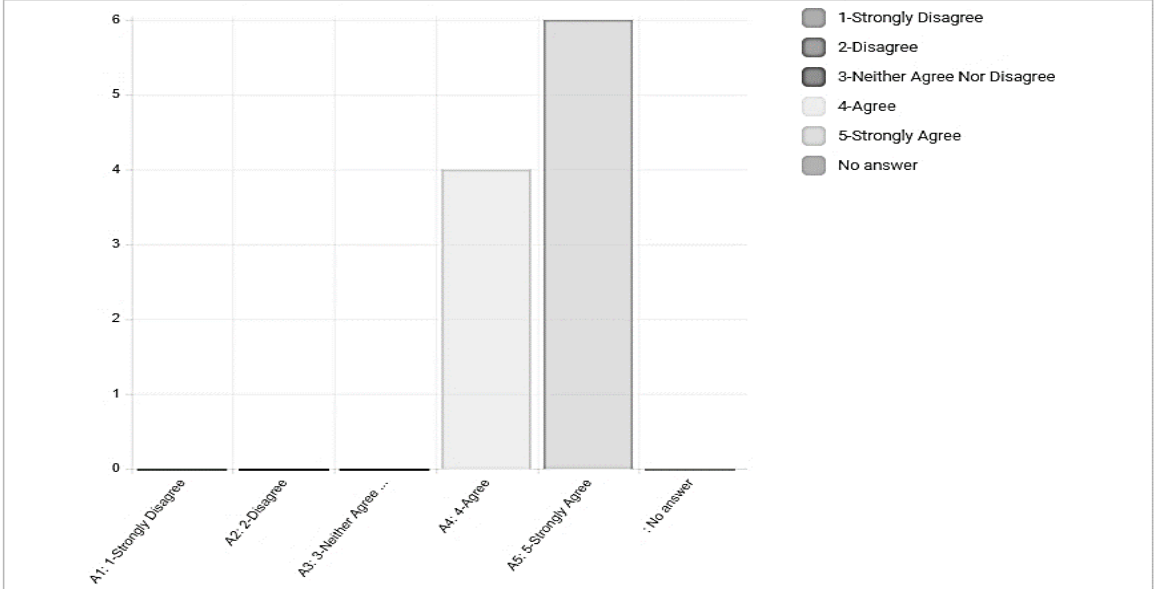


Figure 6-35: Q2 Delphi Round 2 Questionnaire

The statement above focussed on unpacking the ability of SMS to interoperate with other SMS. This boiled down to communication and information sharing. 40% of the experts agreed with the statement, whereas 60% of the experts strongly agreed with the statement. Based on the results, it is evident that South Africa has a long way to go in terms of integrating its education systems. Interoperability is the ultimate integration solution (Ostadzadeh *et al.*, 2015). When organizations cannot share information and communicate, Margariti et al. (2020) place these organizations at an adhoc level, the first level of interoperability maturity. The SMSIM model indicates that finance and legacy systems are the main barriers to interoperability.

- *Schools don't use SMS to share information and communicate with other schools.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	5	50.00%
5-Strongly Agree (A5)	5	50.00%
No answer	0	0.00%

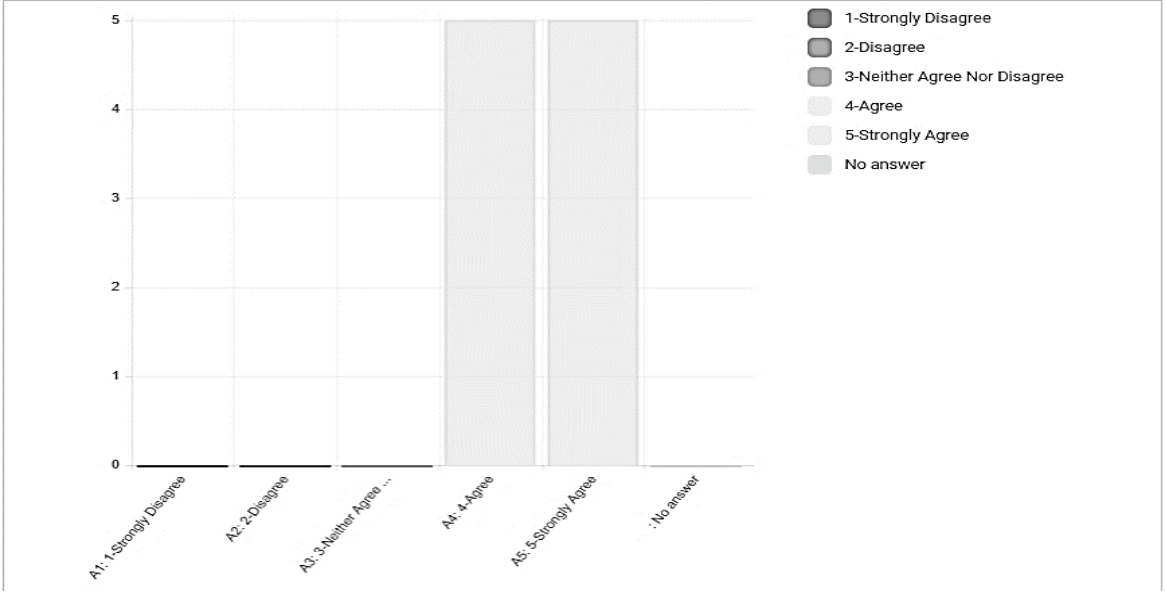


Figure 6-36: Q3 Delphi Round 2 Questionnaire

The past two statements and this statement are the same in that they unpack the interoperability of SMS. While the passed statement focused on the inability of schools to share information and communicate, this statement focuses on utilizing SMS to share information and communicate with other schools. This resulted in 50% of experts agreeing to the statement and the other 50% strongly agreeing to the statement. As in round 1 of the questionnaires, some experts who use Ed-Admin confirmed that the SMS does not have many of the disadvantages SA-SAMS has. Their SMS is interoperable to some degree, but unfortunately, the information sharing issue is still open for improvements. SMSs in South Africa are not used as a means of communication and information sharing. This validates the need for a SMSIM model that can assess SMS and provide guidelines for integrating SMSs.

- *In most schools, SMS is installed in a standalone computer with limited access.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	1	10.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	2	20.00%
5-Strongly Agree (A5)	7	70.00%
No answer	0	0.00%

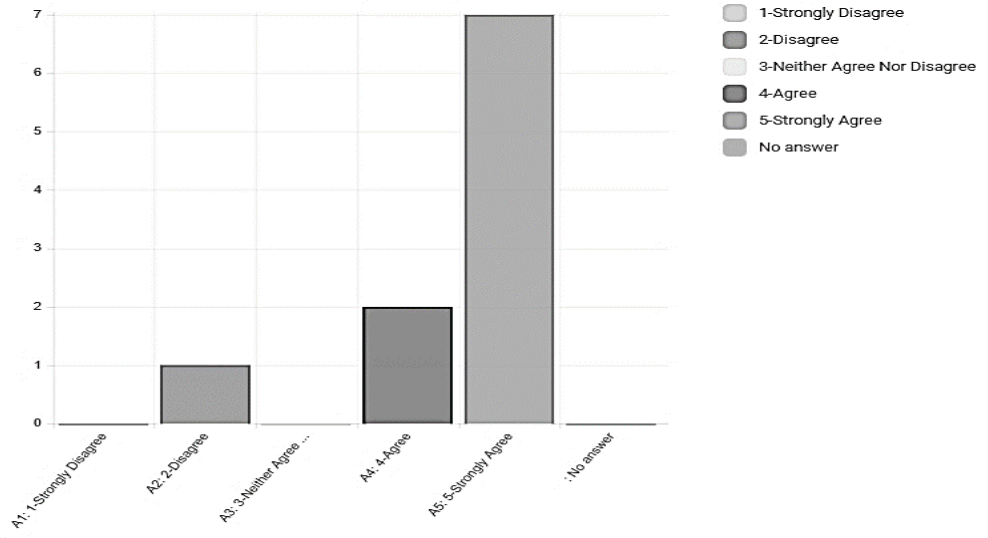


Figure 6-37: Q4 Delphi Round 2 Questionnaire

10% of the experts disagreed with the statement, this was evident even in the round 1 questionnaire as other schools use Ed-Admin, which can be accessed from anywhere in the world. This completely falsifies this statement in such an incident. However, based on the 70% of experts who strongly agreed with the statement and 20% who agreed, SMS has a long way to go in implementing interoperability. Ed-Admin is a good paid SMS that other SMSs can use to learn from. When assessed using the SMSIM model, Ed-Admin laid on the intermediate phase, which is a good level of interoperability.

- *All the other systems and applications that exist in schools are most probably not connected to SMS.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	5	50.00%
5-Strongly Agree (A5)	5	50.00%
No answer	0	0.00%

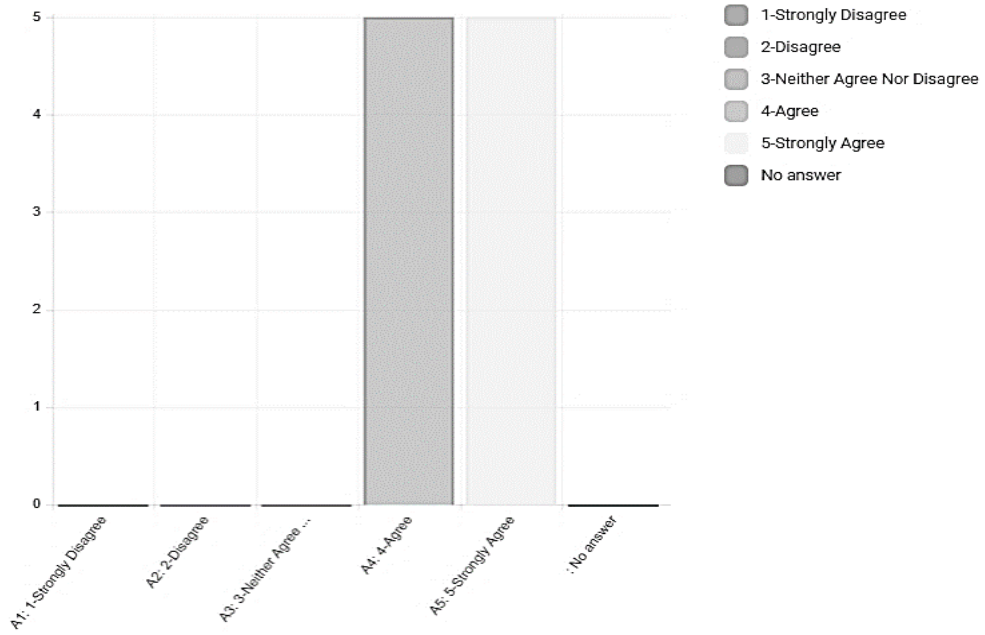


Figure 6-38: Q5 Delphi Round 2 Questionnaire

This statement resulted in 50% of experts agreeing and the other 50% strongly agreeing with the statement. As it can be observed, SMS can be interoperable on its own to a certain degree. However, it does not communicate with other systems and applications in the school. The SMSIM model provides guidelines that can help schools know what is required to get to the next level of interoperability. This is valuable because interoperability encourages system integrations; when systems are integrated, communication and information sharing become easy (Bone, Blackburn, Kruse, Dzielski, Hagedorn & Grosse, 2018).

- *The systems in the schools are most probably unable to share data and communicate with each other.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	7	70.00%
No answer	0	0.00%

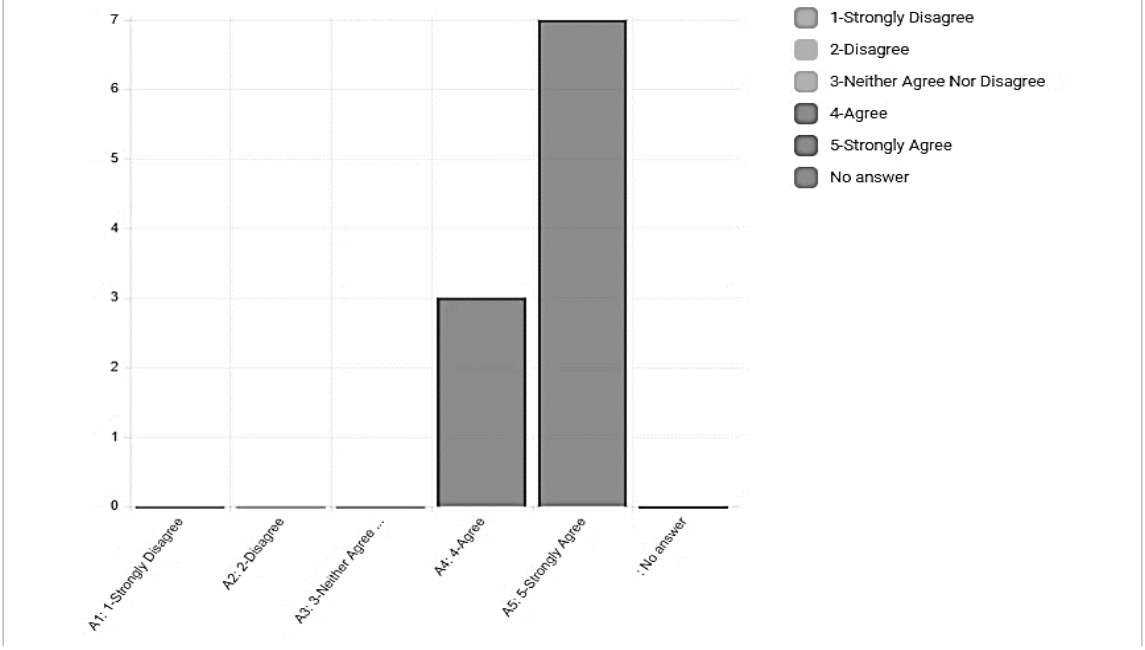


Figure 6-39: Q6 Delphi Round 2 Questionnaire

This is another statement that has a higher percentage of experts strongly agreeing with the statement. The reality is that systems in the schools are still separate, and there is no communication among them. However, SMS such as Ed-Admin reduces workloads on staff members as it can be accessed from anywhere (Walsh, 2022). Despite this fact, systems are still unable to interoperate. The SMSIM model offers guidelines for achieving system integrations not only to SA-SAMS but also to other systems in the school.

- *With the current state of SMS, the SMSIM model assesses the level of interoperability and shows guidelines for achieving the next level to address the disadvantages of SMS.*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	0	0.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	7	70.00%
No answer	0	0.00%

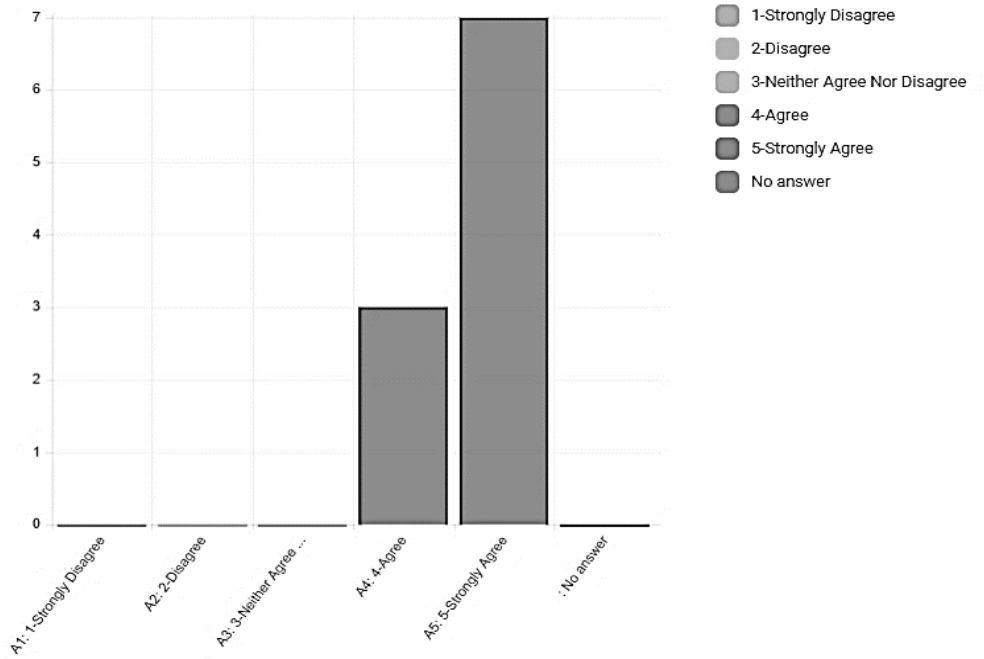


Figure 6-40: Q7 Delphi Round 2 Questionnaire

All experts who participated in the study, supported this statement. They agreed that the SMSIM model is able to assess the interoperability of SMS and provide guidelines as it intends to do, which is a good overall result that verifies and validates the accuracy, relevancy, merit and worth of the SMSIM model. Moreover, it shows that the model does what it intends to do.

- *Is the SMSIM model effectively and accurately able to assess the level of interoperability in SMS and provide guidelines on how to get to the next level?*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	3	30.00%
5-Strongly Agree (A5)	6	60.00%
No answer	0	0.00%

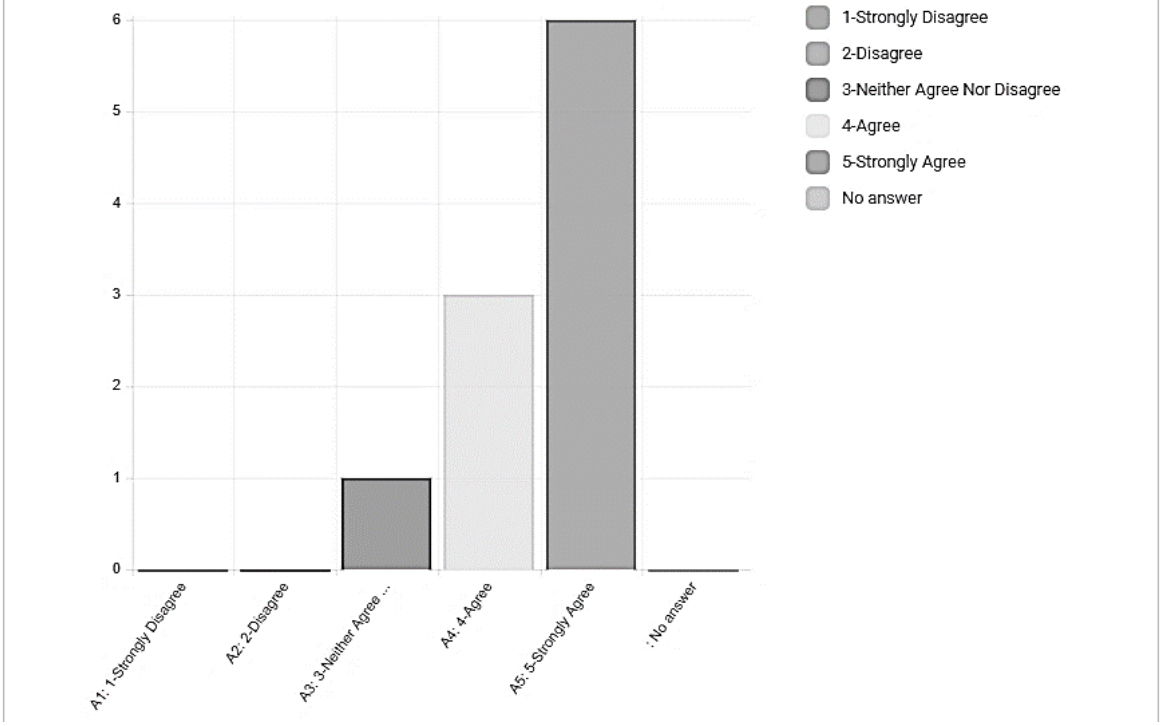


Figure 6-41: Q8 Delphi Round 2 Questionnaire

This question resulted in 90% of experts in support of the question. The 90% is formed by 60% of experts strongly agreeing with the posed question and 30% of experts who agreed with the statement. Without a reasonable doubt, experts in different fields of SMS and ICT in education, as well as interoperability as displayed in the demographic section of this chapter, agreed that this model is effectively and accurately able to do what it intends to do.

- *Is the SMSIM model a valid model for providing guidelines to address the current problems of SMS?*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	2	20.00%
5-Strongly Agree (A5)	7	70.00%
No answer	0	0.00%

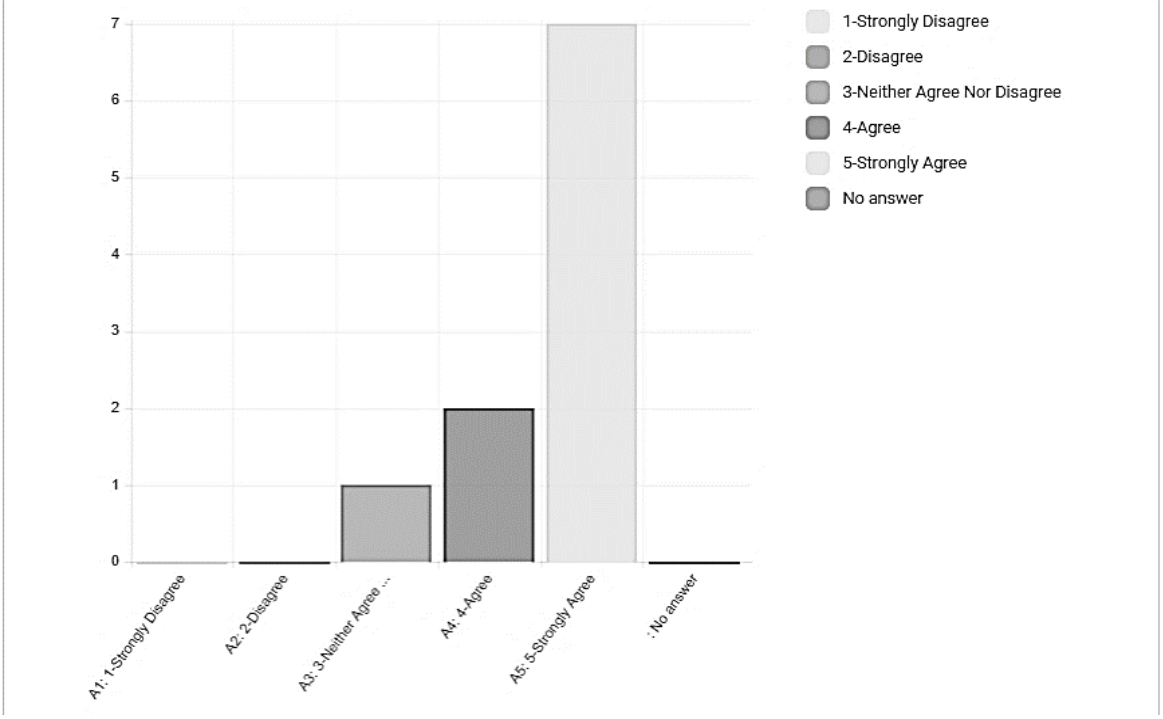


Figure 6-42: Q9 Delphi Round 2 Questionnaire

The result of this question is also satisfactory, with an overall agreement of 90% of experts supporting the validity of the model. As observed from the figure above, 70% of experts strongly agreed with the statement. In the comment section, experts felt,

> *"It is essential to share this model with DoE - they urgently need to fix SA-SAMS. This model is a good solution".*
>
> *"This model of yours can be regarded as a possible solution- I think it is innovative and well-researched".*
>
> *"Great model and worth pursuing to overcome current interoperability problems"*

Thus it can be worthwhile to utilise this model to potentially solve currently experienced SMS problems.

- *SMS will be improved when utilizing this model*

Answer	Count	Percentage
1-Strongly Disagree (A1)	0	0.00%
2-Disagree (A2)	0	0.00%
3-Neither Agree Nor Disagree (A3)	1	10.00%
4-Agree (A4)	2	20.00%
5-Strongly Agree (A5)	7	70.00%
No answer	0	0.00%

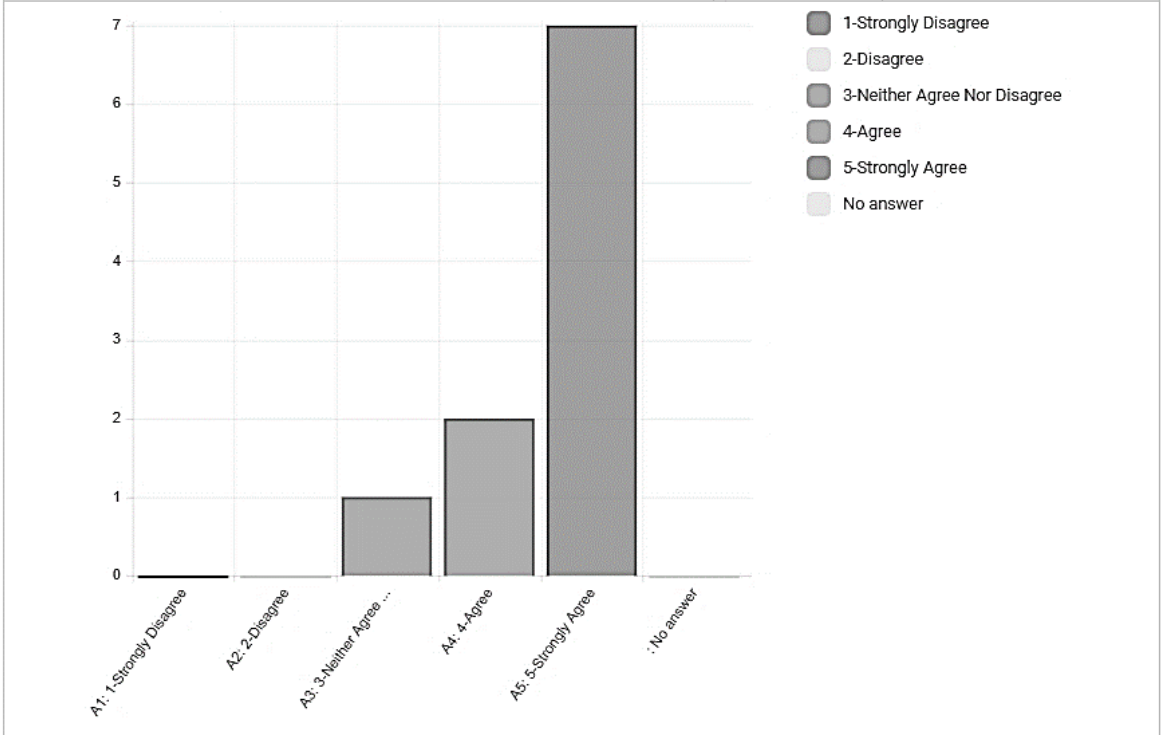


Figure 6-43: Q10 Delphi Round 2 Questionnaire

As with other questions about the model, this question also resulted in 90% of experts agreeing to the posed question. And the comment above bears' reference. This model is seen as a good model to overcome the current SMS problem. Moreover, it is said to be most valuable for improving SA-SAMS.

As observed from Table 6-2 below of iteration 2, the overall percentage is higher than the set agreement of consensus. Most experts agree that the SMSIM model is relevant to solve current SMS problems, specifically, problems in SA-SAMS. The overall purpose of this iteration was

to validate and verify the SMSIM model based on relevancy, accuracy, worth, validity, and efficiency to solve current problems experienced with SMS of schools in South Africa. Like iteration 1, themes were converted into statements and questions to develop the round 2 questionnaire, and the consensus of the agreement was set at 55% and a consensus for round 2 was reached at 100%.

The last question on how the model can be improved was answered by only one expert, indicating that the model can be simplified. The researcher felt that if the detailed information within the model is deleted, it may not be understood how the detail of the middle column is supported by the depth of each of the selected models on the side.

Table 6-2: Iteration 2: Descriptive statistics

Questionnaires	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	No Answer	Mean	stdDeve	Percentage
Schools cannot use SMS to share information and communicate, importing data into SA-SAMS is done manually.	6	4	0	0	0	0	1.666667	2.65832	100%
Schools don't use SMS to share information and communicate with other schools.	5	5	0	0	0	0	1.666667	2.581989	100%
In most schools, SMS is installed in a standalone computer and there is limited access.	7	2	0	1	0	0	1.666667	2.73252	90%
All the other systems and applications that exists in schools are most probably not connected to SMS.	5	5	0	0	0	0	1.666667	2.581989	100%
The systems in the schools are most probably unable to share data & communicate with each other.	7	3	0	0	0	0	1.666667	2.875181	100%
With the current state of SMS, the SMSIM Model assesses the level of interoperability and shows guidelines for achieving the next level to address the disadvantages of SMS.	7	3	0	0	0	0	1.666667	2.875181	100%
Is the SMSIM Model effectively and accurately able to assess the level of interoperability in SMS and provide guidelines on how to get to the next level?	6	3	1	0	0	0	1.666667	2.42212	100%
Is the SMSIM Model a valid model for providing guidelines to address the current problems of SMS?	7	2	1	0	0	0	1.666667	2.73252	90%
SMS will be improved when utilizing this model	7	2	1	0	0	0	1.666667	2.73252	90%

6.6 THE FINAL SCHOOL MANAGEMENT SYSTEMS INTEROPERABILITY MATURITY (SMSIM) MODEL

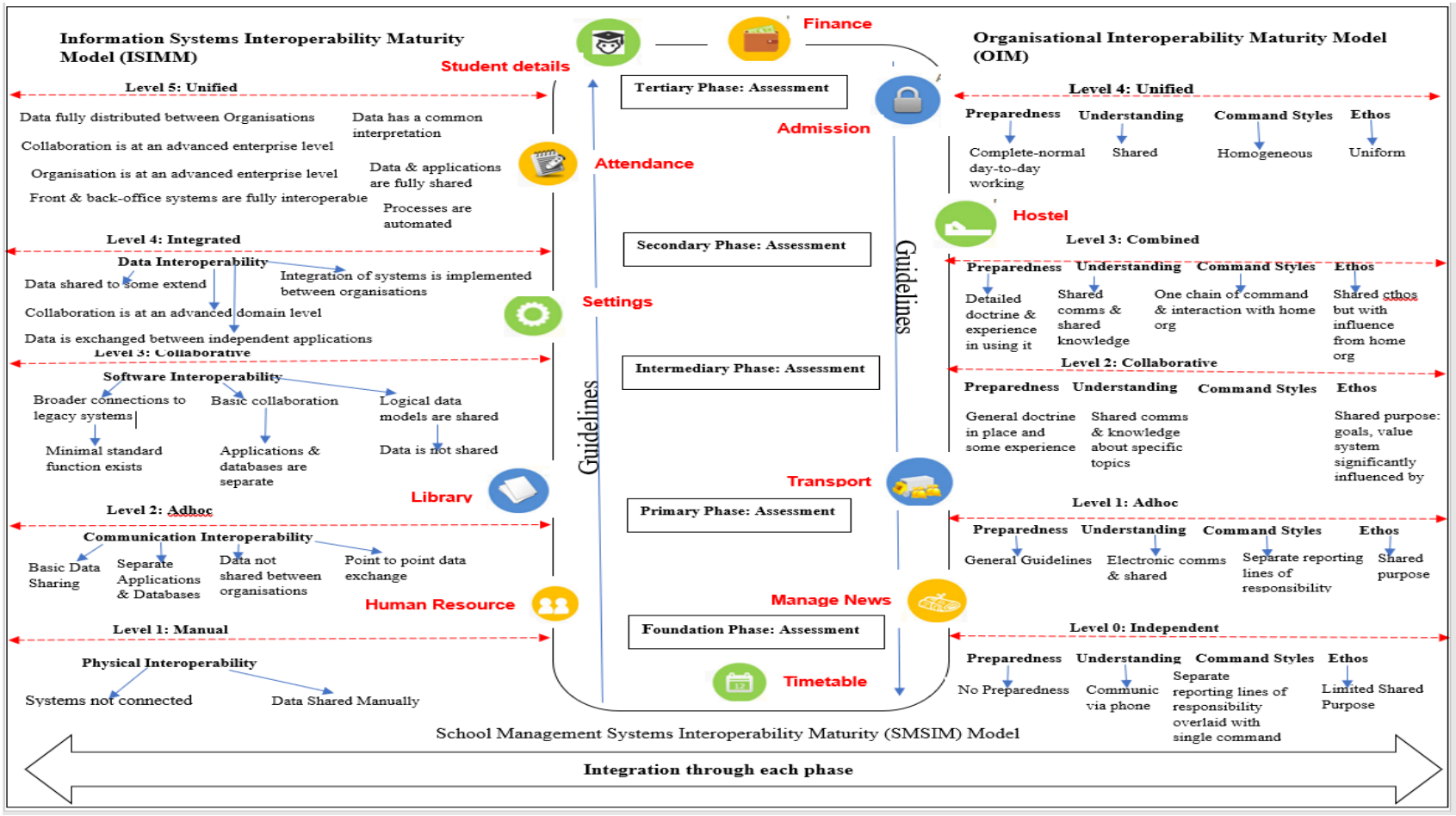


Figure 6-44: School Management Systems Interoperability Maturity (SMSIM) model

At the end of Round 1 of the Delphi expert reviews, the SMSIM model was tested by assessing Ed-Admin's current level of interoperability and then providing guidelines for advancing to the next level. The result of the assessment is based on the information gathered from the Ed-admin website, experts who directly interact with Ed-Admin may use the SMSIM model more efficiently to assess the level of interoperability in Ed-Admin and obtain guidelines to get to the next level of interoperability, and this can be seen in the final version of the SMSIM model as presented in the figure 6-44 above.

Based on the results from both Delphi expert review results, the final SMSIM model did not change or was not adapted. This model has been validated by experts for integrity, validity, accuracy, and efficiency. Based on the results, the model addresses the current SMS problems for South African schools, mainly SA-SAMS. Guidelines for moving to the next level of interoperability were provided in Chapter 4 Section 4.7. Furthermore, a summary of these guidelines is provided in section 6.7 below.

Experts were provided with the report for the round 1 questionnaire, and this report included the use of the interim SMSIM model to assess the level of interoperability in Ed-Admin and provided guidelines on what is required to move to the next level of interoperability. As a result, the model met its intended purpose and was found to be valid, accurate, and efficient. The description of the model can be found in Chapter 4, Section 4.7. This will not be repeated here as it was already provided, and the Delphi results did not add any changes to the interim model. The next section provides a refined summary of the guidelines for implementing the SMSIM model.

6.7 SUMMARY OF THE SMSIM MODEL GUIDELINES

The section below presents a summary of guidelines for SMSIM model, which can be used by schools in South Africa to improve SMS. The guideline in this section and the ones in Chapter 4, Section 4.7 are the same. Nothing was changed as experts found that the initial guidelines met the requirements of improving SMS. These guidelines were further used to evaluate the level of interoperability in Ed-Admin, see Section 6.4:

- **Foundation phase** requires the guidelines below to achieve the **primary phase** of interoperability maturity level:

  - Communication Interoperability such as:
    - Basic data sharing.
    - Separate application & databases.
    - Point to point data exchange.
  - General Guidelines of achieving interoperability.
  - Electronic communication such as:
    - Telephones.
    - Emails.
  - A shared purpose with other schools.

- **The primary phase** requires guidelines below to achieve the **intermediate phase** of interoperability maturity level:
  - Software Interoperability that enables:
    - Broader connections to legacy systems.
    - Basic collaborations.
    - Logical data models that are shared.
  - General doctrine put in place and some experience.
  - Shared communication and knowledge about specific topics.
  - Shared purpose and a shared goal with other schools and SMS.
- **The intermediate phase** requires the guidelines below to achieve the **secondary phase** of interoperability maturity level:
  - Data Interoperability that enables:
    - Data to be shared to some extent.
    - Collaboration at an advanced domain level.
    - Data is exchanged between independent applications.
    - System integrations is implemented between organizations.
  - Detailed doctrines & experience in using it.
  - Shared communications and shared knowledge.
  - One chain of command and integration with home organizations.

- Secondary phases require the guidelines below to achieve the **tertiary phase** of interoperability maturity level:
    - Data that is fully distributed between organizations.
    - Collaboration that is on an advanced enterprise level.
    - The organization is at an advanced enterprise level.
    - Fully interoperable front and back-office systems.
    - Data that has a common interpretation.
    - Fully shared data and applications.
    - Automated processes.
    - Complete and normal day-to-day working.
    - A shared understanding with other organizations.
    - Homogeneous systems.
    - Uniform ethos.

The tertiary phase is the last level of interoperability maturity and at this level, there is no further improvements required. See Section 6.6 for more details. After using the exploratory qualitative design of Delphi, it became evident that this is a good technique to collect data without face-to-face contact and without jeopardizing the integrity, quality, and accuracy of the study. This technique assisted in conceptualizing the SMSIM model by reaffirming literature findings and experts' expertise. Thus, the SMSIM model was successfully assessed, verified, and validated to achieve what it intends to achieve. More information about the design can be found in Chapter 5, Section 5.7.

6.8 POSSIBILITIES OF ADDRESSING SMS PROBLEMS USING SMSIM MODEL

- Each level of the SMSIM model has guidelines that shows what is required, and to advance to the next level, the SMS must meet the requirements of the next level as per the specified guidelines. In guideline one for example which lies in level 1 of foundation phase in the SMSIM model, schools share data with the DBE manually through USB, CD etc, this will apply for schools without internet access as depicted in a diagram (Figure 3-2) in chapter 3. Also, there is increased workloads for teachers because the SMS can only be accessed on one computer as a results teachers are manually capturing marks and then providing the

to the system administrator who has to later on capture into the SMS and this creates a lot of erros and redundancy due to human error. In this level, a lot of problems arise that are caused by the actual SMS and others by the under resourced school as an organisation itself. The systems in the school are not connected nor with the DBE and the staff members are not prepared for the changes, not in skills development nor in understanding of what the technology advancements will do. The SMSIM model intends to guide the school on seeing and knowing the level of interoperability the school is on. This provides a perspective to the school on what they need to do to advance to the next level of interoperability. In guideline two for example, which lies on the primary phase in the SMSIM model, schools can share basic data, and this can be seen through many SMS that has tools and applications to conduct a lot of administrative tasks in the system, although data is not shared with other schools. Other SMSs will meet the requirements of level three-intermediate phase which at a click of a button, schools are able to submit data to the DBE. With every advancement to the next level of interoperability, problems of SMS listed in the chapter 1, section 1.2 are resolved. School can thus use this model to determine the level of interoperability they are on and see what the next level requires, then schools can formulate a plan on how to financially budget to meet the requirements of the next level. When there is a sufficient budget set aside for improvements, then updates can be made on SMS and the school itself-this include skills development of the staff members especially in the rural development. Training can be conducted so changed is easily embraced and handled. There are few certainties in life, but one of them is that change is inevitable (Sampathkumar, 2020), progress is impossible without change and those who cannot change their minds cannot change anything. However, change disrupts this comfort creating a situation filled with anxiety and uncertainty among change recipients (Issah, 2018). The guidelines provided in the SMSIM model can ease uncertainty that comes with technology advancements.

6.9 SUMMARY

In conclusion, the outcome of the Delphi study Round 1 questionnaire suggested that SMS requires improvements, especially SA-SAMS. All the experts who participated mentioned that SA-SAMS is problematic and requires a lot of improvements. It is also highly costly for private schools that

already use their paid version of SMS, and this is a result of features and changes made by the Department of Basic Education to the goalposts for data needed for SA-SAMS. A SMSIM model can thus be a valuable tool for improving SMS in schools in South Africa. Round 2 of the Delphi Study questionnaires focused on the SMSIM model that can be used as a guideline for solving SMS problems. A consensus was reached after two rounds of the Delphi questionnaire, and thus, a SMSIM model was successfully conceptualized.

CHAPTER 7: CONCLUSION, REFLECTION AND RECOMMENDATIONS.

7.1 INTRODUCTION

Chapter 6 discussed and analyzed the results of the expert review questionnaires for the round 1 and round 2 Delphi study. The School Management Systems Interoperability Maturity (SMSIM) model was further conceptualized, verified, and validated based on the expert review results. To reflect on the process undertaken to conceptualize this SMSIM model, this chapter provides a reflection on how the research questions and objectives were addressed and recommendations that can be made for implementing this model. This is accomplished by first outlining the goals and research questions that guided this study. This chapter next considers the methodological contributions. The research's drawbacks and suggestions for further investigation are then discussed. The third phase of the research process is covered in this chapter:

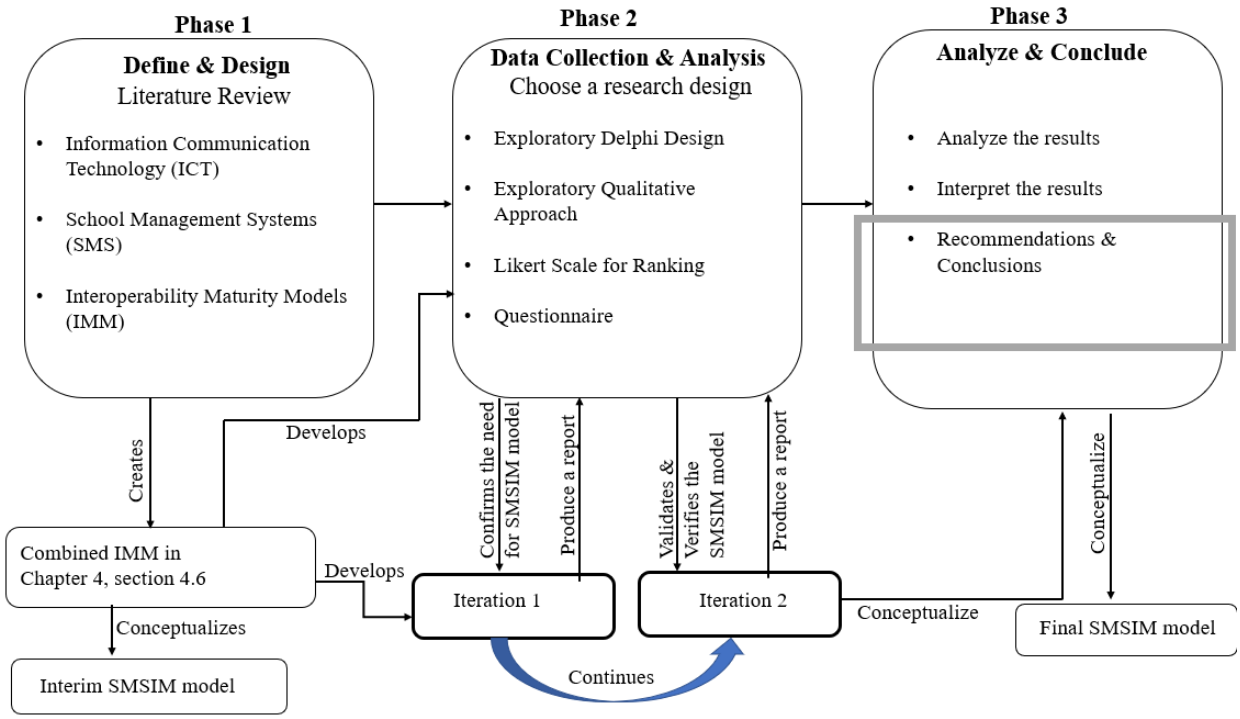


Figure 7-1: The research process and how this chapter supports Phase 3 of the study

7.2 RESEARCH OVERVIEW

During the COVID-19 Pandemic, schools had no choice but to close all the gates and start finding ways to ensure learning continuity by utilizing digital platforms (Mhlanga & Moloi, 2020). This showed the power of technology when used properly. With the help of the SMSIM model, the level of interoperability in SMS can be improved and with every interoperability maturity level, problems of SMS may be addressed. Change is not easy and does not come cheap, but it's worth it (Ayala, 2022). Therefore, the experts who participated in the study are from different fields of expertise as per section 5.7.3 to provide feedback through the Exploratory Delphi questionnaire for a SMSIM model that will not only assess the level of interoperability in SMS but to also solve SMS problems potentially. The next section provides a perspective of how the research questions of this study were addressed.

7.2.1 Addressing the Research Questions

Main Research Question: How can a SMSIM model assist schools in improving the interoperability and maturity levels of their current SMS?

The main research question is addressed by the fact that the SMSIM model can be used by any school in South Africa to improve SMS. This model assesses the level of interoperability in SMS and provide guidelines on achieving the next level of maturity. Developers can use this model to build an evaluation feature that sets SMS at different level of maturity. Schools can use this model to check which level of interoperability their SMS is currently at and refer to the guidelines to determine what is needed to improve their SMS, In section 6.8 more information on how schools can use the SMSIM model to improve SMS in provided. This MRQ is also addressed through the answers to the three SRQs and will be addressed after the findings of the three SRQs.

SRQ 1: What constitutes the components of a model of interoperability maturity for Schools Management Systems?

This sub question 1 was addressed by the different phases in the SMSIM model, such as the foundation phase, primary phase, intermediate phase, secondary phase, and tertiary phase. These phases at each level feed into Organizational Interoperability Maturity Model (OIM) and

Information System Interoperability Maturity Model (ISIMM) to assess the level of interoperability at each level and provide guidelines for reaching the next level, which were presented in Chapter 6.

SRQ 2: What existing models of interoperability maturity can be used to conceptualize a SMSIM model?

This sub question 2 was addressed by the different Interoperability Maturity Model (IMM) listed and discussed in Chapter 4, but mostly the selected IMM (OIM and ISIMM) was used to conceptualize the SMSIM model found in Section 4.6.

SQR 3: What value will a SMSIM model have for schools using Schools Management Systems?

This sub question 3 is addressed by the expert review findings in Chapter 6 and comments provided by the experts. The conceptualized SMSIM model (Chapter 6) assessed interoperability and provided guidelines to help improve SMS. The SMSIM model also solve the problem statements reflected in Chapter 1. When schools use this model to improve SMS, they can realise the benefits of interoperability as documented in section 1.2. The SMSIM model may potentially address the problem in SMS as schools achieve higher interoperability maturity level. This may result in all SMS that could become interoperable and could be accessed from anywhere at any place instead of being accessed only in the school premises using the school's intranet. Finally, all users using SMS could be trained to assess the interoperability maturity levels of their SMS by using the SMSIM model.

In summary, the main research question is addressed by the sub questions and the outcome of the expert reviews, which conceptualized the verified, and validated SMSIM model. The SMSIM model can assist schools in improving the interoperability and maturity levels of their current SMS by a feeder that goes into each level to assess the level of interoperability and provide guidelines for advancing the SMS to move to the next level.

7.3 THE RESEARCH CONTRIBUTIONS

This research aimed to conceptualize a SMSIM model that will assess the level of interoperability in SMS and provide guidelines on achieving the next level of interoperability to improve SMS. This model will guide not just SMS in private schools but SMS worldwide to improve SMS.

The following sections describe the contributions of this study both theoretically and practically.

7.3.1 Theoretical Contribution

The Institutional theory was applied as the theoretical lens in this research to define the setting and contextual influences present when schools use SMS. Through this theory, the research was able to understand the complexities associated with integrating SMS as an IS/IT-based solution (through the conceptual model) in the context of the educational environment.

7.3.2 Practical Contribution

The SMSIM model has been conceptualized to improve SMS and has well-defined, verified, and validated guidelines that can be used to improve SMS practically. This model is designed to contribute to theory in the form of literature and solve real-time problems, as highlighted in Chapter 1 of the study. The SMSIM model is suitable for all schools worldwide that would like to assess the interoperability level of SMS and obtain guidelines on what is required to get to the next level of interoperability to improve SMS. The expert reviews also alluded to this. In addition to this, the software developers of the SMS can use this model to build in a component on evaluating the interoperability maturity of SMS.

7.4 LIMITATIONS OF THE RESEARCH

There are several limitations that occurred during the research as listed below:

- **Availability to participants:** Originally, this research targeted the Principals, ICT Coordinators, Administrators of the school and Experts, however, due to the negative effect of the COVID-19 Pandemic that restricted participants' availability and access to schools, this research only focused on experts using the Delphi Questionnaire. Numerous attempts were made to get access to the school Principals to conduct interviews however only a few

responded with a decline, others opted to remain silent and only when I sent a follow up email of thanking them for accepting to participate in the study did, they respond with a decline. A few of the school Principals indicated that due to the negative impact of the COVID-19 pandemic, the targeted participants have a lot to do, and it will be inconsiderate add to their workload by asking them to participate in the study. Interview through remote access was not even anything to consider as a "no" was provided regardless of how the interview will be conducted. There was a lot of begging as well to get the experts to also participate in the study, I had to promise them that there won't be any interviews, they will participate in a Delphi study which will allow them to complete the questionnaire at the comfort of their own homes.

- **Quantity:** The initial plan was to interview six (6) principals, six (6) ICT Coordinators, six (6) administrators, and six (6) experts, however due to the inability to access schools, this research only used 10 experts' reviews by applying a Delphi technique.
- **Data collection:** This research used the Delphi method to elicit the reviews of experts, allowing the researcher to reach participants from different locations without needing face-to-face contact**.**
- **Time:** Initially, the researcher aimed to conduct the research in a two (2) year's period, however, due to the COVID-19 Pandemic, this period was extended to four (4) years.

The following section elaborates on the lesson learned and the personal reflections during the research. This section aims to reflect on the experience of the researcher during the research and what could be done differently should an opportunity arise to conduct the research again in future.

7.5 LESSON LEARNED AND PERSONAL REFLECTIONS

This research was motivated by the need to address the problems schools are encountering when using SMS, and the need to positively contribute to SMS by conceptualizing a SMSIM model that can assess the level of interoperability and provide guidelines for achieving the next level of interoperability to improve it. The impact of this research can be used to potentially improve SMS of schools in South Africa by maturing the interoperability of SMS and by hopefully addressing the problems in SMS as the maturity level advances. Without a clear procedure shown by the research methodology used across all chapters of this research, the outcome of this study would

not have been accomplished. The research methodology was critically important to guide the research, collect the data using the Delphi method, engage with participants and interpret the literature findings and experts' reviews.

There were great difficulties encountered during this research and conceptualizing the SMSIM model was certainly not easy. The COVID-19 Pandemic restricted access to schools and thus, interacting directly with the anticipated target group of participants (Principals, ICT Co-ordinators, and Administrators) was impossible. With time, the COVID-19 pandemic restrictions were lifted and there was hope to gain access to schools, but the negative effect of the pandemic remained. All the schools which were asked to participate in the research, either did not respond to the request or completely refused to partake in the study as they had indicated that "there is a lot of work to do and catch up on, and so little time", "Staff members are burdened with a lot of work, it is impossible to expect them to additionally add more work to a very hectic workload". Unfortunately, my progress was derailed, not only by the negative impact of the COVID-19 pandemic on restrictions but also emotionally by the people around me who lost their lives due to this, the worry of the unknown, who will lose their lives next, who will be infected, should I contract the virus, will I be able to survive it? In future, I will ensure I find a balance to deal with not only the hardships that life may bring but any natural disaster that may come my way.

Through this research, I have learned the importance of investing myself in literature to understand the context of my research and ensure the sources are recent. This process has really improved my thinking and my views on research in general. I feel that my mind has been broadly opened and I value other authors who also went through this journey to write and publish papers, books, and articles that really helped me support the problem statement and build a base for this research. I have also learned the importance of the methodology in the research which provided guidance, structure, and direction to the research.

Most importantly, I have learned the importance of having support from family members at home who understand the need to work after hours and the support from supervisors. Although they were exposed to many students, and despite also being negatively impacted by the COVID-19 Pandemic, they took the time to go through my work and provide fruitful feedback that helped

build and shape the outcome of this research. Working with my two (2) supervisors has been an honour, and I learned a lot from them.

7.6 RECOMMENDATIONS FOR FUTURE STUDIES

Literature findings proved that there are schools, especially in the private sectors, that are using different SMSs from SA-SAMS, but the biggest problem is system integration as data must be manually imported into SA-SAMS, it is recommended that a new study on SA-SAMS can be conducted based on the findings in this research and to add the model from this research to the SA_SAMS for improvement. Future research can then focus on how the DBE can use interoperability for integrating systems in the Department and different SMS used by all schools in South Africa to ensure reporting is conducted with a click of a button. Another recommendation is that a study can be done to adjust SA-SAMS to allow for the best features found in the best SMS discussed in this study. After adding the best features, SA-SAMS can then be piloted to determine its maturity to address interoperability.

7.7 CONCLUSION

- This exploratory qualitative study identified two Interoperability Maturity models (IMM) from literature findings that could be used to conceptualize a SMSIM model. The conceptualized SMSIM model was then assessed to ensure it could solve currently identified SMS problems and to be certain that the model does what it is intended to do. For this purpose, expert reviews were conducted following the exploratory Delphi design. The feedback and insights obtained from these reviews allowed for the refinement of the conceptualized SMSIM model for SMS and guidelines were provided to use this model. Through this chapter, the researcher considered the value and significance of the research, personal learning objectives, the limits discussed, and suggestions for further research. Lastly, the results of the study regarding SA-SAMS identified this system as a flawed system that would drastically benefit from the SMSIM model, this outcome could be a result of not having the targeted participants (Principals, ICT Coordinators, and Administrators) in the study. Only one deputy principal and administrator participated in the study, the rest of the participants were IT managers etc. as listed in section 5.7.5. The aim of this research is not to downgrade any SMS but to help improve it by assessing the level of interoperability in SMS and provide

guidelines to advance to the next level and the conceptualised SMSIM model is for all SMSs.

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APPENDIX A: Ethics clearance certificate

UNISA university of south africa

UNISA COLLEGE OF SCIENCE,ENGINEERING AND TECHNOLOGY ETHICS REVIEW COMMITTEE

2021-11-02

ERC Reference # :2021/CSET/SOC/070
Name : KJ Maremi
Student #: 44977883
Staff #:

Dear Ms KJ Maremi

Decision: Ethics Approval from 2021/11/02 for three years

Researcher(s): Ms KJ Maremi; 44977883@mylife.unisa.ac.za; 0846164296

Supervisor (s): Prof M Herselman; MHerselman@csir.co.za; 012 841 3081
Prof A Botha, Abotha@csir.co.za; 012 841 3265

Working title of research: A School Management System Interoperability Maturity (SMSIM) Model for Private Schools in South Africa

Qualification: MSc Computing

Thank you for the application for research ethics clearance by the Unisa College of Science Engineering and Technology Ethics Review Committee for the above-mentioned research. Ethics approval is granted for 3 years.

*The **low risk application** was **reviewed** by the College of Science, Engineering and Technology (CSET) Ethics Review Committee on 2021-11-02 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment. The decision will be tabled at the next Committee meeting for ratification.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the SOC Ethics Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.

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4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No field work activities may continue after the expiry date (2024-11-02). Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number 2021/CSET/SOC/070 should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.

Yours sincerely,

HH Lotriet

Prof HH Lotriet
Chair of the Department of Information Systems Ethics Review Subcommittee
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APPENDIX B: Informed consent form

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number: 2021-CSET-SOC-070

30 November 2021

Title: A School Management Systems Interoperability Maturity (SMSIM) Model for Private Schools in South Africa.

Dear Prospective Participant

My name is Keneilwe Maremi and I am doing research with Prof Marlien Herselman, an adjunct Professor in the Department of Science, Engineering and Technology (School of Computing) towards an MSC in Computing at the University of South Africa. We invite you to participate in a study entitled: School Management Systems Interoperability Maturity (SMSIM) Model for Private Schools in South Africa.

WHAT IS THE PURPOSE OF THE STUDY?

The purpose of the study is to conceptualize a School Management Systems Interoperability Maturity (SMSIM) model for private schools in South Africa. This conceptualized SMSIM model will apply a specific Interoperability Maturity Model to assess the level of interoperability in SMS and provide clear guidance on how SMS can benefit from using interoperability maturity levels to improve their current SMS systems. In addition, this model may enhance the level of interoperability maturity in SMS and highlight the value of such a model for existing SMS in schools.

WHY AM I BEING INVITED TO PARTICIPATE?

You have been identified as a participant because you have a minimum of 10 years experience in one of the following fields: ICT in Education, Interoperability, Schools Management Systems (SMS), and Information Technology. The study aims to conceptualise a model that will help improve SMS and your input in validating and verifying the model will add value to any school that aims to improve their SMS.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study uses the Delphi method which is **a process used to arrive at a group opinion or decision by surveying a panel of experts.** Interviews will take place in several rounds until a consensus is reached. The advantage of this method is location: Interviews can be conducted without face-to-face contact. The questions that will be asked are about SMS, and challenges faced in schools when submitting data to the Department of Education and daily administrative tasks, also how interoperability can help mitigate these problems. The interview is expected to take 30-45 minutes. You will be expected to anonymously answer these questions and evaluate a copy of the other experts' feedback without knowing the identity of the experts, then based on the first round of feedback from experts, more questions will be developed, and you will also need to participate in the second round, this process will repeat itself over and over until a consensus is reached.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason however it is encouraged to finish all the rounds until a consensus is reached to ensure the conceptualized model is accurate, valid and effective.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The benefits are if the model is successfully conceptualized and schools in South Africa apply it to improve their SMS. Your role in making this model effective, valid and accurate would have added much value to schools in South Africa and you will be acknowledged for your contribution. In addition, this model may enhance the level of interoperability maturity in SMS and highlight the value of such a model for existing SMS in schools.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no identified risks.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Your identifiable information will not be collected. Your name will not be recorded anywhere, and no one will be able to connect you to the answers you give. Your answers will be given a code number, or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. Only the supervisor and I will have access to this data.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

The researcher will store hard copies of your answers for a minimum period of five years in a locked cupboard/filing cabinet at the CSIR for future research or academic purposes; electronic information will be stored on a password-protected computer and authenticated cloud. Hard copies will be shredded, and electronic copies will be permanently deleted from the hard drive of the computer.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No compensation is provided for participating nor is any cost incurred. This research does not force anyone to participate, and participation is voluntary.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Health Research Ethics Committee of the College of Agriculture and Environmental Sciences, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Keneilwe Maremi on 0128427262 or KMaremi@csir.co.za. The findings will be published in conferences, journals and the dissertation. If you require further information or want to contact the researcher about this study, please contact Prof Marlien Herselman, 0128413081, MHerselman@csir.co.za.

Should you have concerns about how the research has been conducted, you may contact Prof Marlien Herselman, 0128413081, MHerselman@csir.co.za.

Thank you for taking the time to read this information sheet and for participating in this study.

Thank you.
KMaremi

Keneilwe Maremi

APPENDIX C: Delphi round one information

The informed consent form was accompanied by the School Management systems Interoperability Maturity (SMSIM) Model Round 1 Questionnaire

Purpose: The purpose of the study is to conceptualize a School Management Systems Interoperability Maturity (SMSIM) model for private schools in South Africa. This conceptualized SMSIM model will apply a specific Interoperability Maturity Model to assess the level of interoperability in SMS and provide clear guidance on how SMS can benefit from using interoperability maturity levels to improve their current SMS systems.

Please provide answers to the following questions based on your knowledge as a selected expert:

Round 1 Questionnaire

	Round 1 Questionnaires	1-Strongly Disagree	2-Disagree	3-Neither Agree Nor Disagree	4-Agree	5-Strongly Agree	Comments
1	School Management Systems (SMS) are large repositories that schools use to manage the day-to-day administrative activities of the school						
2	Multiple users use SMS and these can be configured to meet the needs of each school independently						
3	SMS help to overcome monotonous paperwork in schools, are very easy to use, and can work accurately and smoothly in different scenarios. SMS reduce workload, increases efficiency in school management, and saves time						
4	Many schools in South Africa use a SMS called SA-SAMS (South African School and Administration Management System) as mandated by the South African Department of Basic Education DBE)						
5	To make the administration of schools more effective, the DBE developed SA-SAMS to solve not only management and administration challenges but also to streamline data in schools						
6	Not all schools in South Africa are using SA-SAMS, but their SMS should easily integrate with SA-SAMS to reduce duplicate work						
7	Although SMS offers many advantages to schools, it also comes with many disadvantages such as:						
7.1	Increased workloads for teachers						
7.2	Duplication of work						

	Round 1 Questionnaires	1-Strongly Disagree	2-Disagree	3-Neither Agree Nor Disagree	4-Agree	5-Strongly Agree	Comments
7.3	Redundancy and errors						
7.4	Delays for the submission of reports to the DBE by schools						
7.5	Most schools use a free version of SMS which often lacks features such as discipline, custom reports, registration, and inventory. Some are narrowed by space capacity, the number of learners, and storage.						
7.6	SMS are often installed on one standalone computer, which limits access, which causes substantial tension and stress on the administrator working alone and is the only resource available during peak demand times such as the end of the term when schools are required to process learner reports. This mostly results in annoying delays.						
7.7	Teachers have a small amount of access to the system for performing simple tasks like capturing marks and mostly consume teaching time by manually validating learner's marks on paper that are never-ending, increasing the chances of errors.						
7.8	Non-availability of skilled ICT personnel who can utilise the system. There is a lack of specific and inadequate availability of relevant software, lack of maintenance culture, and lack of data security and impurity on the government's side.						
7.9	SMS can only be accessed within the school's intranet.						

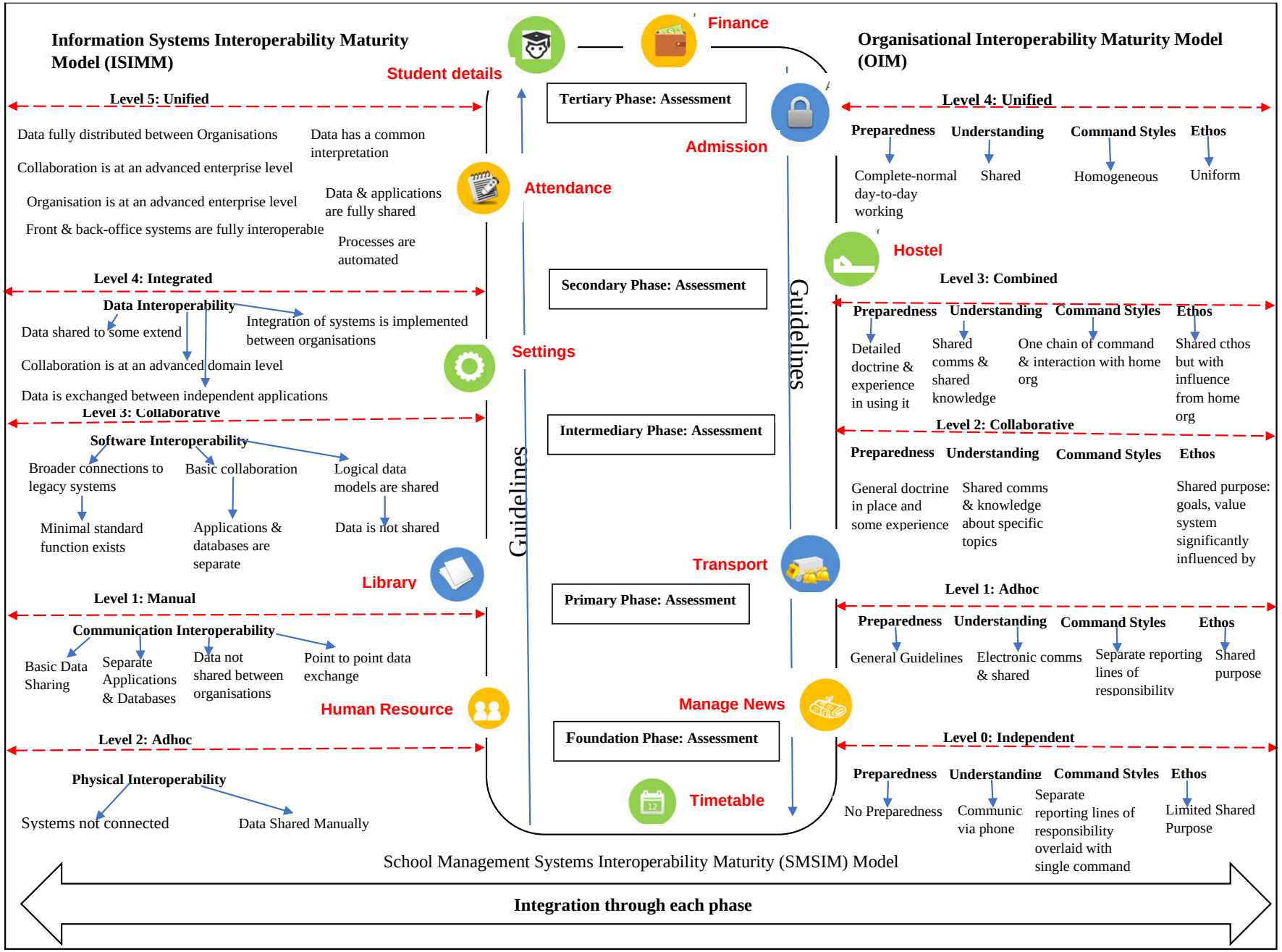
	Round 1 Questionnaires	1-Strongly Disagree	2-Disagree	3-Neither Agree Nor Disagree	4-Agree	5-Strongly Agree	Comments
7.10	Limit learners and parents or guardians from accessing the learners' information.						
8	SMS has room for improvement due to its disadvantages						
9. Interoperability has educational benefits that can help address the above-mentioned disadvantages of SMS. As these advantages include:							
9.1	Reducing the burden on staff members of the school to enter data						
9.2	Improving data quality						
9.3	Promoting adaptability and promote data sharing						
9.4	Supporting data-driven decision making						
9.5	Enhancing efficiency and timeliness						
10	These advantages of interoperability can enhance SMS to ensure an improved overall information flow for effective decision making and management of schools						
11	Interoperability is the platform that provides continuous information exchange, for example, exchanging information that other systems can use to improve the performance, create services, control the processing of information systems and operations						
12	There is a need to conceptualise a model that will bring together interoperability in SMS						

Appendix D: Delphi round two information

SMSIM Model Round 2 Questionnaire

Purpose: The purpose of the study is to conceptualize a School Management Systems Interoperability Maturity (SMSIM) model for private schools in South Africa. This conceptualized SMSIM model will apply a specific Interoperability Maturity Model to assess the level of interoperability in SMS and provide clear guidance on how SMS can benefit from using interoperability maturity levels to improve their current SMS systems. School Management Systems Interoperability Maturity (SMSIM) model

The School Management Systems Interoperability Maturity (SMSIM) model is a feeder model that assesses the level of interoperability in the School Management Systems (SMS) and continuously provides guidelines to improve the current level of interoperability in SMS. This model consists of five phases: the foundation, primary, intermediate, and tertiary phases. SMSIM model uses the tested, verified, and approved Interoperability Maturity Models (IMM), which are a combination of Information System Interoperability Maturity Model (ISIMM) and Organisational Interoperability Maturity Model (OIM) to assess and provide guidelines for bettering and improving SMS. A feeder at each phase goes into each level of ISIMM and OIM to assess interoperability at each level and provide guidelines for the next level.


Information Systems Interoperability Maturity Model (ISIMM)
Organisational Interoperability Maturity Model (OIM)
Student details
Finance
Tertiary Phase: Assessment
Admission
Level 5: Unified
Data fully distributed between Organisations
Data has a common interpretation
Collaboration is at an advanced enterprise level
Organisation is at an advanced enterprise level
Data & applications are fully shared
Front & back-office systems are fully interoperable
Processes are automated
Attendance
Level 4: Integrated
Data Interoperability
Data shared to some extend
Integration of systems is implemented between organisations
Collaboration is at an advanced domain level
Data is exchanged between independent applications
Settings
Secondary Phase: Assessment
Level 3: Collaborative
Software Interoperability
Broader connections to legacy systems
Basic collaboration
Logical data models are shared
Minimal standard function exists
Applications & databases are separate
Data is not shared
Library
Intermediary Phase: Assessment
Guidelines
Guidelines
Level 1: Manual
Communication Interoperability
Basic Data Sharing
Separate Applications & Databases
Data not shared between organisations
Point to point data exchange
Human Resource
Transport
Primary Phase: Assessment
Level 2: Adhoc
Physical Interoperability
Systems not connected
Data Shared Manually
Manage News
Foundation Phase: Assessment
Timetable
Level 4: Unified
Preparedness
Understanding
Command Styles
Ethos
Complete-normal day-to-day working
Shared
Homogeneous
Uniform
Hostel
Level 3: Combined
Preparedness
Understanding
Command Styles
Ethos
Detailed doctrine & experience in using it
Shared comms & shared knowledge
One chain of command & interaction with home org
Shared cthos but with influence from home org
Level 2: Collaborative
Preparedness
Understanding
Command Styles
Ethos
General doctrine in place and some experience
Shared comms & knowledge about specific topics
Shared purpose: goals, value system significantly influenced by
Level 1: Adhoc
Preparedness
Understanding
Command Styles
Ethos
General Guidelines
Electronic comms & shared
Separate reporting lines of responsibility
Shared purpose
Level 0: Independent
Preparedness
Understanding
Command Styles
Ethos
No Preparedness
Communic via phone
Separate reporting lines of responsibility overlaid with single command
Limited Shared Purpose
School Management Systems Interoperability Maturity (SMSIM) Model
Integration through each phase

In order to explain the model, each phase (middle section of the model) will be addressed as this section is supported by both models on either side.

Foundation phase: At this level, a feeder is sent into Information Systems Interoperability Maturity Model (ISIMM) and Organisational Interoperability Maturity Model (OIM) manual or independent level parallelly to assess the required level of interoperability, the outcome of the level serves as a guideline for the next level: Systems are not connected in this interoperability level, and data is shared manually through mail posts. Schools are normally unprepared for interoperability to occur, they only communicate via phones among staff members and other schools, there is no interaction with other schools except through communicating via manual means, and there is a limited shared purpose. For schools to get to the adhoc level, they need to have basic data sharing and general guidelines for interoperability and some electronic means of communicating and sharing information. This can be as simple as using email to communicate with other schools and each other.

At this phase, teachers have increased workloads, there is duplication of work as marks and administrative tasks are done manually and then transferred to SMS later, there is a lot of redundance and errors because of fatigue and human error, submission of reports to the DBE are always delayed, and there are no skilled ICT personnel who can utilize the system. There is a lack of specific and inadequate availability of relevant software, maintenance culture, and data security and impurity on the government's side. According to literature and the capabilities of SMS, most schools, especially in the private sector, have passed this stage, specifically when it comes to manual communication and data sharing. Although, some of these disadvantages still exists even with School Management Systems (SMS) put in place in private schools of South Africa and the data analysis of the results of round 1 questionnaire has confirmed this, Interoperability can integrate these systems to ensure seamless information exchange, reduce the burden on staff members of the schools, improve data quality, promote adaptability, and enhance efficiency.

Primary phase: At this level, a feeder is sent into **ISIMM and OIM Adhoc level** parallelly to assess the required level of interoperability, the outcome of the level serves as a guideline for the next level**:** In this level of interoperability, The school has separate reporting lines of responsibility, general guidelines to achieve interoperability, and a shared purpose with other schools, there is

basic data sharing, applications and databases are separate, data is not shared with other schools, and data is exchanged through systems in a point-to-point manner. To get to the collaborative level, schools need to have a shared logical data model, basic collaboration with other schools, and general doctrine to support interoperability and some experience in interoperability.

Schools in this level of interoperability have improved decimally compared to the schools in the foundation phase of interoperability, however the improvement is minimal, and a lot of work has to be implemented to realise the full benefits of interoperability. It is observed that, at this level, school staff members are still burdened with entering data into the systems of the schools as databases and applications are separate and data is shared in a point-to-point manner. This opens room for errors, duplicates, redundancy and compromising the integrity of the data between the back-and-forth communication of the systems. By using a SMSIM model as a guideline model to help improve SMS, the requirements of the next level will be obtained and with slow progress, this type of school will run smoothly.

Intermediary phase: At this level, a feeder is sent into **ISIMM and OIM collaborative level** parallelly to assess the required level of interoperability, the outcome of the level serves as a guideline for the next level**:** In the collaborative level of interoperability, there is broader connections to legacy systems although minimal standard functions exist, applications and databases are still separate at this level. There is basic data collaboration with other schools, and data is still not shared, however logical data models are shared with other schools. Schools can share communications and knowledge about specific topics with other schools. General doctrine is put in place to support interoperability and some experience, reporting lines are still separate, and the school shares goals, purpose, and value system with other schools. Schools need to exchange data between independent applications to get to the integrative level. Collaboration must be at an advanced level, share communication and knowledge with other schools, and have a detailed doctrine and experience in interoperability systems.

Unfortunately, legacy systems are outdated computing software and/or hardware that are still being used. These types of systems meet the needs they were originally designed for, but they don’t allow for growth. These systems present a major investment and for the most part, they cannot be abandoned. Interoperability provides means of connecting these types of legacy systems with the

new breed. With this advantage of interoperability, information is never lost and there is room for growth, although majority of the disadvantages of SMS are still not entirely solved in this phase as data is still not shared and there are still silos in the schools even though some communication between schools can occur. Schools in this phase must work on getting to the next phase to fully realise the benefits of interoperability. Many schools in South Africa are in this phase of interoperability, they know the benefit of interoperability and to some degree, measures are put in place to support interoperability, but data is still not shared, applications and databases are still separate and unfortunately there is still too much strain on the staff members of the schools to enter data into different systems.

When interoperability is applied correctly in the school, there should be seamless information exchange between the systems, by a click of a button, other departments, such as finance and administrative must be able to retrieve information without the need to reenter what was already entered by another staff member from another department. Paid SMSs can do this to some degree, Ed-admin which was mentioned by one of the experts during round 1 questionnaire of the Delphi study, has 40 different modules which can be accessed from anywhere at any time. To some degree these SMS is interoperable, it is also able to integrate with other systems for ultimate benefits however it unfortunately still works in silos with other schools and other applications not included in the system. Also, there is no evidence of such an SMS integrating with legacy systems. The SMSIM model will assess and provide guidelines to achieve the next level of interoperability.

Secondary phase: At this level, a feeder is sent into **ISIMM and OIM Integrative or combined level** parallelly to assess the required level of interoperability, the outcome of the level serves as a guideline for the next level**:** At this level of interoperability, schools need to have detailed doctrine & experience in using interoperability's systems as well as the ability to communicate, sharing knowledge, and interact with other schools. On a technical level, data is shared and exchanged between independent applications, integration of systems is implemented between organisations. For schools to get to the unified level, they need to have interoperability completely implemented in the school, both on a technical level and the human activity level. Schools need to interoperate with other school on a day-to-day basis completely.

Schools that qualify to be on this level have implemented interoperability effectively, which means there is integrations of systems from one organisation to another, this is the ultimate goal with disadvantages of interoperability closed observed and addressed. Schools can communicate and seamlessly share information without compromising security and privacy. Most schools have yet to reach this stage of interoperability; hence disadvantages of SMS are still evident.

To get to the next level of interoperability, schools must be completely interoperable with other schools on a day-to-day basis. The school's data is fully distributed between organisations with a common interpretation on a technical level. Schools are continuously interoperating, data and applications are fully shared, processes are completely automated, and front and back-office systems are fully interoperable.

Tertiary phase: At this level, a feeder is sent into **ISIMM and OIM's Unified level** parallelly to assess the required level of interoperability, the outcome of the level serves as a guideline for the next level: At this level, schools have a shared understanding with other schools, completely interoperable with other schools on a day-to-day basis. The school's data is fully distributed between organisations with a common interpretation on a technical level. Schools are continuously interoperating, data and applications are fully shared, processes are completely automated, and front and back-office systems are fully interoperable. This is the last level of interoperability, and schools would have reached the ultimate level of interoperability by getting to this level. This level is normally easy to achieve for schools of the same kind.

The section below presents the round 2 questionnaires that were used to assess the model's utility, validity, effectiveness, and quality.

Round 2 Questionnaire

	Round 2 Questionnaire	1-Strongly Disagree	2-Disagree	3-Neither Agree Nor Disagree	4-Agree	5-Strongly Agree	Comments
1	There are no doctrines put in place that enable SMS to cooperate with other SMS						
2	Schools cannot use SMS to share information and communicate, important data into SA-SAMS is done manually.						
3	Schools do not use SMS to share information and communicate with other schools.						
4	In most schools, SMS is installed on a standalone computer with limited access.						
5	All the other systems and applications that exist in schools are most probably not connected to SMS						
6	The systems in the schools are most probably unable to share data & communicate with each other						
7	Questions about the Model						

	Round 2 Questionnaire	1-Strongly Disagree	2-Disagree	3-Neither Agree Nor Disagree	4-Agree	5-Strongly Agree	Comments
7.1	With the current state of SMS, the SMSIM model assess the level of interoperability and shows guidelines for achieving the next level with the ultimate aim of addressing the disadvantages of SMS						
7.2	Is the SMSIM model effective and accurately able to assess the level of interoperability in SMS and provide guidelines on how to get to the next level?						
7.3	Is the SMSIM model a valid model for providing guidelines to address the current SMS problems?						
7.4	SMS will be improved when utilising this model						

In your view, how can the model be improved?

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