A SUSTAINABILITY FRAMEWORK FOR MOBILE TECHNOLOGY INTEGRATION IN RESOURCE-CONSTRAINED SCHOOLS: A CASE STUDY IN SOUTH AFRICA

BY

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I declare that

"A sustainability framework for mobile technology integration in resource-constrained schools: a case study 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.

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Date: November 2017

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Abstract

The importance of sustainability for ICT4D projects has been acknowledged but there remains, however, a lack of frameworks to guide the long-term sustainability of mobile technology integration to support teaching. The diversity of contexts complicates the development of a consolidated view of how to sustain mobile technology integration into teaching. This study sought to investigate and develop *a sustainability framework for mobile technology integration in schools in resource-constrained environments in South Africa (SFMTIS).*

The Design Science Research Methodology (DSRM) was applied to answer the research questions and to iteratively develop the SFMTIS artifact. The main philosophy which guided the research is pragmatism. Interpretivism was applied, when a case study was used, to refine and validate the framework within the DSRM process model. This research was undertaken from 2014 to 2017 and the SFMTIS was developed in three phases. Based on the review of the existing literature, an initial framework was synthesised in Phase 1. A systematic literature review was conducted to investigate mobile technology integration in the South African basic education system as well as ICT4D sustainability models and frameworks. The SFMTIS sustainability dimensions, as abstracted from the literature, include financial, political, social/cultural, technological, environmental and pedagogical sustainability.

In Phase 2 of the research a case study was done to investigate the perspectives held by teachers and district officials regarding mobile learning integration in the schools. The findings were used to improve the initial SFMTIS. The case study involved teachers from schools that had formerly participated in the ICT for rural education and development (ICT4RED) initiative who were selected through purposive sampling to participate in this research as well as district officials from the same school district. The ICT4RED initiative is a large-scale South African government research, development and implementation initiative which was carried out over a period of three years, from 2012 to 2014, at one of the school districts in the Eastern Cape province of South Africa. The initiative investigated ways in which ICTs can be integrated into teaching and learning in rural areas.

The findings from the interviews with teachers and district officials, provided evidence which confirmed the value of the sustainability dimensions identified in literature. The study highlighted financial and technical support mechanisms required for the sustainable

deployment of ICTs. The research findings indicate that communication and coordination at all levels of the education system, micro (school), meso (school circuit and district) and macro (provincial and national) are essential for ensuring sustainability. The findings highlighted some specific issues related to institutional challenges. This motivated the proposition of the *institutional dimension* to represent the structure, processes and practices at micro, meso and macro levels of the education system. The intermediate SFMTIS was refined by applying the findings of the case study to the initial framework.

In Phase 3 the intermediate framework was presented to the teachers and district officials who had formerly been interviewed during the development of the SFMTIS, as well as other experienced individuals who had been involved in the implementation of the ICT4RED initiative, for their expert evaluations. The expert reviewers' feedback was applied to refine the intermediate SFMTIS and aided in the development of the final SFMTIS. The research contributes to theory by developing the theoretically grounded, evidence-based SFMTIS, thus contributing to praxis and adding new knowledge of a focal theory that addresses sustainable mobile technology integration in schools in resource-constrained environments.

Table of contents

List of Figures

List of Tables

List of acronyms and abbreviations

CAPS	Curriculum Assessment Policy Statements
CSF	Critical success factors
CSIR	Council for Scientific and Industrial Research
DBE	Department of Basic Education
DoC	Department of Communications
ECDoE	Eastern Cape Department of Education
EMIS	Education management information system
ICT4D	Information and communication technology for development
ICT4RED	Information and communication technology for rural education development
LTSM	Learner and teacher support material
M & E	Monitoring and evaluation
ICT	Information communications technology
MTI	Mobile technology integration
P21	Partnerships for 21st century learning
RCE	Resource-constrained environments
SACE	South African Council of Educators
SGB	School governing body
SMT	School management team
SFMTIS	Sustainability framework for mobile technology integration into schools in resource constrained environments in South Africa
TECH4RED	Technology for rural education and development

List of appendices

Publications

Mabila, J., Van Biljon, J., & Herselman, M. (2017). A sustainability framework for mobile technology integration in schools: The case of resource-constrained environments in South Africa. *The Journal of Community Informatics*, *13*(2).

Mabila, J., Herselman M. & Van Biljon, J. (2016). A framework for sustainable mobile learning. *13th Prato Cirn Conference*, 2-4 November 2016, Monash Centre, Prato Italy, ISBN: 978-0-9874652-5-2

Chapter 1: Introduction

1.1 INTRODUCTION

Sustaining the integration of information and communication technologies (ICTs) in order to support teaching and learning in government schools in resource-constrained environments in South Africa remains a challenge (Meyer, Roux, Marais & Ford, 2016). Resource-constrained environments can be described as environments that are characterised by limiting economic circumstances, inadequate infrastructure and basic amenities (Anderson, Anderson, Borriello & Kolko, 2012). Consequently, teachers who operate within the limits of these constraints try to implement mobile technology in circumstances that are less-than-favourable. Challenges relate to electrical power and network connectivity as well as economic conditions which are characteristic of low-income communities (Anderson et al., 2012; Herselman & Botha, 2014).

Mobile learning and the implementation of mobile devices in educational environments have been investigated in many studies (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012; Pegrum, Oakley & Faulkner, 2013). However, few studies have extensively examined the dimensions that sustain mobile learning and developed frameworks for sustaining mobile learning in educational environments (Ng & Nicholas, 2013). There has been a lack of discourse supporting the sustainable use of mobile devices for learning in relation to factors such as policy, infrastructure, technical, administrative and community support. In addition, few studies have holistically explored the elements that sustain mobile learning (Ng & Nicholas, 2013). Categorisation and synthesis of mobile learning models and frameworks by Hsu and Ching (2015), support the assertion that prior to the development of the "Framework for sustainable mobile learning in schools" and the "Person-centred sustainable model for mobile learning", there was no model of sustainable mobile learning in schools in the literature (Ng & Nicholas, 2013). The latter was developed in the context of secondary education in Australia and thus based on data collected at an Australian school. This research differs as it is set within resource-constrained environments in South Africa. A study conducted by Mamba and Isabirye (2015) found that developing countries lack ICT for development (ICT4D) frameworks that are relevant to their contexts, and that it is critical to understand the context of the ICT4D project when developing these frameworks.

This research will develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa. The objective of this chapter is to provide the background to the thesis and to define the problem and research goals. In Section 1.2 the background to the thesis is described whilst the rationale and purpose of the thesis is presented in Section 1.3. This is followed by the research questions and objectives in Section 1.4 with Section 1.5 stating the research methodology and process. Ethical considerations are dealt with in Section 1.6 and the relevance and contribution of the study are addressed in Section 1.7. Scope and limitations of the research are specified in Section 1.8 whilst the summary and chapter map are presented in Sections 1.9 and 1.10 respectively.

1.2 BACKGROUND

South Africa's foundational strategic, pedagogical and developmental framework regarding e-Education implementation is outlined in the White paper on e-Education - Transforming Learning and Teaching through ICTs (DoE, 2004). The White paper on e-Education states that every South African manager, administrator, teacher and learner in general and further education and training, should be ICT capable. The paper further identifies regular access to reliable infrastructure as essential for successful e-learning (DoE, 2004). The National Development Plan (NDP) advocates for an e-literate society by 2030 and states that education, training, life-long learning and innovation are key to eliminating poverty, reducing inequality and boosting the country's economic development (National Planning Commission, 2012).

The South African government's objective is to roll out e-learning infrastructure and connectivity to each and every school in the country (NSTF, 2014). The impact and effectiveness of ICTs rest on the extent to which end-users: learners, teachers, managers and administrators, have access to hardware, software and connectivity (DoE, 2004). Electronic content resource development and distribution, ICT professional development for management, teaching and learning, access to ICT infrastructure and connectivity are main features for transforming teaching and learning through ICTs (DoE, 2004).

The 21st century environment is technology and media suffused, and effective citizens and workers need to be able to create, evaluate and effectively utilise information, media and technology (P21, 2016). Teachers need to develop learners' ICT competence, creativity and their ability to collaborate and solve problems through the use of ICT (UNESCO, 2016). Technology literate learners can use ICT to learn more efficiently, acquire in-depth knowledge of their school subjects and apply this gained knowledge to complex, real-world problems (UNESCO, 2016). South Africa's White paper on e-Education's policy goal is for learners to be ICT capable and to develop the skills and knowledge they need to achieve personal goals and fully participate as effective global citizens (DoE, 2004).

The term *digital literacy* is "a multi-faceted skill that includes the ability to find, use, interpret, modify and create a variety of digital media" (Spector, 2013: 22). Digital literacy is "using digital technologies to find, evaluate, synthesise, create and communicate information in an ethically and legally responsible manner" and integrates information, media and ICT literacy (Hagel, 2015: 13). To be digitally literate means having access to practices and cultural resources that one can then apply to digital tools to make and share meaning in different modes and formats, creating, collaborating and communicating effectively and having an understanding of how and when digital technologies can best be used to support these processes (Hague & Payton, 2010). Voogt and Roblin (2012) maintain that a set of capabilities, beyond ICT literacy, are required to enable productivity in a globalised 21st century world and these include: communication, collaboration, creativity, critical thinking, problem-solving, learning to learn skills, self-direction, planning, flexibility, risk taking, conflict management and a sense of initiative and entrepreneurship.

In modern knowledge-based economies, education is a leading determinant of economic growth, employment and earnings, and as such it affects individual and societal prosperity (Willard, 2012). Schools need to impart the relevant skills to learners in line with the new workforce realities. Learners need to develop flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, as well as leadership and responsibility (P21, 2016).

Teachers need to harness technology to teach learners the skills which they will need to successfully navigate the 21st century (DoC, 2014) where literacy is also perceived in terms of technology and media literacy (P21, 2016). Teachers' preparedness and knowledge to integrate technology into their teaching is central. There is a need for pedagogical knowledge to help guide teachers to teach with technologies and for learners to learn with technologies (Ng'ambi & Bozalek, 2016). Teachers' ICT literacy skills and competence are important factors that influence the success and sustainability of integrating the use of web-based technology resources in educational practices (Garba, Singh & Yusuf, 2013). Teachers' use of technology in the classroom can be impacted by first-order or second-order barriers. First-order barriers are those *external* to the teacher and include resources, institution, subject culture and assessment. Second-order barriers are those *internal* to the teacher such as his/her attitudes, beliefs, knowledge and skills (Ertmer et al., 2012).

There are various programmes that have been undertaken by the Department of Education with the goal to integrate ICTs in support of education (Meyer et al., 2016). An example of these programmes is "Operation *Phakisa* ICT in Education". This programme is Department of Basic Education (DBE) initiated and aimed at guiding and accelerating the integration of technology and connectivity into teaching and learning activities in South African schools. The programme was officially launched in 2015 and identifies digital content and curriculum, ICT teacher professional development, e-administration, information technology lifecycle management and connectivity as focal areas for accelerating the integration of technology into teaching and learning (More, 2015). "Phakisa" means to accelerate and "Operation Phakisa ICT in Education" is indicative of the importance and urgency with which the use of ICT in education is viewed for South African schools.

It is important to sustain ICT programmes that are rolled-out to support teaching because of the investments made in establishing the programmes, and the negative impact that failure can generate within the education system and the affected community.

1.3 RATIONALE AND PURPOSE

There is a shortage of suitable frameworks to guide the long-term sustainability of ICT4D programmes, particularly in resource-constrained environments in developing countries (Mamba & Isabirye, 2015; Nawi et al., 2013). On-going support and maintenance of many ICT programmes in rural areas often occur without the aid of the original team which were involved in the development stage (Conger, 2015). This is an essential factor if one considers Trucano's (2010) statement that educational initiatives for adoption of ICTs at schools in developing countries are susceptible to failure. Failure, or decay, often occurs when project leadership transitions from the project managers to the institution's middle managers who are tasked with continuing with the project (Parsons & Cornett, 2011).

In their study of ICT hubs in developing countries, Nawi et al. (2013) concluded that there is a need for research to determine significant criteria for sustainability of ICT4D projects in developing countries. The diversity of contexts and devices complicates a consolidated view of how to best sustain the practices and learning with mobile devices (Ng, 2013).

Theoretical frameworks exist which explain sustainability of ICT4D projects in resource-constrained environments. These include the "Critical Success Factors of rural ICT project sustainability" (Pade-Khene, Mallinson & Sewry, 2011) and the "Framework to guide development through ICTs in rural areas in South Africa" (Mamba & Isabirye, 2015).

Although these frameworks are specific to rural areas, they are not specific to the education environment. The "Evidence-based ICT4RED Implementation Framework" (Herselman & Botha, 2014), which resulted from the Information Communication Technology for Rural Education Development (ICT4RED) initiative, is specific to the integration of appropriate technology to improve teaching and learning and, as such, incorporates sustainability factors. Although the Evidence-based ICT4RED Implementation framework incorporates sustainability elements it is, however, an implementation framework. This study is relevant as it builds on the discussed frameworks and focuses on sustainability for mobile technology integration in resource-constrained schools.

Successful and sustainable integration of web-based technology resources in educational practices requires teachers to be ICT literate and competent (Garba et al., 2013). Teachers require adequate knowledge and confidence in how to use ICT in their daily teaching activities, and support, otherwise they are likely to revert to traditional teaching methods in spite of the potential benefits offered by new technologies (De la Iglesia, Sollervall, Delgado & Mazarico, 2015). Teachers' willingness and preparedness to adopt mobile learning as a mechanism to support teaching and learning are also important factors which govern the successful implementation of ICT programmes (Ismail, Azizan & Azman, 2013). In order to understand *how best* to sustain ICT programmes, it is necessary to determine what influences teachers to use technology to support teaching (Chiu & Churchill, 2015) and to understand the classroom practices which are influenced by their pedagogical beliefs (Fives & Gill, 2015).

Teachers are increasingly expected to be skilled at using technology to promote learner-centred learning and, in so doing, equip learners to become digitally literate and help them to adapt to a knowledge economy (Blonder et al., 2013; Riel, Lawless & Brown, 2016). Mobile learning (mlearning) involves the engagement of learners in educational activities, using technology as a mediating tool for learning via mobile devices accessing data, and communicating with others through wireless technology (Wu et al., 2012). Mobile devices such as laptops, tablets, mobile phones, smartphones, personal digital assistants (PDAs) and Web 2.0 technologies and resources on the Internet can be used for mlearning. A learner, or teacher, who is mlearning literate is empowered to learn more independently and more safely when using mobile devices and their applications (Ng, 2013).

Ng and Nicholas (2013) developed a "Person-centred sustainable model for mobile learning" (Ng & Nicholas, 2013) in the context of secondary education in Australia, based on data collected at an Australian school, as previously indicated in Section 1.1. The Australian school was selected because of the enthusiasm and active involvement of the "technologically savvy" principal who actively participated in the mlearning programme. Funding for the programme was internal, thus provided within the school. This environment differs from the context of this study which pertains to resource-constrained environments in South Africa.

The context in which this research was conducted is the Eastern Cape province of South Africa, Cofimvaba, Nciba school district where the ICT4RED initiative occurred. Teachers who participated in this research had formerly participated in the ICT4RED initiative. A South African government-initiated project, ICT4RED, investigated ways in which ICTs could be integrated into teaching and learning in rural areas. The ICT4RED initiative was carried out over 3 years, from 2012 to 2014, testing the use of mobile tablets in 26 schools in Cofimvaba circuit in the Nciba school district in the Eastern Cape province of South Africa. A major objective of the ICT4RED initiative was to design systemic and sustainable approaches to provide access to digital content to learners at marginalised rural schools in South Africa.

As in many other educational ICT4D projects, ICT4RED had in its initial assessment identified *sustainability* as a risk for the ICT4RED (Ford & Botha, 2014), and noted factors that had to be mitigated. Infrastructure such as buildings, ICT infrastructure and financial resources were identified as possible risks in ICT implementation in resource-constrained environments (Coetsee, 2014; Ford & Botha, 2014). The state of school buildings made it difficult to set up and securely store ICT infrastructure and equipment, and the ICT infrastructure in some areas was not well established (Ford & Botha, 2014; Herselman, Botha & Ford, 2014). This is illustrated by the use of satellite technology as the currently implemented alternative solution. This solution was adopted because wireless mesh, which the ICT4RED project had planned to use to connect schools and then access the South African National Research Network (SANReN) for broadband Internet connectivity, could not be implemented because the closest SANReN node was in another town that was much further away than originally projected (Ford & Botha, 2014). Satellite systems often require expensive installation, high monthly fees, and are relatively expensive (Olson et al., 2011).

Restricted or non-existing financial resources contribute to the sustainability risk. The funding of the ICT4RED initiative was allocated at a strategic, national level, with a short-term, three-year implementation focus rather than long-term sustainability focus (Meyer & Marais, 2014). The educational system itself is funded within pre-defined budgets, and there is limited flexibility as to the re-allocation of funds. Furthermore, resource-constrained schools have limited financial resources to commit towards such initiatives. Financial resources are required to support: Teacher Professional Development (TPD), a key driver in implementing ICT for rural education and development, provision of a reliable network, Internet access and Wi-Fi and operational costs for tablet maintenance. Content, such as e-books uploaded to the servers of the schools participating in the ICT4RED project, requires updating and appropriate licensing. Financial sustainability is therefore essential. The ICT4RED programme identified that the Eastern Cape Department of Education's (ECDoE) budget and strategy needed to make provision for continued operational costs (Herselman, 2014; Meyer & Marais, 2014).

The "Provincial ICT Forum" of the ECDoE was identified as a significant organisational structure and consequently assigned the role to coordinate the implementation of technology and teacher learning in the province. This forum was viewed as well positioned to coordinate and optimise the ICT4RED initiative activities after implementation. It was, however, noted that for the forum to function optimally and effectively execute its crucial mandate, it had to be appropriately structured (Meyer & Marais, 2014).

Other identified risk factors included the limited guidelines governing educational digital content creation and that school and district environments evolve slowly whilst the implementation of the ICT4RED initiative was done within a relatively short time frame (Meyer & Marais, 2014). The stakeholders (the circuit manager, district officials and the Eastern Cape Department of Education) had to develop a sustainability plan and strategy. The objective of this plan was to address ICT architecture issues such as Internet and Wi-Fi connection problems, tablet problems and upgrades, training of new teachers after the ICT4RED initiative had ended, and the provision of support to school ICT Champions (Herselman et al., 2014). Sustained ICT integration thus extends beyond the mere implementation of the technology but also involves processes and systems at different levels of the education system including the school, district and provincial levels (Meyer et al., 2016).

The need for evidence-based frameworks which provide guidance and practical advice regarding the increased sustainability of mobile technology integration at schools in resource-constrained environments is thus evident. A conceptual framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa will be developed in this research. A conceptual framework is a graphic, or narrated, artifact which explains important factors, concepts or variables, and the relationships among them (Miles & Huberman, 1994). Conceptual frameworks represent ways of thinking about a problem, its complexities, processes, variables and outcomes and its inter-relatedness, thus allowing researchers to build on each other's work in order to arrive at a deeper understanding of a problem, and to so help guide the development of possible solutions (Bordage, 2009).

1.4 RESEARCH QUESTIONS AND OBJECTIVES

This section outlines the research questions and objectives which will address the research purpose.

1.4.1 Research questions

The main research question is:

What constitutes a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa?

In order to address this question, the following research sub-questions (SRQs) will be answered:

SRQ1: What frameworks exist for sustainable mobile technology integration?

SRQ2: What are the perspectives of teachers on mobile technology integration in schools in resource-constrained environments?

SRQ3: What are the perspectives of school district officials on mobile technology integration in resource-constrained environments?

1.4.2 Research objectives

The main objective of the research is to:

Develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa.

For this purpose, the framework will be referred to as *the sustainability framework for mobile technology integration into schools (SFMTIS)*, focusing on mobile technology integration into teaching for a specific project in schools in a resource-constrained environment in South Africa.

The study research objectives (SRO) are to:

SRO1: Determine what frameworks exist for sustainable mobile technology integration in schools,

SRQ2: Investigate the perspectives of teachers on mobile technology integration in schools in resource-constrained environments, and

SRQ3: Investigate the perspectives of school district officials on mobile technology integration in resource-constrained environments.

1.5 RESEARCH METHODOLOGY

The research strategy selected for this study is Design Science Research (DSR). DSR is a problem-solving research paradigm used to answer questions that are relevant to human problems and, in so doing, to produce useful artifacts: concepts, models, methods and instantiations (Drechsler & Hevner, 2016). The artifact that will be developed in this research is a sustainability framework for mobile technology integration in schools in resource-constrained environments in South Africa. The Design Science Research Methodology process (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007) will be applied to develop the framework.

More in-depth discussions on the methodology can be found in Chapter 2.

1.6 ETHICAL CONSIDERATIONS

Ethical clearance was granted by the University of South Africa (Unisa) as per clearance certificate in Annexure 1.1. Ethical considerations and concerns to promote research integrity were undertaken in line with the University of South Africa's research ethics policy (Unisa, 2014). Permission granted by the Eastern Cape Department of Education to the ICT4RED initiative, under whose auspices the study was conducted, is included in Annexure 1.2. Participants had to be informed of: the purpose of the study, their right to choose whether to participate or not and their right to withdraw at any time during the research. Consent forms, as per Annexure 1.3, were provided to participants to sign once they had elected to participate. Principles of anonymity and confidentiality had to be adhered to.

1.7 RELEVANCE AND CONTRIBUTION

The research relevance and contribution is through:

1. Developing a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa, the SFMTIS.
2. Making a practical contribution by providing a mechanism which could increase the likelihood of sustainability of mobile technology integration initiatives in schools.
3. Providing a guideline for the Department of Basic Education (DBE) and the provincial Eastern Cape Department of Education (ECDoE) to use when considering sustainability in integrating technology into resource-constrained schools in South Africa.

4. Summarising extant literature by reviewing previous frameworks. The initial conceptual framework was synthesised from: relevant extant sustainability frameworks, frameworks for ICT4D implementation in resource-constrained environments specifically and frameworks for sustainable mobile learning in schools. An initial conceptual framework was synthesised from the relevant extant sustainability frameworks. The other theories provided the knowledge base in the applied DSR methodology. These frameworks include: theoretical frameworks which explain the long-term sustainability of ICT4D projects in general, frameworks which have been developed based on the findings of ICT4D projects conducted in resource-constrained environments in South Africa highlighting sustainability dimensions not necessarily specific to the education domain, and a framework that addresses sustainable mobile learning in schools in a different context.
5. Analysing policy and strategy documents of the Department of Basic Education and other government departments in South Africa towards the development of the SFMTIS.
6. Contributing to theory by developing the theoretically grounded, and evidence-based, SFMTIS as a focal theory which can then be used to describe the sustainability of mobile technology integration in schools in resource-constrained environments in South Africa.

1.8 SCOPE AND LIMITATIONS

The research scope is limited to public schools located in the Nciba school district of Cofimvaba in the Eastern Cape province, South Africa. The research participants are limited to teachers and district officials from the Nciba school district who had participated in the ICT4RED initiative. The study focuses on *teaching* rather than *learning* or mobile learning per se, and the participants at school level are teachers (and not learners). Teaching and learning approaches are beyond the scope of this study. The study uses feedback from teachers and district officials to inform the sustainable mobile technology integration framework (SFMTIF).

A limited number of models and frameworks for mobile technology integration in schools were reviewed. This is due to the limited number of available frameworks for mobile technology integration in schools. This provides an opportunity for the research to contribute to frameworks that are relevant for resource-constrained environments.

The researchers’ experiences and values could subjectively influence the research data collection and analysis. Application of design science research provides structure and rigor to enhance objectivity of the research.

1.9 SUMMARY

Sustainability is an important consideration, and risk factor, in many ICT4D initiatives. This research addresses the shortage of suitable frameworks to guide the long-term sustainability of mobile technology integration into schools in developing countries. This research applied design science research (DSR) to develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa. The research scope is limited to public schools, and to teachers and district officials as participants in the case study, and not to learners. The study focuses on teaching and not on learning or mobile learning. Teaching and learning approaches are beyond the scope of the study.

The research contributes to praxis and to theoretical knowledge generation. The practical contribution is developing the SFMTIS artifact as a guide on how to increase the likelihood of sustainability of mobile technology integration initiatives in schools. The SFMTIS can be applied as a guideline at micro (school), meso (circuit and district) and macro (provincial and national) levels of the education system. The SFMTIS is a DSR artifact that contributes to knowledge and theory development. The research applies relevant extant sustainability frameworks, is situated in a specific environment, and therefore provides insights on sustainable mobile technology integration in schools in resource-constrained environments in South Africa.

1.10 CHAPTER MAP

The chapter map depicted in Figure 1.1 provides an overview of the thesis chapters. The narration for each of the chapters indicates the main discussion points and outcome of the chapter. A similar diagram is presented at the beginning of each chapter with further details regarding the specific chapter.

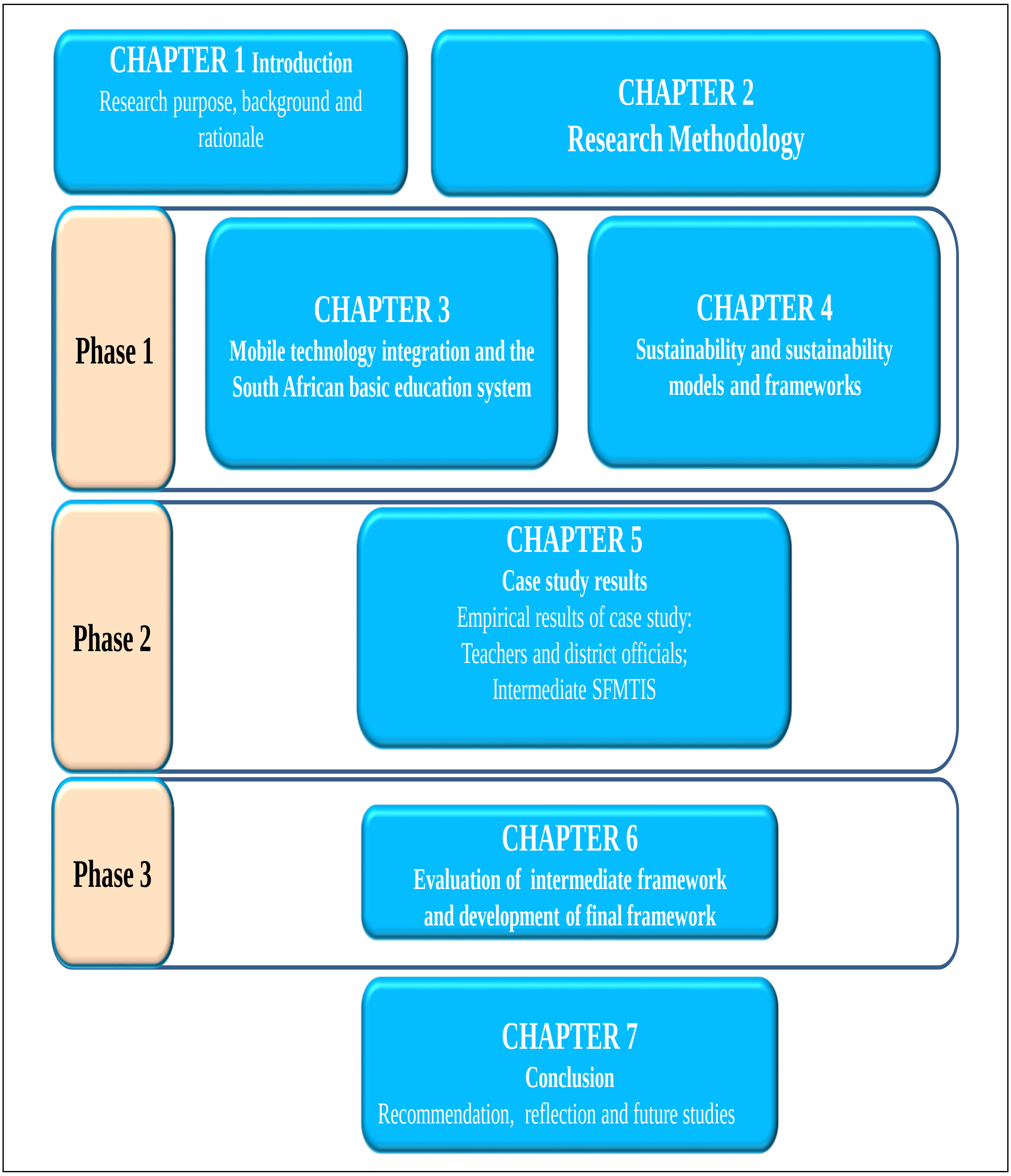


Figure 1.1 Chapter Map

There are 7 chapters in this thesis, as depicted in Figure 1.1.

Chapter 1 presents the research purpose, background and rationale for the study. The research problem and the need for the research as well as the research questions and objectives are stated. The selected research methodology and philosophies are outlined.

Chapter 2 discusses the research methodology. The selected design science research (DSR) and design science research methodology (DSRM) process are discussed, and the reasons for their selection in this research are explained. Research philosophies are outlined and the pragmatic philosophy applied in this study is deliberated.

Chapter 3 discusses mobile technology integration and the South African basic education system. The environment in terms of people as well as organisational and technical systems within which mobile learning integration is implemented in the South African basic education system is discussed. ICT related challenges in the basic education system are deliberated.

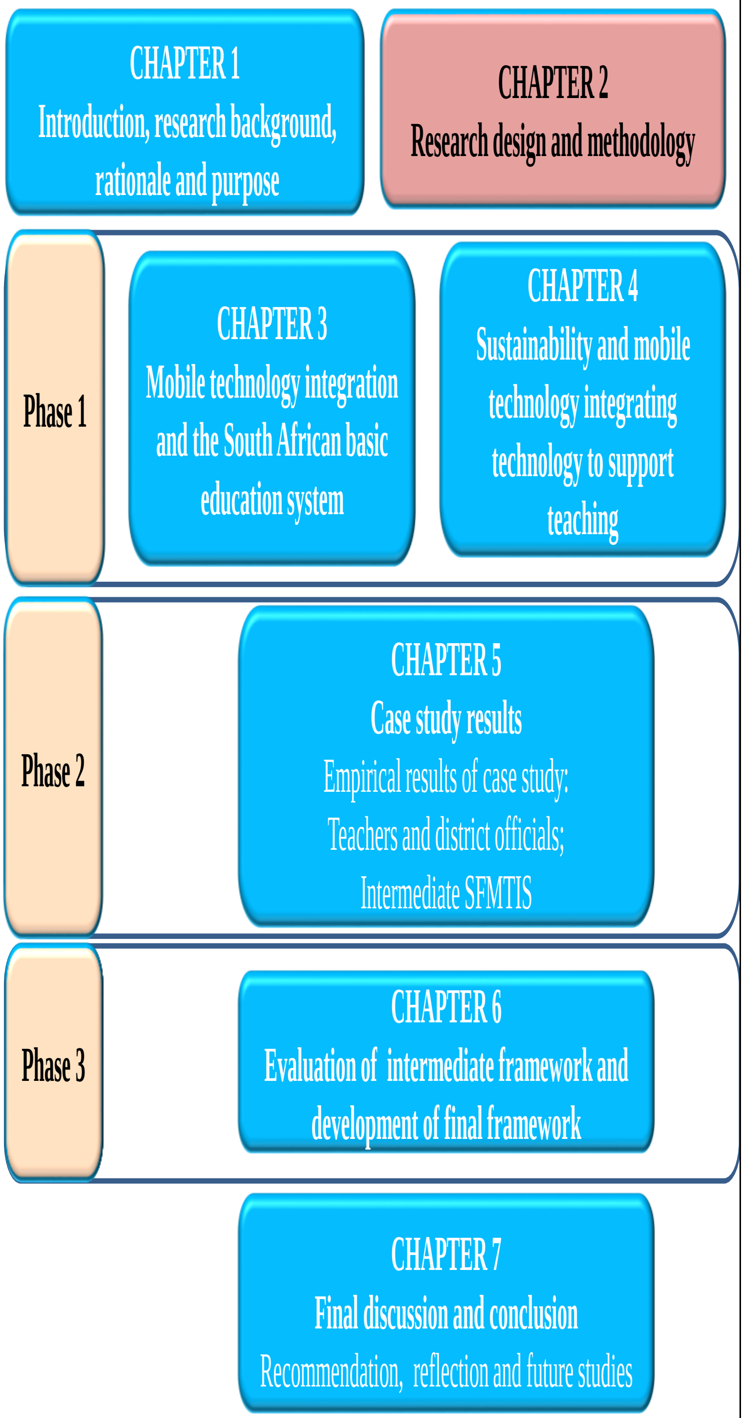
Chapter 4 discusses sustainability: sustainability of ICT4D models and frameworks in general and in resource-constrained environments specifically. The sustainability dimensions relevant to developing the SFMTIS are identified. The initial SFMTIS is presented.

Chapter 5 presents the empirical results of the case study carried out to investigate the perspectives of teachers and district officials on mobile learning integration in their schools. The perspectives of the teachers and district officials regarding mobile technology integration in their schools are applied to inform and refine the initial SFMTIS based on the literature review. The intermediate SFMTIS is presented.

Chapter 6 discusses the findings, the expert evaluation of the intermediate SFMTIS, and how these inform and refine the framework. The final SFMTIS is presented.

Chapter 7 concludes the research and presents recommendations, reflections and scope for future studies.

Chapter 2: Research design and methodology



Chapter 2: Research design and methodology

"To be a human being is to be a purposive agent, who both has reasons for his or her activities, and is able if asked to elaborate discursively upon those reasons" (Giddens, 1984: 3)

2.1 INTRODUCTION

The research purpose, background and rationale for the study were presented in Chapter 1. This chapter discusses the research methodology. Design Science Research (DSR) (Drechsler & Hevner, 2016) was selected for developing the *sustainability framework for mobile technology integration in schools* (SFMTIS) in resource-constrained environments in South Africa. The philosophy applied for the research is pragmatism. Many DSR researchers consider pragmatic philosophy applicable when employing the Design Science Research Methodology (DSRM) (Hevner, March, Park & Ram, 2004; Hevner & Chatterjee, 2010; Simon, 1996). Design science research is fundamentally pragmatic in nature, it emphasises relevance and requires that the contribution into the application environment should be clear (Hevner et al., 2004). A pragmatist philosophy argues that scientific research should be evaluated for its practical implications and that its practical relevance should be equally valued in terms of the rigour with which the research was performed to achieve the result (Hevner & Chatterjee, 2010). The DSRM process of Peffers et al. (2007) was followed in developing the framework. Interpretivism was only applied when a case study was used within the DSRM process model to refine and validate the framework (Figure 2.9 and Table 2.4).

The research methodology is discussed in Section 2.2. The research questions and chapters are mapped to the relevant questions that, according to Hevner and Chatterjee (2010), should be addressed by DSR research. The philosophies, research paradigms and philosophical assumptions are deliberated. The research theoretical foundations are discussed in Section 2.3. This is followed by a discussion of DSR, and how it was applied in this study, in Section 2.4. The DSR methodology and its application in the research are discussed in Section 2.5 and the research design is dealt with in Section 2.6.

2.2 RESEARCH METHODOLOGY

In the following section research questions and thesis chapters are related to questions that DSR should address. The philosophical and theoretical foundations made for the research are then presented.

2.2.1 Mapping the questions that DSR should address to research questions and chapters

There are eight essential questions that DSR should address (Hevner & Chatterjee, 2010). Table 2.1 maps these questions to the research questions and thesis chapters.

Table 2.1: Mapping questions DSR research should address to thesis research questions and chapters (Adapted: Hevner & Chatterjee, 2010)

Questions for DSR research (Hevner & Chatterjee, 2010)	Thesis research questions	Chapters
1. What is the research question (design requirements)?	What constitutes a framework for sustainable mobile technology integration in schools in resource-constrained environments?	Chapter 1: Introduction. Research purpose, background and rationale.
2. What is the artifact? How is the artifact represented?	What constitutes a framework for sustainable mobile technology integration in schools in resource-constrained environments?	Chapter 6: Validation of the intermediate SFMTIS and development of the final framework.
3. What design processes (search heuristics) will be used to apply (or develop) the artifact?	What are the perspectives of teachers on mobile technology integration in schools in resource-constrained environments? What are the perspectives of school district officials on mobile technology integration in resource-constrained environments?	Chapter 2: Research methodology DSR (Drechsler & Hevner, 2016); DSRM process (Hevner, 2007). Chapter 5: Case study results.
4. How are the artifact and the design processes grounded by the knowledge base? What, if any, theories support the artifact design and the design process?	What frameworks exist for sustainable mobile technology integration?	Literature review: Chapter 3: Mobile technology integration in South African basic education system. Chapter 4: Sustainability and sustainability models and frameworks.
5. What evaluations are performed during the internal design cycles? What design improvements are identified during each design cycle?	Evaluation metrics: Utility, quality and efficacy (Hevner et al., 2004).	Chapter 2: Research methodology. Chapter 6: Evaluation of Intermediate framework.
6. How is the artifact introduced into the application environments and how is it field-tested? What metrics are used to demonstrate artifact utility and improvement over previous artifacts?	Framework went through 3 phases of iterations and improvements. Expert reviewers (including teachers, district officials and ICT4RED initiative management).	Chapter 2: Research methodology. Chapter 6: Evaluation of Intermediate framework.
7. What new knowledge is added to the knowledge base and in what form (e.g. peer-reviewed literature, meta-artifacts, new theory, new method)?	What role does the perspectives of teachers and district officials in schools in resource-constrained environments play in the development of the SFMTIS?	Chapter 5: Case study results. Chapter 6: Evaluation of Intermediate framework.
8. Has the research question been satisfactorily addressed?	The main question is: What constitutes a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa?	Chapter 6: Evaluation of Intermediate framework. Chapter 7: Conclusions, recommendations, reflection and future studies.

2.2.2 Philosophy in Design Science Research Methodology

The researcher's real starting point as regards the methodological choice in information systems (IS) is not so much the methods employed, be they qualitative or quantitative, but rather the researcher's ability to identify the philosophical and theoretical foundations that lead to the choice of an appropriate methodology (Creswell, 2014). The philosophical worldview which the researcher brings to a study is "a basic set of beliefs that guide action" (Guba, 1990: 17), the "general philosophical orientation about the world and the nature of research" (Creswell, 2014b: 6), paradigms (Lincoln, Lynham & Guba, 2011) and epistemologies and ontologies (Wayhuni, 2012). These paradigms (or worldviews) are philosophical assumptions about the phenomena to be studied, about how they can be understood, and the purpose and product of the research (Hammersley, 2012).

The philosophical viewpoint applied for this DSR study is pragmatism. Pragmatism acknowledges that cultural and personal perspectives can affect how the researcher observes, interprets and reports the findings, and that the researcher's values play an important role in his/her interpretation of results (Morgan, 2014; Teddlie & Tashakkori., 2012).

2.2.3 Philosophies

Philosophy provides a conscious and critical conception of the world which guides the researcher's sphere of activity. Well-defined philosophical assumptions and justification are necessary because we make assumptions based on our own positionality which biases how we view the world (Hopkins, Regehr & Pratt, 2017; Reed-Sandoval & Sykes, 2016; Takacs, 2003). A researcher's positionality matters because one's positionality influences how one interprets, values and discovers meaning (Reed-Sandoval & Sykes, 2016). Adopting a philosophical position enables the researcher to justify the range of activities and selected research approaches whilst recognising implied philosophical beliefs which may not have been acknowledged (Takacs, 2003). Understanding how one's experiences and identity influence what one knows about the world can enable the use of this experience as a source of valued expertise (Takacs, 2003).

Ontology relates to the nature of reality, that is, what things, if any, have existence or whether reality is "the product of one's mind" (Burrell & Morgan, 1979: 1; 2017), thus, how the thing actually works (Biesta, 2015). The researcher's view of reality is the basis of all other assumptions (Holden & Lynch, 2004). *Epistemology* concerns the study of the nature of knowledge, that is, "How is it possible, if it is, for us to gain knowledge of the world?" (Hughes & Sharrock, 1997: 5), and what is the "the nature, validity, and the limits of inquiry" (Rosenau, 1992: 109). Babbie (2015: 6) defines epistemology as “the science of knowing; systems of knowledge” and “methodology” as “the science of finding out; procedures for scientific investigation”.

Axiology has to do with the “values that give direction to…” (Biesta, 2015: 18) and “what it should work for (axiology)” (Biesta, 2015: 13). This is relevant in relation to judgements about the purpose, and consequently the ways of working towards the purpose (Biesta, 2015).

Table 2.2: Philosophical assumptions

Philosophical assumption	**Meaning**	**Related questions** (Vaishnavi & Kuechler, 2004)
Ontology	The study that describes the nature of reality (Vaishnavi & Kuechler, 2004; Wayhuni, 2012). What exists in the human world that researchers can acquire knowledge about? (Moon & Blackman, 2014: 1167)	What is real and what is not? What is fundamental and what is derivative?
Epistemology	The study that explores the nature of knowledge reality (Vaishnavi & Kuechler, 2004). How knowledge is created (Moon & Blackman, 2014: 1167).	On what does knowledge depend? How can we be certain of what we know?
Axiology	The study of values (Vaishnavi & Kuechler, 2004).	What values does an individual, or group, hold and why?

As we make assumptions based our positionality we need to distill well-defined philosophical assumptions and justification (Morgan, 2014). It is therefore necessary for the researcher to reflect on his/her personal ontological and epistemological views (Van Zyl, 2015).

Methodology is the researcher’s “tool-kit” and, as such, it represents all the means available to the researcher to investigate the phenomenon (Holden & Lynch, 2004). A researcher’s core assumptions of ontology (reality) affect his/her epistemological (knowledge) persuasion which, in turn, effects his/her view of axiology (values) which, consequently, effects the choice of methodology (Holden & Lynch, 2004). Pragmatists argue that truth (justified theory) and utility (effective artifacts) are two sides of the same coin, and therefore scientific research should be evaluated on merit of its practical implications, and that practical relevance is as important as research rigour (Vaishnavi & Kuechler, 2007).

2.2.4 Research paradigms

A pragmatic approach implies the use of methods that suit the problem rather than methods that suit ontological or epistemological concerns (Holden & Lynch, 2004). Pragmatism emphasises practicality (Morgan, 2014; Shusterman, 2016), however it goes beyond "what works" and is a coherent philosophy (Morgan, 2014). Within the context of a pragmatic approach, a philosophical review can open the researcher's mind to other possibilities, enrich his/her research abilities and enhance confidence in the appropriateness of his/her chosen methodology to the research problem, thus also enhancing confidence in the research results (Holden & Lynch, 2004). Pragmatism is suited to the analysis of problem solving as a human activity (Morgan, 2014). Table 2.3 depicts the ontology, epistemology and axiology of three research philosophies: positivist, interpretivist and design science research.

Table 2.3: Research philosophy (Based on Source: Vaishnavi and Kuechler, 2007)

Basic belief	**Positivist**	**Interpretivist**	**DSR**	**This study**
Ontology	A single reality. Knowable. Probabilistic.	Multiple realities, socially constructed.	Multiple, contextually situated alternative world-states. Socio-technically enabled.	Perspectives of teachers and district officials in a resource-constrained environment in South Africa.
Epistemology	Objective. Dispassionate. Detached. Observer of truth.	Subjective (i.e. values and knowledge emerge from the researcher-participant interaction).	Knowing through making; objectively constrained construction within a context. Iterative circumscription reveals meaning.	Apply existing frameworks to build a new one.
Axiology	Truth. Universal and beautiful. Prediction.	Understanding; situated and descriptive.	Control; creation; progress (i.e. improvement); understanding.	Understand context and interpret feedback to improve the framework through 3 phases.

The axiological implications for this research are that the context of the study needs to be understood and that the feedback should be interpreted through an iterative DSR process. The epistemological position adopted taken is that the framework will be developed by applying an iterative approach of understanding existing sustainability frameworks. From an ontological view, multiple perspectives presented by participants will be analysed.

2.2.5 Research paradigms and philosophical assumptions

Research paradigms which researchers may apply include: positivism, interpretivism, critical theory and DSR. These are discussed in the following section.

2.2.5.1 Research paradigms

Positivism is a scientific research paradigm that focuses on the objectivity of the research process for investigating, confirming and predicting law-like behaviour patterns and is commonly used to test theories or hypotheses (Creswell, 2014; Vaishnavi & Kuechler, 2013). Positivists believe that different researchers, applying a similar research process to the same factual problem, will generate a similar result when a large sample is investigated and that a universal generalisation, that can be applied across contexts exists (Wahyuni, 2012). In positivism the ontological view is that social reality is external and objective. Consequently positivists axiologically perceive the researcher as separate from the researched and, consequently, the conducted research is considered to be value-free (Vaishnavi & Kuechler, 2013). Quantitative methodology using experiments, control groups and pre- and post-test measures is often applied in a positivist paradigm. The classic formulation of positivism is insufficient for studying and understanding human-environment action because it cannot fully account for the subjective nature of human reasoning and choices (Evely, Fazey, Pinard & Lambin, 2008; Moon & Blackman, 2014).

A positivist paradigm states that knowledge is absolute and that a single objective reality exists (Wayhuni, 2012). Studies that adopt a positivist view are often hypothesis-driven and primarily rely on quantitative methods. A positivist approach is equated with the scientific method where knowledge is discovered through controlled empirical means, such as experiments. The studies are often hypothesis-driven and the research results expected to be reliable and consistent, free from perceptions and researcher bias. Consequently, other researchers should be able to replicate the findings (Wayhuni, 2012).

Interpretive research is a humanistic research paradigm that aims to understand cultures, and the culturally different, by standing in the other's shoes and looking through their eyes. The epistemology of this paradigm is inter-subjective knowledge construction in which interpretive knowledge is produced through prolonged interaction. The researcher uses data collection methods (such as interviews and participant observation) to understand others' experiences and construct an authentic and trustworthy account. The position adopted in interpretive research is that our knowledge of reality is a social construct created by human actors (Chowdhury, 2014; Walsham, 1995). Interpretivism seeks to find underlying meaning and new interpretations which are time and context dependent and which adhere to the ontological assumption of multiple realities. Interpretivism uses qualitative studies to investigate research questions, focusing on understanding phenomena that occur in natural settings (Chowdhury, 2014). Consequently, the data collection and analysis is primarily qualitative and describing the phenomena and interpreting the data is important (Chowdhury, 2014; Moon and Blackman, 2014). Interpretivists consider individual cases to understand phenomena, often adopting a qualitative approach (Moon & Blackman, 2014).

Interpretivism promotes qualitative research in its concern for uniqueness of a particular situation and pursuit of contextual depth (Chowdhury, 2014). The research is conducted in a natural setting, thus helping to understand activities taking place in social or organisational contexts. Interpretivists consider reality as a construct by social actors, based on their perceptions of reality. These perceptions are influenced by individuals' varied backgrounds, their assumptions, experiences, social interaction and broader social context (Wahyuni, 2012). In *interpretivism*, research participants and researchers' experiences and values both have a significant influence on data collection and its analysis (Wahyuni, 2012).

Critical theory enables the researcher to identify gross power imbalances in society and socially unjust social structures, policies, beliefs and practices, particularly those that result in ethically questionable profit-making activities which, in turn, contribute to systematic inequalities and injustices and the economic exclusion of some sectors of society (Taylor & Medina, 2013). Critical theory challenges, and reveals, conflict and oppression in order to bring about change (Moon & Blackman, 2014). Critical theory empowers imaginative, critical thinking and addresses questions such as: "Whose interests are not being (and should be) served by particular social policies and practices?" It involves identifying social structures, policies, beliefs and practices that are socially unjust and transforming them (Taylor & Medina, 2013: 5). Critical theory primarily identifies, challenges and contributes to the resolution of gross societal power imbalances that contribute to systemic inequalities and injustices (Taylor & Medina, 2013).

Design Science Research (DSR) is a way of performing research in IS and involves the creation of new knowledge, through the design of novel or innovative artifacts, and analysis of the use and/or performance of such artifacts (Hevner & Chatterjee, 2010). DSR is a research paradigm that is relevant in information systems research projects as it focuses on the creation of innovative IT artifacts and their application in solving real-world problems (Hevner & Chatterjee, 2010).

DSR involves the iterative building and evaluating of design artifacts in research cycles (Dreschler & Hevner, 2016). The problem trigger is explicitly identified as the starting point in the Change and Impact cycle. The core activities of building and evaluating the design artifacts and processes occur in the rigour cycle. The contextual environment of the research project is connected to the design science activities in the rigour cycle by the relevance cycle. The design science activities are connected to the knowledge base of scientific foundations, experience, and expertise which inform the research project through the rigour cycle. DSR places significance on innovativeness within a specific context (Gregor

& Hevner, 2013; Hevner & Chatterjee, 2010). DSR involves reflection and abstraction to improve and understand behavioural aspects of IS.

DSR was selected for this research and is further discussed in Section 2.4. A case study was used within the DSRM process to obtain feedback from participants (as shown in Figure 2.9) and Interpretivism was used application of hermeneutics for data analysis, and to refine and validate the framework. The human sociological, technological and computational aspects of computing make interpretive and qualitative analysis relevant whilst the interpretivist paradigm is suited for studies of complex human behaviour and social phenomena (Gregor & Hevner, 2013).

2.2.5.2 Philosophical positionality and research paradigms

Takacs (2003), in a classical paper on "How does your positionality bias your epistemology," noted that philosophy provides a conscious and critical conception of the world which guides the researcher's sphere of activity. As Takacs (2003: 3) states:

> *"We come to know the world more fully by knowing how we know the world," and the 'researcher' should be aware of the conceptual shackles imposed by their identity and experiences. As the 'researcher' becomes aware of the conceptual shackles imposed by their identity and experience, and… takes necessary steps the 'researcher' can be more objective." ('researcher' paraphrased)*

The researcher interacts with people who hold different views. Consequently, who the researcher is, what they know, their values and experience of the world, these all may influence the knowledge that they produce. A self-reflective approach and examination of his/her worldview by the design science researcher, done in an effort to understand how positionality biases our epistemology, can lead to a more balanced and accurate knowledge about the world.

The theoretical foundations applicable to this research are discussed in the following section.

2.3 THEORETICAL FOUNDATIONS

Section 2.3.1 outlines the three theories, structuration, institutional and capability theories that provide the theoretical foundation for the study. In section 2.3.2 the theoretical considerations in developing the SFMTIS are further discussed.

2.3.1 The three theories that provide the theoretical foundation for the study

Section 2.3.1.1 outlines the Structuration theory. The Capability approach is discussed in Section 2.3.1.2, and the Institutional theory is deliberated in Section 2.3.1.3.

2.3.1.1 Structuration theory

Gidden's (1984) view of the structuration theory explains reproduction of social structure. In "The Constitution of Society - Outline of the theory of Structuration", Giddens (1984) describes structuration theory, stating that structuration addresses both *agency* and *structure,* thus providing a way for understanding the social element. The main assertion of the structuration theory draws together two principal strands of social thinking: the structuralist tradition, with its emphasis on *structure*, and the phenomenological and hermeneutic traditions, in which the *human agent* is the primary focus. Social practice is mutually dependent on structure and social interaction. According to Giddens the "duality of structure" means that structure and agency are recursively related and interdependent and that agents' actions produce, reproduce and develop social structures (Giddens, 1984). "Duality" of structure refers to the mutual dependence of structure and agency. The basic tenants of the structuration theory thus include *agency* and *structure*. "Agency", which refers to human agency, is "the capacity to make a difference" (Giddens, 1984: 14) and is associated with transformative capacity and power (Giddens, 1984).

In this study structuration theory was applied when discussing the human element as well as the structures and power dynamics that individuals have to navigate and fit into within institutions. The teachers and district officials who participated in Phase 2 of the study provided data, insight and understanding of organisational systems and processes that were used to refine the initial SFMTIS framework that was developed in Phase 1 (Figure 2.9).

Structuration theory in this research is aligned to consider the human element, as *agents*, and the structures which they have to fit into in the context of the South African basic education system and schools in resource-constrained environments, all the while taking into account the influences of authority and power systems. Structure is aligned to institutionalised features of social systems through which relationships are stabilised across time and space (Giddens, 1984). "Rules and resources" that are recursively involved in institutions are the most important aspects of structure (Giddens 1984: 24). Structure can be viewed as both *constraining* and *enabling* (Giddens, 1984).

The significance of "Agency" and its role in sustainability transformations should be considered. Agency is the capacity to "make a difference" in one's situation (Scott, 2004: 12). Agents can refer to individual actors and/or groups of actors. Individual actors, in this research, are the teachers, district officers, parents, learners, Department of Education officials and community members. Groups of actors, or agents, who share an interest in a particular domain of activity in an organisation form organisational sub-communities (Henfridsson & Lind, 2014. In this research these organisational sub-communities include teachers' communities of practice, school management teams and school governing bodies. The organisation serves as the *context* and the different actors and collective structures of organisational sub-communities make up the *organisational community* (Henfridsson & Lind, 2014).

The conduct of individual actors reproduces the structural properties of larger collectivities (or societies). These collectivities would cease to exist if all agents involved disappeared (Giddens, 1984). However, action depends on the "capability" of the individual to make a difference to a pre-existing state of affairs, or course of events. An agent ceases to be such if he/she loses the capacity to make a difference, that is, to exercise some sort of power (Giddens, 1984; 14).

According to Giddens (1984: 15), resources are structured properties of social systems and "knowledgeable agents" draw on, and reproduce, resources in the course of interaction. All social interaction is *situated interaction*, as it is situated in time and space. Giddens states that power involves the exploitation of resources where resources are authoritative and allocative. Allocative resources stem from a control of material products, or aspects, of the natural world. Authoritative resources derive from coordination of human agents (Giddens, 1984).

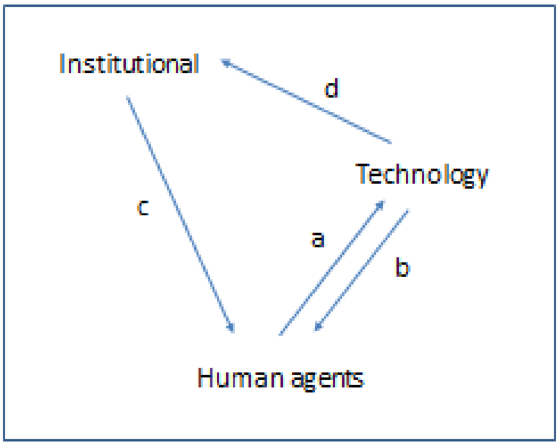
Structuration theory can be used as both meta-theory and as an analytical tool (Oppong, 2014). This means that it can be used to theorise the IS field, to analyse empirical situations and, if operationalised, to influence practice. Rose and Scheepers (2001) posit that the duality of technology relates to the fact that technology is created and changed by human action but is also used by humans to accomplish action. Structuration theory provides insights that inform this research.

This research considers the role of human agents in sustainability transformations at different levels of the education system – micro (school), meso (circuit and district) and macro (provincial and national) levels. The structuration theory is used to analyse the empirical situation and to provide insights regarding the human agent's capabilities, institutional context and implications for the research.

The structurational model of technology (Orlikowoski, 1992) represents the interactions, conditions and influences of institutional, technology and human agents over time. The use of the technology, according to strategic objectives, enhances sustainability.

However, human agents function within an institutional and social context and have capability and autonomy in relation to technology use.

Figure 2.1 presents the relationships between institutional, technology and human agents. These relationships vary over time and can account for technology related changes that occur in the institution (Orlikowoski, 1992). Variations in the relative strengths of these relationships over time can lead to the development of points of tension and instability can result in change and transformation (Jones & Karsten, 2003).



Type of influence represented by arrow:

a: Technology as *product* of human action
b: Technology as a *medium* of human action
c: Institutional *conditions* of interaction with technology
d: Institutional *consequences* of interaction with technology

Figure 2.1: Structurational model of technology (Orlikowoski, 1992)

The structurational model of technology (Orlikowoski, 1992) posits that the four main influences between institutions, technology and human agents are:

- Information technology (IT) as an outcome or product of human action, developed and used by human agents. Human action maintains and adapts technology by using the technology. Human agents may choose not to use the technology.
- IT as a means of human action that facilitates communication. Technology has both restricting and enabling implications, depending on human agents' autonomy and capability as well as the institutional context.
- The particular social context in which IT is built and used. The existing institutional conditions of interaction with technology such as the resources, norms and knowledge as well as social and historical circumstances.
- The influences that interaction with IT has in the context in which it is built and used. The use of the technology may become normalised when the human agents use the technology and sustain its use as intended. The technology could be undermined if it is not used according to the strategic objectives.

This research focuses on the context of mobile technology integration into schools in South Africa in a resource-constrained environment in Cofimvaba school district, Nciba circuit, in the provincial Eastern Cape Education Department through the ICT4RED programme. The introduction of the mobile tablets and the associated technology infrastructure, and teacher professional development to support teaching, influenced the social context into which it was introduced.

The main aspects of social thinking are structuralist with emphasis on constraints because of structure, and phenomenological and hermeneutic traditions, where the primary focus is on the human agent. The problem is *how* to use individual and societal innovative and transformative capacity to solve social problems, and in this case, create the conditions for sustainable mobile technology integration for both today and the future. As Seyfang and Haxeltine (2012) observe, solutions should be adapted to specific social and cultural conditions. Innovative solutions provided should be inclusive and coproduced by policy makers, researchers and individuals who are affected by the changes.

In this research the actors, or agents (for example teachers, district officers, parents, learners, Department of Education officials, community members and community leaders), can make a difference as individuals through their day-to-day activities and interactions, as part of sub-communities (for example teachers' communities of practice, school management teams, school governing bodies), and as part of the organisational community.

A question, which relates to the use of structuration theory in this research as well as pertaining to sustainability, is: *"Why do some forms of social reproduction succeed and become institutionalised and others do not?"* (Archer, 1966 in Rose & Scheepers, 2001: 6). This requires consideration of everyday processes and practices in the organisation. In order to analyse the structuration of social systems, the context in which such systems occur need to be studied.

In this research structuration theory is applied in an effort to understand and interpret the role and interaction of the various stakeholders for sustainable mobile technology integration at different levels of the system: micro (school), meso (district and circuit) and macro (provincial and national) levels. Structuration theory provides insights into the nature of the institutional, technology and human agents' interactions (Orlikowoski, 1992).

Criticisms levelled against structuration theory: Criticism of Giddens's structuration theory vary from Craib (1992) who accuses Giddens of being "reductionist", analysing and describing complex phenomena in terms of simple constituents, to Gregson (1989) and

Archer (1990) who criticise the structuration theory for being too complex and ambiguous. Critics of the structuration theory point out that social structure and agency are dependent (Jones & Karsten, 2003) and question Giddens's use of agency and the view that social order is produced and reproduced entirely through individual action. Critics argue that individual structurational agency may be insignificant in well-ordered institutions and that social rules may dominate social reproduction (Jones & Karsten, 2003). Moreover, agents may not be equally amenable to agency (Storper, 1985: 419).

In this research the structuration theory is applied in conjunction with the capability approach and the institutional theory in order to expound on the context and agency of actors.

2.3.1.2 The Capability Approach

Individuals have capabilities, however, the structure and associated rules and resources that are recursively involved in institutions may be constraining and/or enabling (Giddens, 1984). Sen's capability approach (Sen, 2005), which is rooted in philosophy and classic economic theory, highlights social and economic factors which provide people with the opportunity to do, and be, that which they consider valuable for their fulfillment. This approach advocates that well-being, which is linked to sustainability, should be considered in terms of human functionings and capabilities where *functionings* describe what a person may value being or doing, and *capability* refers to "the opportunity to achieve valuable combinations of human functionings" (Sen, 2005: 4). The capability approach asserts that development implies the broadening of human potential, choices, freedoms and capabilities (Sen, 2005). Sustainability is inextricably linked to basic questions of equity, fairness, social justice and greater access to a better quality of life (UNDP, 2011). Sen observes that individuals are not simply people with needs but are agents of change who can, if given the opportunity, think, assess, evaluate, resolve, inspire, agitate and, through these means, reshape the world (Sen, 2005).

Figure 2.2 represents a person's capability set and his/her social and personal context. The capabilities approach focuses on social institutions and social and legal norms that impact on people's capabilities.

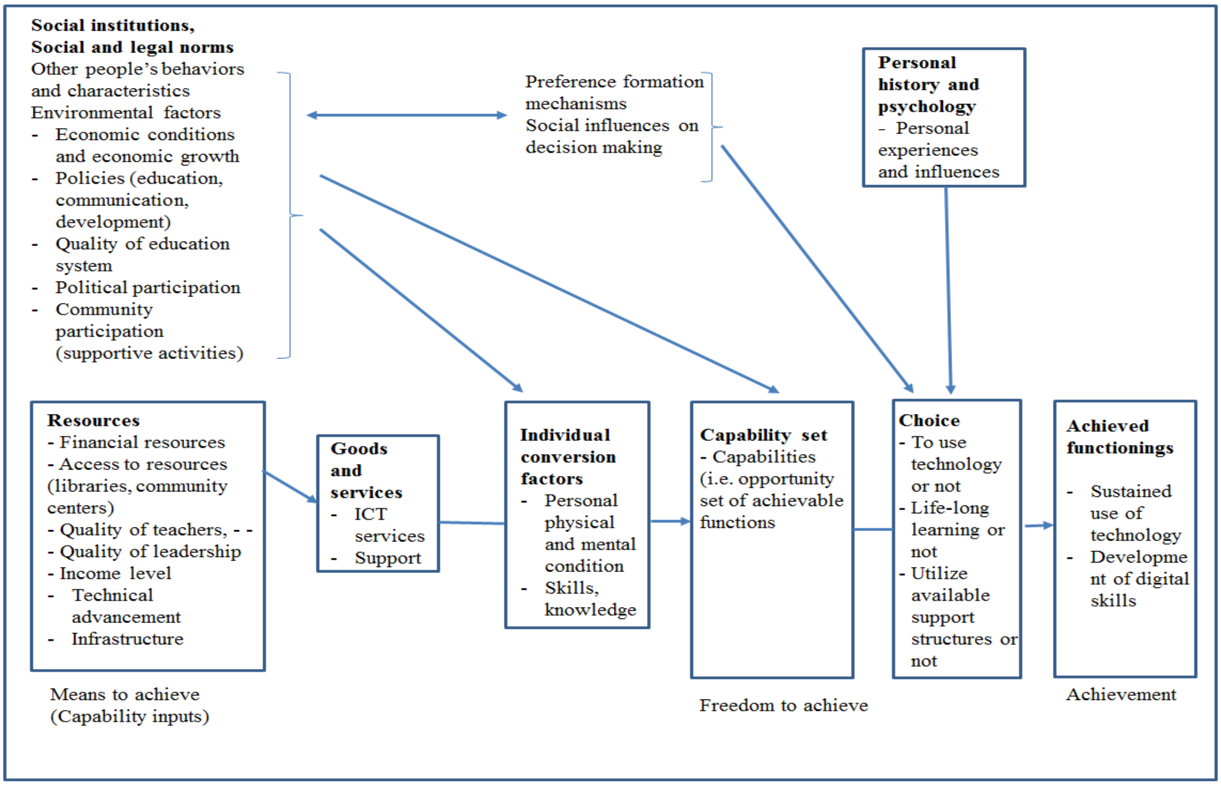


Figure 2.2: A representation of a person's capability set and his/her social and personal context
Adapted from Robeyns (2005)

The circumstances in which individuals live, influence the choices available to them. In the context of this study, the focus should therefore be to provide *enabling circumstances* and to remove obstacles for teachers to use technology through supporting their teaching activities. The capability approach provides a framework for considering the multidimensional aspects of individuals' well-being, social arrangements, policies and available resources, in which social interactions occur.

Policies, economic conditions, political participation and available supportive community activities affect the opportunities that the individual may engage in (Robeyns, 2005). The availability of financial and other resources, infrastructure, quality of teachers and leadership provide means and opportunities which enable effective choices. Individual conversions such as the individual's physical condition, skills and knowledge, influence the ability to effect their aspirations. Educational and development policies, the quality of the education system and the political and community participation impact upon the ICT services and support, and thus the choices available.

ICT integration requires that platforms should be created for societal discussions and debates to examine and address feelings of empowerment, or disempowerment, that can contribute to agents' effectiveness in the organisational community. Examples of this include meetings for specific groups (such as subject committees and school governing bodies) to be held regularly, monthly or quarterly per annum. Appropriate structure, change management, and leadership can facilitate such discussions.

Examining local strategies for solutions to challenges necessitates the consideration of the social systems as well as authority systems and their varying degrees of power.
Actors within institutions should be encouraged to challenge existing realities and to apply transformative measures whilst taking into account cultural beliefs, personal and environmental factors as well as contextual considerations which affect personal constructs and perceptions.

Processes that lead to sustainability transformations can be explored through studies in resilience thinking and social-ecological systems (Olsson, Galaz & Boonstra, 2014). The strategy of combining insights from different theoretical strands such as innovation, socio-ecological-technological systems interaction, agency and transformation, strengthens understanding of sustainability transformations. This involves identifying the role of *power* in transformation processes and how individual and societal innovation and transformation capacity can be used to solve problems and advance current and future human prosperity (Olsson et al., 2014).

In this research teachers and district officials, as human agents, function within an institutional and social context. The teachers and district officials have capability and autonomy in relation to technology use, however factors in their environment can affect their pedagogical practices. ICT interventions need to adopt a holistic approach which also considers the capability of teachers and district officials and how these capabilities can be strengthened in order to facilitate technology integration to support teaching.

The capability approach has been criticised for being individualistic and not paying enough attention to social structures and groups of individuals, however, as Robeyns (2005) states, social entities are the sum of individuals and their properties.

The following section discusses Institutional theory. Institutional frameworks can contribute to the consideration of institutional provisions that support structures more attuned to insuring accountability (Scott, 2004) and thus promote agency and sustainability transformations.

2.3.1.3 Institutional theory: Organisations as rationalised systems

In institutional theory organisations can be viewed as rationalised systems oriented towards achieving specific goals through sets of roles and related activities, in social behaviour and associated resources, anchored in rule systems and cultural schema (Scott, 2004). Models for designing organisational structures are based on positions, policies, programmes and procedures (Meyer & Rowan, 1977). Institutional theory recognises the importance of contextualising information technology within a socio-economic and political landscape (Currie, 2009).

Institutional theory also considers preferred and actual authority systems, the influence of cultural, social and political process and the role of "Agency" – the capacity to make a difference in one's situation (DiMaggio, 1988; Scott, 2004). Institutional theory recognises that actors are institutionally constructed, and examines systems ranging from micro interpersonal interactions to macro frameworks to understand and interpret bureaucratic rules, organisational authority systems and interaction.

2.3.2 Theoretical considerations in developing the SFMTIS

The illustration in Figure 2.3 shows the Structuration, Institutional and Capability theories' concepts, and considerations made in the development of the SFMTIS. Structure in Structuration theory mostly interacts with the Institutional theory, and provides a theoretical basis for studying the processes of institutionalization and organisational context. The organisation serves as the *context* and the different actors and collective structures of organisational sub-communities make up the *organisational community.* Agency in structuration theory interacts with *capabilities* and *functionings* in the Capability theory.

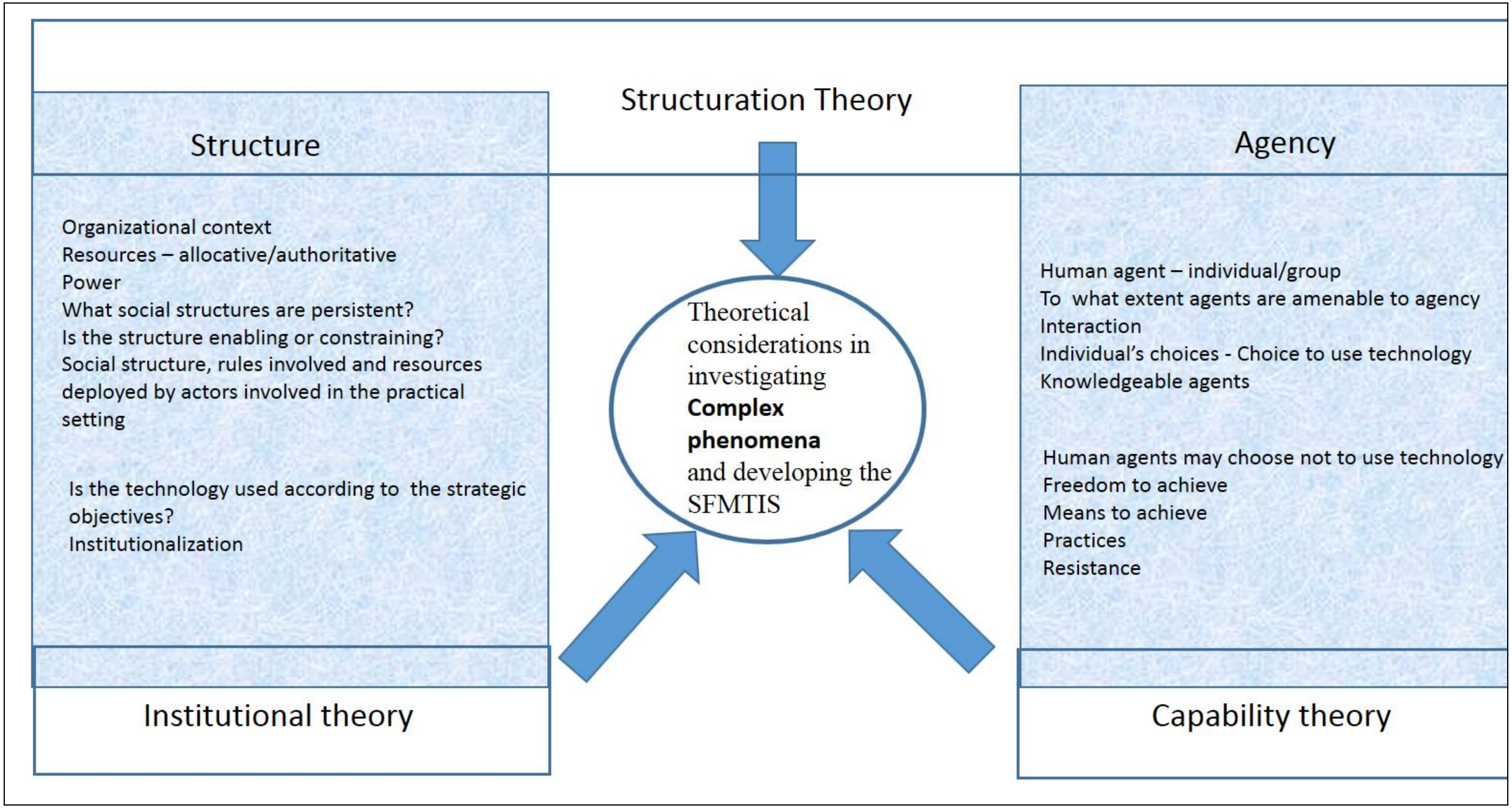


Figure 2.3: Structuration, Institutional and Capability theories and development of the SFMTIS

The application of these theories in this research are further discussed in the following section indicating the structures and agents (actors) in the context of the basic education system.

In South Africa, the national framework for organisation and staffing of education district offices outlines the organisation, roles and responsibilities of education districts for "effective districts and better quality" (DoE, 2013: 4). Districts are accountable to the Provincial Education Department and provide a vital channel for communication between schools and the Provincial office which reports to the National department. The National Education Policy Act (NEPA) 1996 (Act 2 of 1996) empowers the Minister of Basic Education to "determine national policy for the planning, provision, financing, staffing, coordination, management, governance, programmes, monitoring, evaluation and well-being of the education system" (DoE, 2013: 7).

ICT integration requires high-level support and advocacy, e.g. at provincial level, and a well-defined provincial ICT integration strategy with clearly stated realistic objectives aligned to measurable milestones along a well-defined path towards success. Although progress has been made, challenges in comprehensively integrating ICTs in support of teaching remain, particularly at district and provincial levels (Meyer et al., 2016). Clear objectives, measures of progress, an integrated strategy with a well-supported implementation plan, continuous professional training of teachers and subject education specialists (also referred to as subject advisors), technical support and communities of practice are all required for integration (Meyer et al., 2016).

There are four main roles of school districts are: to plan, support and provide oversight and accountability to schools under their care and to engage with the public (SASA, 1996) in line with provincial plans. Districts are tasked with providing support to and collaborating with principals and educators in order to improve the quality of teaching through school visits, classroom observation and cluster meetings. Planning at district level involves collecting data at school, circuit and district levels, helping schools to develop their school improvement plans and integrating them into district plans. Districts support schools through visits, classroom observations, consultations, cluster meetings, feedback reports and related activities. They are thus expected to provide an enabling teaching and learning environment, in line with education policy. Their oversight and accountability roles mean that districts are charged with holding principals accountable for the performance of their schools, and accounting to the provincial department, as per their stipulated roles and responsibilities.

A school is a system within a larger system of school circuits that form part of a district (Meyer, Marais, Ford & Dlamini, 2017). The introduction of technology in the classroom and training of teachers do not guarantee that teachers will integrate technology into their teaching practices (Van Der Ross & Tsibolane, 2017). Sustainable ICT interventions require that elements such as the quality of the school management, prior exposure to ICT interventions, school support structures (funders, sponsors and grants), the role of the community and politics and the geographical location of the school, all of which constitute the implementation readiness framework, be carefully considered (Meyer et al., 2017). Moreover, teachers' pedagogical and self-efficacy beliefs significantly influence their ICT integration behaviour, as teachers who support constructivist practices and are confident in their ability to use technology, integrate ICT into their pedagogical practices (Van Der Ross & Tsibolane, 2017).

Policy requires that districts consult and engage with the public in an open and transparent manner (DoE, 2013), in accordance with normative institutional values. District offices are tasked with "facilitating ICT connectivity in all institutions within their district" (DoE, 2013: 15) and this includes facilitating ICT connectivity and organising professional development for teachers, administrators and managers. Integration is required across different levels - school, district and province (DoE, 2013). In schools, the ICT committee is instrumental in developing the ICT policy in corporation with the School Management team. These structures, together with other school structures such as the School Governing Body (SGB) play a role in safekeeping ICT infrastructure such as servers and tablets as well as ensuring their effective utilisation.

In the context of this research, funding for the ICT4RED initiative was allocated at a strategic, national level, in accordance with a short-term, three-year implementation focus rather than long-term sustainability focus (Meyer & Marais, 2014). Moreover, the educational system itself is funded within pre-defined budgets with limited flexibility of re-allocation of funds. Furthermore, resource-constrained schools have limited financial resources to commit towards ICT initiatives. During the implementation of ICT4RED, the guidelines for educational digital content creation were found to be limited, and while the implementation of the ICT4RED initiative was done within a short time frame, the school and district environments were seen as evolving more slowly (Meyer & Marais, 2014).

In this study, Institutional theory is applied to understanding the basic education system environment, particularly the macro (school) and meso (district) levels, and applying the feedback for teachers and district officials to inform and improve the initial SFMTIS in

Phase 2 (Figure 2.9).

2.4 DESIGN SCIENCE RESEARCH

Design science research *methodology* (DSRM) incorporates principles, practices and procedures required to carry out design science research (Peffers et al., 2007). Design science research (DSR) addresses real world problems, or situations, that often occur in complex settings and involve many stakeholders (Drechsler & Hevner, 2016). These can be considered "wicked" problems (Hevner & Chatterjee, 2010). "Wicked problems" are complex problems which different stakeholders may view differently, they evade easy answers and could be insoluble (Awre et al., 2015: 1).

Design science research (DSR) is relevant for this study because of the nature of the identified problem and research objectives. The research problem can be considered a *wicked problem* as it involves many stakeholders in the education system within the complex context of a resource-constrained environment. The problem addressed by this research is a situated, real-world problem, arising from the challenge of sustaining ICTs in order to support teaching in government schools in South Africa. The research objective is to develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa.

2.4.1 Defining DSR

In DSR, a researcher addresses a particular real-world problem and developing a framework for MTI in schools in resource-constrained environments is one such problem. Major aspects of DSR include:

- Production of new innovative meta-artifacts as its constitutive and distinguishing research outputs.
- Research is a core activity of DSR and
- Meta-artifacts are produced as a result of the epistemology of utility (Iivari, 2015).
- The artifact is designed and refined iteratively through interconnected cycles to increase the artifact's effectiveness and knowledge contributions (Drechsler & Hevner, 2016; Hevner, 2007).

In information systems, the DSR paradigm can be described as:

The production of a useful artifact such as constructs, models, methods and *instantiations, and an iterative design development process, and formative testing and evaluation* (Gregor & Hevner, 2013).

Creating and evaluating information technology artifacts intended to solve identified organisational problems and involves a rigorous process of designing and evaluating the artifacts emanating from an important challenging problem, opportunity, or insight for something innovative in the application environment (Hevner, 2007; Iivari, 2007).

"Design Science…creates and evaluates IT artifacts intended to solve identified organisational problems" (Hevner et al., 2004: 77).

These definitions indicate that DSR in IS involves the creation and evaluation of an artifact to solve an important identified organisational problem, or to provide insight for something innovative in the application environment, through a rigorous, iterative process of designing and evaluating the artifact.

Design science occurs within a context which is the environment comprising of the people, organisational and technical systems in the specific application domain. The major problems which necessitate the design of the innovative DSR artifact in the first place, should be identified and agreed upon in the initial part of a DSR project (Drechsler & Hevner, 2016).

2.4.2 DSR products

An artifact is a coherent human-made entity that constitutes an interface between its inner workings and the elements of its environment (Drechsler & Hevner, 2016) and may be a construct, model, method or instantiation (Hevner, 2007; Iivari, 2007). Table 2.4 outlines examples of DSR artifacts.

Table 2.4: Knowledge outputs of Design Science Research
(Source: Vaishnavi & Kuechler, 2004; updated 2015)

	Output	**Description**
1	Constructs	The conceptual vocabulary of a domain.
2	Models	Sets of propositions, or statements, expressing relationships between constructs.
3	Frameworks	Real or conceptual guides to serve as support or guide.
4	Architectures	High level structures of systems.
5	Design principles	Core principles and concepts to guide design.
6	Methods	Sets of steps used to perform tasks – how to knowledge.
7	Instantiations	Situated implementations in certain environments that do, or do not, operationalise constructs, models, methods, and other abstract artifacts, in

		the latter case such knowledge remains tacit.
8	Design theories	A prescriptive set of statements on how to do something to achieve a certain objective. A theory usually includes other abstract artifacts such as constructs, models, frameworks, architectures, design principles and methods.

Based on the above definitions, the SFMTIS is a framework which can guide researchers when integrating technology into resource-constrained environments. The SFMTIS is the knowledge output of the design science research undertaken in this study. The different DSR artifacts, produced as research deliverables, vary in their abstract levels from less to more abstract, and also in their knowledge maturity levels from level 1 to level 3. Level 1 artifacts, such as situated instantiations, are less abstract while more comprehensive, well-developed bodies of knowledge, such as theories, are level 3 artifacts (Gregor & Hevner, 2013). Figure 2.4 classifies DSR outputs by abstraction level. Frameworks are considered to be in level 2 together with models. Since the research artifact can be a research contribution in itself, level 1 artifacts are still considered a knowledge contribution, even in the absence of abstraction and theorising (Gregor & Hevner, 2013).

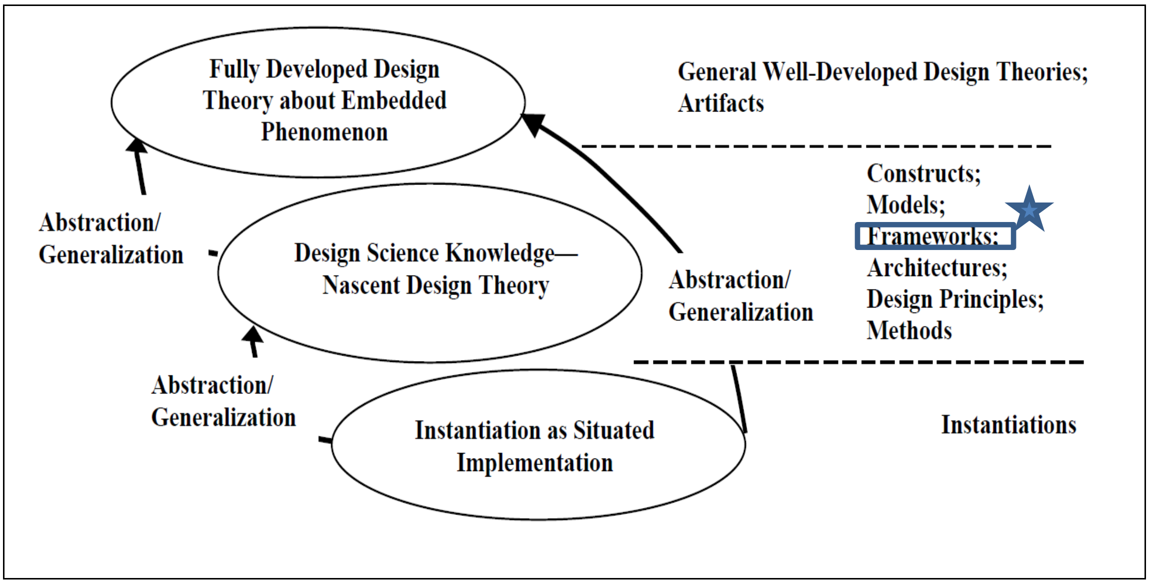


Figure 2.4: Design science knowledge hierarchy
(Gregor & Hevner, 2013 – Adapted from Purao, 2002)

2.4.3 Design Science research and Knowledge production

DSR research involves establishing what is already known from existing descriptive and prescriptive knowledge. Efficient access and investigation of both descriptive and prescriptive knowledge bases enable researchers to provide grounding of the research project (Gregor & Hevner, 2013). Figure 2.5 illustrates the roles of knowledge in design science research. Descriptive knowledge, depicted as “Ω” (omega), is the “what” knowledge about natural phenomena, laws and regulations, while prescriptive knowledge, depicted as “^” (lambda), is the “how” knowledge about the human-built artifact (Gregor & Hevner, 2013).

There are still questions asked about DSR’s contribution to knowledge and generalised theory (Kuechler & Vaishnavi, 2012), however any DSR artifact should be presented and interpreted in such a way that its knowledge contribution can be clearly understood (Gregor & Hevner, 2013). The researcher also needs to establish *how* the knowledge produced through research projects should be positioned and structured to respond to questions such as: “Is it true? Is it new? Is it interesting?” (Wilson, 2002: 168, in Gregor & Hevner, 2013) and “Does it contribute to understanding of the area of specialisation” (Gregor & Hevner, 2013).

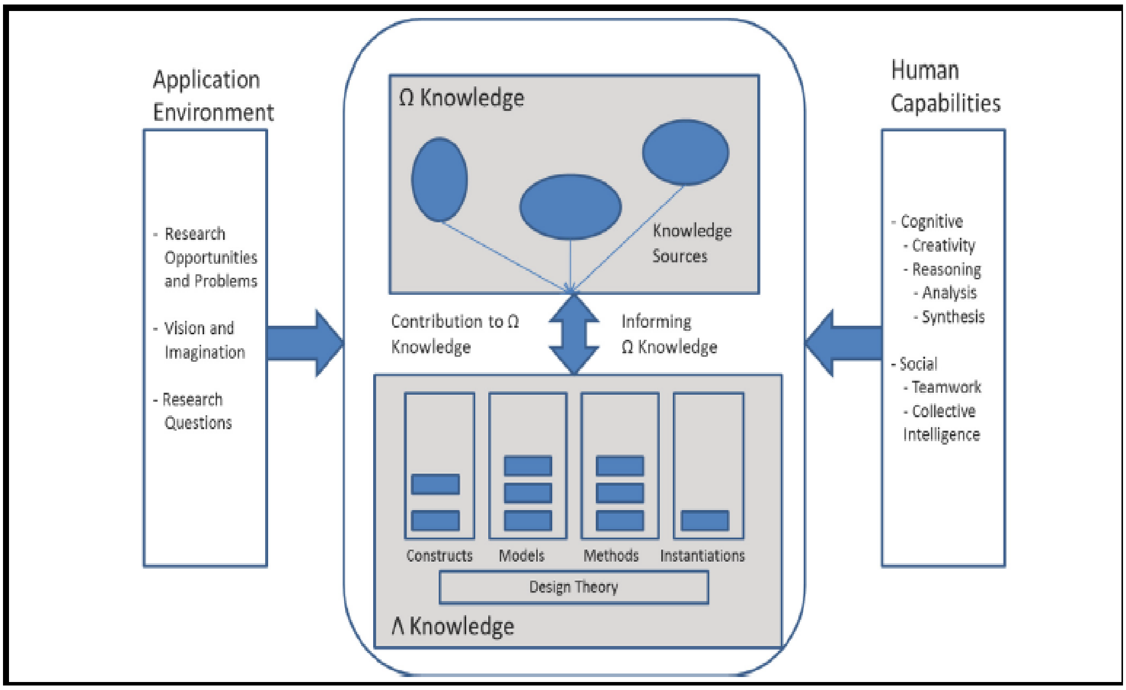


Figure 2.5: The Roles of knowledge in Design Science Research
(Source: Gregor & Hevner, 2013)

In this study DSR is applied, and both descriptive and prescriptive knowledge of existing ICT4D sustainability frameworks, sustainability of ICT projects in resource-constrained environments in South Africa, and sustainability frameworks that address mobile technology integration in schools are applied to provide grounding for the research.

The research contribution is the SFMTIS, a conceptual sustainability framework for mobile technology integration. The application of mobile technology integration in schools has been widely researched (Ertmer et al., 2012; Pegrum et al., 2013), however, only a few studies have extensively examined the sustainability of mobile technology integration in resource-constrained environments (Ng & Nicholas, 2013). Additionally, while the views of teachers from resource-constrained environments on technology integration have been investigated (Van Biljon, Traxler, Van der Merwe & Van Heerden, 2015), a novel angle emerging from this research is the perspectives of district officials. Therefore, the research contributes novel insights into the differing perspectives of the teachers and the district officials, and how these views can impact the sustainability of mobile technology integration in resource-constrained environments. SFMTIS identifies aspects that should be addressed in order to enhance sustainable mobile technology integration, including institutional structures and process, and provides a point of departure for improving sustainability. This knowledge contribution lies on level 2 (see Figure 2.4) and can be considered nascent design theory.

2.4.4 The IS Research framework

Meyer, Helfert, Donnellan and Kenneally (2012) outline seven practical rules as guidelines for well-conducted DSR as shown in Table 2.5.

Table 2.5: Practical guidelines for well-conducted DSR		**Applicability to this study**
Artifact for important problem.	Produce an artifact which addresses an unsolved, important problem.	A few studies have extensively examined the sustainability of mobile technology integration in resource-constrained environments. The research develops the SFMTIS in resource-constrained environment.
Relevance of artifact.	The artifact produced is relevant to the solution of the problem.	The study is situated in a real-life situation, involving public schools, teachers and district officials in the Nciba school district of Cofimvaba in the Eastern Cape province, South Africa, who had participated in the ICT4RED initiative. Sustainability has been identified as a necessary component in the implementation of ICT4RED.
Evaluation of utility.	The utility, quality and efficacy should be vigorously evaluated.	Evaluated by expert reviewers in Phases 2 and 3. Expert reviewers are practitioners in the education field or involved in the ICT4RED initiative, and therefore understand the context of the study: Teachers District officials ICT4RED initiative managers from the CSIR.
Verifiable contribution.	It should present a verifiable contribution.	Artifact: SFMTIS
Rigour.	Rigour should be applied to its development and evaluation.	Iterative development of the artifact applied DSR (Drechsler & Hevner, 2016): Figure 2.7, and the DSRM process (Peffers et al., 2007): Figure 2.9
Extant knowledge.	The development of the artifact should be a process that draws	The research builds on extant literature reviewed for the main themes of the study, focusing on

	from existing theories and knowledge in order to produce a solution to the defined problem.	sustainability frameworks in general, and frameworks for ICT4D implementation in resource-constrained environments specifically, and frameworks for sustainable mobile learning in schools. Document analysis of policy and strategy documents of the Department of Basic Education and other government departments; Department of Science and Technology (DST) reports on the ICT4RED project, including the Monitoring and Evaluation report (Meyer et al., 2016) and sustainability reports.
Communicated effectively.	Must be effectively communicated to appropriate audiences.	Presentations and interviews with stakeholders - teachers, district officials. Dissemination through publications to solicit peer review: scholarly articles - conference articles, presentations and journal articles.

The IS Research framework presented by Meyer et al. (2012), and adapted in Figure 2.5 shows that IS research involves development of artifacts through an iterative process of design, development and evaluation and indicates the significance of "Rigour" and "Relevance" in the IS Design Science Research process. The environment in this study is a real-life situation, involving public schools, teachers and district officials in the Nciba school district of Cofimvaba in the Eastern Cape province, South Africa, considered to be resource-constrained. *The identified problem is a lack of studies that extensively examine the sustainability of mobile technology integration in resource-constrained environments.* In response to this problem, the SFMTIS is developed to be applicable to this environment, and to add to the knowledge base on sustainability theory.

In this research the knowledge base, as indicated in Figure 2.6, is provided by a literature review of the main themes of the study. This literature review focused on: technology integration, ICT4D sustainability frameworks and frameworks for ICT4D implementation in resource-constrained environments specifically, and frameworks for sustainable mobile learning in schools that provided grounding for the research.

Additionally, document analysis of policy and strategy documents of the Department of Basic Education and other government departments (Section 3.3), and the Department of Science and Technology (DST) reports on the ICT4RED project, including the Monitoring and Evaluation report (Meyer et al., 2016), were reviewed in in order to reflect on the environment and to identify challenges in the education system that affect integration of ICTs to support teaching in public schools.

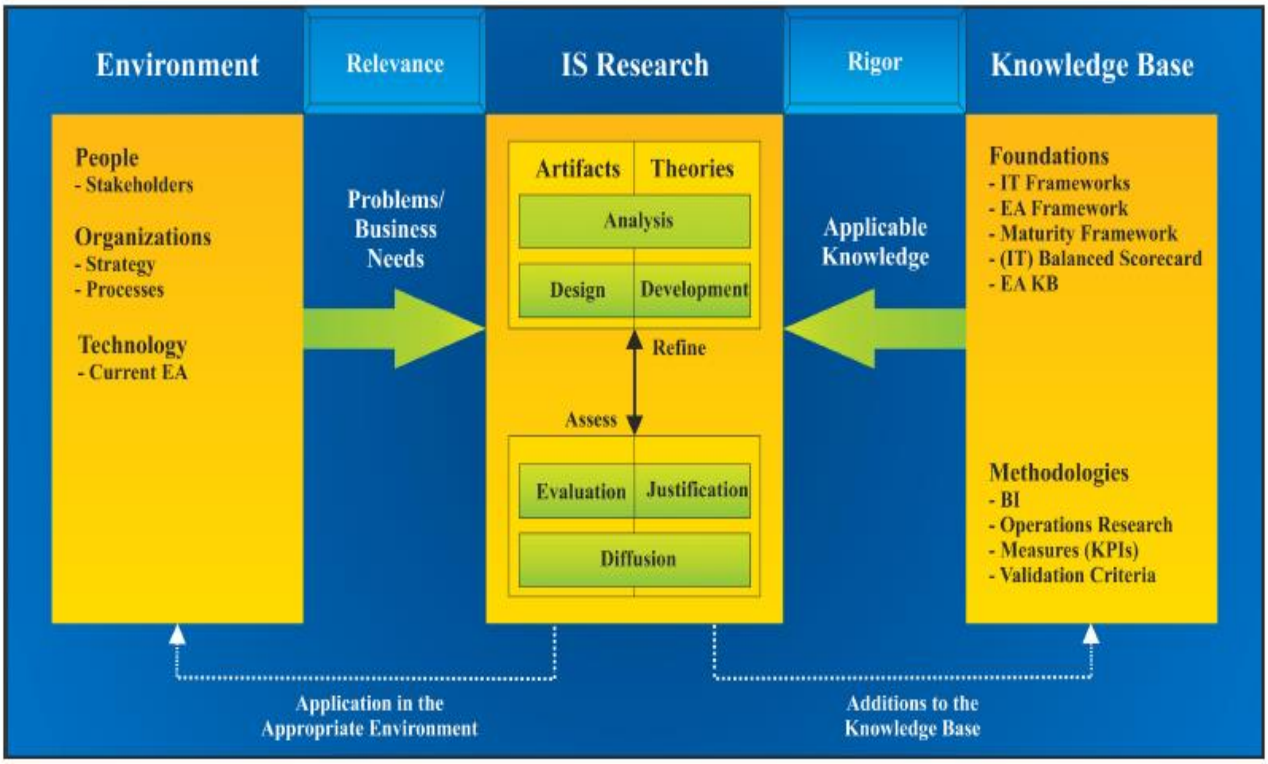


Figure 2.6: IS research framework
(Meyer et al., 2012)

The DSR methodology process (Peffers et al., 2007) that was applied in this research is detailed in Section 2.5.1. The three phases involved in the research, as depicted in Figure 2.9, show that the first phase involved an investigation of the literature to identify sustainability dimensions that can be used in developing the SFMTIS. In the second phase the views of teachers and district officials on mobile technology integration were investigated. Based on the feedback from the teachers and district officials the initial SFMTIS from Phase 1, that was based on a review of the literature, was then refined to develop the SFMTIS. In the third phase the SFMTIS was evaluated through expert reviews.

2.4.5 The three-cycle view of Design Science Research

The three-cycle view of DSR was proposed by Hevner (2007) and is widely cited (Drechsler & Hevner, 2016; Akoka, Comyn-Wattiau & Prat, 2016; Baskerville & Myers, 2015). Hevner's three-cycle view of DSR visualises the DSR paradigm's foundations and critical aspects of a DSR project. The three cycles in the three-cycle view are Relevance, Design and Rigour, as shown in Figure 2.7.

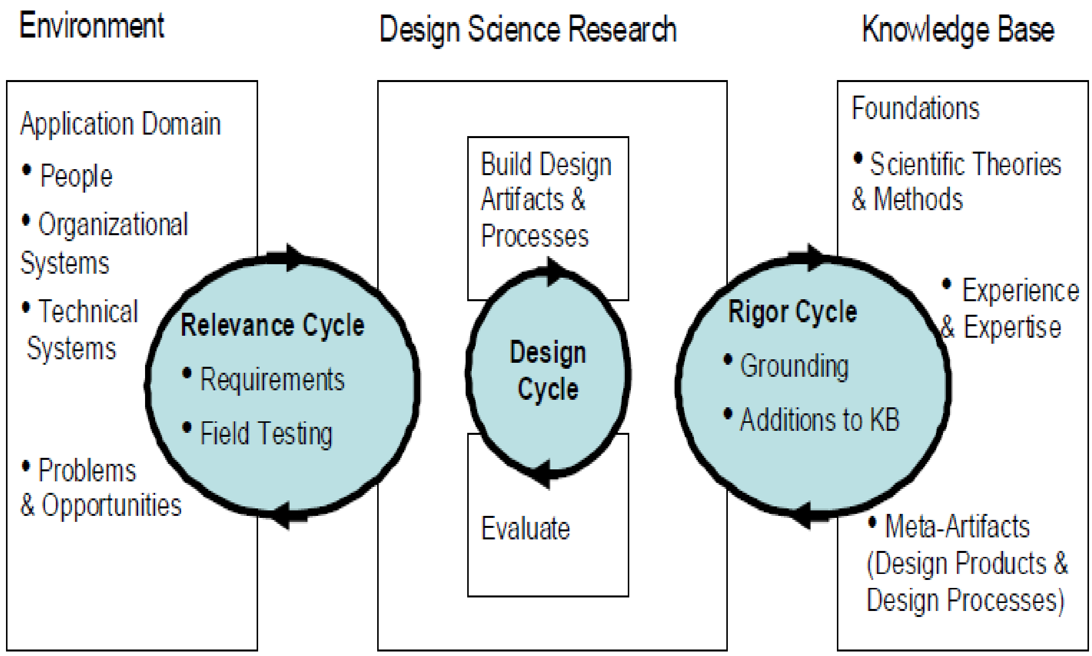


Figure 2.7: Design Science Research Cycles
(Source: Hevner, 2007)

Drechsler and Hevner's (2016) four-cycle view of design science research (DSR) extends Hevner (2007)'s well-known three-cycle view of DSR.

2.4.6 The four-cycle view of design science research

Drechsler and Hevner (2016) proposed the addition of a fourth cycle, the change and impact cycle (CI), to Hevner's three cycles - rigour, design and relevance, and presented the four-cycle view of DSR. The features of each of the four cycles are outlined in Table 2.6. The artifact is continuously designed and evaluated as it is built iteratively throughout the four cycles - Relevance, Design, Rigour and Change and Impact cycles. The arrows between the various steps indicate the iterative nature of the DSR process. Changes in the wider context may create a new problem that constitutes a trigger for the entire DSR project as shown in the fourth cycle, the change and impact cycle. The introduction of the artifact to its immediate application context may also serve as a trigger for additional changes in the wider environment, and trigger new subsequent iterations through the cycles. Rapid generation of new designs are necessary in dynamic and volatile environments (Drechsler & Hevner, 2016). Table 2.6 summarises aspects of the four cycles.

2.4.6.1 Relevance Cycle

The opportunity, problem and requirements in the relevance cycle outline the issues to be addressed. They also serve as inputs to the Design Cycle, and ultimately define the acceptance criteria for the evaluation of the artifact (Hevner, 2007). The identified problem is the shortage of suitable frameworks to guide long-term sustainability of mobile technology integration in schools, as established in the rationale and purpose referred to in Section 1.3. This research will develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa.

2.4.6.2 Rigour Cycle

The rigour cycle provides existing knowledge to the research project. The knowledge base provides grounding and a basis for rigour. Skillful selection of appropriate theories and methods, as well as the consequent application of this information when constructing the artifact, is essential to ensure the artifact's innovation through iterative evaluation (Hevner, 2007). The DSRM process, as discussed in Section 2.5, and systematic literature review, as discussed in Section 2.6, were applied in this study. As Ronau, Rakes and Niess (2012) elucidate, information regarding the databases used in the search helps to establish the representativeness of the study.

2.4.6.3 Design Cycle

The design cycle involves rapid, iterative construction and evaluation of the artifact. The design cycle is core to the Design Science research project where most of the work occurs. The requirements for this cycle are in the form of inputs from the relevance cycle. The design and evaluation theories, as well as the methods, are drawn from the rigour cycle. The feedback is used to design alternatives which are then evaluated against the requirements, all the while the artifact is further refined until a satisfactory design is achieved (Hevner, 2007). In this study, design is addressed during Phases 1, 2 and 3 of the Peffers et al. (2007) process, as depicted in Figure 2.9. The bridge between the design and relevance cycles addresses goodness and fit thus reflecting on the need to successfully adapt an initial artifact to its application context. The evolutionary aspect of artifact fitness relates to long-term artifact adaptability and calls for coverage between the relevance and the newly introduced Change and Impact (CI) cycle (Drechsler & Hevner, 2016).

2.4.6.4 Change and Impact

The fourth cycle, the CI cycle, covers the wider application context. It captures the dynamic nature of IS artifact design for volatile environments by integrating the source of contextual change and dynamics into a conceptual cycle (Drechsler & Hevner, 2016). The CI cycle explicitly contains the starting point and problem trigger.

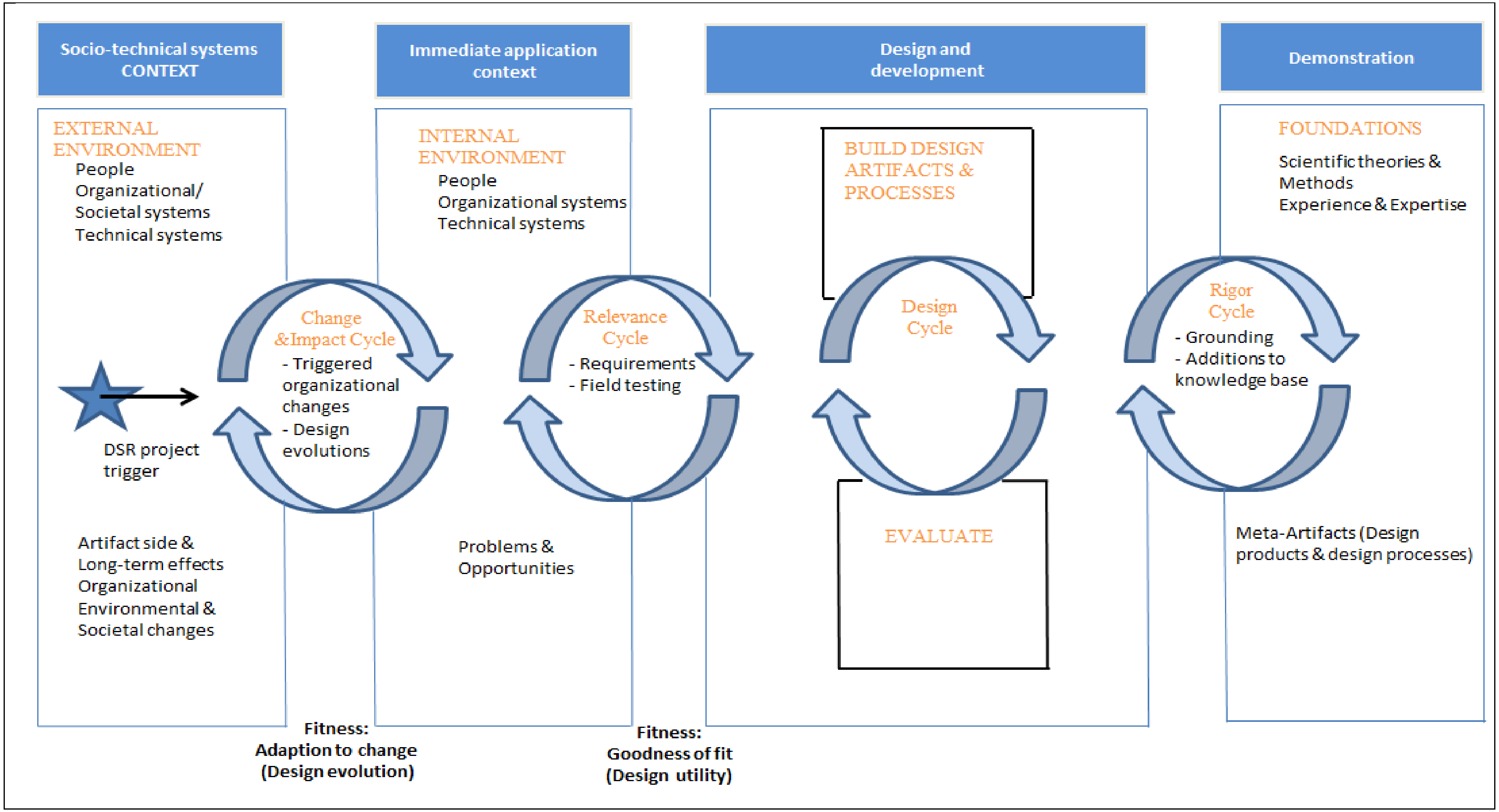


Figure 2.8: Design Science Research
(Adapted: Drechsler & Hevner, 2016)

initially sets the cycle in motion. The CI cycle represents the dynamic way in which the DSR project relates to the organisational context. For DSR projects that are carried out in an organisational context, the implementation of full DSR cycles in design and development can be time consuming (Pirkkalainen, 2015).

The four-cycle view of DSR highlights the possibility of short iteration cycles, or quicker turning speeds. The four-cycle view can raise design science researchers' awareness of short iteration cycles and help them prepare for them by reviewing literature more comprehensively in the initial stages and preparing, gathering and storing data systematically (Drechsler & Hevner, 2016). Internal and external factors can affect information systems which may result in unexpected changes. Therefore, organisational and managerial activities involved in driving the information systems project require careful consideration (Pirkkalainen, 2015). The pace of environmental changes, or urgent needs, may demand quick results in the form of artifacts that address these needs. Consequently short design cycles may be required in rapidly changing environmental conditions to maintain artifact utility. Longer design cycles, on the other hand, are necessary to draw upon and grow extant theoretical knowledge bases in the rigour cycle (Drechsler & Hevner, 2016). Application to this study will be provided in Section 2.4.7.2.

2.4.7 Selection of the four-cycle view of DSR for this research

In the three-cycle DSR model, the relevance cycle bridges the contextual environment with the design science activities (Hevner, 2007). However, the three-cycle DSR model lacks a key dynamic perspective on *how* the DSR project relates to the embedded organisational context and, in addition, it does not conceptualise the time factor and iteration speed in the project (Drechsler & Hevner, 2016). There are many uncertainties that can evolve in DSR projects which incorporate organisational cooperation. The aspect of *how* to deal with contextual disruptors thus requires consideration (Pirkkalainen, 2015). DSR projects are often driven by factors in the environment within which the design artifact is embedded and, as such, these projects not only *build* and *evaluate* artifacts, but also provide *insights* into broader impacts to stakeholder communities, organisations or the society.

2.4.7.1 The CI cycle and dynamics in the wider environment

The extended model adds the notion of societal systems and formally reflects upon the extended role of IS research and its impact in society (Drechsler & Hevner, 2016). Organisations and societies are constantly changing as a result of dynamics, whether deliberate or emergent, which fall outside the project scope. The emergent nature of systems design in DSR projects, as implemented in organisational context, is bound to the context in which the artifact is developed and deployed (Pirkkalainen, 2015). ICT applications do not exist in a vacuum, but are embedded in the application domain, therefore people, processes and the socio-historical context influence the development of the artifact (Heusinger, 2013). The CI cycle enables researchers to be aware of and to cope with these dynamics. After critically reviewing recent advances in the DSR discourse, such as “Emergent” and “Agile” design science, Drechsler and Hevner (2016) incorporated the Change and Impact (CI) cycle to Hevner’s three-cycle view of DSR to accommodate the dynamics and time-related aspects of DSR. Often the root sources of these dynamics lie in the wider environment *outside* the artifact’s immediate application context and, therefore, outside the area three cycles of the original model (Drechsler & Hevner, 2016). Information systems projects are dynamic and emergent in nature, comprising of heterogeneous actor-networks with varying perspectives and realities regarding the project that could be in conflict (Cecez-Kecmanovic, Kautz & Abrahall, 2014). Consequently, the approach may be refined and realignment during the iterative development of the artifact when unexpected changes occur (Pirkkalainen, 2015). The artifact may itself induce organisational change, resulting in a need for follow-up design efforts. The CI cycle allows researchers to explicitly distinguish between the immediate artifact’s effects/impacts, and the long-term effects/impacts on the wider contexts, thus adding a facet to DSR which can cope with dynamic application contexts (Drechsler & Hevner, 2016).

2.4.7.2 DSR Environment in this research

DSR projects address real-world problems or situations, often occurring in complex settings and changing contexts (Conboy, Gleasure & Culina, 2015) which involve many stakeholders (Drechsler & Hevner, 2016). The artifact developed in this research thus addresses “wicked” problems. As explained previously, “wicked problems” are complex problems that are viewed in different ways by different stakeholders and which evade easy answers. These problems could, in actual fact, be *insoluble* and should thus be addressed differently than less complex problems (Awre et al., 2015: 1). According to Drechsler and Hevner (2016), the DSR environment within a particular application domain comprises of:

- People
- Organisational systems and
- Technical systems

In this study, the environment is the Nciba school district in Cofimvaba in the Eastern Cape province of South Africa. Phase 2 of the study involved a case study of selected schools in the Cofimvaba district, an environment that can be considered as resource-constrained. People, organisations and technical systems in this research include two units of analysis in the case study, the teachers and district officials involved in the ICT4RED initiative, and the organisational structures involved in decision-making. Funding for the ICT4RED initiative was external to the schools, and was allocated at national level in accordance with a short-term, three-year implementation focus, rather than a long-term sustainability focus (Meyer & Marais, 2014). Challenges exist in comprehensively integrating ICTs in support of teaching, particularly at district and provincial levels (Meyer et al., 2016). Financial sustainability is considered to be one of these risks. The educational system itself is funded via predefined budgets and flexibility, regarding reallocation of funds, is limited (Meyer & Marais, 2014). Additionally, schools in resource-constrained environments have limited financial resources.

The technical systems, as discussed in detail in Section 3.3.6, include the National Department of Basic Education's website, the Eastern Cape province's Department of Education's website, Education Management Information System (EMIS), South African school administration and management system (SA-SAMS) and the South African education portal, Thutong. Schools and provinces can capture and store education data in EMIS and cost effectively use SA-SAMS as an integrated computer solution for financial control of the schools' finances, timetabling of teachers and classes, a database for class lists and for addressing the schools' management requirements. Thutong provides information regarding the curriculum, digital resources for professional development and teaching guides. These systems are part of the socio-technical systems context (Figure 2.9). Although the existence of these systems is important, it is awareness, access, uptake and the effective use of these digital resources that make them useful.

2.4.8 Utility of artifact

Drechsler and Hevner (2016) distinguish between first- and second-order impacts. First-order impacts refer to the artifact's immediate application context, thus the direct artifact user(s) within their environment. Second-order impacts encompass socio-technical system within which the immediate application context is a sub-system. The newly introduced cycle covers the design artifact's second-order impacts on their wider organisational and societal contexts. In conjunction with satisfying the real-world demands of artifact *utility*, consideration should be given to artifact *generalisability* and other *theoretical* aspects (Drechsler & Hevner, 2016). As per Figure 2.11, the SFMTIS was expertly evaluated by teachers, district officials and implementers of the ICT4RED project in order to determine its utility. However, the data in this research is based on a single case study and consequently generalisations regarding the SFMTIS are limited. Evaluation, verification and further research as regards possible applications of the SFMTIS in similar contexts can improve the generalisability of the study.

2.4.9 Application of DSR in this study

Table 2.6 shows how DSR was applied in this study. The main features of the cycles in DSR are indicated and then related to the research context. The sustainability models and frameworks are relevant in the rigour cycle. The rigour cycle answers the question: How is the artifact design grounded in "extant" knowledge bases, that is scientific theories, experience and expertise? It is within this cycle that one considers *what works* and *what does not work* and where one evaluates the fit with extant theories and experiences. The extant literature in this study comprises sustainability frameworks and models of ICT4D projects in general, ICT4D projects specific to resource-constrained environments and sustainability frameworks specific to mobile technology integration in schools.

The theories that provide the theoretical foundations for this research (refer to Section 2.3) are structuration theory, capability approach and institutional theory and they form part of the extant literature. These theories provide a way for the understanding of the social elements and structures involved in the school and broader education system. The institutional theory provides context for the basic education system environment and the different structural levels involved namely: micro (school), meso (circuit and district) and macro (provincial and national) levels. The institutional theory explains the role of the actors, teachers and district officials in achieving institutional objectives within the organisational structures as well as the institution's social, economic and political environment. The structuration theory's emphasis on agency and structure indicates that social practice is mutually dependent on structure and social interaction, and that teachers and district officials, as human agents, are affected by the institution's structures and power dynamics. The capability model presents individuals within the education system as agents who have capabilities and who are, nonetheless, influenced by their circumstances.

Table 2.6: Design Science research features

	Hevner's three-cycle of DSR (Adapted: Hevner, 2007)			Four-cycle view of DSR: (Adapted: Drechsler & Hevner, 2016)
Cycle	RIGOUR CYCLE	DESIGN CYCLE	RELEVANCE CYCLE	CHANGE AND IMPACT CYCLE
Main features of cycle	Covers the question: How is the artifact design grounded in "extant" knowledge bases that include scientific theories, experience and expertise? What works? What does not work? How does the evaluation fit with extant theories and experiences?	Supports the actual artifact design/redesign. Supports corresponding artifact evaluation. Artifact evaluation can take place within the evaluation cycle in =>ARTIFICIAL settings e.g. through thought or laboratory settings. => Real-world contexts (Venable, Pries-Heje & Baskerville, 2016) e.g. Field tests that become part of the RELEVANCE cycle.	Define: - context - problem - opportunity - requirements State: Acceptance criteria for artifact's usefulness, its UTILITY. Links the environment to the artifact.	Captures the long-term effects, societal changes and environmental changes. The environment within a particular application domain includes: • People • Organisational systems and • Technical systems Captures the dynamic nature of the IS artifact design for volatile environments.
Application in the study	Sustainability frameworks, framework for sustainable mobile learning in schools (Ng & Nicholas, 2013); CSFs of rural ICT project sustainability (Pade-Khene et al., 2011), ICT4RED Implementation framework (Herselman et al., 2014), DBE and government departments' policies and strategies.	Apply DSRM. Build SFMTIS through iterative cycles. Includes evaluation of DSR artifact developed: expert evaluation.	Lack of frameworks for sustainable mobile technology integration in schools in resource-constrained environments. Opportunity to utilise and sustain the use of tablets, ICT infrastructure and teacher training provided in ICT4RED. Optimise use of DBE ICT systems and existing policies such as e-rate for schools' Internet services.	People: Teachers, learners, School Management Teams, School Governing Bodies, parents, community, district officials Systems: • Organisational • Societal • Technical SACE continuous PTD system, National DBE and provincial websites, SA-SAMS, EMIS, Thutong.

The design cycle supports the actual artifact design, redesign and evaluation. In this study the design science research methodologies process was applied which involves iterative development of the framework. This includes evaluation of the DSR artifact by expert reviewers. The design cycle includes evaluation of the artifact which may occur in artificial settings such as the laboratory, or in real-world contexts (Venable et al., 2016). The context, problem, opportunity and requirements are defined in the relevance cycle. The relevance cycle links the environment to the artifact and this requires that the acceptance criteria *usefulness* and *utility* should be stated. In this study, the opportunity to develop a framework can provide a mechanism that can be used to enhance the likelihood of sustaining mobile technology integration of mobile devices in the schools. This because there is a lack of frameworks for sustainable mobile technology integration to support teaching in resource-constrained environments. Expert evaluators assessed the proposed DSR artifact for its usefulness and utility. The change and impact cycle covers the wider application context and the dynamic way in which the DSR project relates to the organisational context.

The people and organisational and technical systems are thus stated and for this study these include: teachers, district officials, parents, communities, the Department of Basic Education and the private sector. In context, the environment includes systems (Section 3.3.6), such as the South African Council for Teachers' (SACE) continuous professional teacher development management system, South African School Administration and Management System (SA-SAMS) and the Education Management Information System (EMIS). Figure 2.9 illustrates this information showing DSR application in this study.

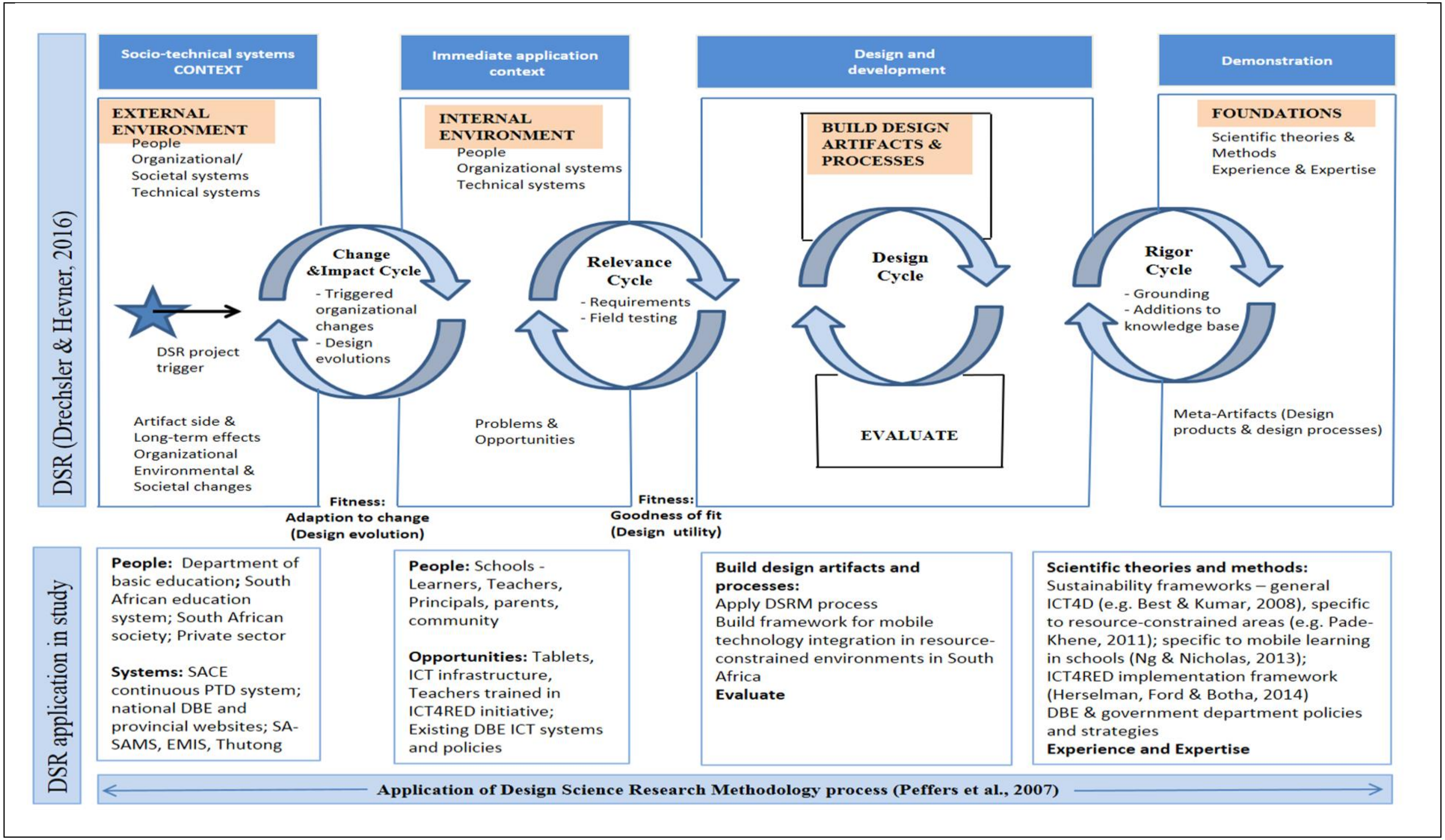


Figure 2.9: DSR - Application in the research
(Adapted: Drechsler & Hevner, 2016)

2.5 DESIGN SCIENCE RESEARCH METHODOLOGY (DSRM) PROCESS

The design science research methodology (DSRM) process (Figure 2.10), as applied in this study, provides a framework for conducting design science research in information systems. The DSRM process provides relevant principles, practices and procedures that are required to carry out information systems research as well as a mental model and framework for the production and presentation of DSR in information systems (Peffers et.al. 2007), hence its relevance for this study. The DSRM consists of six iterative phases: Problem identification and motivation, definition of objectives for a solution, design and development, demonstration, evaluation, and communication (Peffers et al., 2007). Figure 2.10 illustrates the six phases in the DSRM process whilst the following section deliberates on these six phases and how the DSRM process was applied in this research.

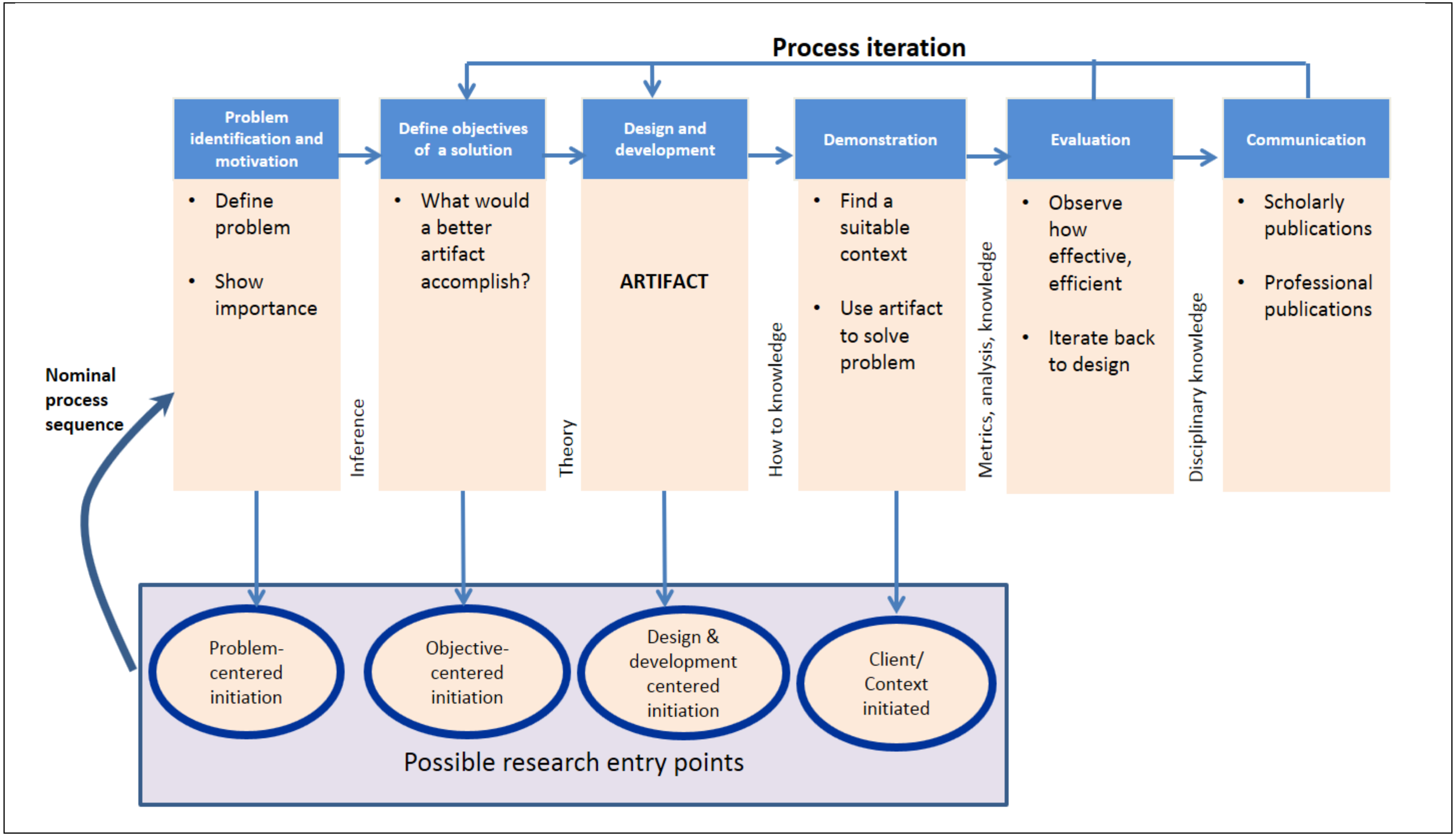


Figure 2.10: Design Science research methodologies process
(Peffers et al., 2007)

2.5.1 Application of the Design Science Research Methodology process in this research

This section outlines the application of the DSRM process (Peffers et al., 2007) in the study as represented in Figure 2.11.

1. *Problem identification and motivation*

This stage of the DSRM process involves defining the specific research problem and justifying the value of a solution. The researcher's reasoning about the problem, and the impetus for undertaking the development of an artifact that can effectively provide a solution to a complex problem, are captured herein.

Literature was reviewed to gather information regarding mobile technology integration information in schools and the sustainability of ICT4D programmes in resource-constrained environments (Chapters 3 and 4). The motivation for the research was the need to ensure the sustainability of programmes implementing mobile technology in schools. In addition, the limited availability of frameworks to provide a guide and practical advice on how to increase sustainability of educational initiatives for adoption of mobile technology at schools, particularly in resource-constrained environments in South Africa, acted as an impetus.

2. *Define the objectives of a solution*

The objectives of a solution are rationally inferred from the specified problem. Knowledge of the state of problems and any existing solutions and their effectiveness is required (Drechsler & Hevner, 2016).

The main research objective for this study is to:

"*Develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa.*"

This will address the shortage of suitable frameworks to guide long-term sustainability of mobile technology integration in schools, as previously discussed in the rationale and purpose (refer to Section 1.3). In order to accomplish this, existing frameworks for sustainable mobile technology integration in schools should be identified. The perspectives of teachers in public schools, and district officials in resource-constrained environments, regarding mobile technology integration (MTI), were established. This was done in an effort to help ascertain the role that these views would play in the development of the framework.

3. *Design and development*

The artifact is created in the design and development stage. This stage involves determining the artifact's desired functionality and consequent architecture and then creating it. Resources, including knowledge of relevant theory, are required to move from objectives to the design and development stage.

The research design has at its foundation several case studies completed within the context of the ICT4RED initiative. Schools, teachers and district officials in the Nciba school circuit, Cofimvaba, in the Eastern Cape province of South Africa who had participated in ICT4RED, provided appropriate cases for the research.

4. *Demonstration*

The demonstration stage of the DSRM process involves using the artifact to solve the identified problem by establishing its utility through relevant activities such as case study, experimentation and simulations (Peffers et al., 2007). In this research, a case study and expert evaluations of the SFMTIS were applied to demonstrate its utility.

5. *Evaluation*

Evaluation is the observed measure of how well the artifact solves the problem. It requires knowledge and the use of relevant metrics and analysis tools. The actual observed results, as gained through the use of the artifact, are compared to the objectives, as established in the second stage of the DSRM process. DSR requires that the assessment and acceptance criteria for evaluating the results be specified so that it is clear whether or not the intended benefits have been achieved (Hevner, 2007; Drechsler & Hevner, 2016).

Evaluation in this research was conducted as part of the DSRM process to validate the framework. The criteria used for selection of the expert valuators (teachers, district officials and external representatives) was their experience, involvement with the ICT4RED initiative and knowledge of the environment and context.

6. *Communication*

Communication involves timely presentation of the artifact to relevant audiences, practicing professionals and researchers as well as the problem which prompted the creation of the artifact, how it was designed and developed and its overall importance. The utility, novelty and effectiveness of the artifact are also demonstrated.

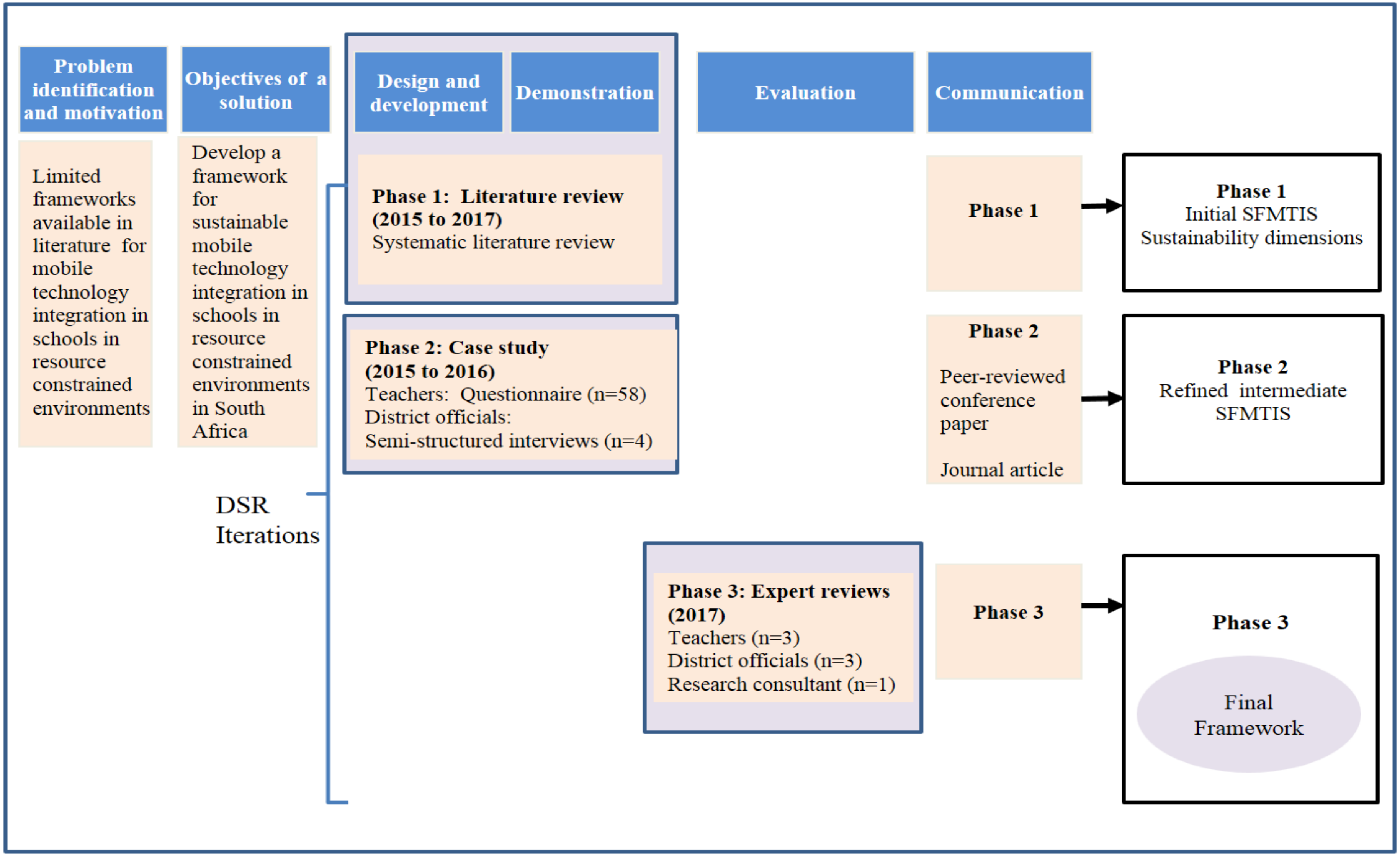


Figure 2.11: Application of Design Science Research Methodology process in the study

2.6 Summary of research philosophy and paradigms considered in developing the SFMTIS

Figure 2.12 represents the research philosophy and paradigm considered when developing the SFMTIS. When planning a research study, it is useful to clarify assumptions related to personal beliefs and values, notably the ontological, epistemological, and methodological levels of enquiry (Proctor, 1998). Research paradigms are generally shaped by researchers' philosophical assumptions (Myers, 1997). The philosophical assumptions that can influence how the researcher conducts research include ontological, epistemological, axiological and methodological assumptions (Proctor, 1998; Vaishnavi & Kuechler, 2013). Philosophical consideration helps the researcher to define and refine research methods relevant for the study, and in selecting the type of data and its interpretation in order to answer the research questions (Esterby-Smith et al., 1997).

The research design is discussed in section 2.7.

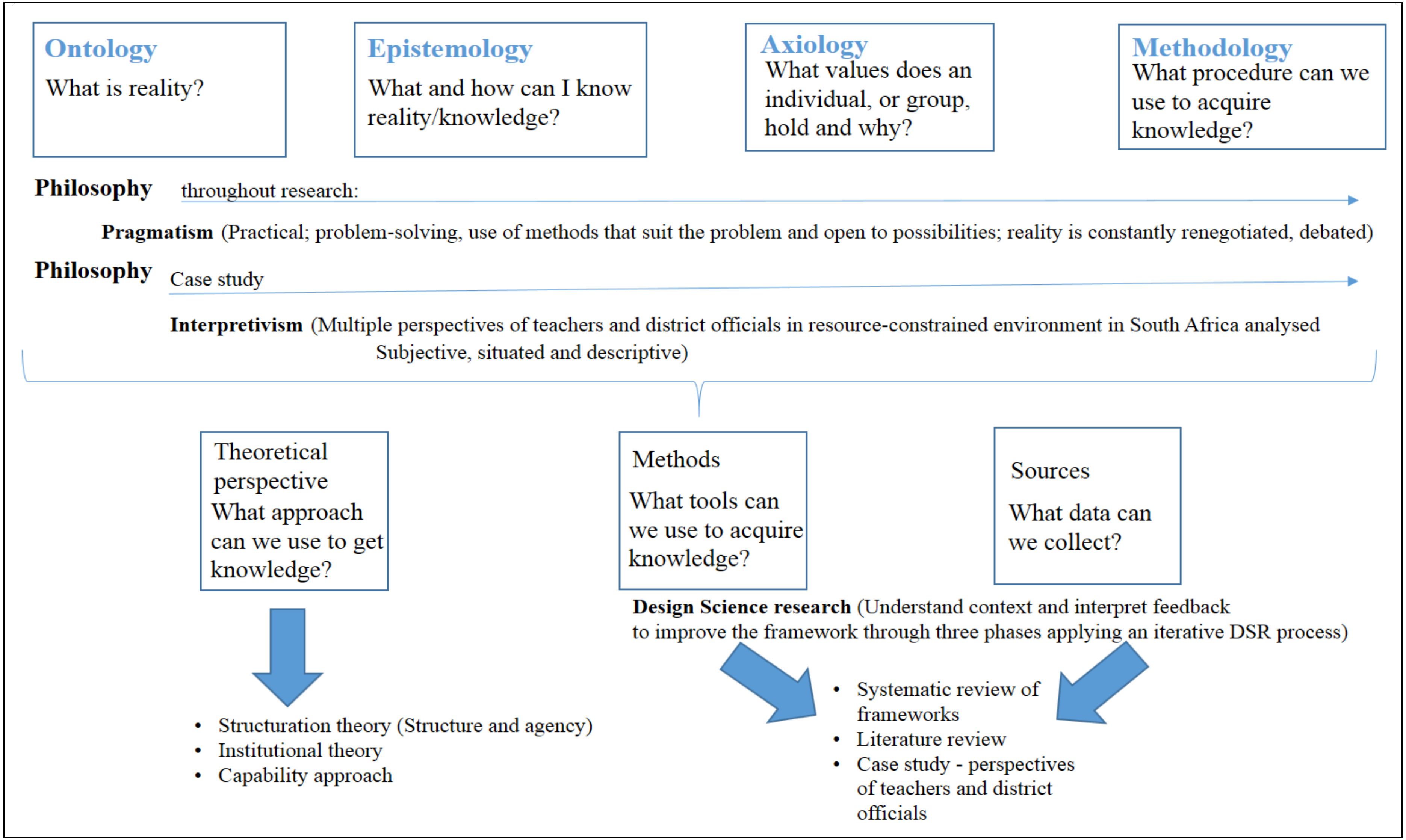


Figure 2.12: Research philosophy and paradigms considered in developing the SFMTIS

2.7 RESEARCH DESIGN

Research design is the course taken to conduct the research and involves using techniques such as: case study, meta-analysis, research synthesis, identification of information that needs to be reported which should provide high quality evidence for the study (Ronau et al., 2012). The research design identifies an issue, or problem, about which information is needed and, as such, it should be related to the interpretation of the results (Ronau et al., 2012). Research design requires consideration of reliability and validity and therefore acceptable validation strategies should be used for enhancing the accuracy of the study (Creswell, 2013).

2.7.1 PHASE 1

"Undertaking a literature review is an important research method in itself"
(Green, Johnson & Adams, 2006 in *Boell & Cecez-Kecmanovic, 2014: 260).*

2.7.1.1 Literature review

A literature review synthesises and summarises past knowledge on a topic, or domain of interest. It entails interpretation of existing knowledge and can thus assist in identifying important knowledge gaps and insightful research propositions (Rowe, 2014).

Literature reviews "examine and critically assess existing knowledge in a particular problem domain, forming a foundation for identifying weaknesses and poorly understood phenomena, or enabling problematisation of assumptions and theoretical claims in the existing body of knowledge" (Boell & Cecez-Kecmanovic, 2014: 258). Literature reviews reveal the research landscape, theory development and provides a foundation for research (Schryen, 2015). The scale and scope of literature reviews are affected by technological developments. Rapid technological developments have increased the importance of literature reviews. There is increased access to publications through digitised literature and online searches, aided by tools such as Atlas.ti, NVivo, CATMA and MAXQDA, have helped to facilitate qualitative data analysis.

It can be more challenging to do IS literature reviews because IS is inter-disciplinary and thus requires authors to draw on theories from a variety of disciplines (Scheryen, 2015).

Undertaking a literature review requires rigour and structure. A systematic literature review adds rigour to the literature review process (Schryen, 2015).

2.7.1.2 Systematic literature review

> *"A systematic review is a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review" (Moher, Liberati, Tetzlaff, Altman & Prisma Group, 2009: 1)*

The value of a systematic review is determined by what was done, what was found and the clarity of reporting (Moher et al., 2009). There are on-going debates regarding the role of systematic literature reviews in information systems, and how they should be applied (Boell & Cecez-Kecmanovic, 2014; Geeling, Brown & Weimann, 2016). There are limitations to the application of systematic literature reviews and careful consideration should be given to *how* systematic literature reviews are portrayed in relation to traditional literature reviews (Boell & Cecez-Kecmanovic, 2014). The application of systematic rigour, when conducting literature reviews, should maintain flexible hermeneutic engagement with the literature (Geeling et al., 2016). Scholarly assessment of knowledge requires in-depth analysis, criticality, imagination and creativity and these may be impoverished by the unquestioned application of systematic literature reviews (Boell & Cecez-Kecmanovic, 2014). The *types* of questions that should be addressed by the literature review, the databases and the key words should be identified, and revised, during the review process as the researcher's understanding of the key topics increases (Pickering & Byrne, 2014).

(i) Databases, when and what was searched

Table 2.7 lists the databases that were searched: Scopus, Web of Science, Mendeley papers and Google Scholar. The document types included: journal articles, conference papers, policy documents and books.

Table 2.7: Databases used to conduct the systematic literature review and when they were searched

Type of database	Database
Multi-disciplinary databases and citation enhanced databases	Scopus Web of Science
Multidisciplinary crowd sourced catalogue	Mendeley papers database
Scholarly search engine	Google Scholar

Initial literature searches were carried out in 2014. This enabled the examination of existing literature on mobile technology integration and sustainability and identified gaps in order to delineate the research parameters. Systematic literature reviews (carried out between 2015 and 2017) were specific to the main concepts in the study, sustainability and mobile technology, as indicated by the keywords selected for the searches. Literature reviews and searches were conducted throughout the research.

(ii) ***Keywords used in the search***

The keywords were identified in accordance with the research objective which is to: *"develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa"*. Consequently, the keywords used in the searches are indicated in Table 2.8:

Table 2.8 Keywords used to search databases

Sustainable	Sustainability Sustainability model Sustainability framework
Tablets	Mobile Tablet Mobile tablet integration
Constrained resources	Resource-constrained Rural schools
ICT in rural schools	ICT AND rural schools ICT AND rural schools AND South Africa ICT AND developing countries
Combinations	Sustain* AND model Sustain* AND framework Tablet OR mobile AND integration AND Rural OR resource-constrained Develop* AND countr* Model AND Technology AND integration AND teaching Sustainability AND Model or Framework AND technology integration AND teaching

(iii) ***Inclusion criteria***

The inclusion criteria, or conditions for selection, applied to the journal and conference paper results returned by the database search were that the papers should have been published within the last five years and written in English.

Exceptions:

(a) Recommended literature: publications by experienced researchers and domain experts.

(b) Policy documents produced by the Department of Basic Education and relevant South African government departments deemed relevant to the research.

(c) Reverse referencing was used when necessary, for example when a reference considered to be relevant was found in another article.

(d) There were exceptions made to the five-year criterion based on the specific topic being reviewed. Published theories and publications deemed important, which fell outside the criteria, were considered.

(e) Some textbooks sourced from the library.

*(iv) **Exclusion criteria***

The exclusion criteria applied to the results was based on the examination of the topics and abstracts. Those deemed to be irrelevant to the topic and research questions were excluded.

*(v) **Read, assess publications and use concept or theme grouping***

Selected publications were further examined and concepts and themes were used to organise the publications. The themes identified were:

- Sustainability/Sustainability models/Sustainability frameworks
- Mobile technology integration and the South African education system
- Challenges faced in basic education in South Africa
- Department of Basic Education (and relevant government departments) publications

There were 1 508 publications retrieved from academic databases including Scopus, Mendeley papers and Google Scholar. The number of publications retrieved from other sources, such as reverse referencing from other publications and publications recommended by experienced researchers, totaled 232. A total of 584 publications were excluded based on the titles and abstracts. There were 159 articles that were included for detailed qualitative analysis. Figure 2.13 represents the selection of the articles.

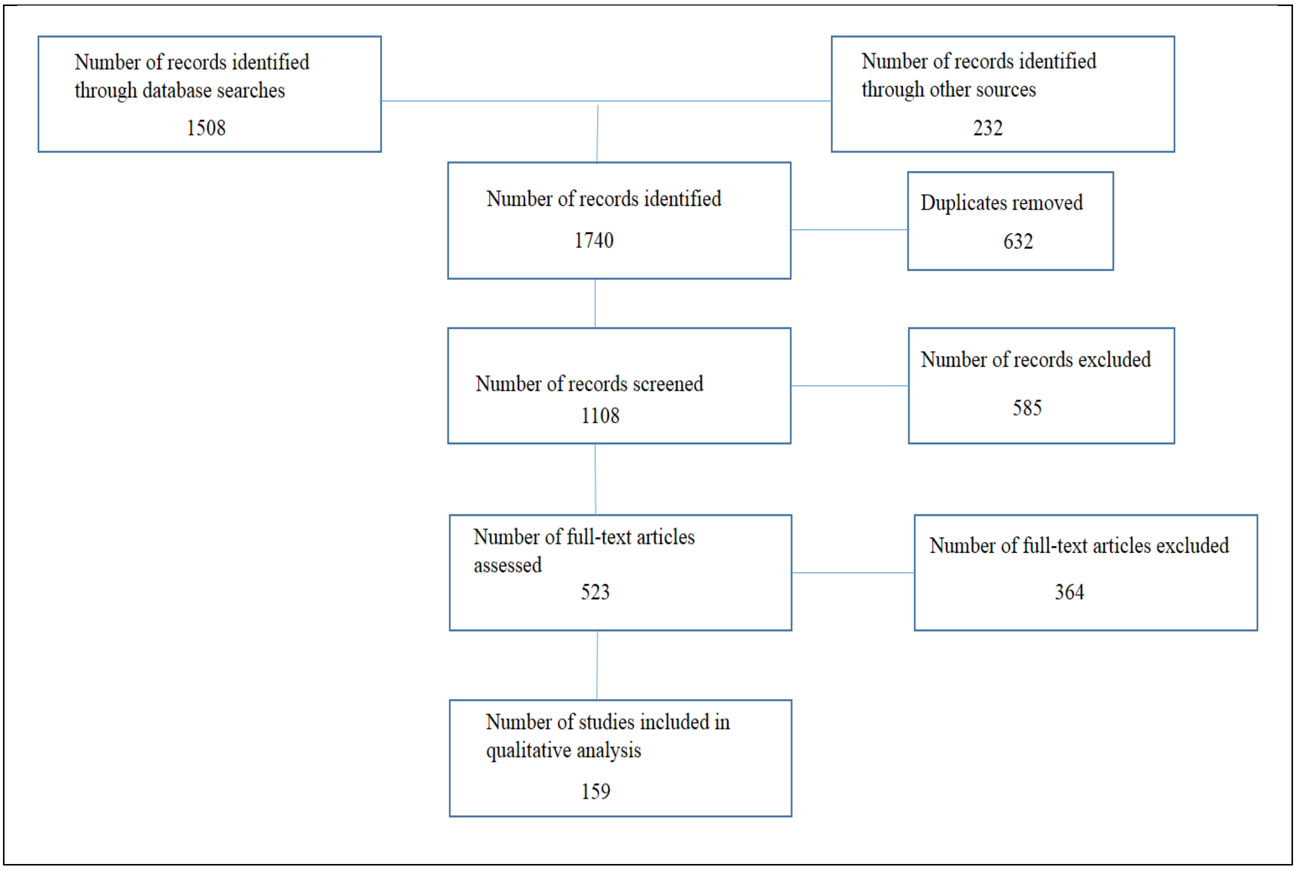


Figure 2.13: Searches of publications in systematic literature review towards the development of the SFMTIS

The extant literature, reviewed for the main themes of the study, provided the knowledge base in the rigour cycle (see Figure 2.7) and is deliberated in Chapters 3 and 4. Chapter 3 discusses mobile technology integration and the South African education system as well as ICT related challenges in the basic education system. Chapter 4 discusses sustainability and ICT4D initiatives integrating technology into support teaching. Literature review of sustainability frameworks focused on: general ICT4D sustainability frameworks, frameworks for ICT4D implementation in resource-constrained environments specifically, and frameworks for sustainable mobile learning in schools. This literature review and document analysis of the Department of Basic Education and relevant government documents, such as the Department of Science and Technology (DST), reports on the ICT4RED project, including the Monitoring and Evaluation report (Meyer et al., 2016) and sustainability reports.

2.7.2 PHASE 2

In this research a case study was used within the DSRM process to refine and validate the framework, as discussed in the following sections. Interpretivism was used in this phase only when case studies were applied within the DSRM process model to refine and validate the framework. A case study was used to obtain feedback from participants and stakeholders selected through purposive sampling.

2.7.2.1 Case Study

Case study research was used in this research as part of the development, demonstration and evaluation phases in the DSRM process of Peffers et al. (2007), as shown in Figure 2.6. A case study entails investigation of a contemporary phenomenon in its real-world context (Yin, 2014). A case study is not just a variant of other research methods but a comprehensive research strategy in itself with its own formal design and systematic procedures (Yin, 2013). A case study method requires that a unit of analysis, *the case*, be defined. A unit of analysis is the case, or group of cases, on which data collection focuses in order to enable the researcher to draw conclusions (Teddlie & Tashakkori, 2009). This involves selecting a set of procedures for designing, data collection and analysis, presentation and reporting the results. The case study method requires that the case should be defined (Creswell, 2014; Yin, 2013) in an endeavor to understand complex social phenomena (Yin, 2013). The most apposite design is then selected and appropriate theory applied to the design (Yin, 2013). Analyses and discussion of the cases should be highly structured and centred around well-defined theoretical frameworks. Research conclusions are made based on data collected from the unit(s) of analysis.

A case study, involving teachers from schools who had formerly participated in the ICT4RED initiative, was selected through purposive sampling to participate in this research. District officials in the same school district were also included. A South African government-initiated project, ICT4RED investigated ways in which ICTs can be integrated into teaching and learning in rural areas (Herselman & Botha, 2014). The ICT4RED initiative was carried out over three years, from 2012 to 2014, to test the use of tablets in 26 schools in the Cofimvaba school district in the Eastern Cape province of South Africa.

The ICT4RED initiative was considered best suited for the research because the Nciba school district is considered resource-constrained and the project had formerly implemented mobile technology integration into schools. A major objective of the ICT4RED initiative was to design systemic and sustainable approaches to provide access to digital content to learners at marginalised rural schools in South Africa. The objective is to use these technologies in a sustainable and replicable way hence evaluation, adoption and implementation of the ICT4RED initiative in the rural education system.

In order to administer the questionnaire, purposive sampling was applied to represent schools from the three different phases of the ICT4RED project. Sampling is the way in which sample units are selected from the population and involves selecting units of analysis in a way that maximises the researcher's ability to answer the research questions (Fetters & Molina-Azorin, 2017; Teddlie & Tashakkori, 2009). The ICT4RED project involved 350 teachers with 1 school involved in Phase one, 11 additional schools in Phase two and 14 more schools in Phase three (Herselman & Botha, 2014). In this study, 100 questionnaires were distributed to 100 teachers from ten schools and 58 responses from 8 schools were received back. Teachers' views regarding mobile technology integration were obtained through the use of a questionnaire (Annexure 2.1). Open-ended and closed questions were used to ascertain: what was going well, what should be done to make things better and the concerns that teachers have. In addition to the data collected from the teacher questionnaires, data was collected from four district officials using semi-structured interviews in order to obtain their perspectives regarding mobile technology integration in the schools. The data collection and participants in the different phases of the study are presented in Table 2.9.

Table 2.9: Study data collection and participants in different phases

	Phase 1	**Phase 2**	**Phase 3**
Systematic literature review	Systematic review of literature: Mobile technology integration and the South African education system; and sustainability models and framework.		
Document analysis	Policy and strategy documents of the Department of Basic Education and relevant government departments.		
Case study questionnaires		Teachers 58 Teachers (8 Schools)	
Case study semi-structured interviews		District official 1 District official 2 District official 3 District official 4	
Expert reviews			*Teachers:* ICT Champion 1 ICT Champion 2 Principal 1 *District:* District officer 1 District officer 2 District officer 3 Research consultant

The following section describes the data collection methods that were used in the research. The data collection methods applied in the research are presented in Table 2.10.

Table 2.10: Data collection methods and reason for their application		
Data collection	Participants	Reasons for selection
Case Study questionnaire	Selected schools in the Cofimvaba school district in the Eastern Cape province of South Africa, which were part of the ICT4RED initiative. Two units of analysis in this case were the teachers and district officials.	The teachers and district officials were involved in the ICT4RED programme, a large-scale pilot South African government research, development and implementation initiative with the goal of improving the quality of teaching and learning by deploying tablets to schools, supported by educator training, the provision of technology hardware and software to boost schools' infrastructure and network connectivity, including Wi-Fi equipment, safekeeping and charging facilities and technical support.
Case study semi-structured interviews	District and circuit officials from the Department of Basic Education (Eastern Cape).	It is imperative to understand the District and Circuit officials' roles and responsibilities regarding technology integration. Monitoring and management of the integration process at the meso-level (District and Circuit) can have significant implications on the sustainable implementation of the programme. Strategic planning, which affects resources and support, in terms of personnel, finances, infrastructure and technical support rendered.
Expert reviews	*Teachers:* ICT Champion 1 and 2 Principal 1.	Involved in ICT4RED initiative, participated in case study and possess expertise.
	District: District officer 1, 2 and 3.	Involved in ICT4RED initiative, participated in case study and possess expertise.
	Research consultant: Council for Scientific and Industrial Research (CSIR).	The CSIR developed, implemented and managed the ICT4RED initiative. The innovative ICT4RED TPD course was also developed by the CSIR and rolled out to the schools over a three-year period. CSIR developed the Evidence-based ICT4RED Implementation Framework and was involved in providing technical support.
Document analysis	Policy and strategy documents of the Department of Basic Education and relevant government departments.	The Department of Basic Education policy and strategy documents; such as the White paper on e-Education (DoE, 2004), South African Schools Act (SASA) (DoE, 1996), Roles responsibilities and functions of education district and circuit offices (DoE, 2013) and the Department of Science and Technology (DST) reports on the ICT4RED project, including the Monitoring and Evaluation report (Meyer et al., 2016). These documents were accessible online and were reviewed and evaluated in this study to provide the knowledge base in the rigour cycle of DSR applied in the research.

2.7.2.2 Document Analysis

Policy documents and reports are used in document analysis to supplement other data sources, such as interviews. Document analysis is a systematic procedure for reviewing or evaluating documents (Bowen, 2009). The goal of document analysis is to understand the document through exploring and examining its elements (Gorochanaz & Latham, 2016). Document analysis, as a qualitative research method, has both *advantages* and *limitations* which stem from the nature and forms of documents being analysed. A major advantage of document analysis is that the materials could already be in the public domain, either published on paper or on the web (Bowen, 2009). Major considerations in document analysis are how to initially discover, source and record the material.

Document analysis in this research included policy and strategy documents of the Department of Basic Education such as: the White paper on e-Education (DoE, 2004); South African Schools Act (SASA) (DoE, 1996); Roles, responsibilities and functions of education district and circuit offices (DoE, 2013); and the Department of Science and Technology (DST) reports on the ICT4RED project, including the Monitoring and Evaluation report (Meyer et al., 2016) and sustainability reports.

2.7.2.3 Questionnaire

Questionnaires are widely used to collect information regarding people's or organisation's knowledge levels, attitudes, beliefs and preferences. Well-designed questionnaires consider layout and question sequencing effectively, collect accurate, relevant data, and can increase the response-rate. It is important to establish a rapport and to explain the purpose of the questionnaire. In this research the site visits and informal discussions and formal meetings with principals, school ICT Champions, teachers and district officials were used to enhance rapport. The purpose of the research and questionnaire were explained. The questionnaires used in this research applied a 5-point Likert scale. A Likert scale is a psychometric response scale primarily used in questionnaires to obtain participants' preferences, or degree of agreement with a statement, or set of statements (Joshi, Kale, Chandel & Pal, 2015). Respondents indicate their level of agreement with a given statement by way of the ordinal scale. The 5-point Likert scale ranges from "strongly disagree" on the one hand to "Strongly agree" on the other with "Disagree, Agree and Disagree" in the middle.

The questionnaire was applied in Phase 2 of the research. The questionnaire was used to obtain teachers' views on mobile technology integration and the sustained use of tablets at their schools. Both closed and open-ended questions were used. The teachers represent one of the two units of analysis in the case of public schools in the Cofimvaba school district in the Eastern Cape province of South Africa. The second unit of analysis was the district officials. The questionnaire was printed and disseminated to teachers who completed it manually. This approach was taken to increase teachers' access to the questionnaire and to increase the response rate. The data collected was applied to inform and refine the SFMTIS.

The questionnaire used is presented as Annexure 2.1.

2.7.2.4 Interview

Interviews can provide important evidence in case studies (Yin, 2014). Interviews are frequently used in qualitative studies for data collection (Brinkmann, 2014). In semi-structured interviews the researcher has predefined questions but he/she may probe further, depending on the participant's responses (Peters & Halcomb, 2015). Structured interviews use formal questionnaires where all the question to be asked are listed, and the interview interaction is carefully scripted. In structured interviews, the interviewer's conduct is consistent when interviewing each participant in order to collect the data as uniformly as possible.

During in-depth interviews the researcher engages with the participant(s) by posing questions, and asking follow-up questions and probes based on the initial responses, in order to elicit a vivid picture of the participant's perspective regarding the research topic (Mack, Woodsong, Macqueen, Guest & Emily, 2005). An interview protocol is used to guide the interviewer regarding interview questions and information to be collected. The protocol also contains a script of what to say before the interview and at its conclusion with prompts as reminders, for example to obtain informed consent (Jacob & Furgerson, 2012). Open-ended questions are more appropriate than closed questions in uncovering as much about the participants and their situation as possible (Jacob & Furgerson, 2012). The interviewer should use appropriate techniques to conduct interviews because subtle persuasive questions could influence interviewees' responses or explanations (Creswell, 2014). Mutual subtle influences, through reflexivity, in which the interviewer's perspective undesirably influence the interviewee's responses, and vice versa, should be minimised (Yin, 2014).

As indicated in Figure 2.11 individual face-to-face, in-depth, semi-structured interviews were used to elicit the perspectives of four district officials regarding mobile technology integration at the schools. The interviews were carried out after the questionnaire had been administered to the teachers. The interviews were semi-structured, and in the form of guided conversations with the district officials.

2.7.3 QUALITATIVE DATA ANALYSIS

This research used a qualitative inquiry in Phases 2 and 3 and applied inductive reasoning as the main reasoning approach. The qualitative methods employed to collect and analyse data, integrate the findings and draw inferences were a case study, interviews and open-ended questions in a questionnaire. Teachers' views were interpreted by applying hermeneutics. Qualitative data analysis is often, though not always, inductive because it is usually used to determine emergent themes. Due to the predominantly inductive nature of qualitative data analysis, data gathered is used to build theory or themes that lead to specific conclusions. Inductive data analysis argues from particular facts, or data, to arrive at general themes or theory (Gioia, Corley & Hamilton, 2013; Teddlie & Tashakkori, 2009). Qualitative research uses methods such as case studies, interviews, observation and textual analyses to gather data whilst qualitative data analysis uses "thematic analysis", the examination of narrative data in search of themes (Denzin & Lincoln, 2011).

Qualitative methods are techniques associated with gathering, analysing, interpreting and presenting narrative information (Corbin, Strauss & Strauss, 2014; Teddlie & Tashakkori, 2009). Classical characteristics of qualitative research are the use of emerging rather than predetermined questions to guide the research. In qualitative research there is an emphasis on fully describing the emerging themes (Noble & Smith, 2015). Qualitative data analysis analyses narrative data using inductive and iterative techniques. These include categorical strategies and contextualising (holistic) strategies which result in themes, hence qualitative data analysis is referred to as thematic analysis (Denzin & Lincoln, 2011).

There are two broad methods of reasoning used in research namely the *inductive* and *deductive* approach. Inductive reasoning moves from specific observations to broader generalisations while deductive reasoning moves from the general to the more specific (Teddlie & Tashakkori, 2009; Venkatesh, Brown & Sullivan, 2016). Conclusions made through an inductive approach involve a degree of uncertainty, while the deductive approach, and conclusions thereof, are confirmations emanating from the gathered facts (Teddlie & Tashakkori, 2009). There are, however, instances when qualitative data analysis is deductive rather than inductive. For example, in analytic induction, qualitative analysis involves a deductive component. This involves examining the data for categories and then determining the relationships among the categories. This requires different cases to be examined and then correlated and developed into hypotheses. The main characteristic of analytic induction is negative case analysis in which the researcher ascertains cases in the qualitative data that do not fit expected patterns (Anney, 2014; Teddlie & Tashakkori, 2009).

Qualitative research and Interpretivism were used for applying hermeneutics for data analysis. Hermeneutics means interpretation, and is concerned with theories for correctly interpreting text (Schmidt, 2016). Hermeneutics is the aspect of a study that involves "interpreting the event(s) being studied to deepen the understanding of the political, historical, sociocultural, and other real-world contexts within which the event(s) occur(s)" (Yin, 2011: 310). Hermeneutics were applied under data analysis. Hermeneutics, as a research activity, involves particular actors defining their present situations. It recognises social reality by interpreting the meanings held by the social actors, or social group members, as key themes, or concepts, on which theory will be built as it emerges from the empirical evidence (Brannick & Coghlan, 2007).

Qualitative data analysis involved identifying emergent themes. Thematic analysis establishes commonality and mutual exclusivity by using similarity and contrast principles (Teddlie & Tashakkori, 2012). Categorical and contextualising strategies, as well as visual presentations of the themes that emerge are then applied to represent the information. Categorical strategies use categories to facilitate comparison while contextualising strategies involve the interpretation of narrative data to answer the research questions (Teddlie & Tashakkori, 2012).

Qualitative analysis of participants' responses to open-ended questions involved the use of ATLAS.ti, a computer-based qualitative data analysis (CAQDAS) tool. ATLAS.ti entails developing codes and using quotations in primary documents to enhance the analysis of data (Woolf, 2014). ATLAS.ti was applied to analyse teachers' perspectives as expressed in responses to open-ended questions of the questionnaire collated in a primary document in the hermeneutic unit for analysis. ATLAS.ti is a popular digital, qualitative data analysis software packages (Paulus, Lester & Dempster, 2013) that enables analysis tasks such as annotating, linking, searching, coding, querying and visualisation (Conteras, 2011). The use of data analysis can lead to increased transparency and enhance the reliability of the study (Conteras, 2011).

2.8 TRIANGULATION

Validation strategies are employed by researchers to enhance the accuracy of their research (Creswell, 2013). There are many perspectives and terms regarding what validation means in qualitative research (Lincoln et al., 2011). In qualitative research validation is an attempt to assess the accuracy of the findings, as described by the researcher and based on the analysis of the participants' responses (Creswell, 2013). Methods for addressing threats to validity include triangulation, thick description and selection of relevant features for the research design. Triangulation encompasses constant checks and rechecks of the consistency of the findings from different, and similar, sources to establish converging lines of evidence from different data sources and provide findings (Yin, 2013). Triangulation was used in this study through the different methods in which data was collected, analysed and integrated. The initial framework was developed by analysing sustainability frameworks based on a systematic review of the literature. A case study was used to demonstrate, and refine, the initial SFMTIS. The integration of different data sources used in this research contribute to enhancing the research validity. The data sources include: literature review, case study, interviews, questionnaire and document analysis. The collected data was analysed and the findings integrated to draw inferences through thematic analysis.

2.9 SUMMARY

This chapter described the research methodology. The philosophical and theoretical foundations made were discussed to indicate their influence on the methodological choices. Design Science Research (DSR) was selected for the research. The philosophy applied is pragmatism which is considered relevant for the DSR research process. Design science research, as described by Drechsler and Hevner (2016), and the design science research methodology process (Peffers et al., 2007) were applied. DSR and its relevance in the research were discussed. The DSR (Drechsler & Hevner, 2016) and design science research methodology process (Peffers et al., 2007) were outlined and discussed in relation to the study. The DSR (Drechsler & Hevner, 2016) applied in the research involves four cycles: rigour, design, relevance and the change and impact cycles. The stages that are involved in the design science research methodology process (Peffers et al., 2007) are: problem identification and motivation, definition of objectives, creation of the artifact in the design and development stage, demonstration, evaluation and communication. The DSR artifact to be developed by the research is the SFMTIS. The knowledge output will also be stated.

The theoretical foundations applicable to the research are the structuration theory, capability model and the institutional theory. The basic tenants of the structuration theory are structure and agency. The theory draws together the structuralist view, with emphasis on structure, and the phenomenological and hermeneutic aspects that focus on the human agent. The relevance for this study is in identifying the actors and the effect of structure on the capability of the agents in the environment. A question, relevant to sustainability in relation to structuration theory is, why some forms of social reproduction succeed and become institutionalised while others do not. This is discussed in Section 2.3.

The capability approach states that development infers a broadening of human potential, choices, freedoms and capabilities. The capability approach considers how human functionings and capabilities are influenced by personal, social, institutional and legal norms. The individuals' achieved functions, such as the development of digital skills and use of technology, are influenced by choices, capabilities and resources (financial, leadership, infrastructure, income level) as well as the social and institutional environment. Institutional theory considers organisations as rationalised systems that are oriented towards achieving specific goals. There are organisational systems and rules within which micro interpersonal interactions occur. Information technology integration occurs in an environment influenced by the social/cultural, economic and political context. The environment can affect the actors or human agents' capability and effectiveness in the organisation (Robeyns, 2005; Olsson et al., 2014).

Reflexivity, in which the researcher-participant interaction may be influenced by the researcher's perspectives, can be minimised through the researcher's awareness of his/her subject values, knowledge and positionality in the research.

The thesis research questions and chapters were mapped to the questions presented by Hevner & Chatterjee (2010) that design science research should address.

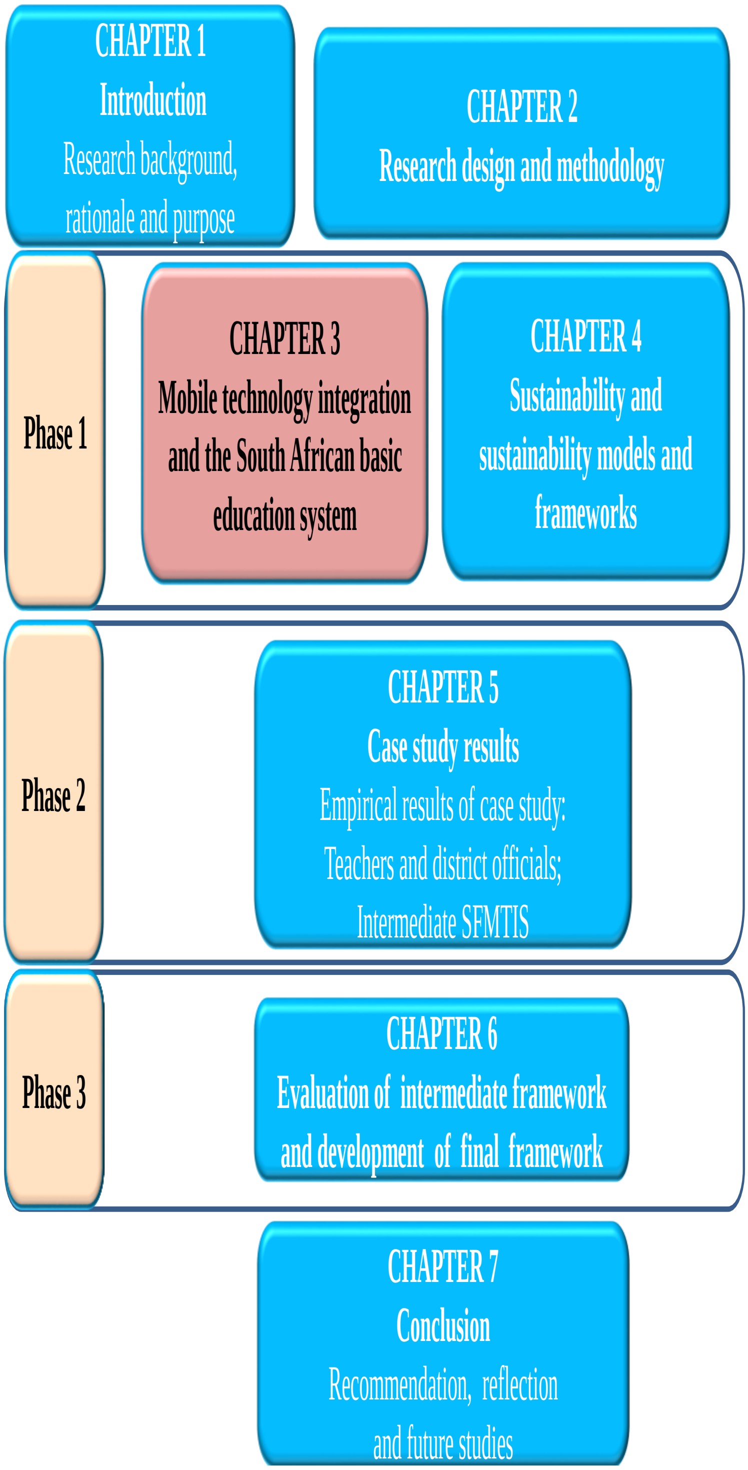
The enquiry was qualitative in nature and the data collection methods that were used include case study, questionnaire, interviews and document analysis. Inductive reasoning and thematic analysis were applied to analyse the data collected. The computer-based tool, ATLAS.ti, was used to facilitate qualitative data analysis. It is important that acceptable validation and reliability strategies be applied. Triangulation, in which different data sources are used, was applied as a validation strategy.

The selected case study involved two units of analysis: *teachers* from schools that had participated in the ICT4RED initiative that are based in the Cofimvaba school district, Nciba circuit, in the Eastern Cape province of South Africa, and *district officials* in the Cofimvaba school district. The ICT4RED initiative implemented technology integration into schools and provided technology infrastructure and related teacher professional training, hence its suitability and selection as the case study for this research.

There were three phases in the research. The first phase involved systematic review of literature aimed at adding rigour to the process of examining the existing knowledge on sustainability and sustainability frameworks and technology integration, and to determine ICT-related challenges in the South African basic education system. The second phase was the application of the case study. These phases were undertaken iteratively as the SFMTIS was developed. The third phase involved evaluation of the SFMTIS by evaluation experts.

The next chapter will discuss mobile technology integration and the South African basic education system. The ICT related challenges in the basic education system, particularly those evident in resource-constrained environments, will also be deliberated.

Chapter 3: Mobile technology integration and the South African basic education system



Chapter 3: Mobile technology integration and the South African basic education system

3.1 INTRODUCTION

Mobile technology integration and the South African basic education system are discussed in this chapter. The literature review phase within the DSR methodology process, as implemented in the study, is highlighted in Figure 3.1 and presented in Chapter 3 (and Chapter 4) providing the knowledge base described in the rigour cycle of design science research (DSR) (Figure 2.8). This chapter comprises of two main sections, namely Section 3.2 (Teaching and learning in the digital age) and Section 3.3 (ICT related challenges in the basic education system in South Africa).

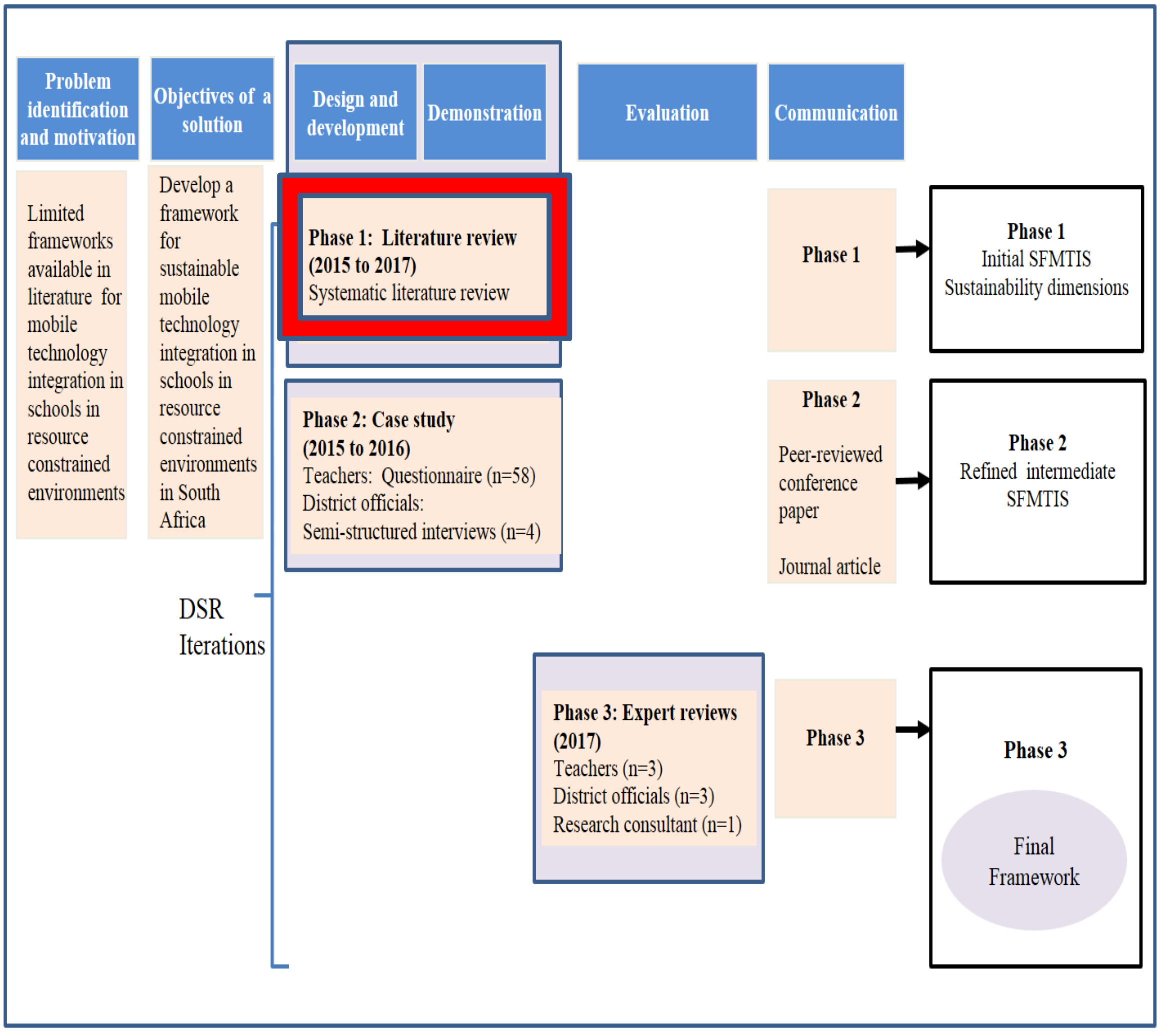


Figure 3.1: Application of DSRM process, Phase 1: Literature review

This chapter forms part of Phase 1 of the Design Science Research Methodology (DSRM) process. It constitutes the highlighted (red) phase in Figure 3.1 that was applied in this research, as discussed in the research design and methodology.

3.2 TEACHING AND LEARNING IN THE DIGITAL AGE

Information and communication technologies (ICTs) are vital to building an information society and knowledge economy (National Planning Commission, 2012) and to foster innovation and competitiveness (DoC, 2016). In a digital era characterised by massive technological changes in the economy, learners need to be equipped with knowledge and skills appropriate for the 21st century, and this includes digital literacy. For learners to be effective global citizens, they need to be competent in using ICTs as collaborative, creative problem solvers (UNESCO, 2016).

In Section 3.2.1 the discussion focuses on the digital era in which knowledge, skills and competencies are required and the use of mobile devices, as pedagogical tools, is also addressed. The concept of digital literacy is deliberated in Section 3.2.2 and 21st century learning environments are discussed in Section 3.2.3. The pedagogical approaches, associated with mlearning, are described in Section 3.2.4, and teacher professional development and support are deliberated in Section 3.2.5. Education systems and technology integration are discussed in Section 3.2.6, and e-Education and the South African education system is introduced in Section 3.2.7.

3.2.1 The digital age - knowledge, skills and competencies required

Learners need technology skills that will enable them to succeed in school, at work, and as lifelong learners (Ally, Grimus & Ebner, 2014). Information, media and ICT literacy are important in today's digital, globally interconnected, technology and media-driven environment. In the 21st century literacy is perceived differently as it is also viewed in terms of technology and media literacy (P21, 2016).

The use of mobile devices as pedagogical tools has been reported on in many studies (Kihoza, Zlotnikova, Bada & Kalegele, 2016; Ng, 2013; Ng'ambi & Bozalek, 2016). Pedagogical uses of mobile devices include communication for sharing, investigating, capturing data, analysing and assessing, managing tasks, assessing multimedia and representing meanings (Cheung & Hew, 2009; Grimus & Ebner, 2016). Mobile learning (mLearning) literacy is the literacy associated with interacting and learning with mobile technologies (Ng, 2013). Portability is one of the affordances mobile devices offer for mlearning in both formal and informal contexts (Ng, 2012). Classroom learning can be connected to the world through mobile learning, and mobile learning allows for people around the world potentially to learn from any location at their own convenience. The use of multimedia in the learning environment can accommodate different learning styles whilst also supporting inquiry learning by making a wide range of resources available.

Today's complex life and work environments require learners to develop relevant thinking skills, content knowledge and social and emotional competencies (Kong et al., 2014). Skills and knowledge needed by learners in order to succeed in work and life in the 21st century include: content and knowledge of basic subjects and disciplines together with learning and innovation skills (creativity and innovation, critical thinking and problem solving, communication and collaboration) as indicated by P21 (2016). Life and career skills such as flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility, and information, media and ICT skills are also important (P21, 2016).

The 21st century is characterised by rapid changes in technology tools, abundant information and profuse collaboration capabilities, hence the importance of digital literacy (P21, 2016; Voogt, Erstad, Dede & Mishra, 2013). ICTs are virtually indispensable for participation in a modern, globalised world (DHET, 2017) and so is *digital literacy*, as described in the following section.

3.2.2 Digital literacy

Literacy is a component of many different forms of learning, and digital literacy is a component and foundation of different types of digital learning, or e-learning (Traxler, 2012). The South African E-Skills Institute defines e-skills as "the ability to use and develop ICTs within the context of an emerging South African information society (or relevant context) and global knowledge economy, and associated competencies that enable individuals to actively participate in a world in which ICT is a requirement for advancement in government, business, education and society in general" (DoC, 2010: 2). Gilster (1997) defined digital literacy as "the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers" (Gilster, 1997: 1).

There are attitudes, skills and capabilities associated with digital literacy (Traxler, 2012). Ng (2012) advances a set of key technical, cognitive and social-emotional skills for digital literacy development, depicted in Figure 3.2. A digitally literate person should have the ability to portray basic computer-based operations, access resources for everyday use, search, identify and effectively assess information for the purposes of research and content learning. The person should be able to choose the most appropriate technological tools to complete tasks and solve problems or create products, demonstrating an understanding of the choices made (Ng, 2012). In addition, a digitally literate person should behave appropriately in online communities, showing an understanding of Internet security issues and so protect themselves from harm in digital environments. The following figure illustrates the position of digital literacy in terms of cognitive, technical and social-emotional literacy components.

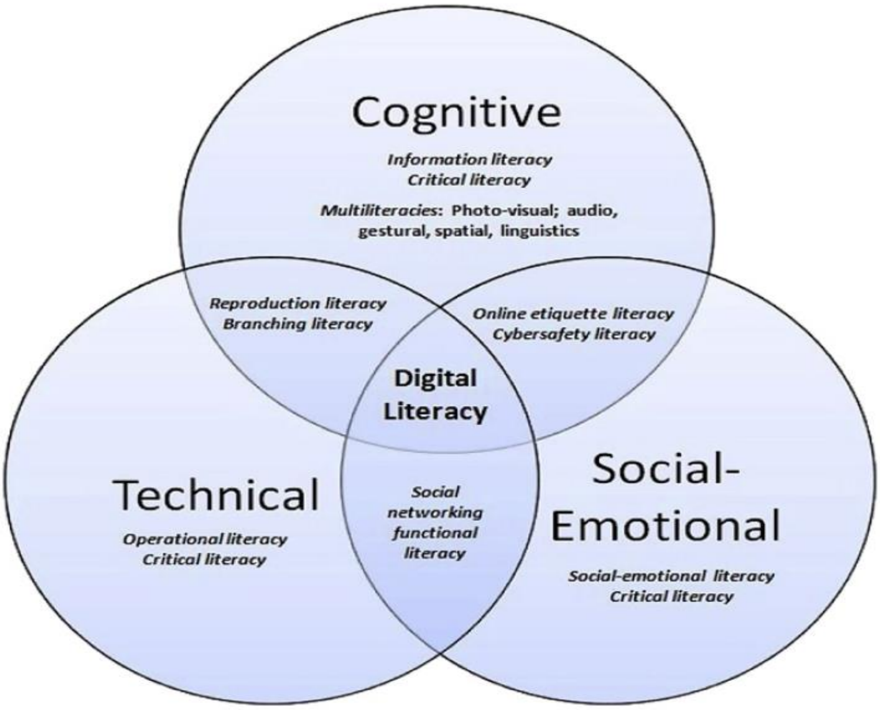


Figure 3.2: Digital literacy model
(Ng, 2012)

- The technical dimension includes operational skills to use ICT for learning and for everyday activities, while the cognitive dimension is the ability to think critically when searching, evaluating, creating and handling digital information. This means that the individual can evaluate, and select, appropriate software for specific tasks. The individual should be knowledgeable about ethical, moral and legal issues such as copyright and plagiarism associated with online information and content reproduction when making use of digitally-based resources (Ng, 2012).
- The social-emotional dimension represents the ability to use the Internet responsibly for communication, socialising and learning. Respect and appropriate language use, avoiding misinterpretation and misunderstanding, individual safety and privacy

through safeguarding personal information and recognising threats and knowing how to deal with them are associated with this dimension. The cognitive and social processes for digital literacy are the ability to create, locate and consume as well as communicate digital content by critically evaluating it (Spires & Bartlett, 2012).

- Critical literacy is central to all three dimensions of the digital literacy framework and implies that the individual should have an understanding that people, behind the scenes, generating the information have their own motivations. Individuals should therefore critically evaluate this digital information, whether it is written, visual, spoken, in multimedia format or performance texts, to question and challenge the attitudes, values and beliefs that lie beneath the surface (Ng, 2012). Critical evaluation of digital content enhances accuracy and integrity in the inquiry (Spires & Bartlett, 2012).

Learning environments should be adequately furnished to equip teachers and learners with the different facets of digital literacy. Teaching and learning in the digital age involves competencies, skills and digital literacy. This is relevant for this study as these are important components to consider when developing a framework for sustainability.

3.2.3 Twenty first century learning environments

Learning is a persisting change in human performance, or performance potential, resulting from the learner’s experience of and interaction with the world. Learning is a lasting emotional, mental or physiological (or skill) changed state, resulting from experiences and interactions with content, or other people (Driscoll, 2000; Siemens, 2004). Learning environments refer to the diverse physical locations, contexts and cultures in which learners learn. These encompass the culture of the school, or classroom, its presiding ethos and characteristics, including how individuals interact with and treat one another - as well as the ways in which teachers organise educational settings to facilitate learning (Ger, 2014). The institutional learning environment includes classrooms, laboratories and resources, such as technologies, but it also encompasses other features such as the characteristics of the learners, the activities to support learning and the assessment strategies (Bates & Sangra, 2011).

Poor learning environments can contribute to teachers feeling unappreciated, demoralised and demotivated. The establishment of appropriate physical environments, human support and learning practices is required to support teaching and learning of 21st century skill outcomes. The physical infrastructure, including architectural and interior designs, should facilitate 21st century group, team and individual learning (P21, 2016).

The creative classroom framework (CCR), depicted in Figure 3.3, presents innovative pedagogical practices that develop when teachers use ICTs to organise enhanced learning activities (Bocconi, Kampylis & Punie, 2012). The CCR considers learning environments as live ecosystems that evolve over time, changing in tune with the context and culture in which they reside. The framework focuses on the systemic approaches that are needed to scale up innovative pedagogical practices, especially in ICT-enabled learning settings. Sustainable implementation of the CCR requires a systematic approach (Bocconi et al., 2012).

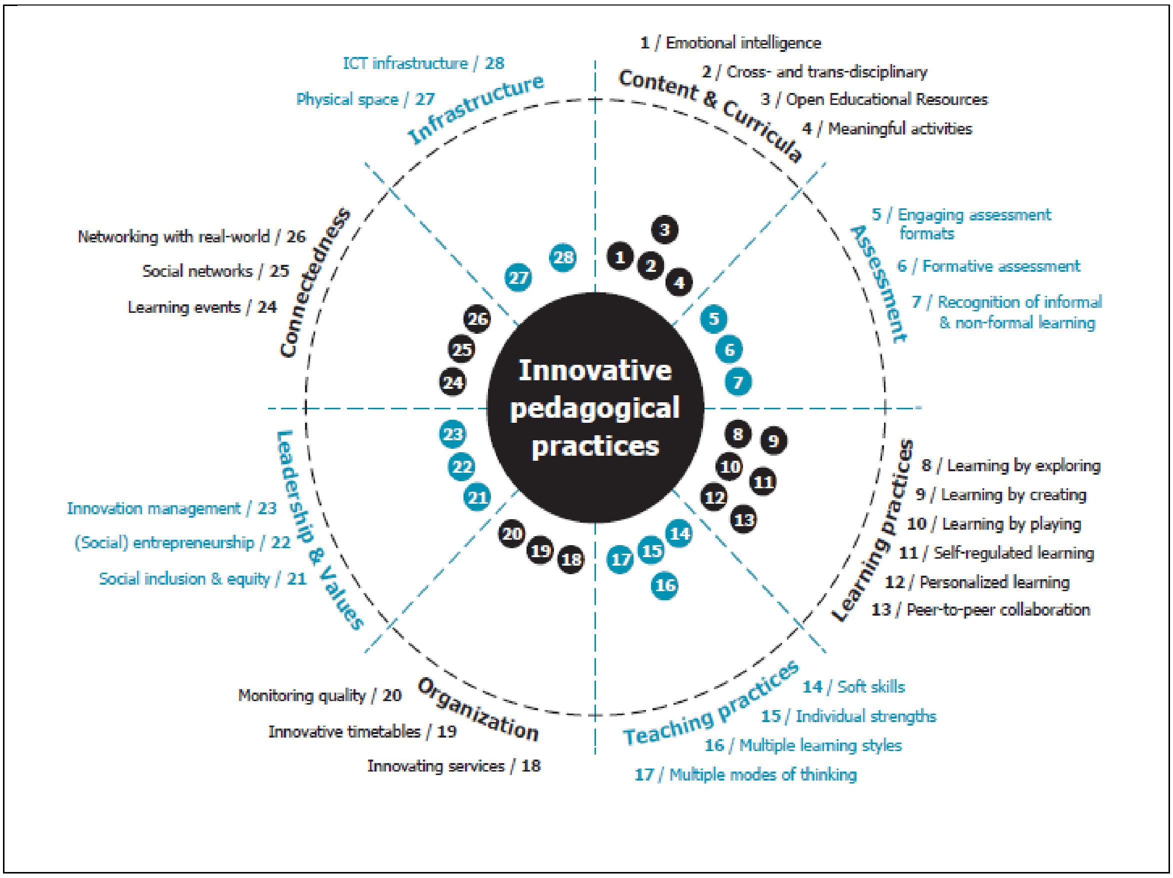


Figure 3.3: Elements of the creative classroom framework
(Source: Bocconi, Kampylis & Punie, 2012)

The CCR comprises eight dimensions that are interconnected: leadership and values, organisation, teaching practices, learning practices, assessment, content and curricula, infrastructure and connectedness. Reference parameters, numbered from 1 to 28, depict the systematic approach that is required for the sustainable implementation of the CCR. Innovative pedagogical practices are at the centre of the

CCR.

Figure 3.4 shows the Partnership for a 21st century learning framework, and depicts the critical support systems required to ensure learners' mastery of 21st century skills. These support systems include 21st century standards, assessments, curriculum, instruction, professional development and learning environments. The term *21st century standards* means that multiple measures of mastery emphasising 21st century skills, content knowledge and expertise should be fostered to deeper understanding. Learners should be actively engaged in solving meaningful problems using real-world data, tools and expertise (P21, 2016). Consequently, teachers' skills need to be developed to enable learners to engage appropriately.

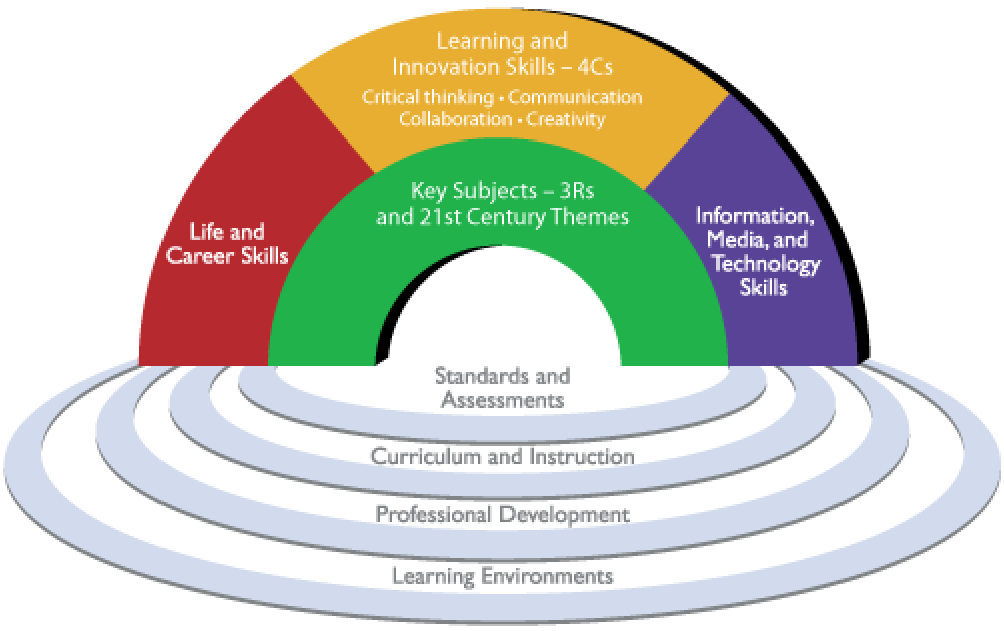


Figure 3.4: Framework for 21st century learning
21st century learner outcomes and support systems (P21, 2011)

Teaching and learning in a digital age requires appropriate pedagogical approaches to utilise technological advances and new learning tools. This is relevant to this study as the research aims to develop a framework for the integration of mobile technologies into teaching. The pedagogical approaches would influence the views of teachers and district officials regarding mobile technology integration.

3.2.4 Pedagogical approaches associated with mlearning

This section briefly discusses three approaches: constructivism, connectivism and heutagogy in order to acknowledge the different approaches that influence the way that teachers use technology for teaching. Pedagogical approaches associated with mlearning are presented in Table 3.1.

Table 3.1: Pedagogical approaches associated with mlearning	
1. Constructivism	
Definition	Learning perceived as a personal, subjective interpretation of the world which occurs as the individual is involved in an active process of interacting with his/her environment, during which knowledge is constructed (Anderson, 2010). Conceptual growth occurs as internal representations of the individual are developed. Previous knowledge and experience form a base for this development (Jordan, Carlile & Stack, 2008).
Explanation	The learners' perspectives, values and diversity should be taken into consideration. The move from a didactic style of teaching, where emphasis is on comprehension, memorisation and reproduction of correct or standardised answers for assessment, towards a constructivist approach to learning based on reflection, discussion and critical thinking facilitates development of 21st century skills. *Learning should encourage active engagement and discovery by the learner and be learner-centred* (Anderson, 2010).
2. Connectivism	
Definition	Learning is a process of connecting specialised nodes, or information sources, which also reside in non-human appliances such as computers. Learning is not simply an internal, individualistic activity, as actionable knowledge can reside outside of the individual. Focus is on connecting specialised information sets that enable us to learn.
Explanation	Provides insight into learning skills and tasks needed for learners to flourish in a digital era (Siemens, 2004). The capacity to know more is more critical than our current state of knowing. Connectivism identifies that new information is continually being acquired and that decisions are based on rapidly changing foundations. Learning is thus considered as a process that occurs within unclear environments of shifting core elements which are not entirely under the control of the individual. *Thus, the ability to plug into sources and to distinguish between important and unimportant information becomes a vital skill* (Siemens, 2004).
3. Heutagogy	
Definition	Heutagogy is derived from the Greek word for "self" and focusses on self-directed learning where *the learner is seen as a major development and control agent of their own learning* (Anderson, 2010). Heutagogy is considered appropriate to the needs of learners in the 21st century, particularly in the development of individual capability (Hase & Kenyon, 2007).
Explanation	It is essential to possess an "all round" capability centred on self-efficacy, knowing how to learn, creativity, the ability to use competencies in novel as well as familiar situations and working with others (Hase & Kenyon, 2007). A heutagogical approach requires teachers to *develop the learner's capability* as much as they develop discipline-based skills and knowledge. There is therefore a need to understand *how to develop capable people and how to enable capability to be expressed*.

Constructivism guides many researchers and educational practitioners (Anderson, 2010). For the purposes of this study, these approaches can be considered *complimentary* in nature. Connectivism advances that as knowledge continues to grow and evolve, access to what is needed is more important than what is currently known, and rather, our ability to learn what we need for tomorrow is more important than what we know today (Siemens, 2004). Heutagogy focuses on self-directed learning.

Criticisms levelled against heutagogy are similar to those directed against connectivism. Critics of connectivism, however, argue that connectivism offers nothing new in learning theory that is not already accounted for in constructivism and complexity theory (Kerr, 2007). Connectivism has also been criticised by Kop and Hill (2008) for not assigning an essential role to the teacher and expecting the learner to engage in self-directed learning, assuming that the learner is capable and motivated for this engagement. Heutagogy is criticised as placing too many requirements on the learner, considering the learner as capable and motivated to engage in self-directed learning (Anderson, 2010; Kop & Hill, 2008).

Further discussion of teaching and learning theories, however, fall beyond the scope of this research. It remains clear though that teachers need to be trained to effectively engage learners when incorporating technologies into teaching in today's digital learning environments (Fritschi et al., 2012). A major concern regarding technology integration in educational institutions is resistance to the constructivist teaching model and the use of technology for teaching (Bates & Sangra, 2011).

3.2.5 Pedagogy, teacher training and teacher beliefs

Teachers' ICT literacy skills and competence are crucial factors which influence the success and sustainability of integrating the use of web-based technology resources in educational practices (Garba et al., 2013).

3.2.5.1 Teacher professional development

A government's investment in teacher training is in many instances "a more important investment than its investment in technology itself" (West & Vosloo, 2013: 31). Teachers are increasingly expected to be skilled at using technology to promote learner-centred learning (Blonder et al., 2013; Riel et al., 2016). This requires teachers to take advantage of the power of emerging technology to design and deliver education to promote learners' understanding of concepts and to develop learners' digital literacy. Investing time and money to improve teachers, and teaching, is viewed by members of School Governing Bodies (SGBs) as pivotal (Bayat, Louw & Rena, 2014).

Teachers require training on how to incorporate digital content and technology for specific subjects (Coetsee, 2014). The teacher professional training provided should be accredited by SACE (as discussed in Section 3.3.11) for teachers to accrue PD points in the SACE continuous PTD system when they complete the training. Teacher support improves practice (Fritschi et al., 2012). Lack of adequate and ongoing school support influences the acceptance and adoption of mobile devices in teaching (Chiu & Churchill, 2016). Teachers also have individual, and collective, responsibility for their own professional development. Teachers have a responsibility to take charge of their own self-development by identifying areas in which they need to develop and to seize opportunities that are available to them through various forums such as the South African Council for Teachers (SACE), which is the teachers' own professional body, and the Integrated Quality Management System (IQMS) (DoE, 2011).

3.2.5.2 Teacher beliefs and attitudes about technology use

The continued and sustained use of technology is linked to teachers' positive attitudes regarding the use of technology and their belief that technology can improve their work performance and make them more efficient in achieving their teaching goals and targets (Chiu & Churchill, 2015). Teachers' beliefs, attitudes and anxiety levels, as these pertain to technology use, are important factors for mobile technology integration into teaching (Blackwell, Lauricella & Wartella, 2014; Kim, Kim, Lee, Spector & DeMeester, 2013). Teachers' choices regarding technology use are influenced by knowledge, experience and their beliefs and attitudes (Ritchie, Lewis, Nicholls & Ormston, 2013). Teachers' beliefs, attitudes and anxiety levels regarding technology use for teaching, change when they *have experience* and *know how* to use new technologies and associated teaching methods (Ertmer et al., 2012). Programmes to develop ICT literacy skills should include strategies to nurture the desired changes in teachers' thinking or beliefs, values and attitudes and insights into how emotions, especially the elimination of anxiety about integrating mobile devices into teaching, impact teaching (Teo, 2012).

Teacher professional development programmes also enhance teachers' self-efficacy (Blonder et al., 2013). Teachers should be mobile learning (mlearning) literate, digitally literate and empowered to learn more independently and more safely when using mobile devices and their applications (Ng, 2013). Professional development of teachers is, however, insufficient to affect change on its own, other aspects such as *change management* and *support impact* on teaching (Olson et al., 2011) should also be considered.

There are schools which are plagued with absenteeism and unprofessional conduct by teachers (Modisaotsile, 2012; Singh, 2017). Teachers' professional behaviour and performance, improvement in their attitude towards their work, reduction in teacher absenteeism from school and active participation in school matters can be improved by providing motivation, career guidance and other relevant courses (Bayat et al., 2014).

3.2.5.3 Teacher support

Teachers may be concerned about insufficient and inconsistent support from the school and that new technologies will increase their workload and responsibilities (Chiu & Churchill, 2015). Inadequate knowledge on how to use ICT in daily teaching activities and feelings that support is lacking can result in teachers reverting to traditional teaching methods, in spite of the potential benefits offered by new technologies (De la Iglesia, 2015). It is essential that effective change transformation programmes, that address prevailing and perceived barriers, should be applied (Olson et al., 2011).

Teachers experience challenges in evaluating, selecting and using existing applications that support teaching for subjects such as mathematics (Kruger, 2015). There are limited guidelines available to aid teachers in making informed decisions when evaluating mathematics mobile technology applications (Kruger, 2015). Models, such as the Information System Success (ISS) model (Zaied, 2012), can be used by teachers to evaluate the usefulness of mobile educational applications. The application's characteristics can be examined to determine whether it promotes proficiencies such as conceptual, procedural, strategic competence, adaptive reasoning and productive disposition. These proficiencies are significant in that learners, for example, who have a productive disposition towards a subject, such as mathematics, view the subject as useful and worthwhile. The applications provide learners with an opportunity to practice more frequently and to build confidence in their abilities (Kruger, 2015). Mobile applications provide opportunities to develop educational learning applications to compliment traditional learning activities whilst affording learners the opportunity to learn *beyond* their normal class setting (Kruger, 2015). Teachers need to be trained to effectively use educational learning applications to teach various curricula. Professional learning communities, which enable teachers to collaborate and share best practices and integrate 21st century skills into classroom practice, should also be supported.

Mentorship programmes, which supply continuous support for implemented programmes, can be provided. These programmes assign mentors to each school in order to provide assistance at any time (Coetsee, 2014). It should, however, be clarified beforehand how teachers should contact these mentors, when the mentors are available and what mechanisms will be applied to ensure continuity of such a programme. Communities of practice can also provide support to teachers (Coetsee, 2014).

Implementing the use of mobile devices in schools requires programmes to help develop ICT literacy skills. Moreover, as indicated by Chiu & Churchill (2016), it is necessary to facilitate the desired changes in teachers' thinking, beliefs, values, emotions (especially anxiety) and attitudes regarding the integration of mobile devices into teaching.

3.2.6 Educational systems and technology integration

Technology integration in educational institutions may be affected by factors such as resistance to adoption of new technologies to support learning and failure to provide systems and environments that result in wider adoption (Garrison & Vaughan, 2013). Bates & Sangra (2011) state that the major concerns regarding the integration of technology in educational institutions include:

- lack of consistency in policy;
- resistance to constructivist teaching model and resistance to the use of technology for teaching;
- many organisational changes; and
- part-time status of contract staff members, who are often insufficiently trained due to their part-time status.

Transformational institutional change requires collaborative leadership that engages all levels of the institution (Garrison & Vaughan, 2013). Despite the potential of digital technology to facilitate new approaches to teaching and learning, effective and appropriate learning outcomes cannot be guaranteed (Venkatesh, Croteau & Rabah, 2014). Thoughtfulness, creativity and commitment to sustain specific action plans are required to successfully integrate technology to support teaching (Garrison & Vaughan, 2013).

Assessment criteria, as shown in Table 3.2, and an analytical framework, as shown in Section 3.2.3.5, have been proposed for considering the likelihood of successful technology integration in educational institutions:

Table 3.2: Assessment criteria for likelihood of successful technology integration in educational institutions (Source: Adapted Bates & Sangra, 2011)

Criterion		Description
1	ICT Champions	*Are there champions with power and influence in the institution who support integration of technology to the institution's activities?*
2	Infrastructure	*Does the institution have an advanced, comprehensive technology infrastructure that enables staff, learners and teachers to access computers, networks, software and services as required?*

3	Digitalisation of administrative systems and information services	*Has the institution digitalised administrative systems and information services which staff, learners and teachers can easily access over the web?*
4	Statement of strategic rationale	*Has the institution clearly identified and stated the strategic rationale for the use of technology within the institution?*
5	Financial resources	*Has the institution allocated additional financial resources, or reallocated resources, to support the integration of technology?*
6	Use of technology	*What is the proportion of staff, learners and teachers using technology as indicative of technology penetration, and what activities is the technology used for?*
7	Innovativeness	*How innovative is the use of technology, particularly for teaching?*
8	Support	*What is the level of support given to teachers to ensure good-quality teaching when using technology?*
9	Improved learning	*Are learners' outcomes improving and are they receiving better services as a result of technology* integration?

There is an increase in the use of emerging technologies among educators and learners, however, the use of these technologies does not guarantee effective teaching and learning (Ng'ambi, 2013). Despite varying socio-cultural contexts in which emerging technologies are implemented, and institutional policies and support provided, teachers' passion for technology and their realisation as to the positive impact that the use of technologies can have on the learners motivate them to use technology for teaching and learning (Ng'ambi, 2013).

An analytical framework that can be used for in-depth analysis of educational institutions' technology integration position, centres on six goals, or focus areas (Bates & Sangra, 2011):

1. ICT goal of improving technology infrastructure, especially connectivity;
2. Increase accessibility to technology for staff, learners and teachers;
3. Improve internal administrative processes through enterprise resource planning (ERP) systems such as financial systems, learner information systems, human resource management systems and accessible administrative web services for learners and teachers;
4. Improve internal and external communication through email, learner portals, institutional web sites for public relations and contact with former learners;
5. Promote and facilitate research through accessing and sharing large databases; and
6. Expand and improve teaching and learning through:
    - Using technology to support classroom teaching;
    - Development of blended or fully online learning courses/programmes;
    - Access to digital resources, for example, enabling online access to library catalogues;

- Design or purchase and installation of software to support teaching and learning, for example installing a learning management system; and
- Teacher development and training in the use of technology.

The education system's technology integration position can be assessed in relation to its ICT related goals, access, processes, communication, research and teaching and learning programmes.

3.2.7 E-education and the South African public education system

> *"The three meta-dimensions likely to drive technology planning and decision-making in the coming years are policy, leadership and practice."*
>
> *(Johnson, Adams, Estrada & Freeman, 2014)*

The "White paper on e-Education - Transforming Learning and Teaching through Information and Communication Technologies" published by the South African Department of Education as early as 2004, presents the strategic, pedagogical and developmental framework regarding e-Education implementation in South Africa (DoE, 2004). The e-Education policy goal is for every learner to be able to use ICTs confidently and creatively to help develop skills and knowledge needed to achieve personal goals and to fully participate in the global community (DoE, 2004).

There are numerous examples of mobile technology integration projects to support teaching in South Africa (Coetsee, 2014; Kruger, 2015; Meyer et al., 2016; More, 2015). The government, private sector and non-governmental organisations are involved in developing and providing electronic content resources such as Thutong (DBE Thutong, 2016), Mindset Learn (Mindset Learn, 2015) and digital classrooms (Vodacom, 2014). Examples of projects to provide mobile technology to support teaching also include provincial government department projects such as the Gauteng and North-West tablet projects as well as subject specific projects such as the Teaching Biology and MoMaths projects (Kruger, 2015). The Teaching Biology project is sponsored by a private company, and is aimed at developing teachers' ICT skills by enabling them to develop digital content of lesson plans and assessment material using ICTs. MoMaths in South Africa enables learners to access mathematics content through mobile devices and to participate in competitions and quizzes (Kruger, 2015).

The ICT4RED project is another example of an initiative to implement mobile technology in schools. The ICT4RED programme, described in Section 1.3, provided over 4 000 tablets to support 350 teachers and 6 500 learners in 26 schools in resource-constrained environments in the Eastern Cape province (ICT4RED, 2015). The deployed tablets were supported by educator training, the provision of technology hardware and software, ICT network connectivity including Wi-Fi equipment and technical support. Other examples are the provincial Gauteng tablet project and the provincial North-West tablet project.

The provincial Gauteng tablet project provided 88 000 tablets to 2 200 public schools in 2014 (Kruger, 2015). There were 40 tablets provided to each school, and learners could access the tablets in the school's computer laboratory. It is important to note that in this example the provincial department provided connectivity in the schools. The provincial North-West tablet project provided each school with 40 tablets, a server and Wi-Fi router. The tablets were loaded with digital content for subjects such as Mathematics, Physics and Life Science, and additional content available on the server could be accessed offline (Kruger, 2015). Burglaries and thefts at the public schools, in which thieves made off with large numbers of tablets, forced the Gauteng Department of Education to withdraw the tablets from schools (More, 2015; SABC, 2015). Tablets stolen at Gauteng public schools have been tracked to other provinces in the country whilst some stolen tablets were even smuggled to other countries (Fengu, 2017).

In order to eliminate poverty, reduce inequality and spur economic development, South Africa's National Development Plan (NDP) identifies education, training, life-long learning and innovation as key priorities (National Planning Commission, 2012). The four major features supported by the E-education policy framework for the use of ICT in teaching and learning are: equity, access to ICT infrastructure, capacity building and norms and standards (DoE, 2004). Education systems must change to facilitate mobile access to education and one of the most important changes is training teachers to prepare them for the mobile world (Ally et al., 2014). E-education also fits into a school system within a broader education system. This will be discussed in the next section.

3.2.7.1 The school system as a component of the education system

As a component of the education system, the school system interacts with socio-economic factors in its environment as illustrated in Figure 3.5.

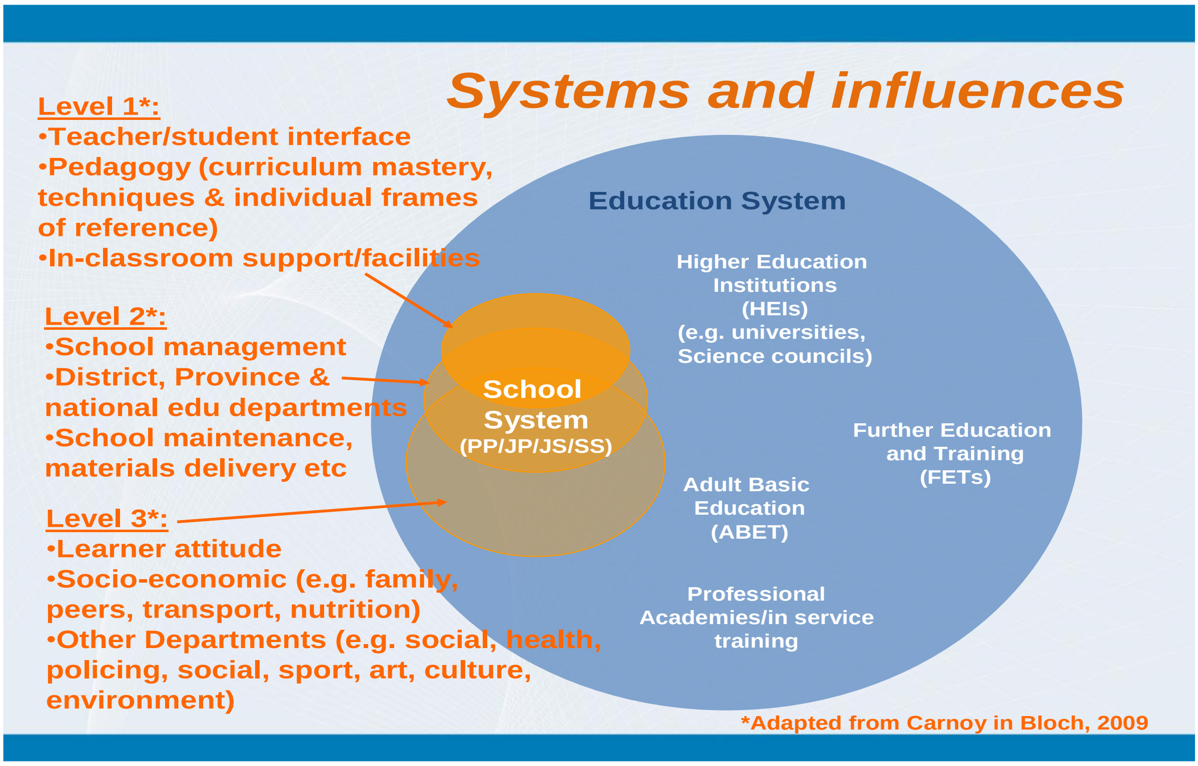


Figure 3.5: The school system and its influences (Adapted from Carnoy in Bloch, 2009)

As indicated in Figure 3.5, the factors which influence the school system are: at the *first level* the teacher who interacts with the learners through teaching and learning activities; at the *second level* the influence of school management and interactions with management at district, provincial and national level; and at the *third level* economic, political and social/cultural factors in the environment of the school system that can influence teachers and learners attitude.

Different schools in South Africa have varied access to ICTs. Ford and Botha (2014) illustrates this in Figure 3.6. Private schools may, for example, have full access to ICTs and may be able to apply bring your own device (BYOD) practices. Well-resourced government schools may have relatively better access to ICTs through computer laboratories in the schools. However, a large number of government schools in resource-constrained areas face challenges such as inadequate ICT infrastructure and minimal access (Ford & Botha, 2014).

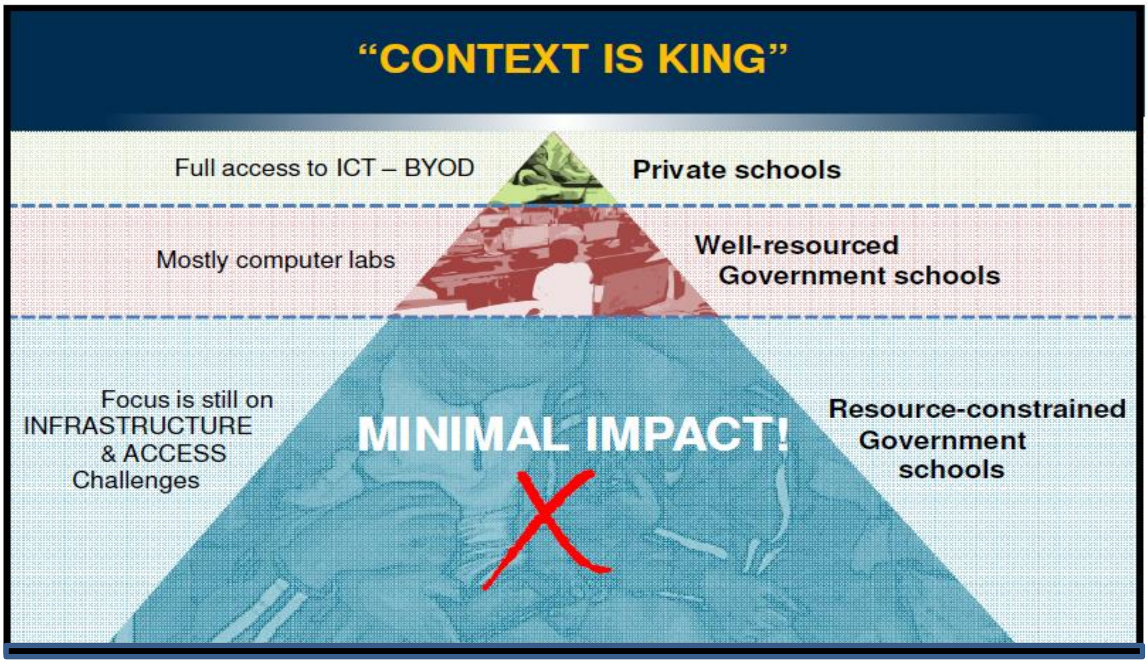


Figure 3.6: South African schools and ICT (Ford & Botha, 2014)

ICT initiatives, such as "Operation Phakisa: ICT in education", aimed at improving ICT infrastructure, connectivity and teacher professional development have been undertaken (More, 2015). However, the education system still faces many challenges. The purpose of this section is to discuss the challenges in the basic education system in order to *explain the context and illuminate the problem*s that characterise the education system. Defining the context is an essential part of the design science research process as shown in Table 2.6 and Figure 2.7 in the methodology section.

The National Development Plan (NDP) advocates for greater use of technology, backed by high-speed broadband, to enhance opportunities for teachers and learners to match the needs of a changing world (National Planning Commission, 2012). However, the education system in South Africa still faces individual and systematic challenges (DHET, 2017).

3.3 ICT RELATED CHALLENGES IN THE BASIC EDUCATION SYSTEM IN SOUTH AFRICA

Challenges in the education system that affect the integration of ICTs into public schools include: socio-economic factors, infrastructure, policy implementation, access and usage of available digital resources, and leadership (DBE, 2012). The Metcalfe report (DBE, 2012) stated that challenges in the education system in South Africa include:

- bureaucratic inefficiencies;

- lack of school leadership and management skills;
- unavailability of learning and teaching materials; and
- ongoing changes to curricula.

The South African National Planning Commission (2012) stated that shortcomings in the basic education system include:

- challenges in management and school support, including the role of the district offices;
- lack of cooperation between key stakeholders, particularly unions and the government; and
- lack of accountability.

The relevance of discussing the ICT related challenges in this section is to deliberate on the ***environment*** and ***context*** of resource-constrained public schools in this research. The DSR environment of the domain in this research, as discussed in Section 2.4.7.2 is composed of the people and organisational and technical systems.

Organisations implement information systems in order to improve their efficiency and effectiveness (Hevner & Chatterjee, 2010). Information systems research advances knowledge that aids in the productive application of information technology to human organisations and their management (Hevner & Chatterjee, 2010). This is achieved by developing and communicating knowledge, concerning both the management of information technology and the use of information technology, for managerial and organisational purposes (Leidner, 2003).

The sub-sections discuss challenges related to the large number of learners in the public education system, discussed in Section 3.3.1, and the need to provide and maintain adequate and appropriate school physical infrastructure, presented in Section 3.3.2. The unavailability of teaching and learning materials, particularly textbooks, is discussed in Section 3.3.3 and social inequality in South Africa (and the resulting school quantile classification system and differences in the role of school governing bodies in schools), in Section 3.3.4. Selected policies are discussed in Section 3.3.5 in relation to the sustainability of ICT integration in schools. Section 3.3.6 discusses accessibility and use of digital resources. Leadership in the education system is elaborated on in Section 3.3.7. Based on the reviewed literature, the sustainability dimensions that can be applied in developing the SFMTIS are presented in Section 3.4.

3.3.1 Large number of learners in the public education system

South Africa spends about 5% of its Gross Domestic Product (GDP) on basic education (DBE Strategy, 2016). The Basic Education system caters for large numbers of learners and the teachers that are required to teach them. Of the 13 068 855 learners enrolled in all sectors of South Africa's basic education system in 2014, 12 117 015 (92.7%) were in ordinary public schools (Figure 3.7). These learners were served by 390 608 teachers in 24 060 public schools. The Eastern Cape province, which this study used as a source of data, is one of South Africa's nine provinces, and has 1 946 884 learners and 64 258 teachers in 5 732 schools (DBE Statistics, 2016).

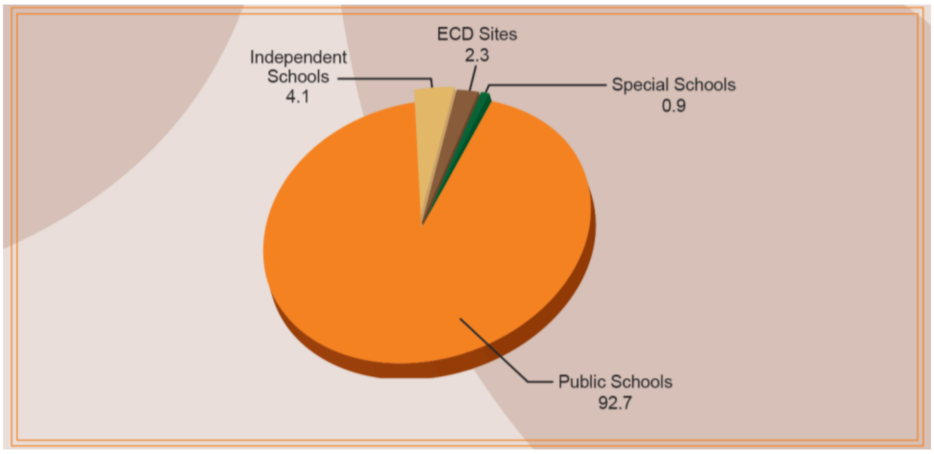


Figure 3.7: Percentage distribution of learners in the education system in 2014 (DBE Statistics, 2016)

The large numbers of learners and teachers require adequate infrastructure and financial resources for the system to provide quality education to all learners in the different provinces, and in varying environments - affluent as well as environments that are resource-constrained. The lack of infrastructure and facilities is a challenge for schools in rural areas of South Africa (Khumalo & Mji, 2014).

3.3.2 Need to provide and maintain school physical infrastructure

The physical environment affects teaching and learning (Khumalo & Mji, 2014). The National Department of Basic Education has improved school infrastructure - building structures, provision of water, sanitation and electricity through the accelerated school infrastructure delivery initiative (ASIDI). The delivery of school infrastructure has improved in recent years (Khumalo & Mji, 2014). Figure 3.8 is an example of a school developed through the Department of Basic Education's on-going ASIDI development process. Figure 3.8 is an example of a school developed as part of the Department of Basic

Education's ASIDI project that is improving school infrastructure. However, the task is enormous, and the physical condition and appearance of some school buildings and grounds indicate that they require maintenance. Some schools lack basic equipment such as tables, desks and chairs, while facilities such as computer labs in some schools are under-serviced and dysfunctional (Bayat et al., 2014). Teachers prefer to teach in schools with adequate infrastructure, buildings, electricity, lavatories, learning materials and resources, as these factors directly affect teachers' and learners' performances (Modisaotsile, 2012). Well-qualified teachers are often lured to schools that are well resourced (Khumalo & Mji, 2014).

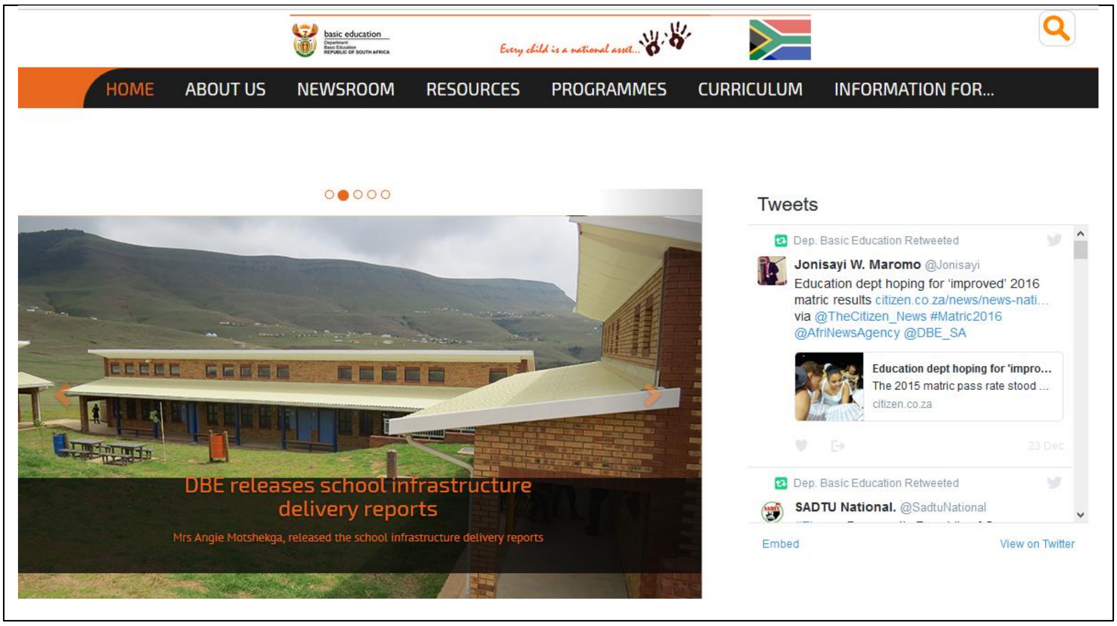


Figure 3.8: School infrastructure improvement
(Source: DBE Asidi, 2016)

3.3.3 Unavailability of learning and teaching materials (textbooks) in public schools

The DBE (2012) detailed the challenges pertaining to the delivery of textbooks to public schools. These include:

- Late and non-delivery of textbooks to schools;
- It may take a long time (up to six weeks) for textbooks to be processed into school-lots and transported from the central warehouse to district warehouses, and to schools; and
- Problems arise when books are not ordered from the publishers on time due to insufficient funds, resulting in orders being rationalised and reduced by Provincial departments.

Timeous delivery of textbooks to schools requires comprehensive planning, adequate resources, capacity and infrastructure and for provincial departments of education to make financial provision for the purchase of textbooks and their delivery (Chisholm, 2013; DBE, 2012). Provinces are required to order textbooks from publishers before the end of the preceding school year for timeous delivery, prior to the start of the following school year. When provincial departments have inadequate funds, this can result in books being ordered from publishers late, or orders rationalised and reduced, impacting negatively on schools. There are costs associated with the millions of textbooks that are transported from central warehouses, and then to district warehouses, before they eventually reach schools (Chisholm, 2013). There are also administrative implications as proof of delivery notes (PODs) have to be issued and maintained for deliveries at different points in the system. Full audits of deliveries to accurately assess the number of books which have reached schools and checks to ensure correct deliveries of quantities, according to language and other categories such as subjects, are also required (DBE, 2012). The lack of textbooks can be alleviated if mobile learning can be applied to support teaching and learning (Section 3.2.4).

3.3.4 Social inequality in South Africa and the quantile school classification system

Inequality is substantial in South Africa as the country has one of the world's highest Gini coefficient, at 63 compared to 44 for sub-Saharan Africa (World Bank, 2016). The Gini index measures the extent to which the distribution of income among individuals, or households, within an economy deviates from a perfectly equal distribution. A Gini index of zero (0) represents perfect equality, while an index of one hundred (100) implies perfect inequality (World Bank, 2016).

Schools cannot be isolated from their local community realities, and therefore the school's socio-economic environment matters (Bayet et al., 2014). Individual's "offline disadvantage" emanating from their circumstances, social and cultural capital, has a direct relation to digital media access and consumption patterns (Villanueva-Mansilla, Nakano & Evaristo, 2015). Digital devices are an extension of the general social and cultural practices of their users, and the computer as a tool of connection and telecommunications services serves as an extension of individual interests. Cultural and social capital are resources for the actors participating in the networks, and the actors receive unequal cultural and economic capital returns from investments made in mobilizing these resources (Villanueva-Mansilla et al., 2015).

Inadequate resources are a critical factor that can adversely affect teaching and learning (Khumalo & Mji, 2014). Chronic lack of adequate funds for day-to-day running of schools and for the purchase of additional educational equipment has been reported as a challenge at some public schools (Bayat et al., 2014). The Department of Basic Education (DBE) implements poverty related programmes, such as the school nutrition programme, which provides a meal a day to pupils in identified schools. The relevance of this is to highlight the needs and challenges that face the education system and resource-constraints prevailing in this context that can impact on mobile technology integration.

3.3.4.1 The school quantile system

The National Norms and Standards for School Funding (NNSSF) outlines the basis for the *school quantiles* concept which classifies public schools in South Africa into five groups, quantiles 1 to 5, from the poorest to the least poor (DBE, 2017). Quantile 1 presents schools in each province which cater for the poorest 20% of schools, followed by the next poorest 20% of schools in quantile 2. All schools in quantiles 1 to 3 are "no-fee" schools, and these account for 60% of the country's learners in public schools (DBE, 2017). Table 3.3 depicts the national poverty distribution showing the percentage distribution of schools in each quantile per province.

The Eastern Cape, the province which is the focus for the purpose of this study, has the second highest number of quantile 1 schools (27.3%) and 11.4% of its schools are quantile 5 schools. In contrast, the Western Cape has the highest number of well-resourced schools, with 31.7% of the provinces schools falling in quantile 5 according to the DBE's national poverty distribution table (Table 3.3).

Table 3.3: National poverty distribution table
(Source: DBE, 2017)

PROVINCE	QUANTILES					
	1 (Poorest)	**2**	**3**	**4**	**5 (Least poor)**	Total
Eastern Cape	27.3	24.7	19.6	17	11.4	100%
Free State	20.5	20.9	22.4	20.8	15.4	100%
Gauteng	14.1	14.7	17.9	21.9	31.4	100%
KwaZulu-Natal	22.1	23.2	20.2	18.7	15.8	100%
Limpopo	28.2	24.6	24.2	14.9	8	100%
Mpumalanga	23.1	24.1	21.5	17.7	13.5	100%
Northern Cape	21.5	19.3	20.7	21.4	17.1	100%
North West	25.6	22.3	20.8	17.6	13.7	100%
Western Cape	8.6	13.3	18.4	28	31.7	100%
South Africa	20	20	20	20	20	100%

3.3.4.2 Environment in resource-constrained public schools

The financial and social pool of resources that the school can draw from may be affected by the demographics and socio-economic context of the community in which the school is located (Bayet, Louw & Rena, 2014). Schools in resource-constrained environments are not only constrained by inadequate infrastructure, but often lack the financial resources to implement technology integration programmes (Coetsee, 2014).

The conditions in which teachers work are complex due to the pervasive legacies of South Africa's history, and the subsequent changes in policies and implementation that have occurred since the dawn of democracy in 1994. Prior to 1994 there were different education departments with different curricula and quality standards. Efforts have been made to rationalise the education system into a single national system, and teachers have had to cope with the changes amid other challenges, as new curricula have been introduced (Bayat et al., 2014; Modisaotsile, 2012). Challenging working conditions contribute to perceived causes of diminishing interest in teaching as a career (Modisaotsile, 2012). Low levels of requisite numeracy and literacy levels among learners have been reported (Modisaotsile, 2012). In some areas, children have to walk long distances to attend schools (Bayat et al., 2014).

Mobile educational applications are implemented and used within a specific social, or organisational, context. This context may affect the use of the applications through the objectives and roles and responsibilities assigned (Kruger, 2015). The constraints imposed by lack of funding available in resource-constrained public schools should be acknowledged and viable solutions explored. Effective implementation of ICT programmes requires: hardware, technical and teacher professional training, digital content, financial resources as well as license fee costs for digital content. These costs should be determined and can be explicitly stated upfront in order to aid in decision-making.

It is important to stipulate the cost of programmes in the long-term in order to facilitate financial planning and ensure the continued availability of funds. The ICT4RED programme led to the development of a cost-utility model (Meyer & Marais, 2014: 217). The cost-utility model was developed to demonstrate the value that is created at several points along the value chain, and to indicate the investment that was made in order to deliver the value. The cost-utility model also provides a means of comparing different strategies and facilitates scaling of the initiative (Meyer & Marais, 2014).

The "online school" demonstrates the need for long-term financial planning for programmes undertaken to integrate technology into schools. The "online schools" programme is an initiative conducted by the Hatfield Christian online schools that collaborated with an under-resourced school in a resource-constrained environment. In this programme all aspects namely hardware (laptop, projector, 3G card, speakers, whiteboard and markers, printer and paper), teacher professional training, Internet connectivity, stationery, license fees and matric winter school, were allocated specific costs per year, over a three year period (Coetsee, 2014). A partnership programme for funding the initiative was developed in which awareness of the E-learning programme was raised among companies, corporations, groups and individuals to sponsor a school or schools (HCoS, 2017). The benefits that the sponsors from the private sector (companies and corporations) accrue from participating in the programme are clearly stated e.g. CSI, broad-based black economic empowerment and, moreover, learners become future candidates for apprenticeships in these companies (Coetsee, 2014; HCoS, 2017). This is important to note as it indicates the role of private sector funding and how companies can be incentivised to fund such programmes.

The stipulation upfront as to the costs over the three year period aids in planning and strategising. DBE policy-makers can also use such information for decision-making regarding how best to support schools. In this example (Coetsee, 2014), it was noted that while other financial requirements such as cost of hardware, overall implementation costs, internet connectivity, matric winter school and stationery remained static, the cost of license fees escalated by 100% from the first year to the second year, and by an additional 50% from the second to the third year of implementation (Coetsee, 2014). Specifying license fee costs upfront can aid in planning, negotiations and consideration of options such as the Department of Education developing its own content and infrastructure. Coordination of the support provided by the private sector, corporations, companies and individuals, and application of economies of scale can enhance efficiencies in implementation.

3.3.4.3 School governing bodies and the role of parent communities

Disparities have been reported in the contribution made towards school governance and operations by parents and SGBs in different socio-economic contexts, that is, more affluent vs. under-resourced areas (Bayat et al., 2014). Support may be provided to the SGB by parents in the community, or other community members. Communities that are involved in the school activities are able to articulate the local school needs, hold officials accountable, and mobilise local resources in order to fill gaps when government response is inadequate (Modisaotsile, 2012). Substantial, effective and valuable support and guidance by parents, who are sometimes even better qualified than the principals, has been reported by principals in schools situated in more affluent areas (Bayat et al., 2014). This underpins the value of social capital. The SGB is mandated by SASA (1996) to set policies that govern the school, and to monitor the implementation of such policies, thus acting as the school *governmen*t (Modisaotsile, 2012).

The social, economic, and cultural context of users is a critical factor for understanding the potential, and impact that digital access and Internet connectivity have in the lives of its users. Not everyone uses digital devices for the same goals as the individuals' social and cultural capital, their background, and ICT expertise influence individual productive use of digital media, technologies and devices (Villanueva-Mansilla et al., 2015). The role played by parents in providing moral, financial and emotional support affects learners' performance (Khumalo & Mji, 2014; Modiaotsile, 2012). There is no remuneration for parents, in recognition of their effort and time, who serve on SGBs because this service is considered voluntary. Moreover, the contribution of parents who volunteer has been found to be modest, particularly where parents are untrained. A study conducted in a less resourced area in South Africa by Bayet et al. (2014) found that some parents were unwilling to volunteer to serve on the SGB, stating that they were busy with their own economic and social struggles and trying to survive and that SGB service holds no remuneration.

The way in which institutions are managed, the quality of the facilities including digital devices and Internet connection, and the cognitive abilities, availability of resources, as well as the characteristics within a group, affect digital access (Villanueva-Mansilla et al., 2015).

School governing bodies in resource constrained environments experience challenges in effectively managing school funds (Mestry, 2016). The quality of support given to SGBs can affect the SGB's effectiveness (Bayat et al., 2014). Parental support provided to SGBs should be comprehensive and sustained. Some parents live far away from the schools and parental, or guardian, involvement in school matters is limited. Attention and corrective action should be taken to address issues pertaining to the quality and amount of support afforded to under-resourced schools, or schools that can be considered as impoverished, compared to more affluent schools. Although schools may sometimes request financial contribution from parents for specific purposes, for some schools, this is too modest to impact on the school's financial viability.

3.3.4.4 Financial management and the SGB's financial tasks

A key challenge is the lack of necessary financial knowledge and skills among SGB members (Modisaotsile, 2012). Funding and operating a school involves large amounts of money. Responsibility and accountability for these monies, and any additional funds that emanate from school fees and fund-raising activities, lies with the SGB and this includes drafting the school's annual budget. Financial planning and financial management competencies are therefore important for SGBs. It is important that members of the SGB Finance Committee, especially those who are designated as treasurers, should be adequately trained and capable of performing their roles. The SGB Finance Committee's role in managing the school finances is important (Mestry, 2016). Financial responsibilities of the SGB include preparing and monitoring budgets as well as developing and implementing the school's financial policy. It is therefore necessary that the SGB ensures that the procurement of goods and services is conducted appropriately, using proper quotations and tendering procedures, and that expenditure is controlled. SGBs should be assisted in providing sound financial management, drawing up annual budgets, and fund-raising skills. SGB members' financial knowledge should be enhanced, and expert financial support provided where necessary.

It is evident from the discussions on social inequality, as presented in Section 3.3.4, that the school quantile system and challenges regarding infrastructure and financial management, are complex. Parental involvement, and the communities' contribution in supporting the school, can influence the way in which the school is managed. All these factors are important to the development of the SFMTIS.

3.3.5 Policy and effect on sustainability

Policies have been developed in order to increase access to ICT infrastructure in resource-constrained environments, as discussed in Section 3.3.5.1. Policies aimed at enhancing teacher professional development and defining roles, responsibilities and functions of education district and circuit offices in managing ICTs in schools are discussed in Section 3.3.5.2. The degree of awareness, and the extent to which the policies are implemented at the relevant levels of education governance, affects their effectiveness.

3.3.5.1 Policies and access

Legislative and regulatory provisions have been put in place in South Africa to ensure universal access. These include, for example, the special *e-Rate* which affords a discount of at least 50% on Internet services provided to schools and other public institutions such as public health facilities and colleges (DoC, 2016: 34). However, in spite of these initiatives, access gaps still exist. Internet access in many rural areas, and smaller urban centres in Africa, is only obtainable via satellite systems or cellular networks. While *cellular networks* require minimal installation costs, *satellite systems* often require expensive installation and high monthly fees (Olson et al., 2011). Data transfer speeds are often slow, insufficient for sharing large amounts of data and relatively expensive. Consequently, most rural areas have very limited access to the Internet. Providing Internet to rural schools can be a continuing, expensive commitment, and conducting video conferencing is often costly (Olson et al., 2011).

3.3.5.2 Existing digital divide, digital literacy levels and ICT access gaps

ICT access gaps can exist, as outlined in the DoC (2016), in terms of:

- **Availability** of networks and coverage;
- **Affordability** including the ability to pay for access to infrastructure, networks, devices and services;
- **Accessibility** and the ability of people to use and access services, regardless of education and other characteristics;
- **Awareness** by users and potential users of what is available and the benefits thereof;
- **Ability** of different groups of people, and individuals, to not only access services and acquire information and data but to also use the information and data to enhance the quality of their lives (i.e. digital literacy); and the
- **Quality** of services provided should be good and be of acceptable standards.

Lack of digital literacy and awareness can become a barrier to the uptake and usage of broadband in communities. In order to increase the impact of digital literacy interventions and to increase their sustainability and accountability, the interventions should be targeted at the communities and channeled via community institutions such as libraries and schools (DoC, 2016). Access, uptake and usage of digital resources makes them useful. Addressing the digital divide requires digital literacy, awareness and the ability to effectively exploit the evolving technology (DoC, 2016), as already indicated in Section 3.2.2.

3.3.5.3 Policy - effective implementation and awareness

In South Africa, district and provincial e-learning officials are inadequately equipped for their roles in implementing the national e-Education policy, and district's inadequate capacity negatively impacts on their ability to implement policy and offer support to schools (Vandeyar, 2015). Policy makers need to structure teacher training programmes in formats which address the lack of positive ICT integration that teachers can exhibit, even when resources are provided, to positively influence teacher pedagogical and self-efficacy beliefs regarding technology integration to support teaching (Van Der Ross & Tsibolane, 2017).

When assessing the success or failure of technology integration at institutional level, Bates and Sangra (2011) pose the following questions in relation to policy:

1. Has the institution clearly identified and stated the strategic rationale for use of technology within the institution? and
2. Has the institution allocated additional financial resources, or reallocated resources, to support integration of technology?

"All systems including schools need policies"
(Bayat et al., 2014: 126)

In context, policy refers to formal laws, regulations, rules and guidelines that affect public schools. It is not only the existence of, but also effective implementation and awareness of relevant policies by teachers, school managers, parents, district officials and policy makers that makes a difference. The existence of excellent policies, without effective implemented through appropriate strategies, or knowledge thereof by those who should benefit, has minimal effect. Schools are implicitly informed as to the content of policies but without adequate induction into *how* policy should be implemented into teaching and learning (Vandeyar, 2015). District and provincial leaders responsible for e-learning need to understand their role in e-Education policy, as policy intermediaries, and not policy conduits merely disseminating policy to schools (Vandeyar, 2015).

An example is the *e-Rate*, a special discount of at least 50% that South Africa's Internet service providers allow for public schools' Internet services, including call charges, facilities and connectivity (DoC, 2016: 34). The e-rate is prescribed through e-rate legislated regulations by the Independent Communications Authority of South Africa (ICASA) for the purpose of promoting and ensuring universal service and access to basic communications services to all South Africans (DoC, 2016). Promoting schools' awareness and ability for uptake of the e-rate could enable them to utilise the services.

Education policies that are important include:

- School ICT policy;
- The South African Schools Act (SASA) (1996);
- DoE Roles, responsibilities and functions of education district and circuit offices (DoE Roles and responsibilities, 2013);
- Eastern Cape Department of Education 2015/16 – 2019/20 five-year strategic plan (ECDoE, 2015);
- The Eastern Cape Department of Education's (ECDoE) 2016/2017 Head Office Operational plan (ECDoE, 2016);
- District Operational plan;
- The Integrated strategic planning framework for teacher education and development in South Africa for 2011-2025 (DoE, 2011);
- The White paper on e-Education - Transforming Learning and Teaching through Information and Communication Technologies (DoE, 2004); and
- National Integrated ICT Policy White paper (DoC, 2016).

These policies will now be discussed.

The School ICT policy should be developed and *owned* by all stakeholders within the school community. When successfully articulated and implemented, the school ICT policy provides guidance and consistent approach to issues, some of which could otherwise be contentious. In schools, the ICT committee is instrumental in developing the ICT policy, in corporation with the School Management Team (SMT). These structures, together with other school structures such as the School Governing Body (SGB), have a role in safekeeping ICT infrastructure such as servers and tablets, and ensuring their effective utilisation. The ICT policy may also include matters pertaining to lost or damaged mobile devices (Blackwell et al., 2014). The ICT committee should be familiar with, and accountable for, implementing asset management policies relating to maintenance and record keeping of the schools' assets such as tablets and servers.

The White paper on e-Education: Transforming Learning and Teaching through ICTs (DoE, 2004), is a strategic document which presents the pedagogical and developmental framework regarding e-education implementation in South Africa. The Integrated strategic planning framework for teacher education and development in South Africa 2011- 2025 forms part of an ongoing planning process for teacher education and development. The objective of the policy is to improve the quality of teacher education and development and, subsequently, to improve the quality of teaching at schools. The National Policy Framework for Teacher Education and development in South Africa (DoE, 2007: i) stresses the need for *"more teachers, better teachers"*. The policy provides an overall strategy for the successful recruitment, retention and professional development of teachers in order to enable teachers to continually enhance their professional competence and performance.

The South African Schools Act (SASA) (1996) outlines the system for the organisation and governance of schools (Act, 1996), while the national framework for organisation and staffing of education district offices outlines the roles and responsibilities of district offices (DoE, 2013). The policy is aimed at qualitative changes to the operations of provincial education departments, districts and circuits, and outlines the organisation, roles and responsibilities of education districts for "effective districts and better quality" (DoE, 2013: 4). The Eastern Cape Department of Education 2015/16 – 2019/20 five-year strategic plan (ECDoE, 2015) and the Eastern Cape Department of Education's (ECDoE, 2016) operational plan's purpose is to build a functional, quality schooling system and enhance accountability. The operational plan informs district operational plans.

The South African government's objective is to achieve roll out of e-learning infrastructure, including connectivity, to each school in the country (DoC, 2014). While DBE, through Operation Phakisa ICT in Education, seeks to deploy ICT programmes that will develop and modernise the skills of teachers and learners (More, 2015), the Eastern Cape Department of Education (ECDoE) also has a key priority of accelerating the deployment of ICT by providing infrastructure, financial and human resources to schools (ECDoE, 2016).

The National Development Plan (NDP) is emphatic in its position regarding more extensive use of technology (National Planning Commission, 2012). The NDP identified quality education and skills development as core elements to ensuring that all South Africans attain a decent standard of living through the elimination of poverty and the reduction of inequality. Other relevant national policies include the National Development

Plan (NDP) 2030, the National Information Society and Development (ISAD) Plan (DBE, 2007), and the National Integrated ICT Policy White paper (DoC, 2016).

The DBE is the main agent responsible for policy planning, monitoring and funding of teacher education. Planning and adequate allocation of resources should support strategies. Some of DBE's statutory responsibilities include: ensuring that there are sufficient well-prepared teachers who can provide quality education and to improve coordination and coherence among the many bodies and institutions involved in teacher education.

ICTs can be effective as tools for social and economic development if they are used efficiently, sustainably and cost-effectively (DoE, 2004). The National integrated ICT policy White paper outlines the country's interventions for building an inclusive knowledge economy in which users, across the country, can have access to the same types of networks with similar quality and speeds to enable them to participate equally in a digital society. It details universal service and access strategies to increase the geographical reach of ICT networks, facilities, connectivity and reduce costs (DoC, 2016). Resources and leadership are required to implement appropriate strategies to fulfil policy. This has significant implications for the development of the SFMTIS framework.

The discussion presented in Section 3.3.5 is important as it indicates the existence of policies, and the existing structures in the education system which affect these policies. In developing the SFMTIS, monitoring of strategies for action these policies, and how information is communicated in the education system, and within the school system need to be considered.

3.3.6 Accessibility and use of available digital resources

It is not only the existence, but also the awareness and effective use of digital resources that is critical. Increasing digital literacy, particularly that of potential users in rural and low-income communities, through digital literacy training and skills development components should be incorporated into projects (DoC, 2016). Digital resources are available to teachers, learners, principals and SGB members in the Department of Basic Education's ICT systems and websites. However, as discussed in Section 3.3.5.1, available digital resources should also be accessible. Teachers may experience challenges in providing feedback regarding their experiences in using educational applications. This important feedback can however, if appropriately collected and managed, be used to improve the design of educational applications (Kruger, 2015).

The four systems and departmental websites that are discussed in this section are important digital resources and provide examples of systems that are available to teachers, but whose accessibility and usage by teachers needs to be closely monitored in order to devise strategies to maximise their usage. These include:

- ✓ *National Department of Basic Education and provincial websites (Section 3.3.6.1);*
- ✓ *Education management information system (EMIS) (Section 3.3.6.2);*
- ✓ *South African school administration and management system (Section 3.3.6.3);*
- ✓ *Thutong South African educational portal (Section 3.3.6.4), and the*
- ✓ *South African Council for Teachers' (SACE) continuous professional teacher development management system (Section 3.3.6.5).*

Each of these will now be discussed:

3.3.6.1 National Department of Basic Education and provincial websites

Examples of the DBE's systems and website are: National DBE website (www.education.gov.za) (Figure 3.9) and the Eastern Cape Department of Education's website. These websites are communication tools as well as significant sources of digital resources that can be accessed by teachers, learners, school managers, school governing bodies and parents. Planning, management and monitoring tools, workbooks, guidelines, plans, reports and frameworks are all available on these websites. Basic computer literacy training programmes and training regarding school ICT policies are also provided by the national DBE through online courses via its website. Access and use are therefore important, and users should be identified and monitored with the aim of creating more awareness and stimulating maximum usage.

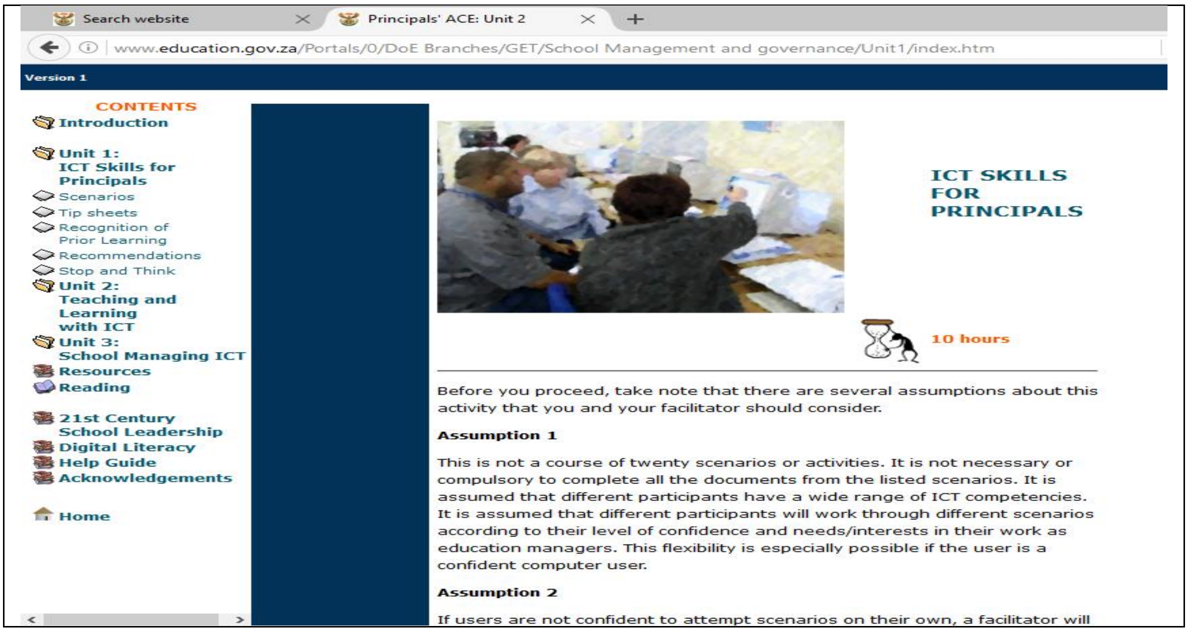


Figure 3.9: National DBE website (Basic computer literacy for school management)
(Source: DBE National, 2016)

3.3.6.2 Education Management Information System

The Education Management Information System (EMIS) is used for the collection, capturing and warehousing of education data from various education sectors, including schools, in each province (DBE EMIS, 2016).

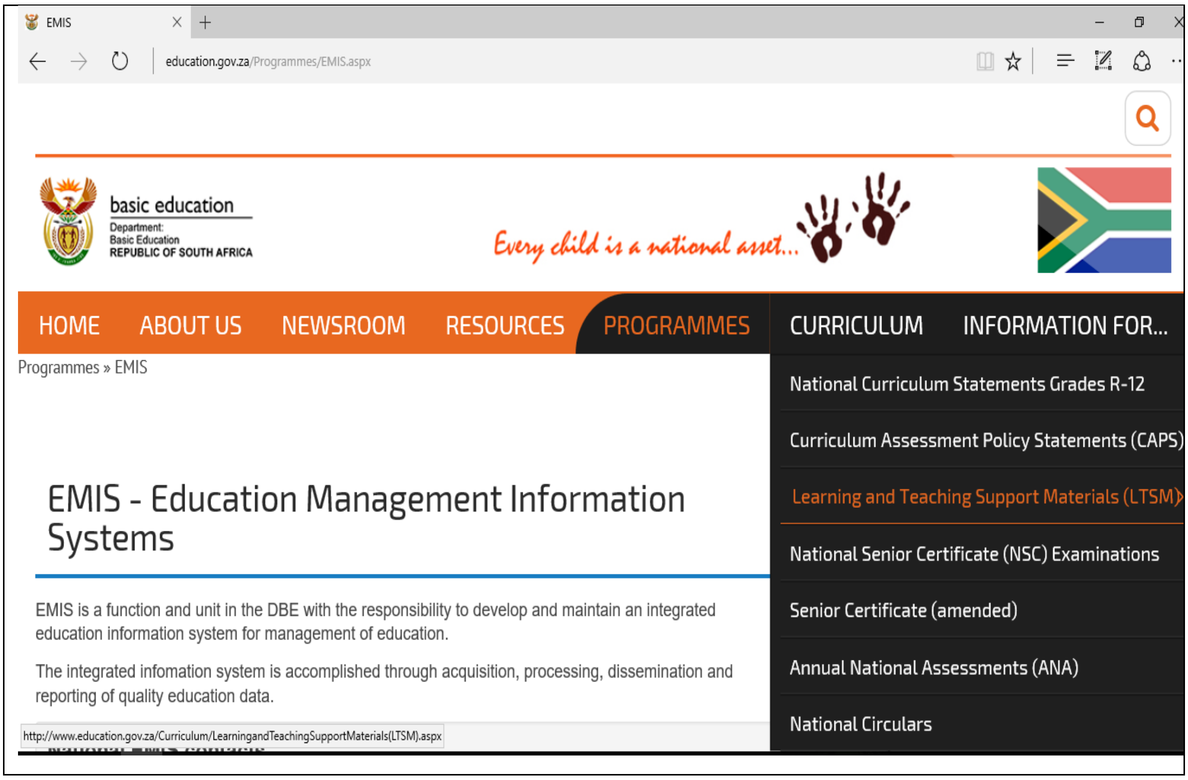


Figure 3.10: Education management information system (EMIS)
(Source: DBE EMIS, 2016)

Figure 3.10 shows the EMIS website and examples of resources that are available on the system including learning and teaching support materials (LTSM) and the curriculum assessment policy statements (CAPS). There is also an on-going process of moving EMIS from paper based surveys to electronic data collection methods via institution-based administration systems. Examples of data collected are learner gender, age, grade and population group (DBE EMIS, 2016).

3.3.6.3 South African school administration and management system (SA-SAMS)

The South African school administration and management system (SA-SAMS) is a computer application specifically designed to assist in the management, administration and governance functions of public schools (Figure 3.11).

SA-SAMS provides schools with a cost effective, easy to use, fully integrated computer solution which contains a financial element for the control of schools’ finances, an element for timetables and class lists, thus supporting school management requirements.

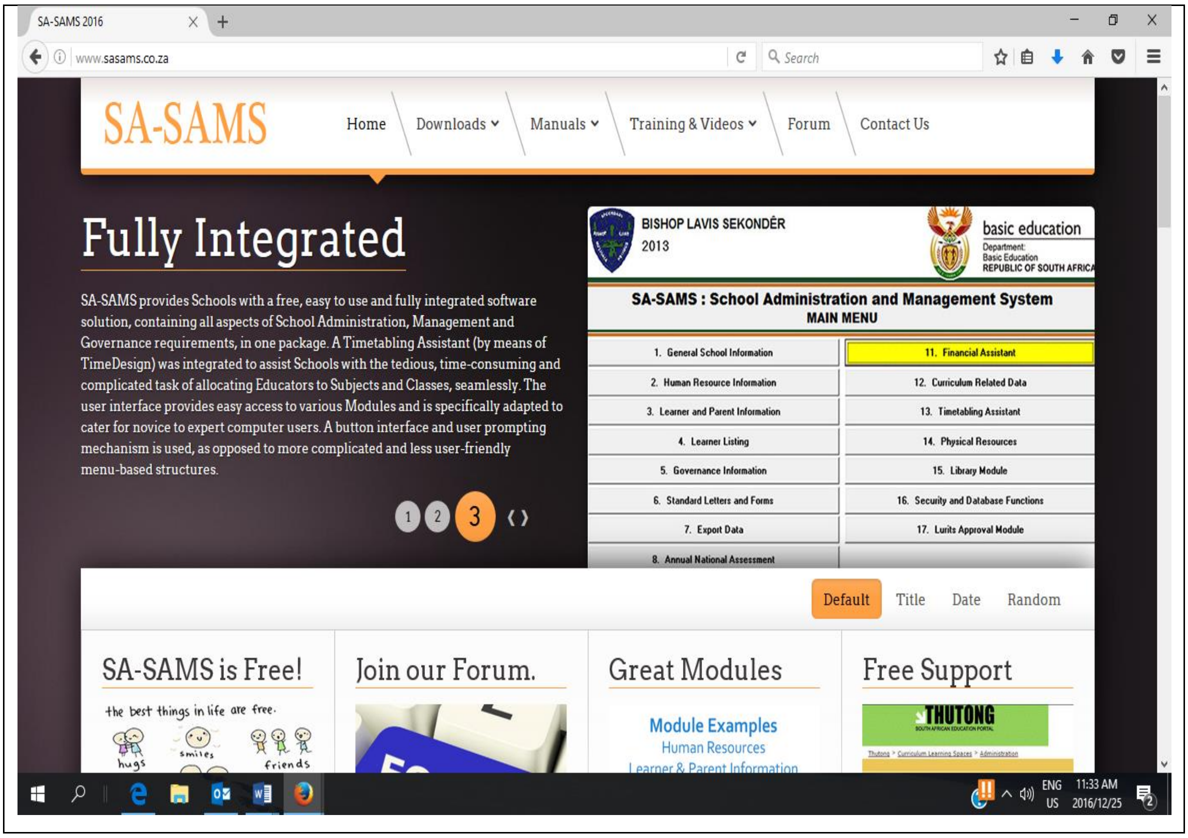


Figure 3.11: South African school administration and management system (SA-SAMS)
(Source: DBE SA-SAMS, 2016)

It also incorporates a module which can assist schools with the task of allocating teachers to subjects, and to classes.

3.3.6.4 *Thutong - South African education portal*

Thutong (a place of learning) is the Department of Basic Education’s online education portal which offers a range of curriculum and learner-support material, professional development programmes for educators and administration and management resources for schools. Figure 3.12 shows the Thutong website and indicates the digital resources, including past Grade 12 examination papers, and professional development digital resources as well as guides available to teachers and learners.

Figure 3.12: DBE Thutong South African education portal
(Source: DBE Thutong, 2016)

These information systems (DBE websites, Education Management Information System [EMIS], South African school administration and management system [SA-SAMS] and Thutong - the South African education portal) highlight the extent to which investments have been made within the education system in developing them. These ICT systems are available to teachers. It is important that information regarding the information these systems should be communicated to the teachers. The usage of these resources can also be monitored in order to identify how to best maximise their utilisation. The SACE continuous professional teacher development management system is one of these ICT systems available to teachers.

3.3.6.5 Usage of the South African Council for Teachers' continuous professional teacher development management system

Teachers in South Africa are required to register with the South African Council for Teachers (SACE) - a statutory, regulatory body for professional teachers - as a condition for them to practice teaching. Registering with SACE for teachers is like obtaining a "license to teach", and together with this, teachers agree to a "Code of Professional Ethics" that includes acceptance of a responsibility to keep abreast of professional trends and developments. SACE is responsible for the implementation and management of Continuous Professional Teacher Development (CPTD) and holds overall responsibility for the implementation, management and quality assurance of the CPTD. Teachers are allocated specific units (hours) of professional development time for CPTD and teachers' participation in professional development activities is rewarded through the professional development (PD) points system (DoE, 2011).

Schools, districts, provincial and national departments may provide and pay for programmes where teachers can earn PD points, through the professional development points system. The PD points method is an internationally recognised technique used in various fields by professional bodies. In the South African teaching profession, PD points are earned by teachers when they undertake professional development activities endorsed by SACE. Each teacher is expected to earn a target number of PD points within each three year successive cycle. PD points are allocated to activities that teachers can undertake and may be school-led, employer-led and/or qualification programmes. Some programmes are offered by NGOs, teachers' unions, the community, faith-based organisations and other approved providers. Additionally, there are activities which may be self-selected by the teacher, but considered compulsory CPTD activities, for example activities related to IQMS processes. Successful upgrade of qualifications by teachers also earns them PD points (DoE, 2011). Section 3.2.5 discussed the importance of teacher professional development in developing digital literacy skills and competencies.

There are risks related to the PD points system. For example, teachers may neglect their main responsibilities in an effort to earn PD points, they may become overburdened with the administrative work of recording and reporting on PD points earned or they may have providers that offer poor quality PD activities. These risks can be alleviated by directly relating PD activities to teachers' classroom activities and the number of PD points that can be earned per year, can be capped (DoE, 2011). The responsibility of performing the administrative tasks of recording and reporting PD points earned by individual teachers can be assigned to providers of the CPTD activities. The CPTD management information and communication system should facilitate the quick and accurate capturing, recording, retrieval and monitoring of all teachers' PD points (DoE, 2011). The challenge is ensuring effective usage of the SACE CPTD Management and PD points system.

3.3.7 Leadership in the education system

School districts face differing challenges, and in areas where educational support needs are high, for example in districts with many under-performing or remote schools, schools and districts face particular challenges that require leadership at different levels of the education system.

3.3.7.1 Leadership – micro (school) level

The common feature of well-run schools is leadership (DBE National, 2016). Leadership at school (micro) level is provided by the school principal, school management team and school governing body. Principals should have power over school management, however, they should also be held accountable for the performance in their schools, including fulfilment of ICT programmes. Strong leadership provided by principals who insist on teachers' punctuality, accountability for teaching responsibilities, and who provide a conducive disciplined teaching and learning environment, even in poorly resourced schools, achieve good results (Modisaotsile, 2012). The school principal is an important link between the school, the school management team (SMT) and the school governing body (SGB). The school principal is coopted as a member of the SGB.

The School Governing Body (SGB) should primarily consist of parents. Teachers, learners, non-teaching staff and other community members may also be elected as SGB members. Other community members and learners (Grade 8 - 12 learners) may also be coopted to the SGB. School governing bodies (SGBs) are mandated by SASA to manage school administration and finances, and to provide school leadership (SASA, 1996). SGBs serve to build a rapport between educational authorities and parent communities and to enhance teaching and learning environments. SGBs are expected to participate in the formulation of school policies and to develop, and effectively implement, schools' financial policies. This includes drawing up the school's annual budget, managing the school's finances, property and assets (SASA, 1996; Bayat et al., 2014). SGBs are required to hold regular meetings to discuss financial matters and should commit to the responsibility for financial management, also holding the SGB Finance committee accountable.

School governing bodies (SGBs) require broad-based parent support. The SGB is required to schedule regular meetings with parents and the community in order to interact with and inform them about the state of the school, achievements, challenges and financial status. Parents and the community are informed of any fund-raising events and should be mobilised to participate in fund-raising events. Emphasis needs to be placed on the sound principles of school governance and management, and on efficient, effective SGBs and SMTs (Bayat et al., 2014). Committed leadership, in which decisions and procedures are clear and transparent, should be provided. School leaders should ensure that leadership in schools, as it relates to decision-making processes, policy determination, problem-solving processes and general governance of the school, is participatory and transformational in nature (Modisaotsile, 2012).

3.3.7.2 Leadership – meso (circuit, district) level

Districts are tasked with providing support to schools and are often responsible for dealing directly with schools in administrative and managerial matters, whilst keeping schools informed of provincial education priorities (DoE, 2013). The roles of education district offices include: planning, support, oversight and accountability, and public engagement in relation to the education institutions for which they are responsible. Districts are tasked with providing support to and collaborating with principals and teachers to improve the quality of teaching through school visits, classroom observation and cluster meetings. The policy on roles and responsibilities states that district offices should: "*Facilitate ICT connectivity in all institutions within their district"* (DoE, 2013: 13).

Districts are accountable to the Provincial Education Department and provide a vital communication link between schools and the Provincial office which, in turn, reports to the National department. While resources are essential, planning, communication, coordination, and accountability are required in order to achieve this objective. Districts are tasked with planning which involves collecting data at school, circuit, and district levels, helping schools develop their improvement plans and integrating them into district plans. The districts support schools through visits, classroom observations, consultations, cluster meetings, feedback reports and related activities. Districts provide an enabling teaching and learning environment in line with the education policy (DoE, 2013). The oversight and accountability role means that districts are assigned with holding principals accountable for the performance of their schools. Districts account to the provincial department according to stipulated roles and responsibilities of district officials. Districts' role also includes consulting and engaging with the public in an open and transparent manner. Districts are tasked with facilitating ICT connectivity and organising professional development for teachers, administrators and managers. Education districts are, however, not empowered to raise their own revenue (DoE, 2013). Timeous support and guidance to schools from district and provincial education departments is required. The DBE has an eminent role to play in providing financial expertise support to SGBs as well as workshops and training.

3.3.7.3 Leadership – macro (provincial) level

Leadership at provincial level can be provided by the “Provincial ICT Forum” in the Eastern Cape Department of Education (ECDoE), one of the significant organisational structures that play a coordinating role in implementing technology and teacher learning in the province. The Provincial ICT Forum is well positioned to coordinate and optimise ICT initiative activities, however, it has to be appropriately structured and should function optimally for the effective execution of its crucial mandate (Meyer & Marais, 2014).

3.3.8 Relationships and communication between regional education departments, principal, SGBs, SMTs and parents

The relationship between some SGBs and the regional education departments are described by SGB members as weak and non-existent in quality, often due to lack of contact and interaction between them, or long intervals between visits (Bayat et al., 2014). The relationship between the principal, SMT and SGB is vital. An unhealthy, non-communicative culture and poor link between school staff, principal and SGB can cause challenges in the leadership of the school. The SGB’s relationship with relevant stakeholders (parents, principal, School Management Team, teachers and the district and provincial departments of education) is very important. The SGB needs to demonstrate teamwork and collaborate with relevant stakeholders. The communication culture, interaction and cooperation between the SGB and the SMT should be sound and productive in order to strengthen the leadership and management function of the school. SGBs require SMT and teacher support. Principals need to provide support to SGBs, just as SGBs need to provide support to principals.

The preceding two sections, Sections 3.2 and 3.3, discussed teaching and learning in the digital age, and the ICT related challenges in the basic education system in South Africa respectively. The following section presents a summary of these discussions and the emanating sustainability elements essential to the development of the SFMTIS.

3.4 SUMMARY

There has been significant progress in the rollout of ICT in support of teaching and learning in South Africa resulting from government and private sector initiatives, however, integration of technology into teaching in resource-constrained environments remains a challenge. Challenges in the education system include the need for leadership at various levels of the basic education system. Leadership is required at different levels of the education system: micro (school), meso (circuit and district) and macro (provincial and national) levels. Strong leadership, provided by school principals, can produce positive results, even in schools in resource-constrained environments. School governing bodies have a critical role to play in developing and monitoring the implementation of school policies for good governance.

Existing policies such as the White paper on e-Education, SASA, the National Integrated ICT Policy White paper, and the DoE's policy on the roles, responsibilities and functions of education district and circuit offices, provide important guidelines in the use of ICTs in schools. The effectiveness of policies lies in their implementation and the resulting outcomes. Access and awareness of policies, such as the special e-rate for Internet access allowed for public schools, can encourage use by schools. Inadequate communication and weak working relationships among regional education departments, SGBs, principals, school management teams and parents, have been reported as challenges. Investments in the ICT systems that have been developed by the national DBE and provinces should be accompanied by effective usage, differentiating between availability and access and *actual use* by teachers, learners, principals, SGBs and SMTs. Efficient use of systems such as EMIS, SA-SAMS and the SACE continuous professional development (CPTD) management systems can enhance communication and management in the education system. Efficient utilisation of the SACE Continuous Professional Teacher Development Management System and PD points can contribute to the management of teacher professional development.

Available digital resources need to be monitored in order to determine their accessibility and degree of usage. The digital divide, digital literacy levels and ICT access gaps between different regions and schools are a reality. This is compounded by the social inequality in South Africa. The quantile school classification system demonstrates the differences in the financial capabilities between schools. SGBs in schools in resource-constrained schools face financial management challenges in managing their school funds.

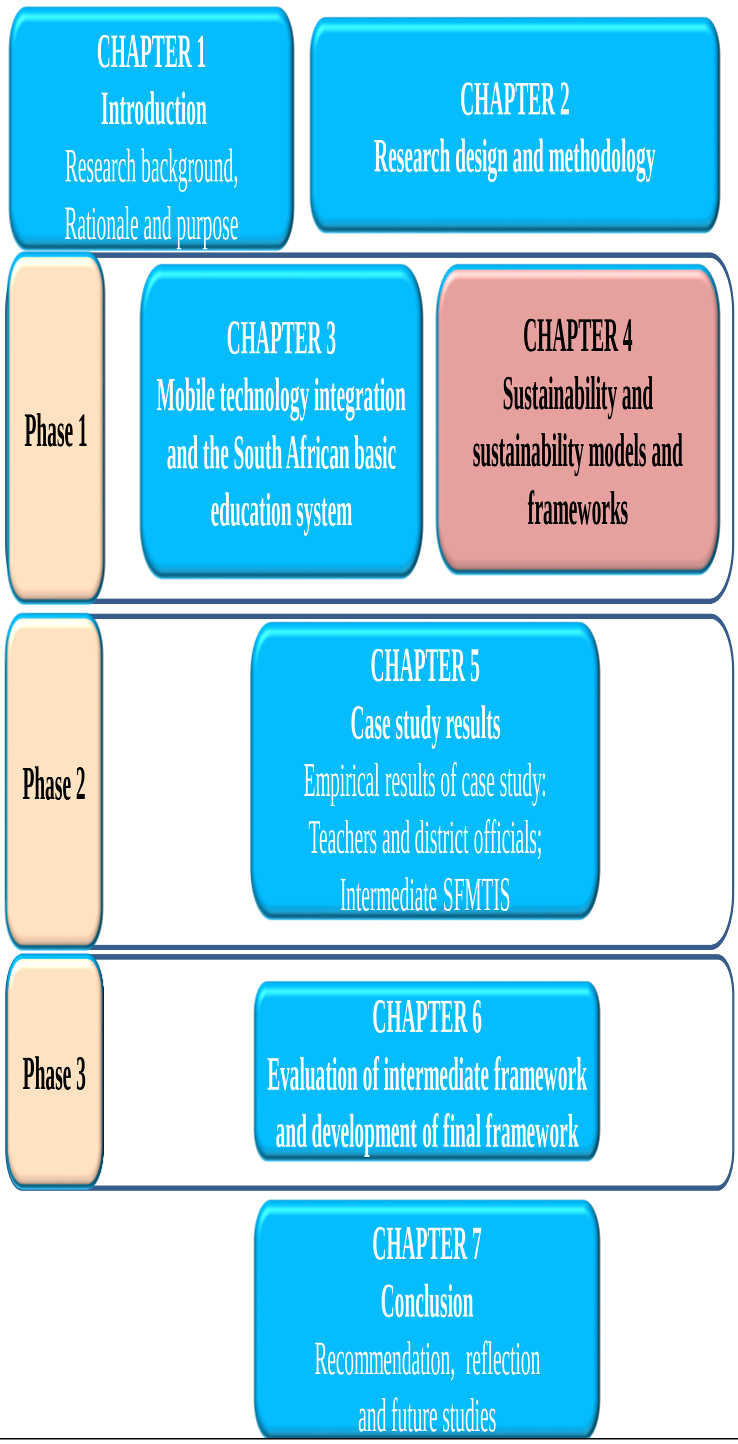
The unavailability of learning and teaching materials (textbooks) in public schools, the need to provide and maintain school physical infrastructure as well as the large number of learners that need to be supported by the public education system are challenges that persist in the South African education system. ICT-related challenges in the basic education system in South Africa, such as ICT gaps, need to be addressed in terms of availability, access, awareness and quality. Table 3.4 presents a summary of the sustainability dimensions essential to the development of the SFMTIS, whilst considering prevailing challenges in the education system in relation to ICT integration, and teaching and learning in the digital age.

Table 3.4: Sustainability dimensions essential for the development of the SFMTIS emanating from literature

Sustainability dimension	Description	Aspects to consider
Monitoring and evaluation (Section 3.3.7)	Ongoing monitoring of progress and evaluation.	Roles and responsibilities should be well defined and communicated at strategic, tactical and operational levels (or macro/meso and micro levels) – Who monitors what and why? What are teachers accountable for? (What are teachers expected to use tablets for?) What are subject education specialists responsible for? Role of SGBs, the district. Reporting procedures and accountability (policies).
	Credibility of evidence: effective gathering and communication of the evidence and benefits of implementing the ICTs.	Data collection processes by schools, district. Who uses the tablets and what for? How many tablets are there, working/ broken? Teachers' feedback regarding tablet use? What are the strategic objectives? What measures are used to evaluate success?
Training (Sections 3.2.1 and 3.2.5)	Training and capacity building: staff involvement in sustaining the process; determining how to recognise characteristics displayed by staff who feel lack of involvement.	Ensure effective use of SACE continuous professional development (CPTD) system that uses the professional point (PD) system to earn a target number of PD points within each 3-year successive cycle. Effective use of Teacher development centres.
Leadership (Section 3.3.7)	Provide management and professional support in planning and providing oversight and accountability.	Align school ICT Champion, District ICT4RED/ E-learning coordinator, communication and coordination. Develop and communicate sustainability plan.
Institutionalisation (Section 3.2.1)	Here it refers to "value infusion" and "behavioural routinisation" as advanced by Levitsky (1998).	Sustainability plan and Change management should focus on identifying structures and processes that will institutionalise mobile technology integration.
Identify benefits (Section 3.2.1)	Identify benefits; simple and clear project objectives.	At all levels benefits and reasons for mobile technology integration should be understood.
Policy (Section 3.3.5)	Awareness of specific ICT policy influencing the project, developing appropriate policies.	Communicate relevant policies e-rate; asset management; "section 21 schools" and implications.
Communication (Sections 3.2.3 and 3.3.7)	Understand existing information channels and communication patterns between communities and relevant organisations.	Identify existing communication channels and strengths and weakness. How do teachers report faults and related issues?
Information and knowledge management (3.3.6)	Knowledge management (KM) is important for sustainability; the ability to identify which information will be gathered, how it will be acquired, stored, retrieved and disseminated.	The number of tablets at each school, how many tablets require repair? How many schools use Internet and how will such data be collected, by whom, and what will this information be used for?
Building on existing public facilities (Section 3.3.6)	Available existing public resources (infrastructure such as buildings, personnel such as technicians) that can be appropriately utilised should be identified and maximised.	Existing facilities such as Vodacom centres should be used. Motivate/incentivise teachers to use for self-development. Provide facilitators and encourage learners to identify and use existing facilities in the community.
Holistic approach (Section 3.3.4)	The broader needs of the community should be considered in line with the project and capabilities.	Identify other projects that support the initiative and how these can be leveraged.
Monitoring (Sections 3.3.4.4 and 3.3.5.2)	The actions required to map institutional processes to assess what is going well and what is not. Adaptability of the process and its effectiveness should be assessed.	Identify means (structures) by which monitoring and evaluation occurs, assess effectiveness and eliminate inefficiencies e.g. in reporting processes. When teachers require technical support – what processes are followed? What are turnaround times?
Partnerships (Sections 3.3.6.5 and 3.3.6.4)	Forming partnerships to increase capacity and improve economic sustainability; key attributes necessary for successful ICT4D partnerships, namely trust, clear focus, champions, focus on sustainability, investment of time in networking activities and transparency and sound ethics.	Long-term private and public-sector partnerships for infrastructure, digital content, teacher professional training.

In the next chapter the concept of sustainability will be defined. It is important to achieve a shared vision of what *sustainability* is in developing the SFMTIS framework. Sustainability models and frameworks relevant to the research will be investigated and discussed towards the development of the framework.

Chapter 4: Sustainability and sustainability models and frameworks



Chapter 4: Sustainability and sustainability models and frameworks

How can we hope to achieve a shared vision when we are uncertain what vision we are sharing? (White, 2013: 213)

4.1 INTRODUCTION

The concept of sustainability as it pertains to development is complex, subjective, and even normative, particularly in relation to inter and intra generational aspects (Sala, Farioli & Zamagni, 2013). Sustainability and sustainable development remain difficult to operationalise, despite being widely debated and defined (Fullan, 2004, Meyer, Marais, Ford & Dlamini, 2017; Meyer & Marais, 2014, Nawi et al., 2013; Ng & Nicholas, 2013). Sustainability means different things to different people, and holistic, system-wide approaches are required to achieve sustainability goals (Sala et al., 2013). Difficulties in defining sustainability can result in operational difficulties when communicating and implementing sustainability practices. As White so aptly queries (2013: 213): "How can we hope to achieve a shared vision when we are uncertain what vision we are sharing?" This chapter is a continuation of Phase 1, the literature review as indicated in Figure 4.1.

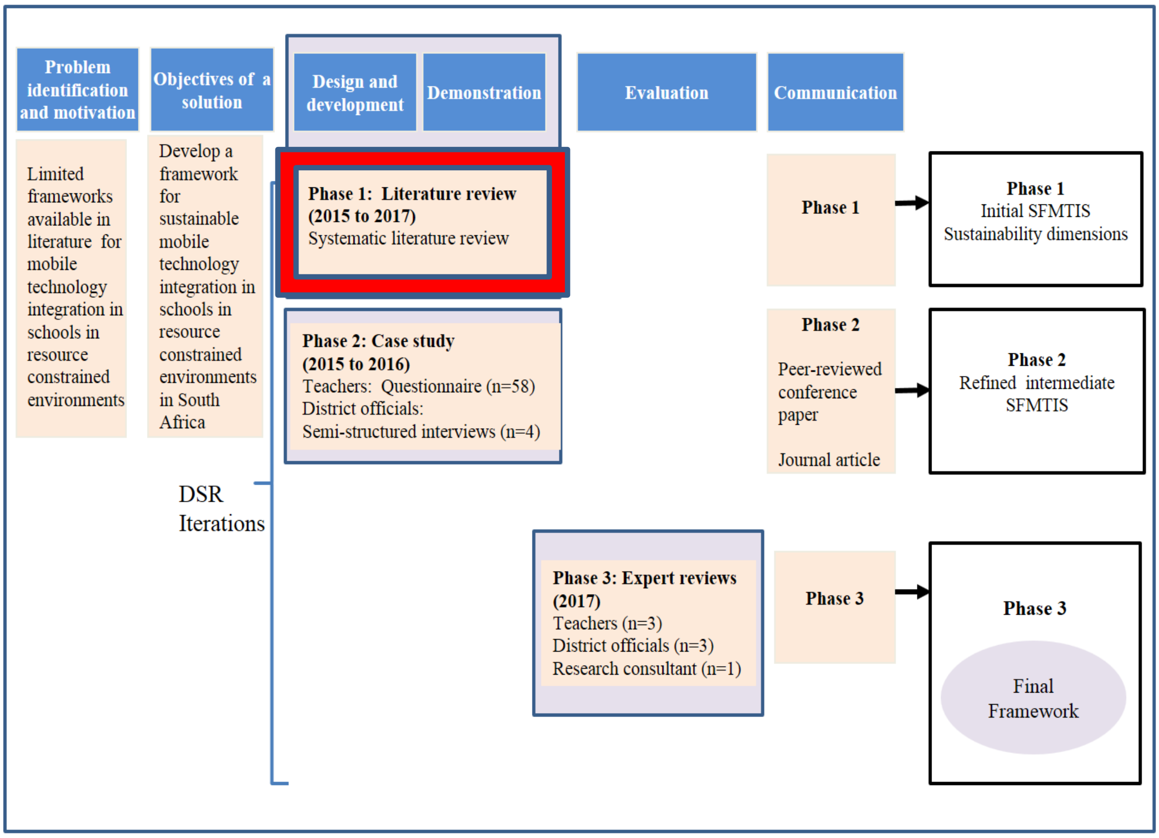


Figure 4.4.1: Application of DSRM process - Phase 1: Literature review

In this chapter the concept of sustainability is defined in Section 4.2 and further deliberated in Sections 4.3 and 4.4 as it relates to systems and development, respectively. Sustainability models and frameworks are discussed in Section 4.5 with the subsequent development of the Initial SFMTIS which is presented at the end of the chapter.

4.2 DEFINING SUSTAINABILITY

The concept of *sustainability* is often mentioned in public and policy discourse, however, defining what sustainability means is challenging (Scoones, 2016). To be sustainable, any use of resources needs to take stock of the impact their utilisation has on the social, economic and political context of people today and in the future (WCED, 1987; Willard, 2012; UNESCO, 2016). Sustainable development is often defined as:

> *"Development which meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987: 41).

Sustainability of organisational innovations occurs when new ways of operating become the norm and the underlying systems and ways or working are transformed in support (Moore, Mascarenhas, Bain & Straus, 2017). There are different perspectives to considering sustainability, e.g. economic, institutional, social and environmental, and whether the term being considered is in relation to the short, medium, or long-term view (Meyer & Marais, 2015). Sustainable development can be considered as a dynamic process of adaptation, learning and action, rather than a destination (Sala et al., 2013). Sustainability is inextricably linked to basic questions of equity, fairness, social justice and greater access to a better quality of life (UNDP, 2011). Sustainability is "not" how to keep going in a linear sustained fashion (Fullan, 2016). Continuous improvement, adaptation and collective problem-solving in the face of complex challenges that keep arising are necessary for sustainability (Fullan, 2004). Other definitions of sustainability include:

> *"Sustainability does not simply mean whether something will last. It addresses how particular initiatives can be developed without compromising the development of others in the surrounding environment now and in the future"* (Hargreaves & Fink, 2000: 30),

> *"Sustainability is the capacity of a system to engage in the complexities of continuous improvement consistent with deep values of human purpose"* (Fullan, 2016: ix), and

> *"Sustainability is the ability to sustain the anticipated benefits of the project or*

programme, over an appropriate period of time, for pre-defined project participants" (Meyer, Marais, Ford et al., 2017: 464).

The definition of sustainability that is adopted in this study combines elements from these definitions:

- Development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987);
- Inextricably linked to basic questions of equity, fairness, social justice and greater access to a better quality of life (UNDP, 2011);
- Continuous improvement, adaptation and collective problem-solving in the face of complex challenges that keep arising (Fullan, 2004); and
- The capacity of a system to engage in the complexities of continuous improvement consistent with deep values of human purpose (Fullan, 2016).

For the purpose of this study sustainability is defined as:
The capacity of a system to engage in development that is directed at meeting the needs of the present without compromising the ability of future generations to meet their own needs, addressing basic questions of equity, fairness, social justice and greater access to a better quality of life, through continuous improvement, adaptation and collective problem-solving.

Apart from defining sustainability, it is important to establish that sustainability also functions within systems. This will be addressed in the following section.

4.3 SUSTAINABILITY AND SYSTEMS

White (2013), in line with Costanza and Patten (1995), states that establishing a shared contextual vision of sustainability requires that the following questions be addressed:

- What is the system and sub-systems that are involved?
- What are the characteristics of the system that should persist?
- How long should said characteristics persist? and
- When will they be assessed to determine whether the characteristics have persisted?

Costanza and Patten (1995) further state that the meta-system, that is the hierarchy of systems over a range of time and space and the desired characteristics which are the predictors of what must persist in the system, should be arrived at through a social consensus within the socio-economic sub-system. The longevity, or amount of time in which the evolving meta-system should be maintained, and the configurations or desired characteristic that should persist when the system is assessed, should also be stated. The uncertainties in socio-economic systems, however, necessitate a major focus on policies and instruments to deal with these uncertainties (Costanza & Patten, 1995).

Large sums of money are spent on projects for sustainability development. In addition, there are relationships between politics, sustainability and development, subsequently political processes affect institutional and governance processes (Scoones, 2016). Development projects often involve multiple role players who make decisions that influence their implementation and long-term sustainability (Meyer & Marais, 2014). Sustainability involves the politics of building alliances and collective action which often occurs in environments where there are multiple actors and diverse knowledge (Scoones, 2016). It is important that these decisions be aligned with and coordinated to the beneficiary systems and processes for sustainable implementation.

Costs are incurred in implementing ICTs, and financial flows, stakeholder interests inevitably raise power relations issues. Consequently, the potential uses of ICTs in local contexts raises questions of how external agencies such as the World bank and United Nations agencies, donor agencies, and other stakeholders should influence ICT interventions towards human development (Mansell, 2011). Mansell (2011) examined the major discourses in ICT and development, and contrasted the dominant model that considers ICTs to have transformative potential to accelerate economic and social progress. Mansell illustrates that there are dominant discourses aligned to exogenous models of perceptions regarding the ways that ICTs contribute to development goals, and argues for consideration of insights from endogenous models. "Exogenous" refers to something with an external cause or origin, and exogenous ICT interventions are mostly aligned to using new technologies such as internet, world-wide-web (www) and telephony to stimulate economic growth. The exogenous model focusses on institutional set-up and policy measures, and "technology gaps". "Endogenous" refers to an internal cause or origin, and is aligned to ICT interventions that focus on "information problems" and considering the local context that influence development processes, and are informed by practice-based approaches, capabilities and human development. However, the dominant exogenous model is not necessarily consistent with human development aspirations, hence the call for *"un* *paradigma atro"*, meaning "another way of thinking" about development to influence policy and practice through alternative models (Mansell, 2011).

Sustainability science is an emerging discipline that is solution-oriented, aimed at identifying problems affecting sustainability, adopting a comprehensive, integrated and participatory approach in order to transition towards a solution (Sala et al., 2013). Sustainability science uses lifecycle-based thinking, methodologies and assessment to provide a basis for a common approach and provides a systematic comprehension of contemporary phenomena within the economic, social, political, environmental and ecological domains. The use of lifecycle-thinking, facilitates the identification of sustainability features and assists in establishing how best to develop robust comprehensive sustainability perspectives to handle social and economic issues considering cultural, historic and institutional dimensions (Sala et al., 2013).

The Strategic sustainability decision-making approach (Robèrt et al., 2002) shown in Table 4.1, indicates the need to define the system, identify outcomes and success, articulate strategies for forward movement, determine actions and list available assessment tools. In each level the relevant questions should be addressed.

Table 4.1: Strategic sustainability decision-making approach
(Source: Adapted from Robèrt et al., 2002)

Level	**Focal scale**	**Questions answered**
Level 1	Define the System	How is the system itself constituted? What are the relevant principles for constitution of the system, including social (and ecological) principles?
Level 2	Identify outcomes and successes	How can sustainability be defined? What are the basic mechanisms by which the system can be destroyed? What are the principles for sustainability, that is, what is the successful outcome?
Level 3	Articulate strategies for forward movement	What are the basic principles and guidelines for sustainable development by which specific actions can be fostered in a strategic way to move purposefully towards success?
Level 4	Determine actions	What concrete actions should be undertaken in order to reach success?
Level 5	List available tools	What tools would help to: Manage and monitor our actions so that they comply with our plan. Build our capacity to carry out effective actions in support of the strategy, and Measure directly whether progress had the intended effect in the system?

The relevant processes, outcomes, monitoring systems and feedback mechanisms through which sustainability will be assessed, need to be determined. Planning for sustainability should include consideration of what new knowledge needs to be assessed and why it is important, how it fits with current priorities and identifying the conditions that need to be created for sustainability (RNAO, 2012). The benefits for stakeholders, including economic, social and organisational benefits, should be identified. The responsibilities for continuing implementation of the innovation should be assigned, and those who will be responsible for new modifications should be identified (RNAO, 2012).

School and educational systems are affected by their environments and by policies that are adopted at national and international level, as already indicated in Chapter 3 (Sections 3.2.6 and 3.3.5). South Africa's National Development Plan (NDP) advocates for an e-literate society in which there is greater use of technology to advance opportunities in a changing world for both teachers and learners (National Planning Commission, 2012). The NDP refers to the United Nation's millennium development goals and their political, economic and social relevance for governments. At a strategic policy level, policies such as the United Nation's sustainable development goals are therefore important.

4.4 SUSTAINABLE DEVELOPMENT GOALS

In the year 2015, the United Nations (UN) published the "Sustainable Development Goals" (UN, 2015). The fourth UN sustainable development goal (SDG 4) on education is to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." (UN, 2015: 1). The related target of this UN SDG 4 is to, "by 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes" (UN, 2015). The sustainable development goals build on previous resolutions, such as the Rio Declaration on Environment and Development (UN, 1992), and reaffirmed at the Rio + 20 United Nations Conference on Sustainable Development in 2012 (UN, 2012), which proclaimed that people are central to concerns of sustainable development and that they are entitled to a healthy, productive life.

Accordingly, today's development should not undermine present and future generations' development, and should reduce and eliminate non-sustainable patterns of production and consumption, and promote appropriate demographic policies (WCED, 1987). Sustainable development advocates for cooperation and promotion of an open international economic system that will lead to economic growth and development in all countries (UN, 1992; UN, 2012). Digital resources such as the United Nations' educational, scientific and cultural organisation (UNESCO's) portal for teachers and the ICT competency framework for teachers are available to teachers and policy makers (UNESCO, 2016). Sustainable development requires better scientific understanding of problems and a sharing of knowledge, and innovative technologies, to achieve the goal of sustainability

(WCED, 1987). The application of the DSR process (Section 2.4) to develop the artifact in this research draws from existing sustainability frameworks that provide extant knowledge.

4.5 SUSTAINABILITY MODELS AND FRAMEWORKS

Sustainability models are discussed in Section 4.5.1. The frameworks relevant for ICT4D implementation in resource-constrained environments are discussed in Section 4.5.2. Mobile learning models and frameworks are presented in Section 4.5.3.

4.5.1 Sustainability models in general

Theoretical frameworks that have been proposed by researchers to explain long-term sustainability of ICT4D projects include Heeks and Bhatnagar's Critical Success Factors (CSF) and Critical Failure factor (CFF) models (Heeks & Bhatnagar, 1999), Stakeholder theory (Bailur, 2006), and Sustainability Failure Model (Best & Kumar, 2008). Heeks and Bhatnagar's CSF and CFF models identified ten critical factors namely: information, technical, people, management, process, culture, structure, strategy, politics, and environment as principal dimensions in sustainability (Heeks & Bhatnagar, 1999). The Stakeholder theory posits the necessity of a well-balanced partnership between players, particularly between actors and the beneficiary (Bailur, 2006).

Kumar and Best's Sustainability Failure Model provides a concise analytical framework of the key factors that endanger the long-term sustainability of programmes, outlining five areas of weaknesses which, if adequately addressed by a project, make it likely to be sustainable (Best & Kumar, 2008). These five principle forms, by which the long-term survival of a project can be at risk, include financial/economic sustainability failure, cultural/social sustainability failure, technological sustainability failure, political/institutional sustainability failure and environmental sustainability failure (Best & Kumar, 2008).

Maher, Gustafson and Evans (2010) identified three main elements when developing a sustainability model for a national health system namely: organisation, people and process. In addition, they explained factors associated with the three elements. The factors associated with *organisation* are infrastructure and fit with goals and culture, while those associated with *people* include training involvement, behavior and senior leaders. Factors that need to be considered in relation to *process* were identified as monitoring progress, adaptability, credibility of evidence and benefits. An example of a sustainability model that can be used to illustrate elements of a sustainability model is the NHS

Sustainability model (Maher et al., 2010). The model is discussed in the following section.

4.5.2 Sustainability model from the health environment - the National Health System

Figure 4.2 shows a diagrammatic representation of the NHS Sustainability Model:

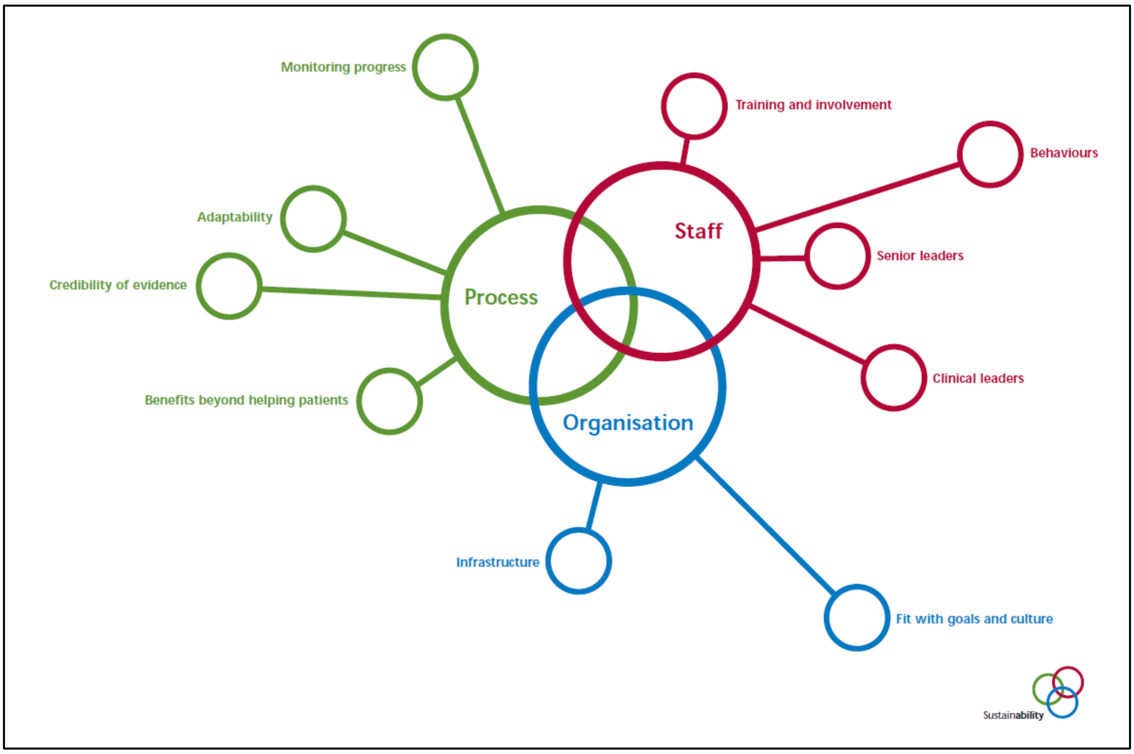


Figure 4.2: Elements of a sustainability model – The NHS Sustainability model
(Source: Maher et al., 2010)

The model was developed as a diagnostic tool to predict the likelihood of sustainability of health projects and to provide a guide for practical advice on how to increase the likelihood of sustainability. The main elements of the model are: Process, Staff and Organisation. Considerations to be made from the NHS Model, in relation to the education environment for each of the three elements, are summarised in Figure 4.3.

The elements of a sustainability model, as described in the NHS model, shown in Figure 4.3 include:

Process: This shows the actions required to map the process, assess what is going well and what is not. This entails an indication of credibility and adaptability of the process and its effectiveness in monitoring progress.

Staff: Staff training is required, and staff behaviour towards sustaining change, and the engagement of leaders, should be closely monitored and enabled.

Organisation: The infrastructure, and organisational strategic aims and culture should facilitate sustainability.

Examination of the NHS model indicates the necessity of considering communication mechanisms and developing a communication plan. Other aspects that should be taken into consideration include: engaging senior leaders, monitoring staff behaviour to sustain the process, providing training for staff and developing a cost-benefit analysis framework to consider the ongoing resource need for staff.

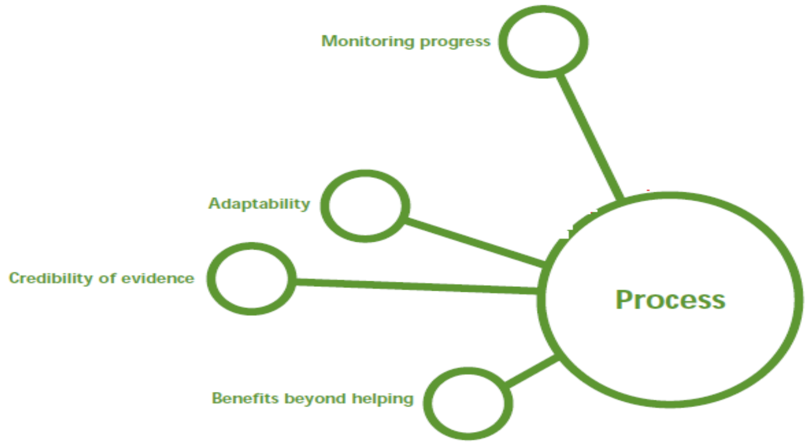
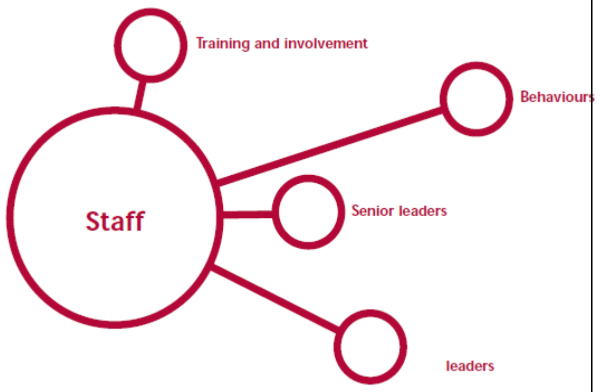
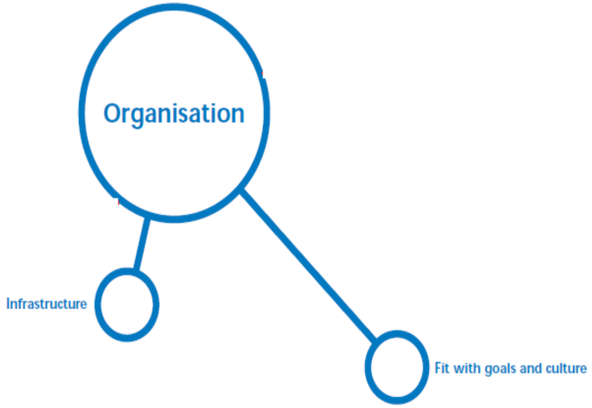
Process	Staff	Organisation
		
Benefits Beyond helping learners: use role/process mapping to illustrate areas of duplication, waste and inefficiency. Mobilise staff to create their own role map that can be updated as roles and processes change. Assess “what is going well” and “even better if…” from the staff’s perspective and prioritise actions. Think of ways to release more time for staff and engage with wider community. Support staff by creating a plan to manage transition.	**Staff involvement and training to sustain the process** Learn how to recognise the characteristics displayed when staff feel a lack of involvement. Create a culture of involvement. How do you create a culture of involvement? Use the Six Thinking Hats for maximum involvement during decision-making.	**Fit with organisational strategic aims and culture** Learn about indicators for receptive context. Embed improvement into the mainstream of the organisation’s business. Use a framework to demonstrate the relationship between the improvement and the organisation’s goals and vision. Change must be integrated into system.
Credibility of evidence Find out *how* you can effectively identify benefits of the change you are making. “Walk in their shoes” to experience change from different perspectives. Gather and effectively communicate evidence and benefits of change.	**Staff behaviors toward sustaining the change** Identify key points that affect staff involvement. Understand a range of possible concerns from staff. Explore a range of steps that you can take to reduce those concerns.	**Infrastructure for sustainability** Align roles and job descriptions with the new process. Use a table to develop new procedures reflecting the improvement. Use a simple cost-benefit analysis framework to consider ongoing resource needs for staff and equipment. Develop a communication plan.
Adaptability Find out how you can adopt and adapt ideas from others. Think about aspects of organisational change that might disrupt the progress of your project. Prepare a succession plan for the future of the process, or service.	**Senior leadership engagement** Enable leaders to be involved and up to date. Think about the most appropriate communication mechanisms for leaders. Formulate a plan to raise awareness of improvements with senior leaders. Identify specific roles for leadership involvement.	
Effectiveness: Use measurement and communication to help staff look forward to continual improvement. Find frameworks to help identify what are the most effective measures to use. Examples: graphs, bubbles, pictures and quotes.	**Leadership engagement** Understand staff’s perspective. Find out how to enlist support.	

Figure 4.3: Elements of a sustainability model - focal points (Source: Adapted from Maher et al., 2010)

4.5.3 Sustainability dimensions identified in general sustainability frameworks

The following table 4.2 provides a selection of sustainability dimensions abstracted from examination of general sustainability frameworks namely: the critical success factor model (CSF); sustainability failure model (SFM), and the NHS sustainability model.

Table 4.2: Sustainability dimensions identified in general sustainability frameworks

Sustainability dimension	**CSF Model (Heeks & Bhatnagar, 1999)**	**SFM (Best & Kumar, 2008)**	**Sustainability Model (Maher et al., 2010)**
Financial/economic	Management	Financial/economic	
Social/cultural	Culture; people	Cultural/social	Organisation: infrastructure; fit with goals and culture
Political	Politics; structure; strategy	Political/institutional (Power shift)	Staff: behaviours; senior leaders
Technological	Technical	Technological	
Environmental	Environmental	Environmental	
Institutional	Structure; strategy		Organisation: infrastructure; fit with goals
Monitoring and evaluation (M&E)	Process; management	(Evaluation and monitoring)	Process: monitoring progress, adaptability, credibility of evidence
Training	People	(Training)	People: training and involvement; behaviours; senior leaders
Sustained leadership	Management	(Sustained leadership and institutionalisation)	
Institutionalisation		(Institutionalisation)	
Identify benefits			Process: benefits
Process	Process		Process: adaptability; credibility of evidence
Information and knowledge management	Information	(Publicity activities to generate awareness of services)	

The principal dimensions that are present in sustainability frameworks are financial/economic, cultural/social, technological and political sustainability. The environmental sustainability dimension is included in sustainability frameworks, such as Best and Kumar (2008)'s Sustainability Failure Model. The environmental dimension includes consideration of the efficient reuse, recycling and disposal of redundant IT equipment (CoA, 2010). This dimension is becoming more important with the increased deployment of IT equipment (CoA, 2010). Potential environmental risks emanate from hazardous substances such as lead and mercury that are contained in IT equipment (Sthiannopkao & Wong, 2013). The sustainability failure model identifies the institutional sustainability dimension, and links the institutional dimension to the political dimension. Institutional sustainability is a dimension that the United Nations uses to address the influence of societal and governmental rules and norms that can be achieved through good governance (Hunt, 2013).

In order to focus on the context of this research, *resource-constrained environments*, the next section will focus on frameworks for ICT4D implementation that are specific to resource-constrained environments, and based on the South African context.

4.5.4 Frameworks relevant for ICT4D implementation in resource-constrained environments

Three frameworks developed from ICT4D research, conducted and implemented in resource-constrained environments in South Africa, are: The "Critical success factors of rural ICT project sustainability" (Pade-Khene et al., 2011), "Framework to guide development through ICTs in rural areas in South Africa" (Mamba & Isabirye, 2015) and the "ICT4RED Implementation Framework".

Musiyandaka, Ranga and Kiwa (2013) also presented a critical success factors model that was developed within the context of resource-constrained environments. They posited that a comprehensive, collaborative policy framework and developmental approach addressing telecommunication, energy (electricity) infrastructure and transport (accessibility), is required for the sustainable implementation of ICT4D projects.

The context, *resource-constrained environment*, is significant because drivers of "unsustainability" emanate from factors relating to the impetus for change, status of the system, project environment and the nature of the interface, or solution, introduced to the beneficiary system (Meyer & Marais, 2015).

4.5.4.1 Critical success factors for rural ICT project sustainability

Nineteen critical success factors for rural ICT project sustainability are identified in the "Critical success factors of rural ICT project sustainability" (Pade-Khene et al., 2011). These are outlined and have been grouped, for the purpose of this study, into: economic, political, technological, social and institutional sustainability, as depicted in Table 4.3.

Table 4.3: Critical success factors (CSFs) of rural ICT project sustainability
(Source: Pade-Khene et al., 2011)
(Original list of factors rearranged and CSFs categorised)

Sustainability Dimension	**Critical success factors**
Economic/financial	Focus on economic self-sustainability.
Political	An understanding of the local political context.
Social/cultural	Participation of community target groups in the project process. Focusing on local-/demand-driven needs. Building on local information and knowledge systems. Facilitating local content development. Encouraging local ownership.

	Building local partnerships. Motivation and incentives for ICT job placement in the community. Using ICT to enhance existing rural development activities. Incorporating socially excluded groups.
Technological	Choosing appropriate technology.
Institutional processes and structures	Simple and clear project objectives. Cultivating an influential project champion. Appropriate training and capacity building. Awareness of specific ICT policy influencing the project. Building on existing public facilities. Ongoing monitoring and evaluation of the project. Approaching the project in a holistic way.

The critical success factors of rural ICT sustainability can be categorised within the identified dimensions of sustainability. A large number of the critical success factors (CSFs) can be categorised in the *social/cultural* and i*nstitutional* sustainability dimensions (Mabila, Herselman & Van Biljon, 2017). The sustainability dimensions are inter-related. The CSFs in the institutional sustainability dimension can be mapped to the economic dimension, and the political dimension is closely related to the institutional dimension.

4.5.4.2 A framework to guide development through ICTs in rural areas in South Africa

Mamba and Isabirye (2015) developed "A Framework to Guide Development Through ICTs in Rural Areas in South Africa" based on the findings of a case study research that evaluated two ICT projects in the Eastern Cape province of South Africa. The framework highlights the need to understand the local context of the ICT4D project before attempting to advance the project in the environment. The framework contributes a set of factors that project implementers in rural areas in developing countries need to consider when carrying out ICT4D projects. These include: skills development, focus on development of local capabilities, long-term partnerships with the private sector and project coordination and management. Sustainability measures need to be identified early in the project (Mamba & Isabirye, 2015).

Involvement of the private sector in committing to long-term partnerships to sustain ICT infrastructure and equipment is essential. Sustainability of ICT4D projects requires development of local capabilities, thus skills development is an important aspect. ICT infrastructure and equipment is susceptible to technical faults and therefore it is important to capacitate local technicians who would be available to provide support. Project coordination and management are important, and increased effort in managing projects and coordination can enhance ICT4D projects' results and sustainability.

4.5.4.3 The Evidence-based ICT4RED Implementation Framework

The Evidence-based ICT4RED Implementation Framework (Ford, Botha &

Herselman, 2014) was developed as part of the ICT4RED initiative. This framework, presented in Figure 4.4, indicates the need for classroom interaction in resource-constrained schools to be brought in line with the introduction of appropriate ICTs and it also highlights the importance of the Teacher Professional Development component (Herselman et al., 2014).

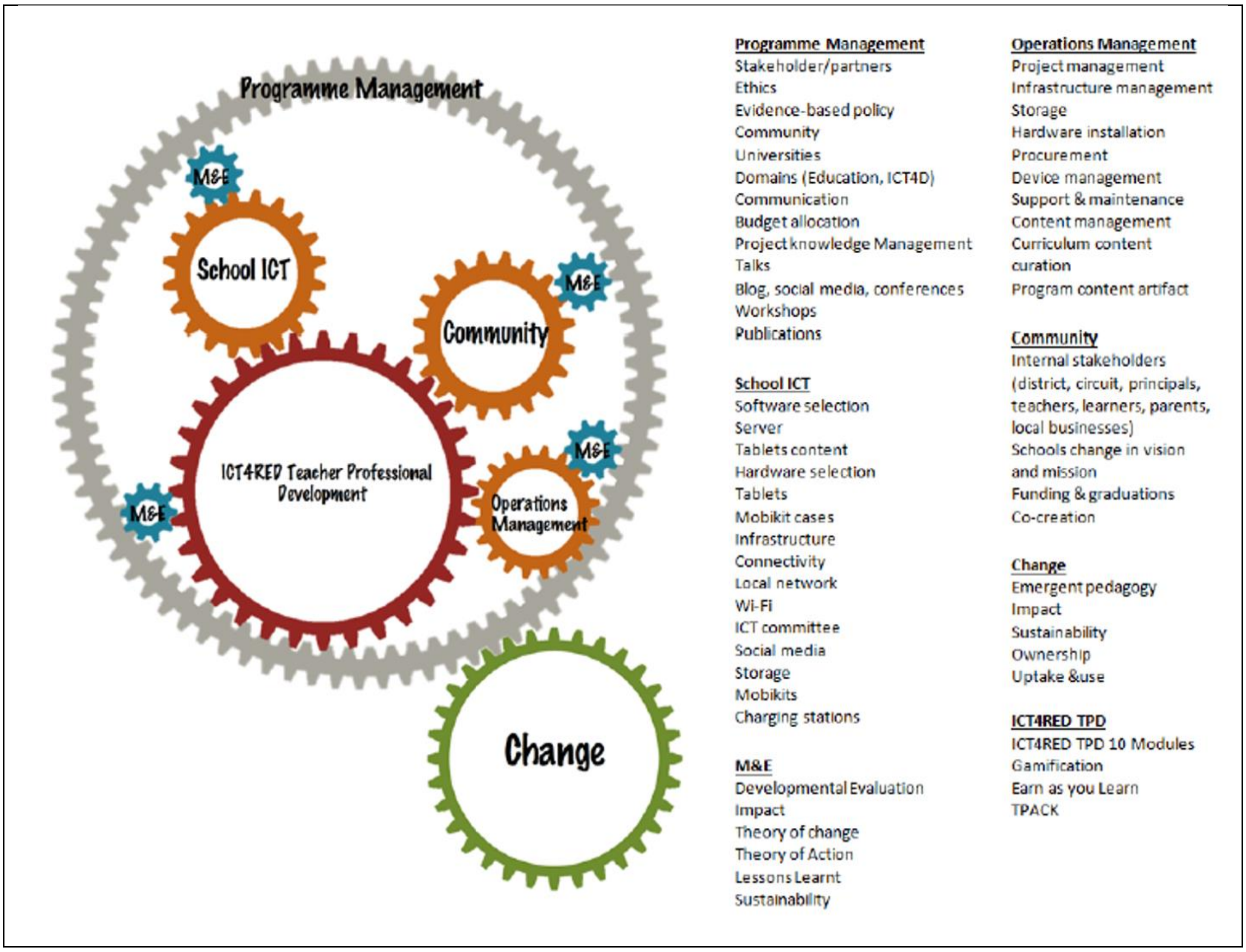


Figure 4.4: Evidence-based ICT4RED Implementation Framework
(Source: Botha & Herselman, 2015)

The Evidence-based ICT4RED Implementation Framework provides a framework for integrating mobile technology in resource-constrained rural schools whilst seeking to address the challenges posed by rural ICT in Education initiatives. In addition, the framework provides guidelines to support similar rollouts in order to maximise the potential for success in terms of implementation, sustainability and impact (Ford, Herselman & Botha, 2014). As concerns the development of the SFMTIS, this framework indicates the need for monitoring and evaluating school ICT implementations. The stakeholders are identified under both the community and programme management categories.

Table 4.4 provides a summary of all the components contained in the evidence-based ICT4RED implementation framework.

Table 4.4: Evidence-based ICT4RED Implementation Framework (Source: Adapted from Herselman et al., 2014)
Programme management - Manage, co-ordinate and support other components of the initiative. - Engage with high-level stakeholders and partners (government departments, research councils, community leaders such as tribal leaders and chiefs, publishers, universities). ****This component recommends actions that have to be taken to facilitate long term sustainability.*** ****Knowledge management*** channels through which information on the initiative is communicated to the outside.
Monitoring and Evaluation - Carried out throughout the initiative. - Involves documentation of what worked and what did not, and why. - Evidence collection and the making of recommendations to inform and influence policies on technology integration. - Examples are learning briefs and impact stories which are documented and shared.
Community - People and organisations involved in the specific context. - Includes district and circuit managers, subject advisors, teachers, learners, parents and local businesses.
School ICT - School related ICT hardware, software and infrastructure decisions. - Teacher professional development at school level; school ICT committee selection. - Hardware and software selection; decisions regarding infrastructure, connectivity (3G/satellites), local area networks, Wi-Fi. - Types of security for storage units, types of charging stations for tablets.
Change - Change is the consequence of the effects of the other components. - Affects impact and sustainability.
Operations Management - Includes the management of content, devices, infrastructure, support and maintenance, initiative management, and infrastructure management. ***Selection and provision of storage facilities at schools; oversees installations of hardware at schools. *Content Management: involves curation and organisation of curriculum content on the server and tablets. - Selection of applications for the tablets, loading applications onto tablets, distribution of hardware. - Contracts with local and other suppliers, logistics support.
Teacher Professional Development This is the main driver. - It involves training of teachers and district officials on *how* to use technology to support teaching and learning. - Requires application of SCHOOL ICT and OPERATIONS MANAGEMENT. - "Empowers" and "disrupts" schools, provincial departments of education and stakeholders. - Influences COMMUNITY component (district and circuit managers, subject advisors, teachers, learners, parent, and local businesses).

In this framework, all the components play an important role which affects sustainability.

The "Critical success factors of rural ICT project sustainability" (Pade-Khene et al., 2011) and the "ICT4RED Evidence-based Implementation Framework" highlight considerations, particularly for resource-constrained environments. Table 4.5 highlights some of the main elements that have been extracted from these two frameworks and the "Framework to guide development through ICTs in rural areas in South Africa" (Mamba & Isabirye, 2015). It is important to note that these are extracted features that are considered relevant to this research, and that the table is not a comparison of the frameworks.

Table 4.5: Sustainability dimensions identified in sustainability frameworks for ICT4D implementation in resource-constrained environments

Sustainability dimension	CSFs of rural ICT project sustainability (Pade-Khene et al., 2011)	Evidence-based ICT4RED implementation framework (Herselman et al., 2014)	Framework to guide development through ICTs in rural areas of South Africa (Mamba & Isabirye, 2015)
Financial/ economic	Economic self-sustainability; motivating and incentivising for community ICT job placement; using ICT to enhance existing rural development activities.	Programme management (budget allocation). Cost-utility model (Meyer & Marais, 2014: 217).	Financial support (private sector and government).
Political	Understanding of local political context; cultivating an influential project champion.	Programme management (managing stakeholders).	Change management.
Social/ cultural	Community participation (target groups), local/demand-driven needs; encouraging local ownership; building local partnerships; incorporating socially excluded groups.	Programme management (managing stakeholders, community); community (people, organisations internal to specific context).	Local participation; long-term private and public sector partnerships.
Technological	Choosing appropriate technology.	School ICT (hardware and software selection, infrastructure, connectivity - decisions and issues); school ICT committee; communication.	Plan for long-term presence of skilled personnel; technical support by local, skilled personnel.
Institutional			
Monitoring and Evaluation	Ongoing monitoring and evaluation of the project.	Monitoring and evaluation (measures success/failure and impact); overarching to include programme management.	
Training	Undergoing appropriate training and capacity building.		Skills development; ICT training.
Sustained leadership	Cultivating an influential project champion.	Programme management.	
Management		Operations' management: content, infrastructure, project, devices, support, maintenance; change management.	
Identify benefits	Stating simple, clear project objectives.	Benefits identified.	Goal determination; identify role of technology.
Process			
Policy	Creating awareness of specific ICT policy influencing the project.	Programme management: evidence-based policy.	Sound policies.
Communication	Building on local information and knowledge systems.	Programme management: Communication.	Coordination and communication are critical.
Building on existing public facilities	Building on existing public facilities.		
Holistic approach to project	Approaching the project in a holistic way.	ICT4RED was part of a programme that addressed other challenges faced by schools in resource-constrained environments.	
Institutional partnerships	Forming partnerships to increase capacity and improve economic sustainability.		Efficient method of multi-stakeholder collaboration and cooperation.
Specific values	Key attributes for successful ICT4D partnerships: trust, sound ethics, transparency; focusing on sustainability; investing time in networking activities.	Openness, transparency, inclusivity; striving for sustainability after the end of the initiative.	
Information and knowledge management	Building on local information and knowledge systems; facilitating local content development.		Incremental implementation.

Although the “Critical Success Factors of rural ICT project sustainability” (Pade-Khene et al., 2011) and the “Framework to guide development through ICTs in rural areas in South Africa” (Mamba & Isabirye, 2015) relate to sustainability of ICT4D projects in resource-constrained environments, they are not specific to the education environment. The “Evidence-based ICT4RED Implementation Framework” is specific to the education environment and tablet use to support teaching and incorporates sustainability factors, however this is an *implementation* framework, not a *sustainability* framework.

Nichols (2008) advances that, in all likelihood, e-learning activities in the long-term will be limited to enthusiasts unless a state of “institutional” sustainability is achieved. Institutional sustainability is achieved when the structures and processes of an organisation can perform their functions over a long term (Mudziwepasi, Nomnga, Scott & Sibanda, 2015).

In the implementation of the ICT4RED initiative it was noted that:

> “The challenge is to introduce technology (in this case tablets and other supporting ICT infrastructure), in ways that will improve teaching and learning, *support sustainability beyond the initiative and ensure true integration into existing education processes*, whilst managing very real logistical and infrastructure problems” (Herselman et al., 2014: 1).

It is thus necessary to build institutional capacity when integrating technology into teaching and learning (Bates & Sangra, 2011). Table 4.6 identifies elements of sustainability in the three frameworks: “Critical Success Factors of rural ICT project sustainability” (Pade-Khene et al., 2011), “Framework to guide development through ICTs in rural areas in South Africa” (Mamba & Isabirye, 2015) and the “Evidence-based ICT4RED Implementation Framework” whilst focusing on sustainability as it pertains to institutional systems and processes.

The next section will focus on frameworks relevant to mobile learning.

4.5.5 Mobile learning models and frameworks

Hsu and Ching (2015) reviewed models and frameworks for designing mobile learning experiences and environments. The findings by Hsu and Ching (2015), as depicted in Table 4.6, are in line with earlier findings by Ng and Nicholas (2013) who stated that there was no model of sustainability for mobile learning in schools to be found in literature.

Table 4.6: A categorisation of mobile learning models and frameworks (Source: Hsu & Ching, 2015)				
Category (number of articles)	**Year**	**Author**	**Article title**	**Proposed framework/model**
Pedagogies and learning Environment design (6)	2009	Koole	A model for framing mobile learning.	The framework for the rational analysis of mobile education (FRAME).
	2009	Peng, Su Chou & Tsai	Ubiquitous knowledge construction: Mobile learning redefined and a conceptual framework.	The conceptual framework of ubiquitous knowledge construction.
	2011	Park	A pedagogical framework for mobile learning: Categorising educational applications of mobile technologies into four types.	A pedagogical framework for mobile learning in distance education.
	2012	Schmit, Klemke & Specht	Effects of mobile gaming patterns on learning outcomes: A literature review.	A framework of analysis of design patterns for mobile learning games.
	2013	Abdullah, Hussan, Asra & Zakaria	Mlearning scaffolding model for undergraduate English language learning: Bridging formal and informal learning.	Mlearning scaffolding Five-stage model.
	2013	Ng & Nicholas	A framework for sustainable learning in schools.	A person-centred model for mobile learning.
Platform/system design (5)	2006	Taylor, Sharples, O'Malley, Vavoula & Waycott	Towards a task model for mobile learning: A dialectical approach.	Task model for mobile learning.
	2007	Motiwalla	Mobile learning: A framework and evaluation.	An M-Learning framework (for designing applications for collaborative learning).
	2007	Parsons, Ryu & Cranshaw	A design requirements framework for mobile learning environments.	A framework for M-Learning Design requirements.
	2007	Uden	Activity theory for designing mobile learning.	Using Activity theory as a framework for designing mobile learning.
	2007	Zurita & Nussbaum	A conceptual framework based on activity theory for mobile CSCL.	The MCSCL Framework (based on Engestrom's expanded activity theory model).
Technology acceptance (4)	2007	Huang, Lin & Chuang	Elucidating user behaviour of mobile learning: A perspective of the extended technology acceptance model.	An extended technology acceptance model
	2010	Yau & Joy	Proposal of mobile learning preferences model.	A mobile learning preferences model.
	2012	Chang, Yan & Tseng	Perceived convenience in an extended technology acceptance model: Mobile technology and English learning for college learners.	An extended technology acceptance model (in the context of mobile learning: adding perceived convenience).
	2012	Park, Nam & Cha	University learners' behavioural intention to use mobile learning: Evaluating the technology acceptance model.	A general structural model of learners' acceptance of mobile learning.
Evaluation (1)	2009	Vavoula & Sharples	Meeting the challenges in evaluating mobile learning: A 3-level evaluation framework.	A 3-level Evaluation framework of mobile learning.
Psychological construct (1)	2012	Sha, Looi, Chen & Zhang	Understanding mobile learning from the perspective of self-regulated learning.	An analytic self-regulated learning (SRL) model of mobile learning.

The “Framework for sustainable mobile learning in schools” and “Person-centred sustainable model for mobile learning” (Ng & Nicholas, 2013), highlighted in Table 4.6, have since been developed. These are relevant to this study and are further discussed in the following sections.

4.5.6 A framework for sustainable mobile learning in schools

Ng and Nicholas (2013) developed a framework for sustainable mobile learning in schools based on secondary education in Australia and data collected at an Australian school. In the case of the Australian school in Ng and Nicholas’ research, the school’s mLearn programme was internally funded. In contrast, most of the mobile learning funding (as reported on in this study) is external to the school (Ng & Nicholas, 2013). The environment in Ng and Nicholas’ study is thus different to the context presented in this research.

The objective of the mLearn programme was to enable learners to access software and a range of multimedia resources that could provide just-in-time information for learning which was loaded onto their personal digital assistants (PDAs). The programme was designed to encourage cooperative learning between learners as well as between learners and teachers, and to thus develop better organisational skills in learners (Ng & Nicholas, 2013). The principal who led, and actively participated in the mLearn programme, was technologically literate and enthusiastic.

Ng and Nicholas based their framework on the “Framework for sustainability of ICT education” (Cisler, 2011). This framework has four elements: economic, political, social and technological sustainability (Cisler, 2011). Ng and Nicholas (2013) proposed a “Framework for sustainable mobile learning in schools”, adding a fifth element namely “pedagogical sustainability”. Pedagogical sustainability articulates the roles of teachers in facilitating learning with mobile devices (Ng & Nicholas, 2013). Ng and Nicholas used this framework, and the findings of their research, to develop the “Person-centred sustainable model for mobile learning” (Ng & Nicholas, 2013) shown in Figure 4.5.

Ng and Nicholas’s (2013) framework for sustainable mobile learning acknowledges the complex relationships between the technical aspects and the *people-related factors* which include interpersonal relationships.

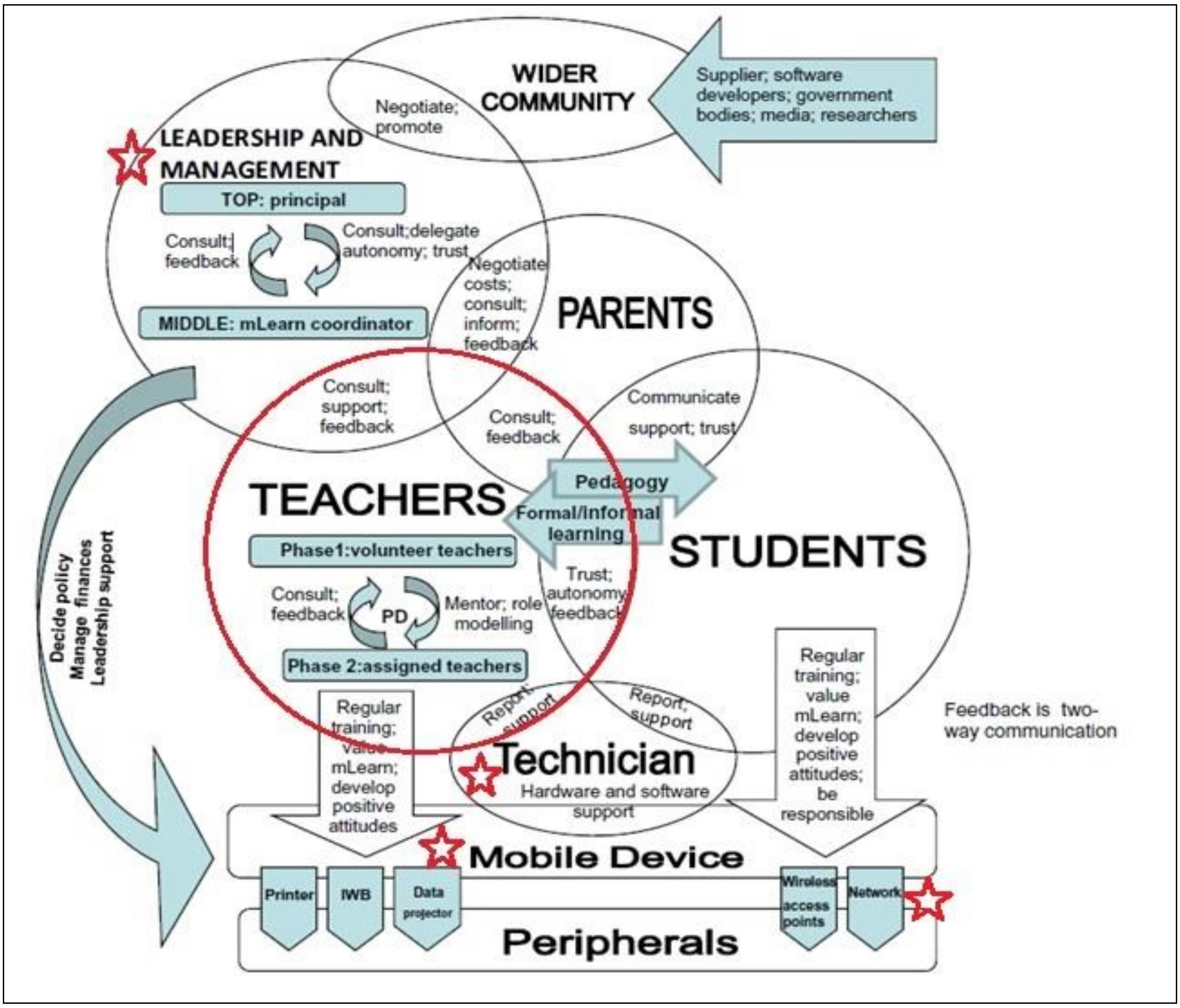


Figure 4.5: Person-centred sustainable model for mobile learning in schools
(Ng & Nicholas, 2013. *Highlights added for emphasis)

These *interpersonal relationships* exist between leadership and management (principal and programme coordinator), teachers, learners, technicians and the wider community (parents, suppliers, policy makers, software developers and researchers).

4.5.7 Sustainability factors identified in ICT4D projects in other countries

Sustainability dimensions and factors that affect long-term sustainability of ICT projects have been identified in ICT4D in other countries. Examples presented in the following section includes ICT4D projects in Egypt, Latin America and India.

4.5.7.1 Egypt

A project that evaluated a large-scale ICT in education program that involved implementation of simple, relevant technology to 166 schools in Egypt, aimed at rapid, efficient and for long-term sustainability was undertaken in 2012, four years after the project started (Pouezevara, Mekhael & Darcy, 2014). The evaluation study was conducted to assess the planning processes of the information technology that were selected to support and improve teaching and learning. Hardware-related processes for procuring and delivering equipment, providing software and training, infrastructure management, and creation of an environment in which the use of the infrastructure was enabled, were also assessed.

Sustainability factors identified in prior research of ICT in development projects, namely, technological, individual and social, economic and political dimensions of sustainability, were used to examine the appropriateness of the design and implementation of the project for long-term sustainability. Questionnaires were administered to individuals in 53 schools, and project reports and phone-calls were used to gather information.

The study confirmed findings from other studies that social, political, economic, and political dimensions affect sustainability and success of ICT projects. A proactive and sustained process of consistent communication, and change management was found to be one of the most important factors in technology integration. Other factors that were found to be critical include:

- Recurrent teacher training programs for teachers and school- based maintenance and support teams,
- Phased approach in preparing for the project site, installation, and training,
- Managing expectations and garnering support from schools, school communities, and the Ministry of Education in Egypt,
- Finding and supporting champions at local and national levels, and
- Collaboration and cooperation with government departments.

The study found that constraints in accessibility of the equipment limits sustainability. Long-term financial planning for the ICT projects to cover recurrent costs until schools could appreciate the value and benefits, and incorporate the costs in their budgets in line with budget cycles of funding public institutions (Pouezevara, Mekhael & Darcy, 2014).

4.5.7.2 Latin America

Ames (2015) investigated the impact of large-scale introduction of ICTs in Peru schools through distribution of one laptop per child (OLPC) XO laptops, five years after implementation. Students, teachers and head teachers' perceptions of the impact of ICT technology integration into teaching and learning through the program were examined

The aim of the OLPC program is to promote self-empowered learning by providing personal laptops to children mainly in developing countries.

The qualitative study was undertaken in three regions in Peru, comprising of schools in rural and urban primary and secondary schools.

The findings of the study indicated that:

- Teachers at some schools lacked adequate ICT training and were unprepared to effectively integrate ICTs into their lessons,
- Technical support is an important factor for ICT integration into teaching in schools,
- Students favour increased ICT integration into teaching and learning,
- Students considered the OLPC laptop as inferior and limited in compared to mobile devices that provide more intensive ICT experiences, and
- Development of relevant policies to address pertinent issues such as replacement of old and faulty laptops.

Schools with teachers trained in ICT integration into teaching and learning, and where head teachers supported the initiative, were more likely to have a higher level of usage of the laptops after five years of introduction of the program. Poor ICT infrastructure, lack of resources, inadequate maintenance and replacement of ICT equipment contributed to lower levels of use of the OLPC XO laptops. Teacher training, technical support and institutionalisation are required for sustainable integration of ICTs into teaching (Ames, 2015).

Research conducted prior to the implementation of the OLPC XO laptops in Latin America had yielding comparable findings.

Prior to the introduction of OLPC XO laptops, Kim, Miranda and Olaciregni (2008) investigated the large-scale “Pocket school” project where mobile technology was applied as a sustainable education option to address learning needs for underserved indigenous children in Latin America. The pocket school uses a mobile learning device to provide educational programs to indigenous children in remote communities where there are poor school facilities, with little or no electricity, where the teachers untrained or there are no teachers.

Sustainability is one of the complex issues that mobile technology solutions for providing literacy education to indigenous children in underserved populations in Latin America need to consider (Kim et al., 2008). Inequality is very acute in Latin America, and there are significant differences in the literacy levels and access to formal education between non-indigenous and indigenous populations.

There are multidimensional complexities that surround the provision of mobile technology solutions to meet the learning needs of children in marginalized indigenous populations. Factors that can affect the effectiveness of a mobile learning model in the Latin America context include the diverse population of learners, environmental, political, cultural and social conditions that affect learning. There are practical problems that are specific to the location and situation of the children in digitally isolated populations in Latin America (Kim et al., 2008).

4.5.7.3 India

Ali and Bailur (2007) investigated the challenges of sustainability of "*Our Voices",* a community radio and IT centre which is part of the Arivu Resource Centre in the village of Bhairavi, with a population of about 3000, in rural, south India. The project had initially been donor-funded, and was run by two non-governmental organisations (NGOs). Donors other than the original funder were also involved in the project. The ethnographic study carried out in 2006 to 2007 was to understand the process of participation in ICT for development projects. Objectives of the project included, providing information to the local villages and providing computer skills to the local community. The villagers indicated that they were not getting relevant information on crops, market prices and health related issues.

The researchers interviewed over two hundred (200) stakeholders involved in the project, including individuals from the donor agency, non-governmental organisations (NGOs), government departments and beneficiaries (local villagers). Findings from the study indicated that unsustainability of the project was due to

- Technical difficulties
- Lack of maintenance of equipment
- Misalignment between the strategic objectives and the reality in the village, and
- Misunderstanding between the community and the implementers of the project

The project's unsustainability was thus considered to be due to lack of social or cultural sustainability.

Ali and Bailur (2007) state that literature shows that sustainability may be divided into five types: economic/financial, social/cultural, political/institutional, technological and environmental, and that unsustainable ICT projects suffer in one or more of these areas. ICT for development projects also fail because of the design-reality gap (Ali & Bailur, 2007). Ali and Bailur argue that "sustainability models and frameworks will not predict the future or guarantee a sustainable project" (Ali & Bailur, 2007: 12), and advance "Bricolage" as a potential answer to the sustainability challenge. "Bricolage" from the Latin word bricola, means tinkering through the combination of resources at hand (Ciborra, 1994; 2002), and allows people at the local level to apply known tools and routines at hand to solve new problems (Ali & Bailur, 2007).

4.5.8 Sustainability dimensions relevant to the development of the SFMTIS

Table 4.7 is a comparison of the sustainability dimensions across the frameworks as discussed in the preceding sections.

Table 4.8 presents sustainability elements that can be used to develop a sustainability framework for tablet integration into teaching, based on the analyses of the definitions of sustainability and the frameworks and models discussed in the preceding sections.

Table 4.7: Comparison of the sustainability dimensions across frameworks as basis of developing the SFMTIS dimensions

	SUSTAINABILITY frameworks			**FRAMEWORKS: ICT4D implementation - resource-constrained environments**			**Mobile**
Sustainability dimension	**CSF Model (Heeks & Bhatnagar, 1999)**	**SFM (Best & Kumar, 2008)**	**Sustainability Model (Maher et al., 2010)**	**Critical success factors of rural ICT project sustainability (Pade-Khene et al., 2011)**	**Evidence-based ICT4RED implementation framework (Herselman et al., 2014)**	**Framework to guide development through ICTs in rural areas in South Africa (Mamba & Isabirye, 2015)**	**Ng & Nicholas (2013); Mabila et al. (2017) adapted from Cisler (2011)**
Economic	Management	Financial/ economic	Use cost benefit analysis framework for ongoing resource needs (staff and equipment).	Economic self-sustainability; Motivate/ incentivise community ICT job placement. Use ICTs to enhance existing rural development activities.	Programme management (budget allocation); risk identification; monitoring and evaluation; change management. Cost-utility model (Meyer & Marais, 2014: 217).	Financial support (private sector and government) for infrastructure and skills development.	Economic
Social/ cultural	Culture; people	Cultural/social	Organisation: fit with goals and culture. Staff: training and involvement, behaviours, senior leaders.	Community participation (target groups), local/demand-driven needs. Encourage local ownership and build local partnerships.	Programme management (managing stakeholders, community). Community (people, organisations internal to specific context).	Local participation; long-term private and public sector partnerships.	Social
Political	Politics; structure; strategy	Political institutional	Organisation: f it with goals; Staff: behaviours, senior leaders	Understanding of local political context. Cultivating an influential project champion.	Programme management (managing stakeholders and partners); change management.	Change management.	Political
Technological	Technical	Technological		Choose appropriate technology.	School ICT (hardware and software selection, infrastructure, connectivity – decisions and issues); school ICT committee; communication.	Plan for long-term presence of skilled personnel, local, skilled personnel should provide technical support.	Technological
Environmental	Environment	Environmental					
Pedagogical					Teacher professional development; curriculum content; content management.		Pedagogical (Ng & Nicholas, 2013)
Institutional		(Institutionali-sation)	Organisation: infrastructure, fit with goals	Simple clear objectives. Awareness of ICT policies. Holistic approach, M&E.	Evidence-based policy; school ICT policy; sustainability plan (district and provincial level); programme and change management.	Goal determination; identify role of technology; sound policies; ICT training.	Institutional (Mabila et al., 2017)

Table 4.8: The INITIAL SFMTIS in resource-constrained environments in South Africa based on reviewed literature

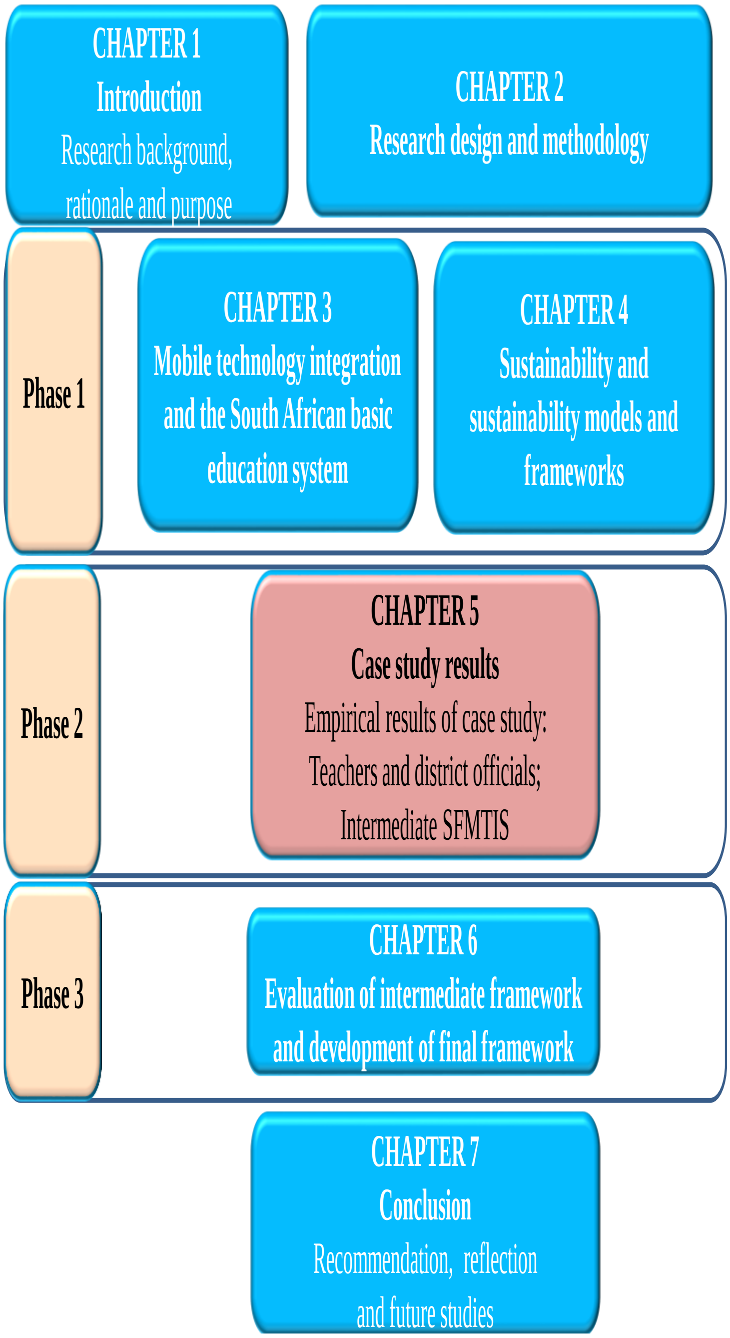
Sustainability dimension	Description	Aspects to consider
Financial/ economic	Expenditure (both short and long term); financial self-sustainability of rural ICT projects is often a major concern. There is a need to focus on economic self-sustainability and entrepreneurship. Infers the need for a sustainable financial model.	Financial model such as Total Cost of Ownership (Meyer & Marais, 2014). Entrepreneurship: School Management Teams (SMTs) and School governing bodies' (SGBs) interpretation of being "section 21 school" should be understood. Appropriate training and capacity building of SMTs and SGBs in planning, resource management, raising funds LTSM structure – ICT element consideration. Annual planning for maintenance costs.
Political	An understanding of the local political context; cultivating an influential project champion.	Province (macro level): Provincial ICT Forum in the Eastern Cape Department of Education (ECDoE). District (meso level): ICT4RED/E-learning coordinator. School (Micro level): Clear roles and responsibilities, as well as planning, communication, coordination, monitoring and evaluation. Identify structures and processes, strengths and weakness and move to eliminate inefficiencies. What structures and processes currently exist for information about tablet use/issues to be communicated between schools, district and province? Assess effectiveness of current structures and capacitate where necessary.
	Can be distinguished from institutional sustainability and includes political leadership.	Clearly defined roles, responsibilities at school (micro), district (meso), and provincial (macro) levels. Accountability.
Social/ cultural	Cultural and social context in which the project operates and its impact. When communities feel empowered by the ICT project they are likely to actively seek ways to sustain it. Create a culture of involvement.	Communicate benefits/rationale. Involve parents/SGBs/SMTs, teachers and learners e.g. in one school the ICT Champion ensures that tablets are stored safely and are charged and available to use by teachers by assigning learners for each of the related tasks namely charging/collecting tablets (develops other skills in learners such as taking responsibility). Involve parents in finding solutions to security issues and finding innovative ways to raise funds. Capacitate SGBs to extent that they can hold teachers, principals, SMTs, learners and Finance committee accountable.
Technological	The choices made for selecting appropriate technology and infrastructure. Decision making on type of technology based on institutional needs and goals. Consideration of costs of technology and innovation. Technical support, access to infrastructure and technical assistance.	Tablet selection: Technology selection model (Meyer & Marais, 2014). Identify existing facilities e.g. e-rate, and communicate to schools. Assist schools in using existing facilities. School Technicians – district could assist in identifying cost-effective ways of providing technicians and infrastructure maintenance to support schools.
Pedagogical	"Teaching or learning practices that support the long-term goals of the mobile learning programmes" (Ng & Nicholas, 2013: 4).	Identify existing facilities: for digital content (What is available at district/provincial/national level?) What structures and processes are available to keep content updated (Institutionalise process – Best & Kumar, 2008). Sourcing digital content - Apply economies of scale. Continuous teacher professional training. Research institutions, Universities involvement in content development. Understanding differences/cost-benefits between open and proprietary digital content.
Environmental	Making plans for eventual disposal, or reuse, of the equipment (large numbers of servers and tablets) when they reach the end of their effective life. Consider the topography, as mountainous areas affect the line of sight and accessibility of Wi-Fi, consequently, more robust ICT infrastructure is needed. Untarred roads that may be muddy and slippery during the rainy season can affect access to the schools.	Coordinated maintenance – the district can work with provincial and national department in identifying cost-effective ways of identifying best quality tablets (e.g. using the Technology selection model of Meyer and Marais (2014).

Institutional	Organisational structures and processes, how organisational structures execute their functions, especially long term. Should consider micro, meso, and macro level of the institution.	Change management: identify benefits of mobile technology integration, communicate to teachers, parents and learners.
	Related CSFs are: fit with goals and culture, leadership. Building on existing public facilities (structures) and awareness of specific education, ICT and national policies influencing the project.	Identify structures and processes that will make mobile technology part of the day to day activities in the school.
Monitoring and evaluation	Ongoing monitoring of progress and evaluation of the project.	Roles and responsibilities should be well defined and communicated at strategic, tactical and operational levels (or macro, meso and micro levels) Who monitors what and why? What are teachers accountable for? What are teachers expected to use tablets for? What are subject education specialists responsible for?
	Credibility of evidence.	Data collection processes by schools, district. Who uses the tablets and what for? How many tablets are there? Working or broken? What are teachers' feedback regarding tablet use?
Training	Training and capacity building; staff involvement in sustaining the process; determining how to recognise characteristics displayed by staff who feel lack of involvement.	Ensure effective use of SACE continuous professional development (CPTD) system that uses the professional point (PD) system to earn a target number of PD points within each 3-year successive cycle. Effective use of Teacher development centres.
Sustained leadership	Provide management and professional support in planning and providing oversight and accountability.	Align school ICT Champion, District ICT4RED/ E-learning coordinator, communication and coordination. Develop and communicate sustainability plan.
Institutionalisati on	Here it refers to "value infusion" and "behavioral routinisation" (Levitsky, 1998).	*Sustainability plan* and *change management* should focus on identifying structures and processes that will institutionalise mobile technology integration.
Identify benefits	Identify benefits; Simple and clear project objectives	At all levels, benefits and reasons for mobile technology integration should be understood.
Policy	Awareness of specific ICT policy influencing the project, developing appropriate policies.	Communicate relevant policies e-rate; asset management; "section 21 schools" and implications.
Communication	Understand existing information channels and communication patterns between communities and relevant organisations.	Identify existing communication channels and strengths and weaknesses. How do teachers report faults and related issues?
Information and knowledge management	Knowledge management (KM) is important for sustainability. The ability to identify *which* information will be gathered, *how* it will be acquired, stored, retrieved and disseminated.	The number of tablets at each school, how many tablets require repair? How many schools use Internet and how will such data be collected and by who? What will this information be used for?
Building on existing public facilities	Available existing public resources (infrastructure such as buildings, personnel such as technicians) that can be appropriately utilised should be identified and maximised.	Existing facilities such as Vodacom centres should be used. Motivate/incentivise teachers to use for self-development. Provide facilitators and encourage learners to identify and use existing facilities in the community.
Holistic approach	The broader needs of the community should be considered in line with the project and capabilities.	Identify other projects that support the initiative and decide how these can be leveraged.
Process	The actions required to map institutional processes to assess what is going well and what is not. Adaptability of the process and its effectiveness should be assessed.	Identify means (structures) by which monitoring and evaluation occurs, assess effectiveness and eliminate inefficiencies e.g. in reporting processes. When teachers require technical support – what processes are followed? What are turnaround times?
Institutional partnerships	Forming partnerships to increase capacity and improve economic sustainability. Investment of time in networking activities. Identifying key attributes necessary for successful ICT4D partnerships e.g. trust, transparency and sound ethics.	Long-term private and public-sector partnerships for infrastructure, digital content, teacher professional training.

4.6 SUMMARY

It is imperative to define *sustainability* in context in order to establish a shared understanding of its meaning. The system and sub-systems to be maintained need to be defined. Definitions of sustainability were presented and a definition of sustainability, as pertaining to this research, was determined. Elements of sustainability that are fundamental in the development of a framework for sustainable mobile learning are: financial, cultural, political, environmental, technological, pedagogical and institutional sustainability. This is based on the examination of sustainability frameworks in general, frameworks for ICT4D implementation in resource-constrained environments specifically, and frameworks for sustainable mobile learning in schools. Political context, process monitoring and evaluation, capacity building and staff training, communication and knowledge management, multi-stakeholder approach and the elimination of inefficiencies are important considerations in the development of the framework.

Chapter 5: Case study results



Chapter 5: Case study results

5.1 INTRODUCTION

In Chapter 4 the concept of sustainability was discussed. Sustainability ICT4D models and frameworks in general, frameworks specific to ICT4D projects in resource-constrained environments specifically, and sustainability mobile learning models and frameworks were analysed. Based on the analysis, sustainability dimensions that can be applied in developing a sustainability framework for mobile technology integration into schools were synthesised, resulting in the initial sustainability framework for mobile technology integration in schools in resource-constrained environments in South Africa (SFMTIS).

In this chapter the research findings of Phase 2 of the research (as per Figure 5.1) in which a case study was applied to investigate the perspectives of teachers and district officials on mobile technology integration, are presented. This case study comprises of selected schools in the Cofimvaba school district in the Eastern Cape province in South Africa (Figures 5.3 and 5.4), an environment that can be considered as resource-constrained. The case study, which was discussed in Section 2.6.2.1, involves two units of analysis, *teachers* and *district officials* who had been involved in the ICT for rural education and development (ICT4RED) initiative.

The research questions, which this chapter aims to address, are describe in Section 1.4.1 as:

What are the perspectives of teachers on mobile technology integration in schools in resource-constrained environments? and
What are the perspectives of school district officials on mobile technology integration in resource-constrained environments?

This addresses the objective of the study in obtaining the views of teachers and district officials regarding mobile technology in their schools, in order to develop and refine the SFMTIS. The teachers and district officials participated in the ICT4RED initiative, as discussed in Section 2.6.2.1. Their perspectives were therefore vital to inform and refine the initial SFMTIS that was developed in Phase 1 of the DSRM following a literature review of sustainability frameworks.

Design science research methodology (DSRM) was selected as the methodology for this research, as discussed in Section 2.5. This chapter comprises Phase 2 of the application of the DSRM process followed to develop the SFMTIS artifact as per Figure 5.1.

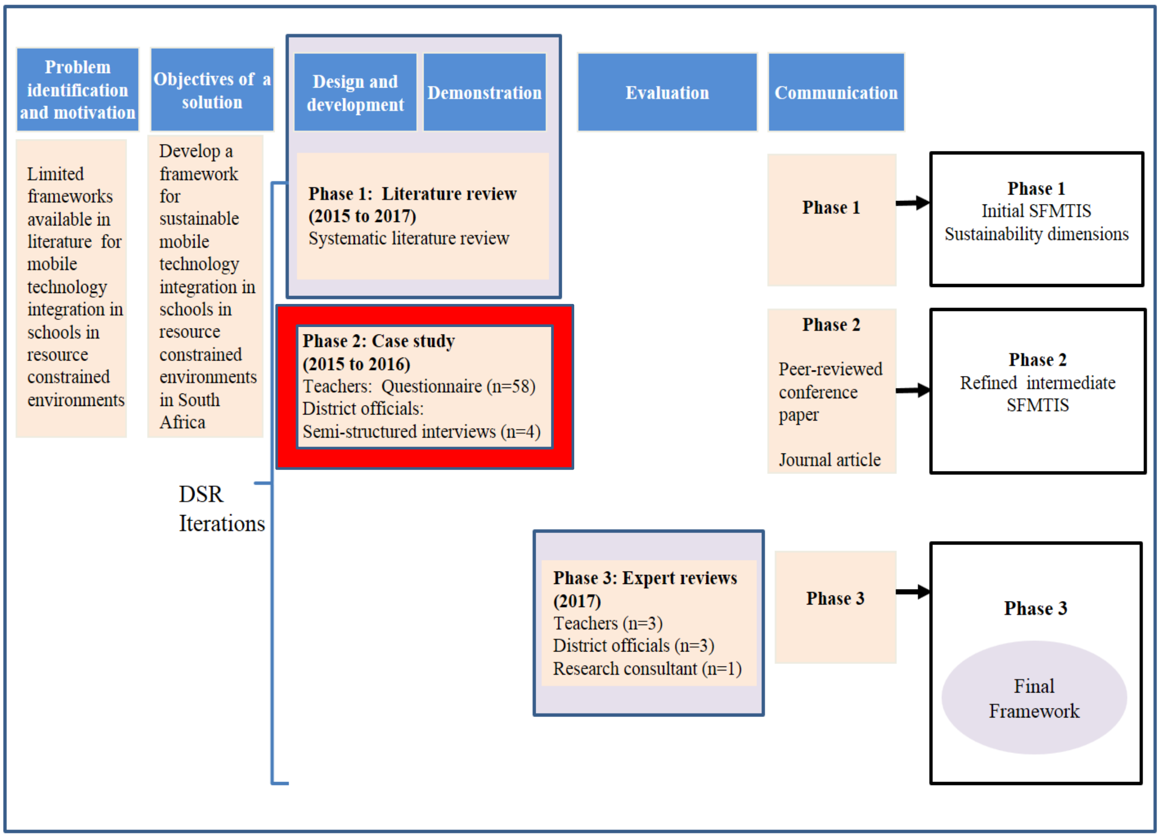


Figure 5.1: Application of DSRM process - Phase 2: Case study

The background information to the case study is presented in Section 5.2 and the results are discussed in Section 5.3.

5.2 BACKGROUND INFORMATION TO THE CASE STUDY

The ICT4RED initiative, in which the teachers and district officials in this case study participated, as discussed in Section 2.6.2.1, is one of the components of the Technology for rural education and development (TECH4RED) programme illustrated in Figure 5.2.

5.2.1 Technology for rural education and development (TECH4RED)

The TECH4RED programme was initiated by the Department of Science and Technology (DST) in South Africa, in collaboration with other government departments namely the Department of Basic Education (DBE), Department of Rural Development and Land Reform (DRDLR) and the Eastern Cape Department of Education (ECDoE). The aim of the TECH4RED programme is to contribute to the improvement of rural education through technology-led innovation to the 26 schools selected for the programme (Botha, Herselman & Ford, 2014). A holistic approach was adopted for TECH4RED in which work groups were assigned to provide these technology-intensive interventions in different sectors namely:

Education, ICTs, nutrition, health, water, sanitation and energy (Veldsman & Van Greunen, 2015).

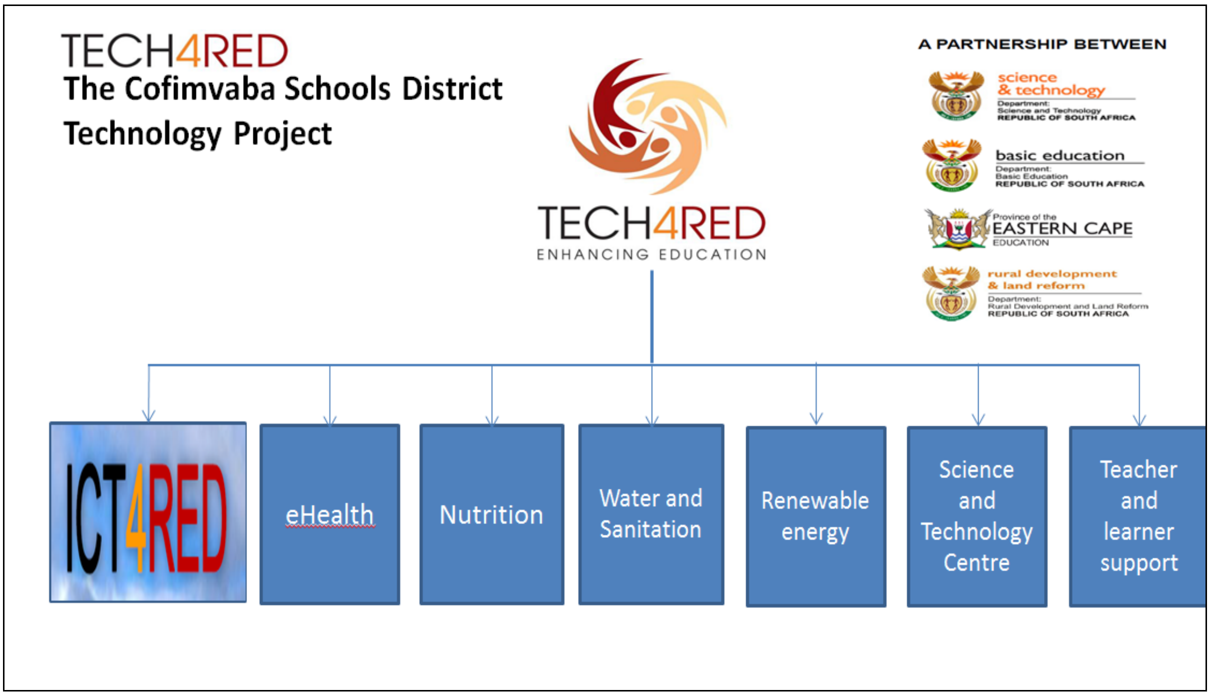


Figure 5.2: ICT4RED as a component of the Technology for rural education and development (TECH4RED) programme

The ICT4RED component of TECH4RED focused on *how* technology can support teaching and learning.

5.2.2 ICT for rural education and development

ICT4RED is discussed in detail in Section 2.6.2.1. The lessons learnt from the implementation of the ICTs to support teaching and learning through the ICT4RED initiative was applied to develop the “Evidence-based ICT4RED implementation framework” (Botha & Herselman, 2015), as discussed in Section 4.5.4.3 and presented in Figure 4.4. This implementation framework informs other tablet initiatives in the country and enables the development of evidence-based policy. In this study the evidence-based ICT4RED implementation framework contributes to the knowledge base in the rigour cycle of the DSR strategy (described in Section 2.4 and represented in Figure 2.8) which was applied in this research.

The locale of the case study is Cofimvaba in the Eastern Cape province of South Africa. Figures 5.3 and 5.4 show the location of the Eastern Cape and Cofimvaba schools, respectively.

Figure 5.3: Eastern Cape province in South Africa
(Source: Wikimedia, 2017)

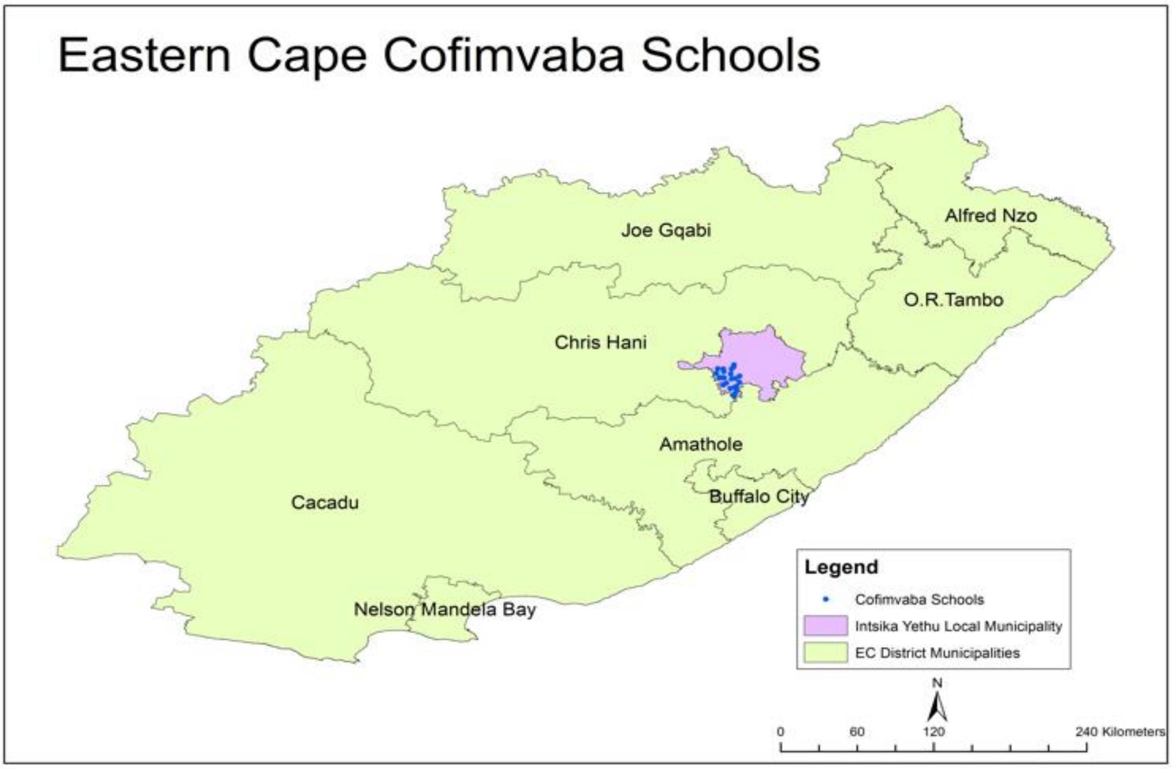


Figure 5.4: Eastern Cape province in South Africa – Cofimvaba schools

5.2.3 The school environment

Cofimvaba is a town with a population of about 9 000 people (8 783 people according to the 2011 Statistics South Africa census figures) (Statistics South Africa, 2011), and it is located in the Intsika yethu municipality as per Figure 5.4. The photos presented in this section show aspects of Cofimvaba and were taken during the course of the research (2014 - 2017). The main road from Queenstown to Cofimvaba is tarred (Photo 2). However, the roads from the Cofimvaba town centre to most schools are gravel roads (Photo 9). Schools are located close to villages and homesteads (Photos 4 and 11).

Mobile devices, earned by the schools through teachers' participation in the ICT4RED initiative (Photo 6), are stored in Mobikits (Photo 7). Photo 6 shows teachers using the tablets during an ICT4RED teacher professional training workshop. Schools have established gardens as part of TECH4RED (Photo 10) and hydrogen fuel cells have been provided to some schools to provide backup power (Photo 12).

Cofimvaba is considered to be a resource-constrained environment. Resource-constrained environments, as already indicated in Chapter 1, Section 1.1, are characterised by unfavourable economic circumstances and constraints such as electricity and network connectivity challenges and low-income communities (Anderson et al., 2012). Section 3.3 provides a detailed analysis of the challenges that the teachers and schools in Cofimvaba face. Section 5.3 presents the results of the case study based on data collected from teachers and district officials in Cofimvaba. ICT4RED occurred 2012 – 2014 and the case study was carried out 2014 - 2017.

	
Photo 1: Welcome sign	Photo 2: A homestead near the tarred road in Cofimvaba
	
Photo 3: Cofimvaba town	Photo 4: Villages in Cofimvaba

Cofimvaba town and villages

Photo 5: School children playing outside a school in Cofimvaba

Photo 6: Teachers using tablets during an ICT4RED training workshop

Photo 7: ICT4RED - Mobikits at one of the schools

Photo 8: Fence around one of the schools

School environment – Tablets used in the schools

	
Photo 9: Gravel road to one of the schools in Cofimvaba	Photo 10: TECH4RED – a garden at one of the schools
	
Photo 11: Fence around a school and a village in the background	Photo 12: TECH4RED - School's hydrogen fuel cells for backup power

School environment - different requirements that need to be addressed

5.3 RESULTS OF CASE STUDY

The data presented in this section were obtained from the case study, as described in Section 2.6.2.1, and collected from teachers and district officials in Phase 2 of the iterative process of the DSRM process illustrated in Figure 5.1. The findings presented reflect the perspectives of teachers (Section 5.3.2) and district officials (Section 5.5) on mobile technology integration in schools in resource-constrained environments thus addressing the research questions as stated in Section 5.1. Establishing teachers' perspectives is essential for mobile technology integration (Section 3.2.5.2). Educators' beliefs and attitudes towards technology use to support teaching are important factors in mobile technology integration into teaching (Chiu & Churchill, 2015). Teachers' positive attitudes toward technology use are associated with factors that support the continued use of technology for teaching (Blackwell et al., 2014; Drossel, Eickelmann & Gerick, 2016; Kim et al., 2013; Teo, 2012). Knowledge, beliefs, attitude and experience influence teachers' choices regarding technology use (Ritchie et al., 2013). The implications for the development of the SFMTIS are presented in Section 5.3.4.

Analysis of teachers' perspectives was applied through ATLAS.ti. This is in line with the triangulation strategy, discussed in Section 2.7, to enhance the validity of the findings.

5.3.1 Qualitative data analysis using ATLAS.ti

ATLAS.ti is a computer-based qualitative data analysis (CAQDAS) tool designed to enable development of codes which can be used to determine the frequency with which each code was cited by the respondents (Woolf, 2014). Teachers' responses to the open-ended questions in the questionnaire (Annexure 2.1) were compiled into a primary document that was analysed in the hermeneutic unit in ATLAS.ti by applying codes that were established for the purpose of analysing the data. Themes were also established for categorising the findings. Figure 5.5 is a cloud view of the codes applied in analysing the data using ATLAS.ti. The cloud view depicts similar results as shown in Figure 5.6 (Relative frequency (%) action recommended by teachers).

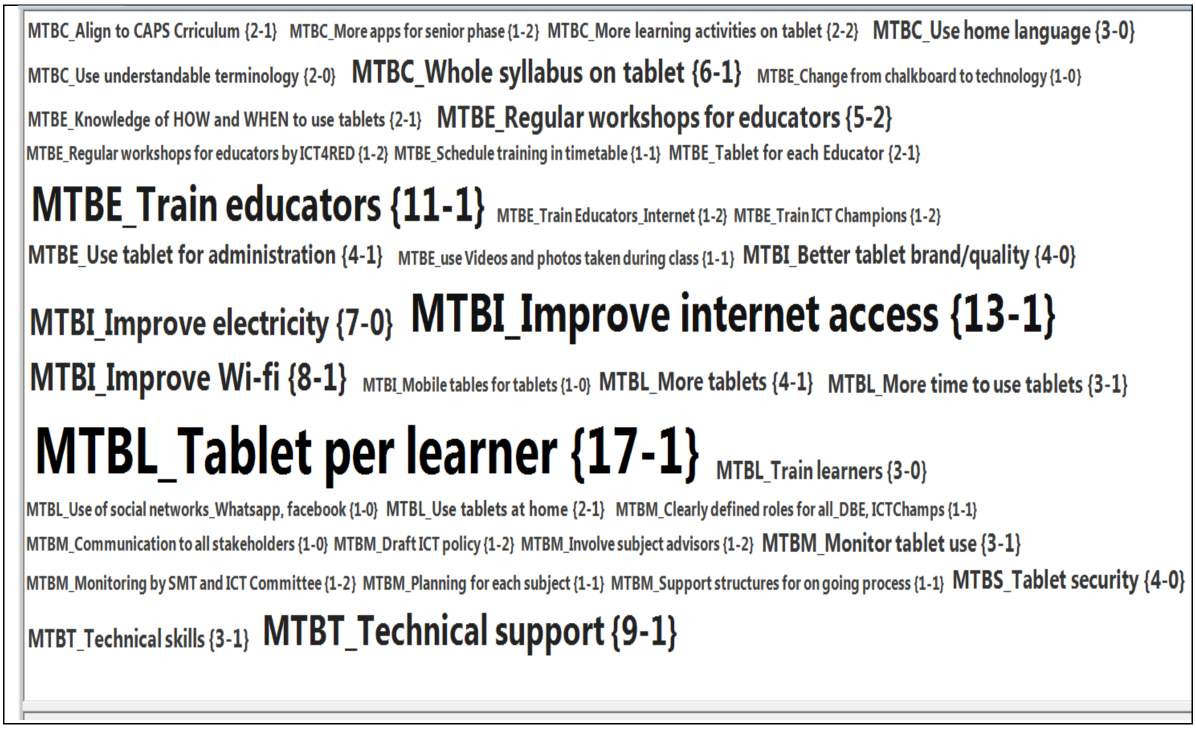


Figure 5.5: Cloud view of codes applied in primary document indicating teachers' views

Figure 5.6 illustrates the relative frequency in percentage (%) of the top ten recommendations by teachers.

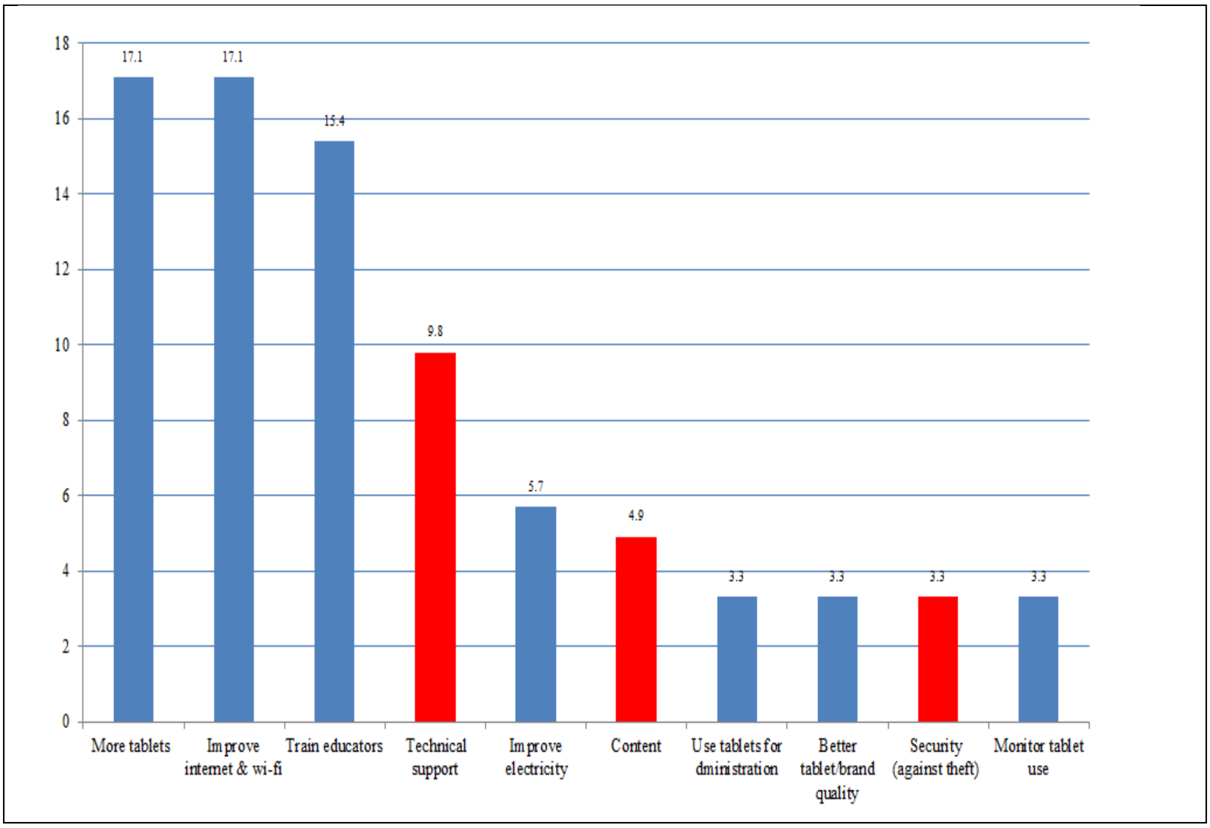


Figure 5.6: Relative frequency (%) action recommended by teachers
(Relative frequency [%] of quotations per code)

The analysed information shows that teachers were concerned about the infrastructure to support tablet technology use. Teachers noted that schools need to have adequate numbers of tablets for their learners to use, enabling individual use by learners. There were more concerns related to infrastructure which includes availability of mobile devices, Internet and W-Fi as well as electricity.

The top ten recommendations by teachers include: increasing the number of tablets in the schools (17.1%), with some teachers suggesting that each learner should have their own tablet. Additionally, improved Internet access and Wi-Fi connectivity (17.1%), technical support (9.8%), electricity (5.7%), quality or brand of tablets (3.3%) and tablet security/theft (3.3%) concerns were cited. The need for training of teachers in the use of tablets and the Internet through regular workshops was a major concern for teachers accounting for 15.4% of issues raised. Other concerns which teachers said should be addressed include access to the whole syllabus using the tablets (4.9%), the need for teachers to use the tablets for administration purposes (3.3%) and that the use of tablets by teachers should be monitored (3.3%). Additional matters which were each raised at about 2.0% include, the use of home language, more time to use tablets, train learners, align to CAPS curriculum, more learning activities on tablet, use understandable terminology, knowledge of how and when to use tablets, and a tablet for each teacher and for learners to be able to use the tablets at home.

Among the top ten concerns that teachers raised in the open-ended questions, there were three highlighted concerns, as shown in Figure 5.6, namely theft (security), technical support and sustained content availability for all the subjects. Teachers stated that they were concerned about these in informal discussions with the researcher during school visits. These observations are also supported by the quotations narrated in Sections 5.3.2.5, 5.3.2.6 and 5.3.2.8 for content, technical support and security, respectively. The following section discusses teachers' views on factors that affect mobile technology integration.

5.3.2 Teachers' views on factors that affect mobile technology integration

The questionnaire (Annexure 2.1) comprises of closed-ended and open-ended questions. Teachers' responses to the closed-ended questions in the questionnaire are summarised in Annexure 5.1 which shows the percentage (%) of teachers who selected each option of the 5-point Liekert scale. These results are presented as *bar charts* and are discussed together with teachers' responses to the open-ended questions in the relevant themes identified from the qualitative analysis with ATLAS.ti (Sections 5.3.2.1 to 5.3.2.13).

The open-ended questions that the teachers responded to in the context of the ICT4RED initiative in which they had previously participated were:

- *List three things, starting with the most important, of what should be done to make things even better?*
- *What are the main things that currently affect teachers' ability at your school to use the tablets for teaching?*
- *What concerns you the most regarding the use of tablets at your school in future?* and
- *What are the steps that can be taken to reduce your concerns?*

Teachers' responses to the questions provided were analysed through thematic analysis (Chapter 2, Section 2.6.3) to provide insights into their perspectives regarding mobile technology integration at their schools. Teachers' responses to the open-ended questions are presented for each of the identified themes as quotations.

Each of the themes is presented in the following structure:

(a) Teachers' responses to related closed-ended questions in the questionnaire (Annexure 2.1) presented graphically (bar charts);

(b) Findings from the open-ended questions in the questionnaire (Annexure 2.1) presented as quotations; and

(c) Observations.

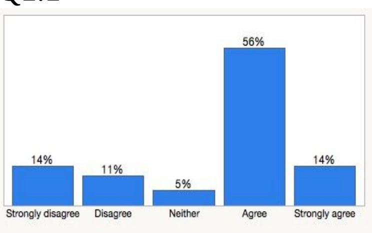
The themes that are discussed in the following sections are: network, Internet access and Wi-Fi connectivity; tablets; leadership; teacher professional training and capacity building; content; technicians and technical support; electricity; security against theft of tablets; monitoring; information and knowledge management; policies and guidelines; financial/economic and holistic approach. The positive (benefits) and negative outcomes stated by teachers are presented in Section 5.3.3.

5.3.2.1 Networks, Internet access, Wi-Fi connectivity

Figure 5.7 depicts teachers' responses to close-ended questions Q1.1 - Q1.6 in the questionnaire as per Annexure 2.1. The responses to Q1.1 indicate that 70% of the teachers agreed (14% strongly agree + 56% agree) that teachers can connect to the Internet whenever they need and 25% disagreed (14% strongly disagree + 11 % disagree). Q1.2 shows that most teachers (72%) agreed that they can access the digital content available in the school servers

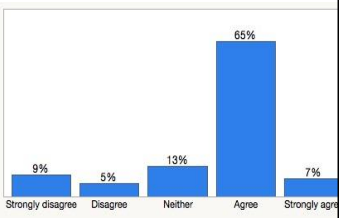
(7% strongly agree + 65% agree). The responses to Q1.3 indicate that 67% of the teachers can access digital content on the tablets and work offline (13% strongly agree + 54% agree) and 22% disagreed (11% strongly disagree + 11% disagree). The responses to Q1.4 indicate a lack of technicians locally who are able to help solve issues quickly when the school ICT network gives problems. There were mixed responses from teachers regarding the amount of time it took to resolve connectivity problems, Q1.4, as 54% disagreed (28% strongly disagree + 26% disagree). Some teachers 24% agreed (5% strongly agree + 19% agree), and 21% neither agreed nor disagreed that there are local technicians to provide technical support.

Q1.1



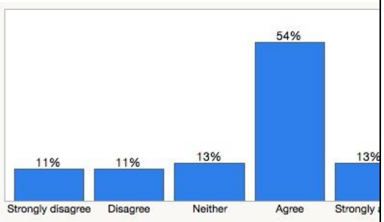
Teachers at my school are able to connect to the Internet whenever they need to.

Q1.2



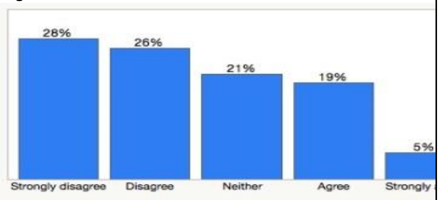
I can access content on the server when I need to use it for teaching.

Q1.3



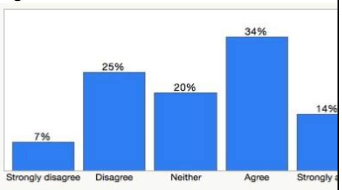
I can use the content on the tablets when I work offline (e.g. without connecting to the Internet).

Q1.4



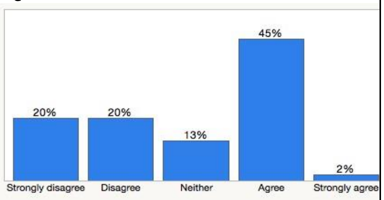
There are local people who are able to help solve issues quickly when the school ICT network gives problems.

Q1.5



We have to wait for long periods to have connectivity problems solved.

Q1.6



The computer systems installed at my school can be fully remotely managed online by a team of ICT experts (without physically coming to the school).

Figure 5.7: Connectivity

Responses to open-ended questions relating to the network infrastructure and connectivity, indicate that teachers consider Internet access as important. Teachers stated that they can access lesson plans from specific sites such as “Thutong”, “Quick Mathematics”, and similar sites using the Internet. Teachers indicated a need for improving the network coverage and Wi-Fi connection, as evident from the following quotations relating to requests regarding the Internet.

Quotations: Networks, Internet access, Wi-Fi connectivity
Participant 40: *“Network coverage”* Participant 43: *“Access to Internet in all classes”*

Participants 29, 30, 32: *"Bad Internet connection"* Participant 35: *"Internet is not connected. Fix Internet problem"* Participant 36: *"Fixing the Wi-Fi. Connectivity to the Wi-Fi problematic"* Participant 26: *"Wi-Fi and Internet connection"* Participant 40: *"Wi-Fi in a single classroom. If the Wi-Fi can be connected to other classrooms e.g. in the Intermediate phase and all classrooms"*

These findings indicate that *technological sustainability* considerations should include improving Internet access, school ICT infrastructure maintenance and technical support. Aspects of *institutional sustainability* that would need deliberation are specifying roles and responsibilities, information management within the organisation and how communication is facilitated. For example, clarifying and communicating *who* should maintain the ICT infrastructure at the schools such as server information, content on server, passwords and changing of passwords. Similarly, the *roles and responsibilities* of school ICT Champions and district based subject education specialists (subject advisors) could be communicated. The findings also indicate a need for *information* regarding maintenance to be appropriately *managed and communicated* in order to *inform policies, processes and strategies* at micro (school) and meso (district) levels. Data on Internet usage (*who* uses the Internet, *when* and *what* do they access) could be collected and the information used to inform *policies, processes and strategies.* Appropriate Internet use could be supported by providing information and guidelines regarding Internet security and communicating the school, learners and teachers' responsibilities regarding digital literacy, including cybersecurity.

5.3.2.2 Tablets

Teachers' responses to the closed-ended question pertaining to tablet availability indicate that mobile devices are available for use to 89% (50% strongly agree + 39% agree) of the teachers whenever teachers need them for use with learners (Q1.7). Sixty three percent (15% strongly agree + 48% agree) of the responses show that teachers agreed that the computer systems at their schools function well and 14% disagreed (7% strongly disagree + 7% disagree), while 22% neither agreed nor disagreed (Q1.8). Teachers' responses regarding the turnaround times in fixing tablets were varied. There were 38% of the teachers (7% strongly agree + 31% agree) who agreed with the statement that tablets are fixed quickly whenever they need to be fixed, however 45% (19% strongly disagree + 26% disagree) and 17% neither agreed nor disagreed (Q1.9). These findings suggest that technical support, technicians and financial resources are required to timeously maintain the tablets and school ICT systems. Teachers' responses suggest that turnaround times for fixing the tablets requires improvement.

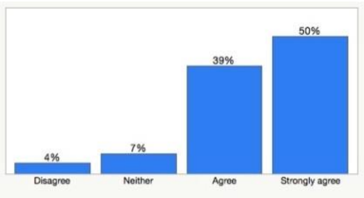
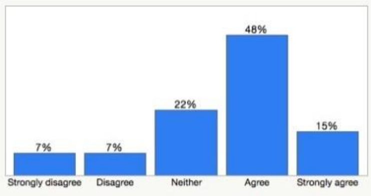
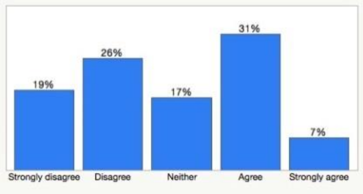
Q1.7	Q1.8	Q1.9
		
Tablets are available for use whenever I need to use them with my learners.	The computer systems at my school function well.	Tablets are fixed quickly whenever they need to be fixed.

Figure 5.8: Devices

Teachers' responses to the open-ended questions indicate that tablet selection and the quality of the tablets acquired are important considerations in mobile technology integration. In addition, financial consideration relates to: tablet acquisition, securing of mobile devices and ICT equipment from theft, maintaining the devices and software and technical support. The following quotations are provided to support these findings:

Quotations: Tablets

Tablet selection and quality
Participant 23: *"Good brand of tablets"*
Participant 25: *"The technical problems in tablets. Some not functioning well"*
Participant 32, 34: *"Quality of the tablet"*
Participant 40: *"Each learner must have a tablet which is in good order"*

Maintenance
Participant 26: *"Maintenance of tablets"*
Participant 40: *"Tablets which are not in good order. Tablets should be maintained"*

Number of tablets available and management:
Participant 27: *"We cannot use the tablets at the same time because they are few"*
Participant 28: *"All teachers should have their own tablets"*
Participant 33: *"Availability of tablets for new teachers"*
Participants 36, 40, 41, 44: *"Each learner must have his/her tablet"*
Participant 40: *"Number of tablets that is not equal to the number of learners"*
Participant 45: *"One learner, one tablet as it was for textbooks"*

Security against theft:
Participant 20: *"It would be a great shame and frustration to the learners if the tablets could get stolen by burglars"*

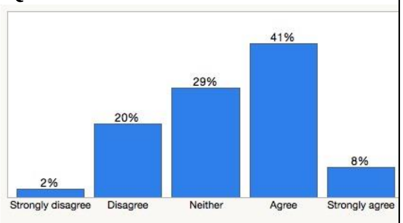
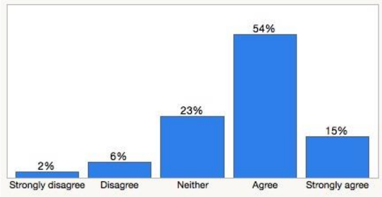
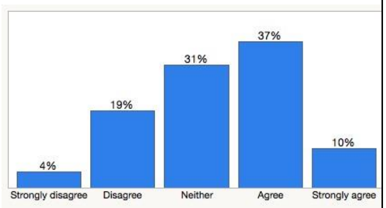
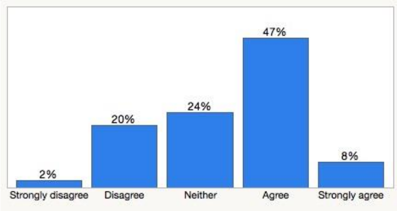
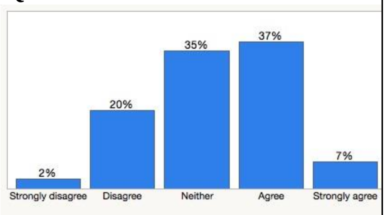
The responses indicate the *financial* and *technological sustainability* considerations that need to be made. The costs of maintaining, securing and replacing the tablets need to be included in strategic planning and budgeting. Appropriate tablet selection models could be identified and applied for selecting appropriate tablets for schools. This supports previous research that the initial investments need to consider affordability, ongoing support and maintenance (Meyer & Marais, 2014). A "multi-criteria technology selection model" can be applied in tablet selection in resource-constrained environments (Meyer & Marais, 2014). This requires that guidelines, criteria and standards on the selection of tablets be objective, deliberate and thought through, and that the mobile devices be suitable for use by learners in the environment, durable with screens that do not break easily and not easily affected by dust.

The management of tablets requires that schools, with district support, identify and communicate information regarding tablet management: *who* will maintain software on tablets and maintain and repair devices when they malfunction, or deal with broken ports or screens, and *who* will manage information and identify *where* funds for infrastructure maintenance must come from. There is also a need to identify reporting processes, thus *how* do teachers log and maintain information regarding hardware and software faults.

5.3.2.3 Leadership

Teachers' responses to closed-ended questions regarding leadership indicate that 49% of the teachers' agreed (8% strongly agree + 41% agree) that the role of the local subject education specialists/subject advisors in supporting the ICT4RED project is clearly defined, and 22% disagreed (2% strongly disagree + 20% disagree), and 29% neither agreed nor disagreed (Q1.13). There were 69% responses that agreed with the statement that the role of the ICT Champion is clearly defined (Q1.14). Only 47% (10% strongly agree + 37% agree) agreed with the statement that the role of the National Rural Youth Service Corps (NARYSEC) in supporting the ICT use at the school is clearly defined (Q1.15).

Twenty two percent disagreed (2% strongly + 20% disagree), and 35% neither agreed nor disagreed that the role of the education developmental officers in supporting the ICT4RED initiative is clearly defined (Q1.16). Responses regarding leadership at district level indicate that there were 47% respondents (7% strongly agree + 37% agree) who agreed with the statement that there is capacity at district level to provide support for the ICT4RED project in the schools (Q1.17). These findings suggest the need to capacitate the district to enable its continued support of the ICT4RED initiative.

<table>
<tr>
<td>Q1.13
</td>
<td>Q1.14
</td>
<td>1.15
</td>
</tr>
<tr>
<td>The role of the local subject advisors in supporting the ICT4RED project is clearly defined.</td>
<td>The role of the ICT Champion is clearly defined.</td>
<td>The role of the National Rural Youth Service corps (NARYSEC) in supporting the ICT use at the school is clearly defined.</td>
</tr>
<tr>
<td>Q1.16
</td>
<td>Q1.17
</td>
<td></td>
</tr>
<tr>
<td>The role of Education Developmental Officers (EDOs) in supporting the ICT4RED project is clearly defined.</td>
<td>There is capacity at district level to provide support for the ICT4RED project in the schools.</td>
<td></td>
</tr>
<tr>
<td colspan="3">Figure 5.9: Organisational leadership</td>
</tr>
</table>

Teachers' responses to open-ended questions regarding leadership indicate that leadership is essential at all levels of the education system, from school (micro) level, district and circuit (meso) level, to provincial and national (macro) level. Monitoring and support are activities which the teachers suggested were mandatory. The following quotations are provided to support these findings:

Quotations: Leadership
(a) Macro level – National and Provincial Leadership
➢ Oversight:
Participant 26: *"Intervention by the Department of Education both at national and provincial"*
Participant 27: *"The Department of Education to be hands on in this programme. Follow up"*
Participant 28: *"The visits from ICT4RED to check the situation here would help"*
➢ ICT specialised unit:
Participant 17: *"DBE has to devise means to organise an office with permanent employees that are skilled in this are (i.e. ICT), who will specifically focus or be responsible for ICT related programmes, problems and all, who will always be there to provide solutions within an appropriate time"*
(b) Meso level – School District and Circuit leadership
Participant 22: *"Involvement of subject advisors"*
Participant 25: *"Regular monitoring by the office of education in the district checking the usage and the condition of the tablets."*
(c) Micro level – School leadership
Participant 36: *"Monitoring by School management team (SMT) and ICT Committee*

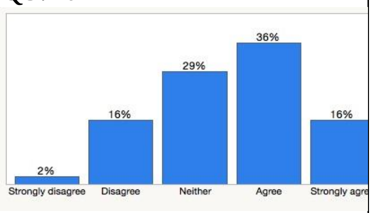
These findings suggest *institutional sustainability* requirements in relation to ICT reporting and monitoring structures and processes, and the roles and responsibilities that need to be fulfilled to sustain mobile technology integration. Teachers noted the need for monitoring and leadership at school and district levels.

5.3.2.4 Teacher professional training and capacity building

Teachers' responses to the closed-ended questions regarding the use of computers for teaching indicate teachers' high confidence levels in using mobile devices and applications such as word processing applications e.g. MS Word and presentations applications such as MS PowerPoint. Fifty two percent of the teachers (16% strongly agree + 36% agree) agreed that they are confident in their ability to use computers when teaching (Q5.10), while 85% (25% strongly agree + 60% agree) agreed that they use mobile tablets when teaching (Q5.13). Sixty three percent (26% strongly agree + 37% agree) of the respondents agreed that they are confident in their ability to use word processing application such as MS Word (Q5.11). Fifty five percent (20% strongly agree + 35% agree) that they are confident in their ability to use presentations applications such as MS PowerPoint (Q5.12). The high confidence levels in ICT use that teachers indicated was expected as the teachers had been trained when the ICT4RED initiative was implemented.

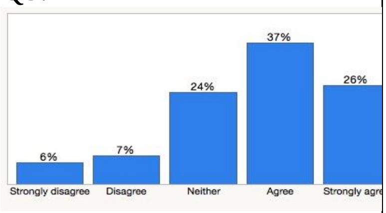
"I am confident in my ability to:"

Q5.10



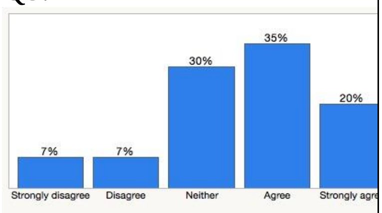
Use computers when teaching.

Q5.11



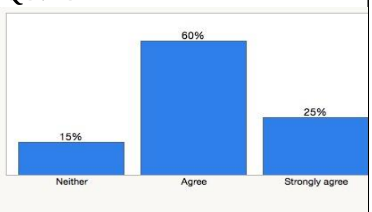
Use word processing applications (e.g. MS Word).

Q5.12



Use presentations applications (e.g. MS PowerPoint).

Q5.13



Use mobile tablets for teaching.

Figure 5.10: Teacher professional training and capacity building

Teachers' responses to open-ended questions support the earlier findings that show that teachers benefited from the ICT training provided to them through the ICT4RED programme and were confident in using tablets when teaching. Teachers stated that training and workshops should occur continuously for teachers to share information and refresh their knowledge. Teachers suggested that training should be provided to new teachers, and that school ICT Champions could be given more enhanced training to better equip them for their facilitating role. Participant 40 stated that: *"If our champions (School ICT Champions) can be fully trained to help learners in connectivity and spread advanced information to all stakeholders".* The following quotations support the findings regarding teachers' views on teacher professional training and capacity building:

Quotations: Teacher professional training and capacity building
Participant 15: *"Quarterly workshops done by department through subject advisors (subject education specialists)"* Participants 18, 19: *"Train teachers"* Participant 28: *"Lack of training: teachers should get training on how to use the tablets"* Participants 33, 34: *"More workshops"* Participants 33, 35: *"Training of new teachers"* Participant 40: *"NARYSEC (Assistants) to be more empowered"* Participant 55: *"Training on technical skills, on learner as well as teachers' tablets"*

The findings suggest that teachers support refresher workshops and training in relevant ICT courses that teachers can access, or attend, regularly. The guidelines/policy regarding the number of hours available to teachers for training per year needs to be communicated, and teachers should be encouraged to use the time allocated to teachers for training. The professional development (PD) points system could be applied to encourage teachers to develop their ICT skills and effectively use the SACE continuous professional teacher development management system (Section 3.3.6.5).

Schools and the district could encourage teachers to participate in ICT training courses provided by the Department of Basic Education and online courses available to teachers such as open educational resources (OERs). This requires that relevant information regarding ICT teacher professional training be communicated to Head teachers, School Management, ICT Committees and teachers. Teachers' training could be monitored and managed through the department's systems. Financial resources and personnel are required to implement strategies for teacher professional development in ICT use. These could be catered for within the *institutional* sustainability dimension.

5.3.2.5 Digital content

Teachers' responses to closed-ended questions regarding digital content indicate that 72% agreed (13% strongly agree + 59% agree) that they know what content is available to them on the school server that they can use for teaching, 13% disagreed (9% strongly disagree + 4% disagree) and 16% neither agreed nor disagreed (Q2.1).

Seventy eight percent (23% strongly agree + 55% agree) of teachers agreed that the e-books provided were aligned to the CAPS (National Curriculum and Assessment Policy Statement) curriculum (Q2.2) and 54 % agreed (7% strongly agree + 47% agree) that they could easily incorporate the e-books content in the server to their lesson plans (Q2.3).

Teachers' responses indicate that 47% agreed (9% strongly agree + 38% agree) that the e-books' content is relevant to their cultural context and 47 % neither agreed nor disagreed with the statement (Q2.4). Fifty five percent of the teachers (7% strongly agree + 48% agree) teachers agreed that they often find themselves asking the question: How is the content on the server relevant to the CAPS curriculum? (Q2.5).

Seventy seven percent agreed (20% strongly agree + 57% agree) that they know how to incorporate the content on the tablets to the CAPS curriculum (Q2.6). Seventy five percent of the teachers agreed that they know who to contact when they have questions regarding content on the server (Q2.7). The responses indicate that 52% agreed (2% strongly agree + 50% agree) that they use the digital content available on the school server, such as e-books, in their daily teaching (Q2.8).

There were 45% (13% strongly agree + 32% agree) teachers who were concerned that in future the content in the server (e-books) will not be maintained (kept up-to-date) (Q2.9). There were 47% (4% strongly agree + 43% agree) that the Department of Basic Education (DBE) will be able to keep the content on the server up-to-date for the next 5 - 10 years (Q2.10).

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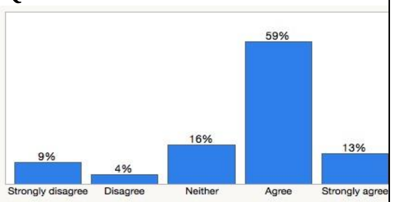
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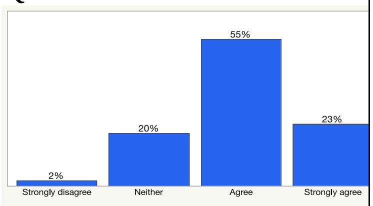
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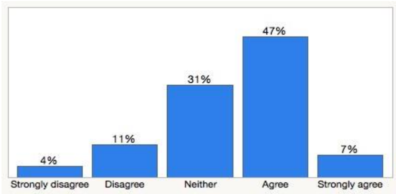
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</tr>
<tr>
<td>I know what content is available to me on the school server which I can use for teaching.</td>
<td>The e-books provided are aligned to the CAPS (National Curriculum and Assessment Policy Statement) curriculum.</td>
<td>I can easily incorporate the e-books content in the server to my lessons.</td>
</tr>
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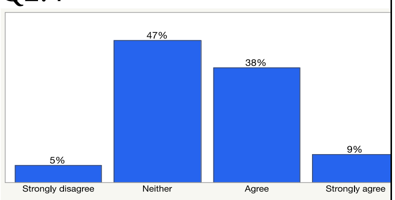
<td>Q2.4

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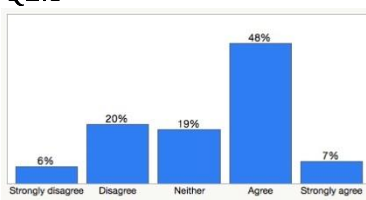
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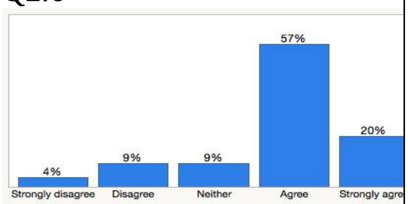
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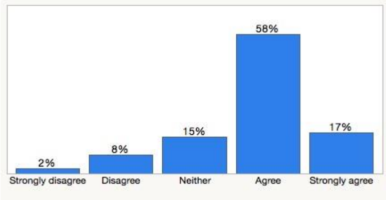
</table>

<table>
<tr><td>The e-books’ content is relevant to our cultural context.</td><td>I often find myself asking the question: “How is the content on the server relevant to the CAPS curriculum?”</td><td>I know how to incorporate the content on the tablets to the CAPS curriculum.</td></tr>
<tr><td>Q2.7

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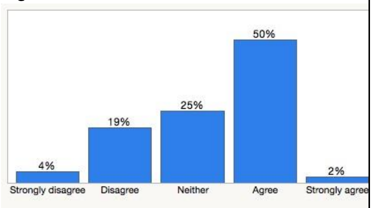
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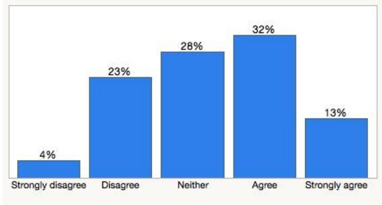
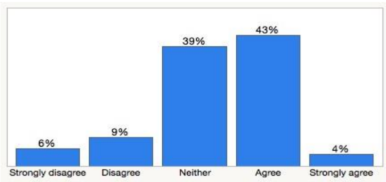

</td></tr>
<tr><td>I know who to contact when I have questions regarding content on the server.</td><td>I use the content on the server, such as e-books, in my daily teaching.</td><td>I am concerned that in future the content on the server (e-books) will not be maintained (kept up-to-date).</td></tr>
<tr><td>Q2.10

</td><td></td><td></td></tr>
<tr><td>The Department of Basic Education (DBE) will be able to keep the content on the server up-to-date even in the next 5 – 10 years.</td><td></td><td></td></tr>
<tr><td colspan="3">Figure 5.11: Content</td></tr>
</table>

Teachers’ responses to open-ended questions regarding digital content indicate teachers support increasing the digital content to be comprehensive and that the Internet is important in accessing digital content available on the Department of Basic Education’s websites and online resources. Teachers also indicated that monitoring, evaluation and support are required in order to maximise the use of digital content available on tablets and school servers. Teachers noted that the amount of available digital content varies for different subjects. Participant 49 noted that: “*Teachers are using tablets but the problem is not all subjects are loaded in the tablets”.* Participant 54 stated that: *“As a language teacher what I have observed is that our tablets are not fully loaded with our content as well as e-books are not available” and* Participant 35 suggested: *“Installation of Literature books (e-books) and videos for IsiXhosa (local language)”.*

The department’s implementation strategy regarding digital content availability for different subjects should be communicated to teachers. Teachers also noted that it is important to ensure that digital content (e-books and workbooks) for all the subjects was loaded onto the tablets and servers and that this content should be Curriculum Assessment Policy Statements (CAPS) aligned. This was an unexpected finding as the content installed during the ICT4RED programme was CAPS aligned. The following quotations are provided to support these findings:

Quotations: Content
Comprehensive digital content in tablets and accessible through school server Participant 22: *"All subjects in one thing"* Participant 29: *"Even if there is a shortage of textbooks at school, we can find the textbooks"* Participant 35: *"Installation of literature books for IsiXhosa (local language)"* Participant 40: *"Teachers' tablets which have no workbooks"* Participant 49: *"Teachers are using tablets but the problem is not all subjects are loaded in the tablets"* Participant 54: *"Upload a lot of content for different subjects"* **Maintenance of digital content** Participant 26: *"Updating the content on the server"* Participant 55: *"Regular update of the content on the server"* **Guidance/leadership** Participant 31: *"That the learners must be aware that there are these apps and they contain this and that also what is expected of them must be clear"*

Based on these findings, the Department of Basic Education's long-term strategy regarding digital content would need to be well communicated. The White paper on e-Education advocates for a *blended approach* in the use of learning and teaching support material (LTSM), stating that digital resources in e-schools should be complimented by conventional print media and radio broadcasts (DoE White paper, 2004). However, some teachers may consider that tablets and digital content will become central.
Participant 14 stated: *"So that teachers can be able to do classwork, tests, homework, etc. from their tablets"*. Relevance and complexity may influence teachers' use of content available on tablets or servers, therefore appropriate content should be maintained on tablets and severs.

Teachers' roles and responsibilities regarding content on the server needs to be clarified and communicated to them. The school ICT committee should ensure that responsibilities for the following are assigned: communicating ICT content available on the server, digital content maintenance, and licensing for digital content such as e-books. The long-term strategy should be communicated to teachers. For example, whether digital content will replace textbooks. The content on tablets and servers should be maintained and access to the content on the servers should be managed. *Communication platforms*, *processes* and *individuals responsible* for reporting content related issues should be identified and all stakeholders informed. Roles and responsibilities of schools and districts should be clearly stated and communicated. Relevant information that can inform policies, processes and strategies should be *identified, recorded* and *communicated (information and knowledge management).*

5.3.2.6 Technicians and technical support

Teachers' responses to closed-ended questions indicate that 55% disagreed (22% strongly disagree + 33% disagree) that there are local people who are able to help solve issues quickly when the school ICT network gives problems (Q3.6) Forty six percent agreed (13% strongly agree + 33% agree) that they have to wait for long periods to have connectivity problems resolved (Q3.7). Fifty three percent disagreed (21% strongly disagree + 32% disagree) with the statement that tablets are fixed quickly whenever they need to be fixed (Q3.8).

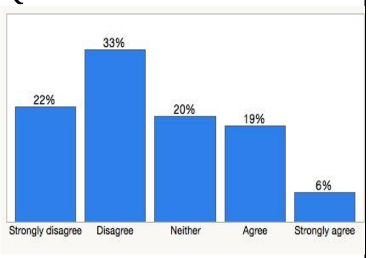
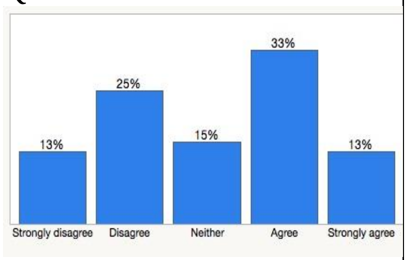
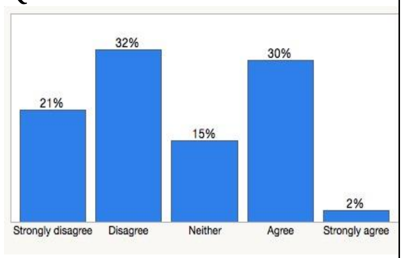
Q3.6	Q3.7	Q3.8
		
There are local people who are able to help solve issues quickly when the school ICT network gives problems.	We have to wait for long periods to have connectivity problems solved.	Tablets are fixed quickly whenever they need to be fixed.

Figure 5.12: Technicians and technical support

Teachers' responses to closed-ended questions indicate that they view technicians as important in assisting them when technical problems in the ICT systems and devices at the schools occur. Technical problems that teachers encounter include apps that "disappear" from tablets and connectivity problems. The following quotations are provided to support these findings:

Quotations: Technicians and technical support
Technicians Participant 22: *"Technician around the school"* Participant 23: *"We need some technicians to help us to maintain tablets"* Participant 25: *"Technicians must be organised for each and every school"* Participant 26: *"Technical support"* Participant 34: *"Train people to go to schools to fix the Internet problems"* Participant 35: *"Ensure that apps do not just remove themselves in teachers' tablets"*

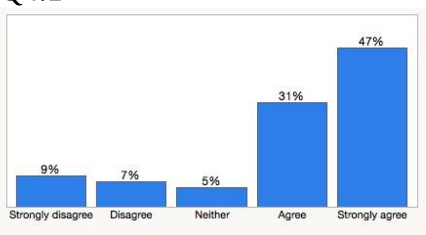
Technical support
Participant 26: *"How to deal with trouble shooting"* Participant 31: *"Lack of people to assist in charging and distribution of tablets to various classes"* Participant 55: "*A support system to make this an ongoing process"*

These findings indicate that technicians are required in order to provide technical support to system users, teachers and learners and to identify and solve hardware and software faults. The timeous attendance to connectivity issues requires that the processes to be followed when reporting ICT faults and logging incidents should be clearly outlined and communicated.

5.3.2.7 Electricity

Teachers' responses to close-ended question regarding electricity access, Q4.1, show that most schools (78%) have access to electricity (47% strongly agree + 31% agree). There is however a small proportion of teachers that indicated that electricity is not available for charging tablets as 16% disagreed with the statement that electricity is available to charge tablets, and 5% neither agreed nor disagreed. The finding that a small proportion of schools have electricity challenges is unexpected since access to "electrical power" is included in the definition of resource-constrained environments, as described in Section 1.1.

Q4.1



Electricity is available for us to charge the tablets.

Figure 5.13: Electricity

The following quotations are statements of teachers that have electricity challenges at their schools:

Quotations: Electricity
Participant 38: *"Having no electricity in lower classroom affects teachers, especially if you want to charge tablets"* Participant 43: *"Installation of electricity"*

Participant 44: *"Electricity for charging tablets. Installation of electricity in our school"*

The policies and implementation strategies in the Department of Basic Education considers school infrastructure, in this case electricity supply, as essential. Electricity supply to schools and addressing schools' power needs require intervention of relevant government departments, local municipalities and basic education officials at district, province and school management levels, depending on the specific challenges facing the schools.

5.3.2.8 Security

Teachers' responses to closed-ended questions regarding security of mobile devices against theft show that 50% agreed (15% strongly agree + 35% agree) that good security is available at their schools for mobile devices and other ICT equipment (Q4.2). There were teachers who indicated that there had been attempts to steal ICT equipment at some of the schools, as 52% agreed (17% strongly agree + 35% agree) to the statement and 33% disagreed (Q4.3). Most teachers' responses to Q4.4 indicate their concern that the tablets could be stolen as 62% agreed (34% strongly agree + 28% agree) to the statement.

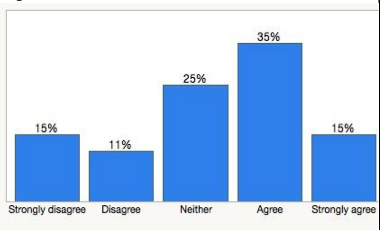
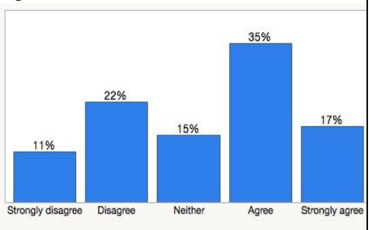
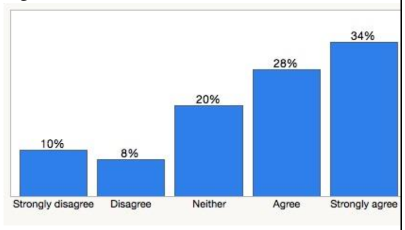
Q4.2	Q4.3	Q4.4
		
There is good security at the school for the ICT equipment (e.g. tablets, servers, charging stations).	There have been attempts to steal ICT equipment (e.g. tablets, computers) at the school.	I am concerned that the tablets can be stolen.

Figure 5.14: Security

Teachers' responses to open-ended questions show that there are schools that have adequate security measures to ensure the safety of the tablets, however, security at some schools need to be upgraded. The following quotations indicate statements made by teachers that considered their school's security as inadequate:

Quotations: Security
Participant 31: "*Cyber bullying and the misuse of these apps e.g. YouTube"*   Participant 32: *"Safety of the gadgets. Enhance security"*   Participant 36: *"Beefing up other alternative measures for security (spray security, mesh wire with spikes"*

Participant 38: *"Although the school tries to make tablets to be secured, criminals persist to take tablets at schools"* Participant 36: *"Safety as we only rely on Red Guard (local security company). Safety of the room for ICT to be beefed up"* Participant 45: *"Installation of security measures"*

Based on these findings, security of mobile devices and ICT equipment is important for sustaining mobile technology integration to support teaching. Consequently, schools, with district support need to assess the costs associated with securing the tablets, assign responsibility for security, plan for security costs and find cost-effective and efficient ways to implement security measures against theft. The responses from teachers seem to focus on physical security which seems to be teachers' major concern. There is also an indication that teachers are concerned with cyber-security, as stated by Participant 31: *"Cyber bullying and the misuse of these apps*".

Cyber-security is an important consideration when using mobile devices and accessing the Internet. Digitally literate individuals can behave appropriately in online activities, based on their understanding of Internet security issues, and protect themselves from harm in digital environments. Increased use of mobile devices to access the Internet also exposes teachers and learners to viruses, hacks and malware that could be maliciously propagated. All this requires increased emphasis on providing guidelines and measures towards information security in relation to passwords (changing passwords and creating complex passwords), e-mails (unsolicited and suspicious e-mails) and the use of anti-virus software. Awareness of these issues among teachers and learners is essential. A strategy for integrating mobile devices to support teaching would need to incorporate well-defined security protocols in addition to ensuring the physical security of infrastructure.

5.3.2.9 Monitoring

The responses to closed-ended questions Q1.5 to Q5.9 show that large percentages of teachers use mobile tablets. Teachers' responses indicate that eighty percent agreed (13% strongly agree + 67% agree) that they use mobile tablets for presenting information to the whole class (Q5.1). There were 80% (13% strongly agree + 67% agree) that agreed that they use the tablets for teaching learners in small groups (Q5.2).

Based on teachers' responses, 79% agreed (20% strongly agree + 59% agree) that they use the tablets to assist learners with investigative or exploratory activities (Q5.3). There were 71% of the teachers that agreed (19% strongly agree + 52% agree) that they use the tablets for assessing learners by means of tests or exercises (Q5.4). There were 67%

responses from teachers (9% strongly agree + 58% agree) who indicated that they use the tablets to manage their classes effectively (Q5.5). Seventy eight percent (25% strongly agree + 63% agree) indicated that that they used the tablets to facilitate collaboration (learners' learning by working together) and team building among learners (Q5.6). Teachers' responses also show that 79% (22% strongly agree + 67% agree) of them use the tablets for managing (organising, supporting and monitoring) collaborative work done by the learners (Q5.7).

Based on the teachers' responses, a large proportion of teachers, 72% (20% strongly agree + 52% agree) used the tablets to browse the Internet for information related to teaching, while 23% disagreed (4% strongly disagree + 19% disagree) and 6% neither agreed nor disagreed (Q5.8). The responses indicate that 56% of the teachers agreed (19% strongly agree + 37% agree) that they use social media, such as Facebook and Twitter, when teaching and 26% disagreed (11% strongly disagree + 15% disagree) and 19% neither agreed nor disagreed (Q5.9).

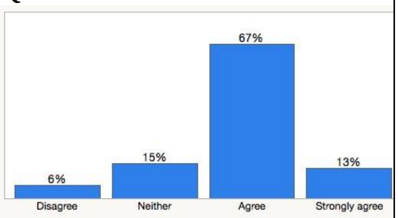
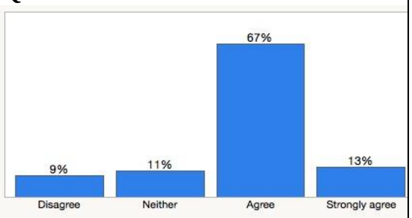
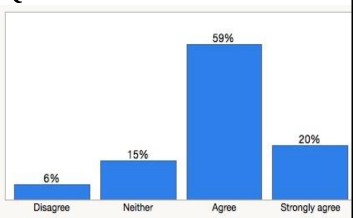
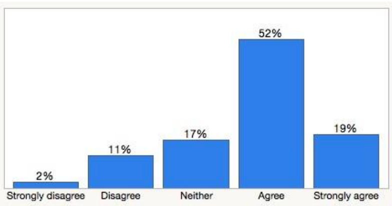
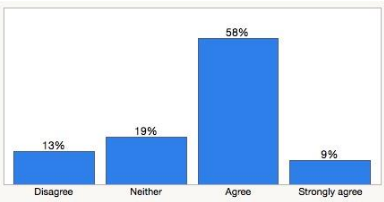
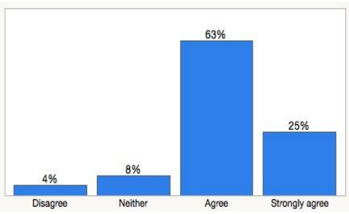
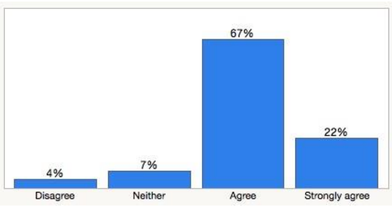
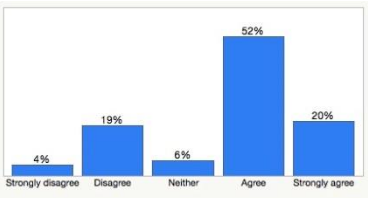
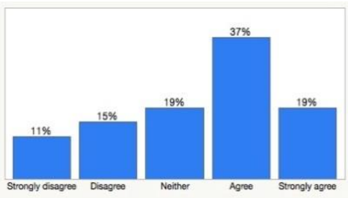
<table>
<tr><td colspan="3">"When teaching I use mobile tablets for…"</td></tr>
<tr>
<td>Q5.1

</td>
<td>Q5.2

</td>
<td>Q5.3

</td>
</tr>
<tr>
<td>Presenting information to the whole class.</td>
<td>Teaching learners in small groups.</td>
<td>Assisting learners with activities where they make investigations (exploratory).</td>
</tr>
<tr>
<td>Q5.4

</td>
<td>Q5.5

</td>
<td>Q5.6

</td>
</tr>
<tr>
<td>Assessing learners through tests or exercises.</td>
<td>Managing my classes more effectively.</td>
<td>Facilitating collaboration (learners' learning by working together) and team building among learners.</td>
</tr>
<tr>
<td>Q5.7

</td>
<td>Q5.8

</td>
<td>Q5.9

</td>
</tr>
<tr>
<td>Managing (organising, supporting and monitoring) collaborative work done by learners.</td>
<td>Browsing the Internet for information related to teaching.</td>
<td>Social media (e.g. Facebook or Twitter).</td>
</tr>
</table>

Figure 5.15: Technology integration

Based on these findings, the use of the tablets in teaching varies amongst the teachers, and the tablets are not used for *all* the activities by *all* the teachers. For example, 23% indicated that they do not use tablets to browse the Internet when teaching. This suggests that organisational reporting and monitoring mechanisms are necessary to identify teachers' use of mobile devices for teaching and thus identify challenges encountered by teachers. Monitoring and evaluation can help to identify and communicate benefits of teachers' use of the tablets as well as challenges experienced which can then inform policy and strategy at different organisational levels. Districts' support and oversight responsibilities for schools necessitates communication and coordination with schools and provincial offices. Teachers' responses to open-ended questions suggest the need for monitoring and support to be provided by ICT committees, subject education specialists and other district officials. These are aspects of *institutional sustainability*. The following quotations are provided to support these findings:

Quotations: Monitoring	
Participant 18:	*"Teachers only concentrate (on) apps that are not mostly relevant to their subject"*
Participant 25:	*"Regular monitoring by the office of education in the district checking the usage and the condition of the tablets"*
Participant 26:	*"Intervention by the Department of Education both at National and Provincial level."*
Participant 28:	*"Visits from ICT4RED to check the situation would help."*
Participant 36:	*"Monitoring by SMT (School Management Team) and ICT Committee*
Participant 37:	*"Monitoring the use of technology"; "Monitor tablet use"*
Participant 41:	*"Monitoring the use of technology. Check-ups and assessment"*
Participant 41:	*"Overseeing that all the problems raised are being taken care of"*

Based on these findings, it seems important that there should be alignment in the strategies applied to sustain mobile technology integration to support teaching at different levels of the education system: micro (school), meso (circuit and district) and macro levels (provincial and national). The *institutional sustainability* dimension thus encompasses various aspects, including the need for monitoring and support and identifying the benefits and objectives for the use of mobile devices in schools. These benefits need to be clearly communicated to teachers to encourage their participation in strategies to sustain tablet use at schools whilst, in addition, developing and aligning appropriate policies and strategies.

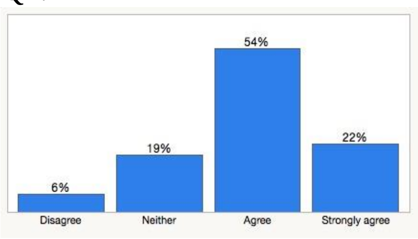
5.3.2.10 Information and knowledge management

Teachers' responses to the closed-ended questions relating to reporting and record keeping, indicate that there is high accountability in terms of reporting. Most teachers (76%)

agreed (22% strongly agree + 54% agree) that they can produce records to show how they use tablets in their lessons (Q7.1), 6% disagreed (6% strongly disagree) and 19% neither agreed nor disagreed. Based on teachers' responses 74% agreed (20% strongly agree + 54% agree) that records are maintained in schools to indicate the use of tablets in teaching (Q7.2) and 81% indicated that schools maintain asset registers in which information regarding tablets is recorded (Q7.3). Teachers' responses indicate that 76% (20% strongly agree + 56% agree) of them agreed with the statement that schools maintain records of technical problems that are reported to the call centre (Q7.4). The teachers' responses to availability of information regarding the content on the school server (Q7.5) shows that 57% (11% strongly agree, and 46% agree) of the respondents agreed that Information regarding the content in the server is available to them.

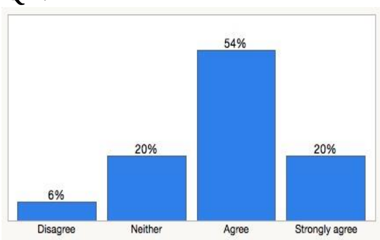
There were mixed responses regarding teachers' knowledge of the minimum standards that the Department of Basic Education expects teachers to apply when using computers (Q7.6). There were 55% of teachers who agreed (15% strongly agree + 40% agree) that they know the minimum standards that the Department of Basic Education (DBE) expects them to apply in teaching using computers, 8% disagreed and 38% neither agreed nor disagreed.

Q7.1



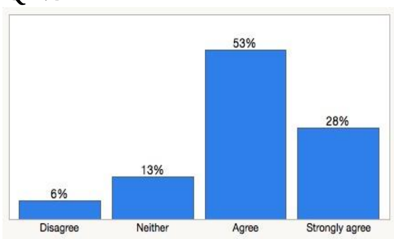
I am able to show information such as records on how I use tablets in my lessons.

Q7.2



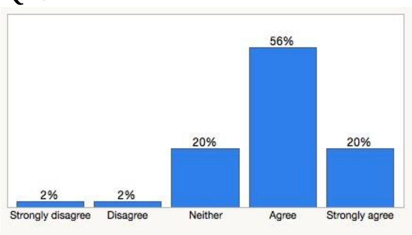
There are records maintained in the school showing the usage of the tablets.

Q7.3



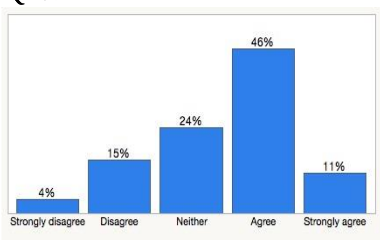
There is an asset register at the school where information on the school tablets is maintained.

Q7.4



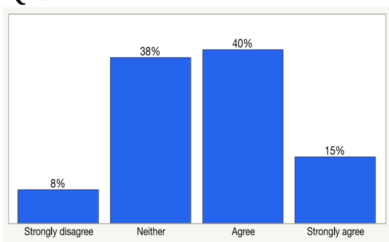
The school maintains records of technical problems that are reported to the call centre.

Q7.5



Information regarding the content in the server is available to me.

Q7.6



I know the minimum standards that the Department of Basic Education expects me to apply in teaching using computers.

Figure 5.16: Information and knowledge management

Teachers did not explicitly state the need for maintaining records in order to reflect mobile technology integration into classroom activities, however, reference was made to the records completed by teachers when they collected tablets for class use. The reason for this may be due to existing reporting procedures that may already cater for this, however, there was an indication that manual records existed in schools for teachers to record when they collected the Mobikits in which tablets are stored. The following quotations are provided to support these findings:

Quotations: Information and knowledge management
Participant 36: "*Records indicate that some teachers make use of the Mobikits in their teaching although I am not sure whether lessons are prepared"* Participant 41: *"Teachers are using Mobikits as I am in the ICT Committee I have a look in that tablet recording book"* Participant 41: *"Knowledge of how and when to use technology in teaching and learning"*

Teacher professional training and support is required because, as Participant 41 explained, teachers require *"knowledge of how and when to use technology in teaching and learning"*. Training and support are aspects that can be considered within *institutional sustainability*.

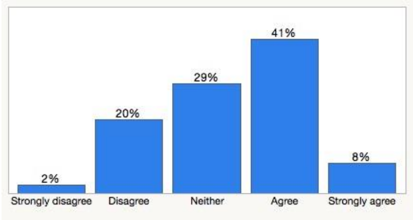
Strategies that support electronic reporting methods that can be easily analysed, could be considered in relation to recording methods on papers or exercise books that may not facilitate monitoring and analysis of teachers' mobile technology integration activities. Platforms and processes that are available to teachers to record, inform and report about tablet use and concerns could be identified within existing structures and communicated to both teachers and districts. Such platforms could include the use of existing departmental information systems.

Teachers could be encouraged and given support to participate in communities of practice that enable them to share ICT related knowledge. Information regarding ICT assets, such as tablets and servers and their condition, should be maintained, monitored and used appropriately.

5.3.2.11 Policies and guidelines

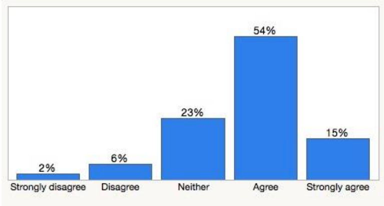
Teachers' responses indicate that 49% agreed (8% strongly agree + 41% agree) that the role of the local subject advisors in supporting the ICT4RED project is clearly defined (Q1.13), and 69% agreed (15% strongly agree + 54% agree) that the role of the ICT Champion is clearly defined (Q1.14).

Q1.13



The role of the local subject advisors in supporting the ICT4RED project is clearly defined.

Q1.14



The role of the ICT Champion is clearly defined.

Figure 5.17: Organisational policies and guidelines

Teachers' responses to open-ended questions in relation to policies indicated the need for schools to have ICT policies in place and that schools' roles and responsibilities in ICT implementation need to be understood.

Quotations: Policies and guidelines
Participant 36: *"Drafting of a policy on Mobikit use"* Participant 55: *"Teachers work within the South African Schools Act (SASA)"*

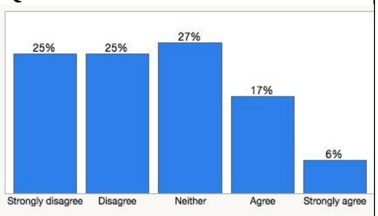
Schools and districts should ensure that schools have well developed ICT policies and that these existing policies are applied. Policies, such as DBE policies, relating to school asset management, roles and responsibilities, continuous teacher professional training, school security and roles and responsibilities should be communicated and applied appropriately. Section 3.3.7 outlines relevant policies.

5.3.2.12 Financial/Economic

Figure 5.16 shows teachers' responses to closed-ended questions Q1.10 to Q1.12, relating to the financial dimension. A large proportion of teachers' responses to Q1.10, 50% (25% strongly agree + 25% agree) indicated that the Learning and Teacher Support Material (LTSM) funds provided to schools are inadequate to cater for mobile tablet maintenance. There was 23% (17% agree + 6% strongly agree) of teachers' responses which considered the LTSM funds adequate to cater for maintaining the tablets and 27% neither agreed nor disagreed. Teachers' responses to Q1.11, regarding the statement that the school can afford to pay for fixing the tablets when they are broken, show that 64% disagreed (35% strongly disagree + 29% disagree). There were 14% of teachers' responses (14% agree) that consented that the school can afford to pay for fixing the tablets when they are broken. There were no teachers who strongly agreed, while 22% neither agreed nor disagreed.

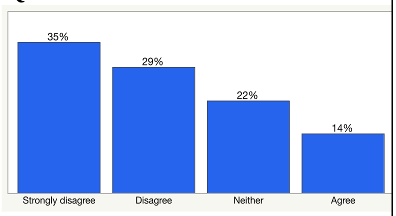
Most teachers, 69% agreed (15% strongly agree + 54% agree) that it is cheaper to use e-books than normal print books (textbooks), while 10% disagreed (2% strongly disagree + 8% disagree) and 21% neither agreed nor disagreed (Q1.12).

Q1.10



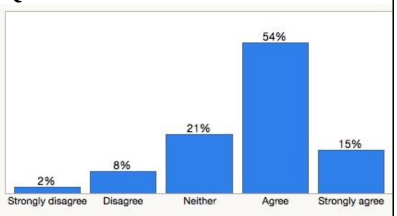
The Learning and Teacher Support Material (LTSM) funds are adequate for mobile tablet maintenance.

Q1.11



The school can afford to pay for fixing the tablets when they are broken.

Q1.12



It is cheaper to use e-books than normal print books (textbooks).

Figure 5.18: Financial

Responses to the open-ended questions indicate that teachers expect financial support from the private and public sectors, as evident from the following quotations:

Quotations: Financial
Participant 26: *"Sponsors that can support us with more tablets"* *"Other resources that work hand in hand with tablets"*

Teachers' responses indicate that schools would be unable to sustain the costs for maintaining the tablets. This relates to *financial sustainability*. Financial resources are required for purchasing tablets, maintaining the devices and infrastructure and acquiring digital content. There are costs to employing technicians, providing technical support to schools and training teachers. Teachers indicated that sponsors could support schools by providing more tablets and that other resources are required. Responses from teachers did not elaborate on school activities that could enable schools to raise funds. This may be an indication that teachers do not consider fundraising, other than the LTSM as a source of funds, as an essential aspect of their environment. Based on teachers' responses, a need seems to exist for the clear communication of the roles of school governing bodies (SGBs) and school management teams (SMTs), as stated in SASA and the department's expectations related to fund management and fund raising by schools.

5.3.2.13 Holistic approach

Factors that were raised by teachers regarding: crime, resignation and retirement, age, accommodation, type of school buildings/infrastructure, the time required to use tablets and the inclusion of this time in the school timetable, indicate the challenges faced by the education system. Addressing such issues requires a holistic view towards the implementation of mobile technology integration. Teachers stated that:

Quotations: Holistic approach
Inadequate time Participant 3: *"Not enough time for teaching or using tablets effectively"* Participant 8: *"They are time consuming as when learners are expected to type, it takes a hell of their time, so the syllabus is not covered"* Participant 24: *"Time management hinders teachers in using tablets in the classroom"* Participant 27: *"The programme to be allocated in the school time table"* Participant 46: *"There is no time for using the tablets"* **Teacher workload and motivation** Participant 4: *"There is also too much workload on teachers"* Participant 11: *"Motivation of teachers"* **Other factors** Participant 11: *"Contextual factors"* Participant 11: *"New developments, i.e., upgrade of the whole system"* Participant 22: *"Crime"* Participant 24: *"Accommodation"* Participant 34: *"Lack of knowledge of new teachers"* Participant 35: *"Age factor"* Participant 55: *"Resignation and retirement of teachers"*

The responses indicate that there are varying concerns that can impact teachers' use of mobile devices to support teaching. Teachers indicated that there is inadequate time during the lesson, that the workload is too much and that some of them lack motivation. Based on teachers' responses, consideration of additional aspects, such as crime levels and teachers' leaving the system through retirement and resignations, is required. A holistic approach to comprehensively address such issues is therefore needed. This is in line with the critical success factors for ICT projects in resource-constrained environments. Sustainability requires that the project should be approached in a holistic way (Pade-Khene et al., 2011).

5.3.3 The outcomes (positive and negative) of mobile technology integration

Teachers could specify *positive* effects resulting from the use of tablets at schools as well as how the use of the mobile devices could impact n*egatively*. In Section 5.3.3.1, the benefits identified by teachers are discussed and in Section 5.3.3.2, the negative outcomes are deliberated.

5.3.3.1 Teachers' views on the positive outcomes of mobile technology integration

Teachers were requested to respond to the open-ended questions in the questionnaire (Annexure 2.1):

- *How has the introduction of tablets at your school affected the way that you teach?*
- *What is going well in terms of using tablets for teaching at your school?*

Educators were positive regarding mobile technology integration as they identified the benefits of using tablets to support teaching. Teachers' views regarding positive outcomes were that the use of tablets at their schools made teaching and learning fun, and that learners participate actively during lessons. Teachers noted that the skills and characteristics that learners develop, such as the ability to use mobile technology to gather information using the Internet, communicate online and work in groups, are all essential 21st century skills. The next section presents the benefits that teachers identified in their responses to the open-ended questions in the questionnaire (Annexure 2.1):

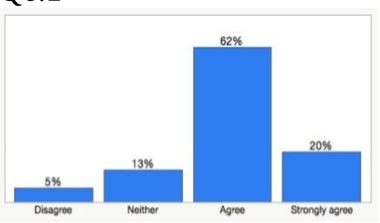
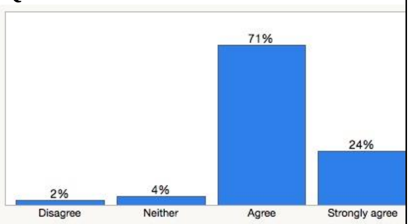
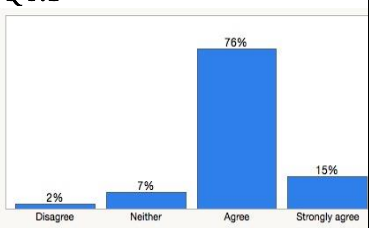
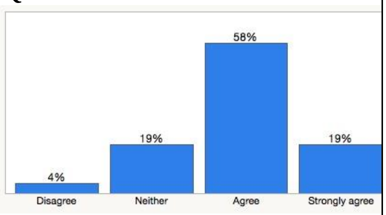
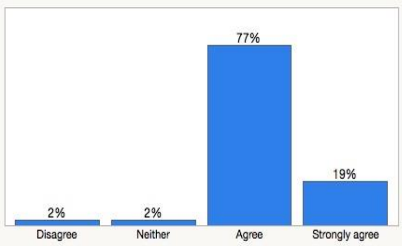
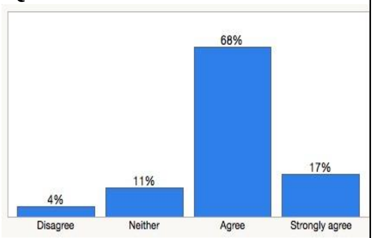
Quotations: Positive outcomes
Makes learning fun and learners actively involved Participant 18: "*It has drastically changed the atmosphere of teaching. Learners become active in using tablets especially communication – Facebook, Twitter, WhatsApp, in searching information from other learners."* Participant 31: *"At first it seemed as if it was disturbing the school functionality. Learner attendance has improved. Learners are actively involved."* Participant 34: *"It becomes more enjoyable, more fun."* Participant 55: *"Positively affected the learners' attitudes towards being eager to come to school regularly."* **Learners develop important skills and traits** Participant 11: *"Learners develop interest in methods that are used that involve group work. Learners are actively involved."* Participant 27: *"Their self-esteem has been improved."* Participant 31: *"Self-esteem is built as they are able to explore/search information using Google app"* Participant 36: *"Learners who are acquainted with technology. 21st century skills."* Participant 36: *"Learners are independently searching for information and are keen to learn."* Participant 37: *"It is much easy for them. The children like the devices as they manipulate on their own. When they research, the learners can google the information using the Wi-Fi. They can get the lesson plans through Thutong (Department of Basic Education (South Africa)'s education website."* Participant 40: *"Learners are able to share their information and participate in their learning actively e.g. when I use role play."* **Teaching strategies developed**

Participant 9: *"It changed the way we used to teach, now I use new methods and learners are excited and eager to learn."*
Participant 16: *"Enhanced and equipped me with better knowledge base and a quick way to access information in order to transfer such information to learners e.g. researching using Internet, Google etc. using a tablet."*
Participant 55: "*Made teaching and learning more learner centred, learners in the senior classes are encouraged to work as teams, critical thinkers and also being creative."*
Participant 57: *"They play a vital role in communication and collaborating with other colleagues. And above all the presentation is much easier than before and they help me to manage the time, because there is no longer wiping of chalkboards as that is time consuming."*

Digital content access:
Participant 5: *"Learners are able to understand the lesson easily because they are able to search for information on their own."*
Participant 9: *"Learners are able to search for information by themselves."*
Participant 23: *"There is a lot of things we get that helps the kids to understand more easily."*

Participant 28: *"Information is easily accessible and it saves time."*
Participant 29: *"It helps a lot. Even if there is a shortage of textbooks at school, we can find the textbooks in the tablets."*
Participant 44: *"Googling of information through Internet, using dictionary searching for meaning of words, using maps, quick mathematics, using apps like email, Facebook, We chat, You tube etc. is exciting."*
Participant 47: *"It is easy for the teachers to keep the information in the tablets such as lesson plans, videos for learners when doing their activities."*

Teachers' responses to the close-ended questions in the questionnaire on learner development *(The numbers, Q6.1 to Q6.10, correspond to questions in questionnaire Annexure 2.1).*

<table>
<tr><td colspan="3">The use of mobile tablets has a positive outcome on learner development in terms of:</td></tr>
<tr><td>Q6.1

</td><td>Q6.2

</td><td>Q6.3

</td></tr>
<tr><td>Subject matter knowledge.</td><td>Learning motivation.</td><td>Information-handling skills.</td></tr>
<tr><td>Q6.4

</td><td>Q6.5

</td><td>Q6.6

</td></tr>
<tr><td>Problem-solving skills.</td><td>Collaborative skills (learning together with others).</td><td>Communication skills.</td></tr>
<tr><td>Q6.7</td><td>Q6.8</td><td>Q6.9</td></tr>
</table>

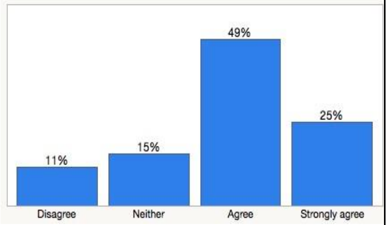
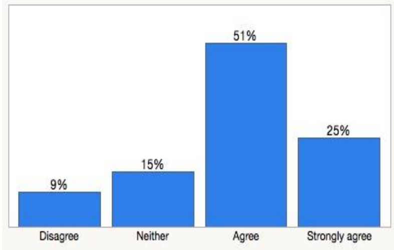
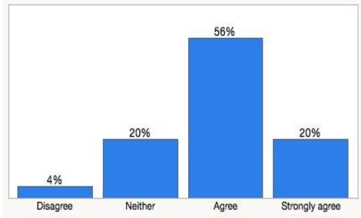
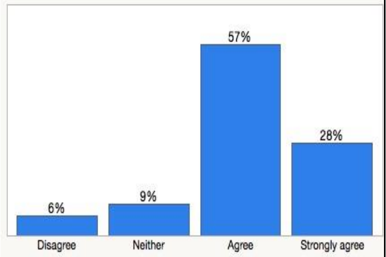
		
Developing learners' ability to use computers.	Learners' ability to learn at their own pace.	Reducing success gap among learners (gives learners equal chances of succeeding).
Q6.10 		
I can confidently explain to someone else what "21st century skills" are.		

Figure 5.19: Positive outcomes

The use of tablets at the schools had a positive outcome on learners' attitudes. Teachers indicated that learners are motivated, excited and enjoy lessons more. Teachers reported a positive impact on class participation, engagement and attendance of learners. The use of tablets increased team-work, communication and cooperation among learners. Learners were also enabled to access information online.

The positive outcome on teachers is that the increased knowledge, regarding 21st century teaching strategies and skills, augmented teachers' ability to apply relevant learner centred teaching strategies. According to the teachers, the use of tablets reduced technophobia and increased their confidence in using the tablets. Participant 50 stated: *"Firstly there were mixed feelings, but at the end everybody is willing to use tablets"* and this is indicative of the change in teachers' attitudes towards mobile technology integration.

Teachers' views regarding digital content were that the use of tablets made it easy to store, retrieve and manage information. Teachers also stated that e-books and workbooks accessible through the tablets help to alleviate the problem of shortage of textbooks. Moreover, teachers could access lesson plans from specific sites such as "Thutong" and Quick Mathematics, and similar sites through the Internet. Thutong (meaning, a place of learning), is the Department of Basic Education's online education portal which offers a range of curriculum and learner-support material, professional development programmes for teachers, and administration and management resources for schools (DBE Thutong, 2016).

Table 5.1 is a summary of positive outcomes identified by the teachers.

Table 5.1: Teachers’ views on positive outcomes of mobile technology integration
✓ Educators are exposed to new, advanced teaching strategies. ✓ Educators, who might have been technophobic, developed skills and confidence to use tablets to support teaching. ✓ Increased educators’ understanding as to the value and importance of 21st century teaching strategies. ✓ Educators acquire knowledge and skills in the use of tablets. ✓ Positively influence teachers’ approach to teaching. ✓ Educators are interested in using the tablets and the Mobikits. ✓ Easier for educators to present lessons. ✓ Can access professional development programmes for educators online, for example in Thutong, the Department of Basic education’s online education portal. ✓ Learners and teachers can access a range of curriculum and learner-support material online, for example in Thutong, the Department of Basic education’s online education portal, this includes lesson plans. ✓ Easier to access information online through the internet. ✓ Teaching is more learner-centred. ✓ Some textbooks, accessible through the tablets, help with the problem of shortage of textbooks. ✓ Information storage, retrieval and management easier.

Teachers also stated that mobile technology integration has had a positive effect on learners’ attitudes as the learners become motivated, excited and enjoy the lessons. The use of tablets to support teaching enhances learners’ participation and engagement and encourages team-work and cooperation. Teachers’ responses suggest that tablet use to support teaching enhances learners’ understanding of concepts, improves communication among learners and enables them to access information in less time. There were teachers who indicated that class attendance had improved and that tablet use had had a positive effect on learners’ self-esteem.

Teachers’ views regarding mobile technology integration were predominantly positive, however, negative effects were also indicated.

5.3.3.2 Teachers’ views on negative outcomes of mobile technology integration

Teachers were concerned that learners’ access of irrelevant games and websites during classes may impact negatively on teaching. Moreover, there is limited time to cover the syllabus. Learners’ mathematical ability to calculate on their own, without using tablets, and their ability to adhere to English grammar structures were also issues which had to be considered. Negative effects stated by teachers:

Quotations: Negative outcomes
Participant 38: *"Always tell them not to socialise with unknown people or to do something that does not have a future, social networks are good to know but use in a proper way/manner"* Participant 31: *"Cyber bullying and the misuse of these apps e.g. YouTube etc."* Participant 3: *"Internet must be limited for them e.g. educational only"* Participant 35: *"It slows down teaching because a lot of time is wasted since they write in the books first and then copy it in the tablet"* Participant 44: *"Writing is affected by use of tablets. Calculation also is my concern. Let learners learn to calculate manually than to give them answers"* Participant 27: *"Foundation phase – they look for the games during the lesson and play them"* Participant 27: *"If possible, during teaching and learning using tablets the games should be locked by the educator so that the learner can focus in that lesson"* Participant 45: *"There must be minimum usage of tablets so as to adhere to basic English grammatical structures"* Participant 38: *"Use of tablets by learners sometimes causes problems. Learners might google something that is not in line with classroom situation"*

These negative outcomes, as provided by the teachers, are important because they need to be managed and mitigated. Teachers' views, regarding benefits, provide feedback that can be used to assess whether the objectives for introducing tablet use and providing training to teachers have been achieved. There is a need for establishing a feedback mechanism to continuously gauge teachers' perspectives. This is critical as it provides teachers with a platform to air their views. Management, on the other hand, can obtain teachers' views, attitudes and concerns, and then use this information toward sustaining the change and identifying key points that may affect teachers' involvement. Providing teachers with a platform that enables them to think about, and express, the benefits of using tablets can influence their thinking about the use of tablets. The steps required to reinforce positive behaviour and to address teachers' concerns can then be taken.

Strategies for ICT integration should communicate clearly, stating objectives and monitor and evaluate mechanisms. The strategic reasons for mobile technology integration should be clearly stated and communicated so that *what* is occurring in the classrooms can be assessed against the objectives. When the objectives are clearly stated, it is easier to know what to monitor in order to identify and measure progress and the effect of the change. Finding effective ways for monitoring progress, and identifying measures that show *how* the change makes teaching easier, or more efficient, can reinforce benefits and initiate progressive action. Additionally, teachers' beliefs and attitudes are important factors in mobile technology integration into teaching (Chiu & Churchill, 2015).

5.3.4 Implications of teachers' views for the refinement of the SFMTIS

Table 5.2 shows the implications of the identified themes for the SFMTIS

Table 5.2: Implications of identified themes for the SFMTIS	
Identified theme	**Implications for development of SFMTIS**
Tablets	Tablets can be selected by using selection tools such as the *multi-criteria technology selection model* for resource-constrained environments (Meyer & Marais, 2014). Standards and quality can be stipulated to improve tablet selection. Financial costs associated with tablets include: acquisition of the mobile devices and software, maintenance, technical support and security. Technicians are required to provide support. Institutional structures, processes and communication platforms that enable logging of faults can improve how these faults are resolved. The framework needs to incorporate financial implications and support for tablet selection, tablet testing, management and enhanced decision-making.
Networks, Internet access and connectivity	The type and quality of infrastructure provided for Internet access and Wi-Fi needs to be appropriate to the environment, such as the remote location and mountainous terrain. Communication of roles and responsibilities is necessary, for example, identifying *who* is responsible for maintaining infrastructure, the role of the school and district needs to be clarified. The framework needs to cater for financial costs of infrastructure maintenance, technical support and technicians. Adopting a holistic approach can ensure that different aspects are addressed including a review of institutional policies, processes and structures and aligning these to the ICT strategy.
Leadership	It is important that leadership be provided at all levels of the education system: micro (school), meso (circuit and district) and macro (provincial and national) levels. Strategic plans and policies that reflect the envisaged path to progress, and the measurements for assessing success, are required. It is necessary to identify and communicate reporting and monitoring structures and processes to relevant personnel. Continuous monitoring, evaluation and support are required.
Teacher professional training and capacity building	Teacher professional development is required. Available information systems, such as the SACE continuous professional teacher development (PTD) system, need to be effectively used to encourage ICT training of teachers, through the use of PD points as incentive for teachers. Leadership, management and monitoring of the SACE PTD system is required. School ICT Champions could be trained in troubleshooting and how to train and support other teachers.
Content	There is a need for digital content for all the subjects and classes

	to be available to teachers. Communication is important towards facilitating a common understanding regarding ICT strategy and the use of e-resources among teachers, subject education specialists and district managers. The financial cost for digital content management needs to be factored into planning and budgeting for schools.
Technicians and technical support	Well trained and qualified technicians are required to support teachers and learners. Financial resources are required to acquire the services of technicians to support teachers. Institutional processes for logging faults need to be clearly defined and communicated. Standards for service providers' turnaround times for fixing faults and repairing mobile devices need to be provided. It is essential to capacitate locals to provide technical support.
Security	Security is an important aspect in mobile technology integration. Security relates to securing the physical assets and also securing software, providing cybersecurity and advancing digital literacy among users of the systems. The costs and long-term economic implications need to be catered for. The roles and responsibilities for providing physical security and ensuring appropriate software, such as antiviruses which need to be provided and updated, need to be outlined. The school and district roles need to be clearly defined. The financial implications need to be considered.
Electricity	As part of a holistic approach to the project, aspects such as provision of electricity or solar power need to be taken into account because the tablets need to be charged. For schools that have struggled to resolve such problems, the intervention and support of different government departments, local municipality, district, province and school management may be required. Government policies that prioritise schools' needs such as roads to schools, ICT infrastructure and electricity need to be implemented and, where necessary, developed.
Monitoring	Monitoring is required at different levels of the education system. This requires that reporting procedures be supported by institutional structures, processes and policies.
Policies	Relevant policies that support mobile technology integration are required. The strategies developed to implement the policies need to clarify the relevant roles and responsibilities. Monitoring is required to evaluate implementation of the policies and promote accountability. Institutional reporting structures and processes need to be assessed for alignment with strategies for implementing the policies.
Financial/ economic	Financial, or economic, consideration is necessary to enable planning and long-term support of mobile technology integration programmes. Government support, for example the Department of Basic Education budgets, and processes, such as implementation of the LTSM, need to be assessed for their ability to provide long-term support. Financial support by the private sector can be encouraged.

	The abilities of SGBs and SMTs in school funds management, and fund raising, can be developed. Clear guidelines are required for schools to understand their financial responsibilities in maintaining ICT infrastructure.
Holistic approach	A holistic approach is required to address the different aspects that need to be catered for when implementing mobile technology integration, including communication, monitoring and evaluation, infrastructure and resources.
Strategic objectives of mobile technology integration	The strategic rationale and benefits for mobile technology integration within the institution need to be clearly identified and communicated. An appropriate reporting platform and mechanisms for continuous feedback are required to assess whether the objectives have been met or not Resources, both financial and personnel, are required to provide monitoring and evaluation to thus determine whether the outcomes align to the stated objectives.
Communication	Provides means by which information is shared within the organisation. For example, regarding ICT strategies, training, logging and resolving of ICT related faults.
Information and knowledge management	Information and knowledge management are important as it provides reporting mechanisms and enable managers to assess whether the objectives for mobile technology integration are being achieved, or not. Continuity is facilitated when there are changes, for example, new teachers or managers, through access to information, e.g. e-resources available to teachers.

Measures for supporting teachers, rather than increasing their workload, should be implemented. This view is in line with De Lima et al.'s (2014) observation that it is important for teachers to be involved in activities which develop their technological competence and keep them abreast of updates in teaching materials. Annetta et al. (2013) also indicated that teachers who use computers often are more efficacious. Training programmes should offer subject teachers practical teaching opportunities and focus on how to use mobile devices to achieve teaching goals, giving cognisance to the different activities employed for different subjects when using tablets.

Teachers' responses that were unexpected are discussed in Section 5.3.5.

5.3.5 Unexpected findings

There were views that teachers presented that were unexpected. These include contradictory views:

Participant 39: *"The tablets make teaching and learning easier",* contradicted by
Participant 8: *"They are time consuming as when learners are expected to type, it takes a hell of their time so syllabus is not covered"*

Establishing the reason for such contradictions is important because it could explain underlying attitudes and differences in the support required by different teachers. It is necessary to identify *reporting and feedback mechanisms* which enable teachers and district officials to communicate. School visits, classroom observation and cluster meetings are some of the activities that district officials (such as the subject education specialists, circuit manager and eLearning coordinator) are expected to undertake as part of their support and oversight responsibilities.

Communication platforms and reporting procedures should be able to collect data continuously in order to establish teachers' attitudes regarding sustaining the change and any discrepancies in order to address any major concerns. Districts are tasked with providing oversight and support functions to schools, principals and educators in order to improve the quality of teaching and to provide an enabling teaching and learning environment. It is important to understand existing information channels, communication patterns and existing information systems used *within* schools by teachers, *between* schools and also *with* the district. Any existing communication gaps should be addressed effectively.

There were also statements that teachers made that were unexpected pertaining to the CAPS alignment of the digital content and how to access the content:

Participant 18: *"Ensure that content is CAPS aligned"*
Participant 54: *"CSIR should introduce e-books in order to decrease the use of manual textbooks"*
Participant 18: *"The problem is that tablets are not installed with the content"*
Participant 54: *"The only document that you can access is the policy document only"*

These statements were unexpected because the ICT4RED programme provided CAPS aligned digital content on both the tablets provided and on the school servers. It was therefore surprising that teachers would mention the CAPS alignment of content. The expectation that e-books should be provided by the CSIR was also surprising because this took place *after* the implementation of the ICT4RED programme. Teachers were expected to be well oriented to anticipate that the Department of Basic Education would be responsible for digital content, rather than the agency which implemented the initiative.

There were teachers who could not access content as the apps had "disappeared" from the tablet screens. Participant 35 stated that: *"Ensure that apps do not just remove themselves in teachers' tablets"*. The provision and access to digital content cannot be viewed in isolation. There is a need for *continuous monitoring* and *evaluation* in order to identify challenges and provide technical support.

There were teachers who indicated that they had difficulty accessing the Internet and that Internet access was required as it facilitates easy access to information. This was an unexpected finding because all schools had been provided with the necessary infrastructure to ensure Internet access. *Communication platforms* are required to ascertain access-related issues that may account for teachers' inability to access digital content or the Internet. Inadequate communication, knowledge gaps and non-availability of technical support can be the cause of these challenges. Teachers may not understand the processes which need to be followed to ensure continued access to the Internet.

The findings from analyses of teachers' responses to open and closed-ended questions of the questionnaire were applied to develop the Intermediate SFMTIS which will be discussed in Section 5.4

5.4 INTERMEDIATE FRAMEWORK

The intermediate framework was developed, based on the reviewed literature, by analysing the gathered teacher responses to the questions posed in the questionnaire (Annexure 2.1). The initial SFMTIS, as presented at the end of Chapter 4 in Table 4.8, was refined and the intermediate SFMTIS, which will be discussed in this section, was developed.

The intermediate SFMTIS is represented in the following figures:

Figure 5.20: Organisational levels - micro (school) and meso (circuit and district) levels.
Figure 5.21: Structural considerations and factors affecting mobile technology integration.
Figure 5.22: Organisational levels and barriers to change.
Figure 5.23: Structure and dimensions affecting sustainability of mobile technology integration.
Figure 5.24: Micro level - mobile technology integration sustainability dimensions.

Figure 5.20 shows the Department of Basic Education's structural considerations for the development of the SFMTIS.

STRUCTURAL considerations for the development of the SFMTIS are micro (school), meso (circuit and district) and the macro (provincial and national) levels.

At national level, the National Education Policy Act (NEPA) 1996 (Act 2 of 1996) empowers the Minister of Basic Education to *"determine national policy for the planning, provision, financing, staffing, coordination, management, governance, programmes, monitoring, evaluation and well-being of the education system"* (DoE, 2013: 5). The national framework for the organisation and staffing of education district offices outlines the roles and responsibilities of district officials for "effective districts and better quality" (DoE, 2013: 2).

The policy is aimed at qualitative changes to the operations of provincial education departments, districts and circuits, and outlines the role of education district offices in planning, support, oversight, accountability and public engagement of the education institutions for which they are responsible. District offices are also tasked with "facilitating ICT connectivity in all institutions within their district" (DoE, 2013: 13), supporting and collaborating with principals and educators to improve the quality of teaching through school visits, classroom observation and cluster meetings. Districts are also accountable to the Provincial Education Department and provide a vital communication line between schools and the Provincial office which reports to the National department. The organisational structure includes micro (school), meso (circuit and district) and macro (provincial and national) levels. This study is limited to the *micro* and *meso* levels, as depicted in Figure 5.20.

Structure is constituted by managerial and governance systems (Scott, 1981) and the institutionalised features of social systems (Giddens, 1984), as per Section 2.3.1. At each of the three organisational levels of the basic education system, micro to macro levels, the actions by these agents, as individuals and collectively, affect change management. Activities targeting teachers and district officials in change management for mobile technology integration should enhance the capability of the individuals through training and capacity building, developing knowledgeable "agents" with transformative capacity and power, through their social interactions. Everyday processes and practices of these agents within the organisation should be considered.

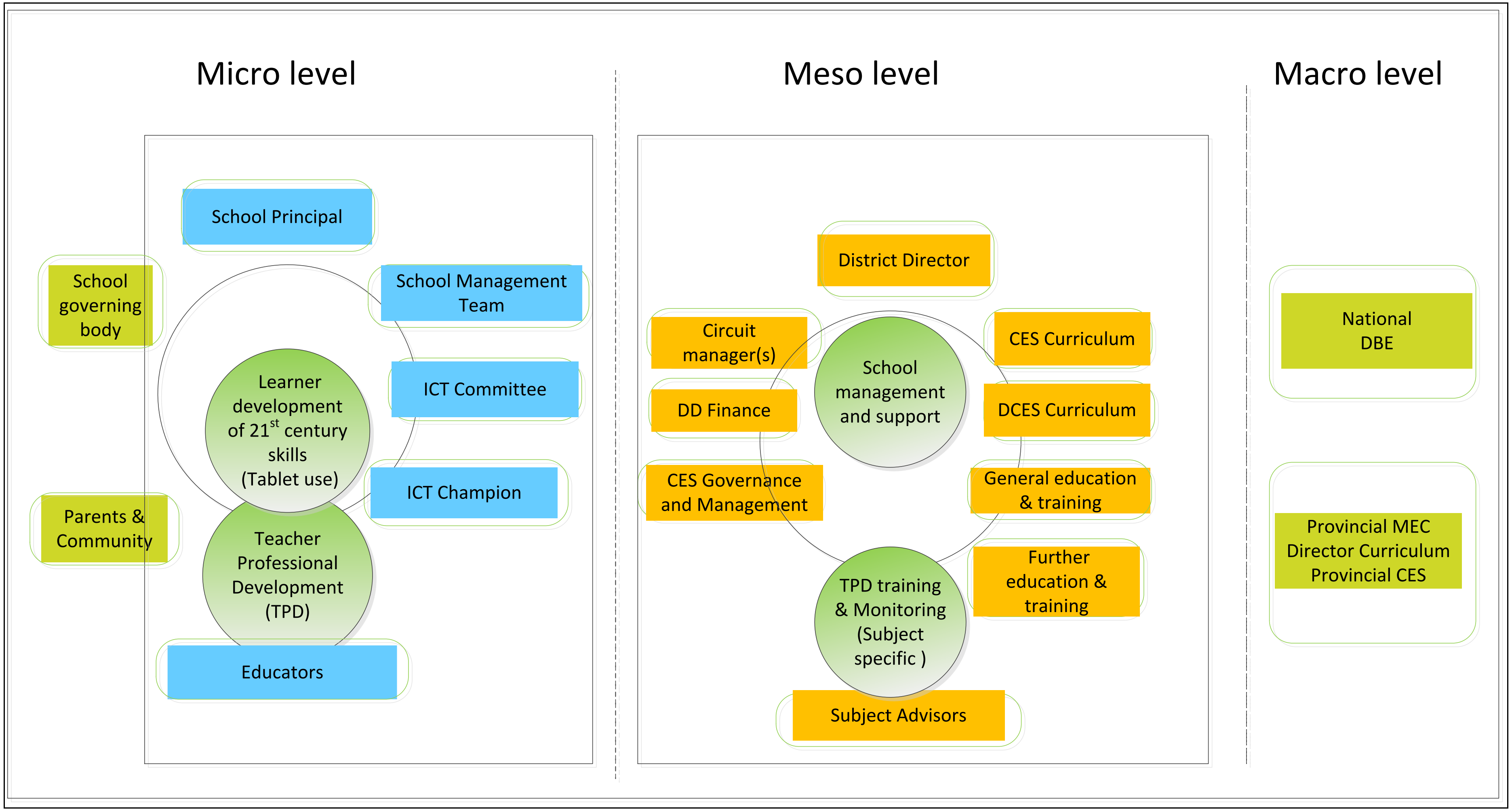


Figure 5.20: Organisational levels - micro (school) and meso (circuit and district) levels

Figure 5.21 indicates barriers to change and agent actions that can affect mobile technology integration.

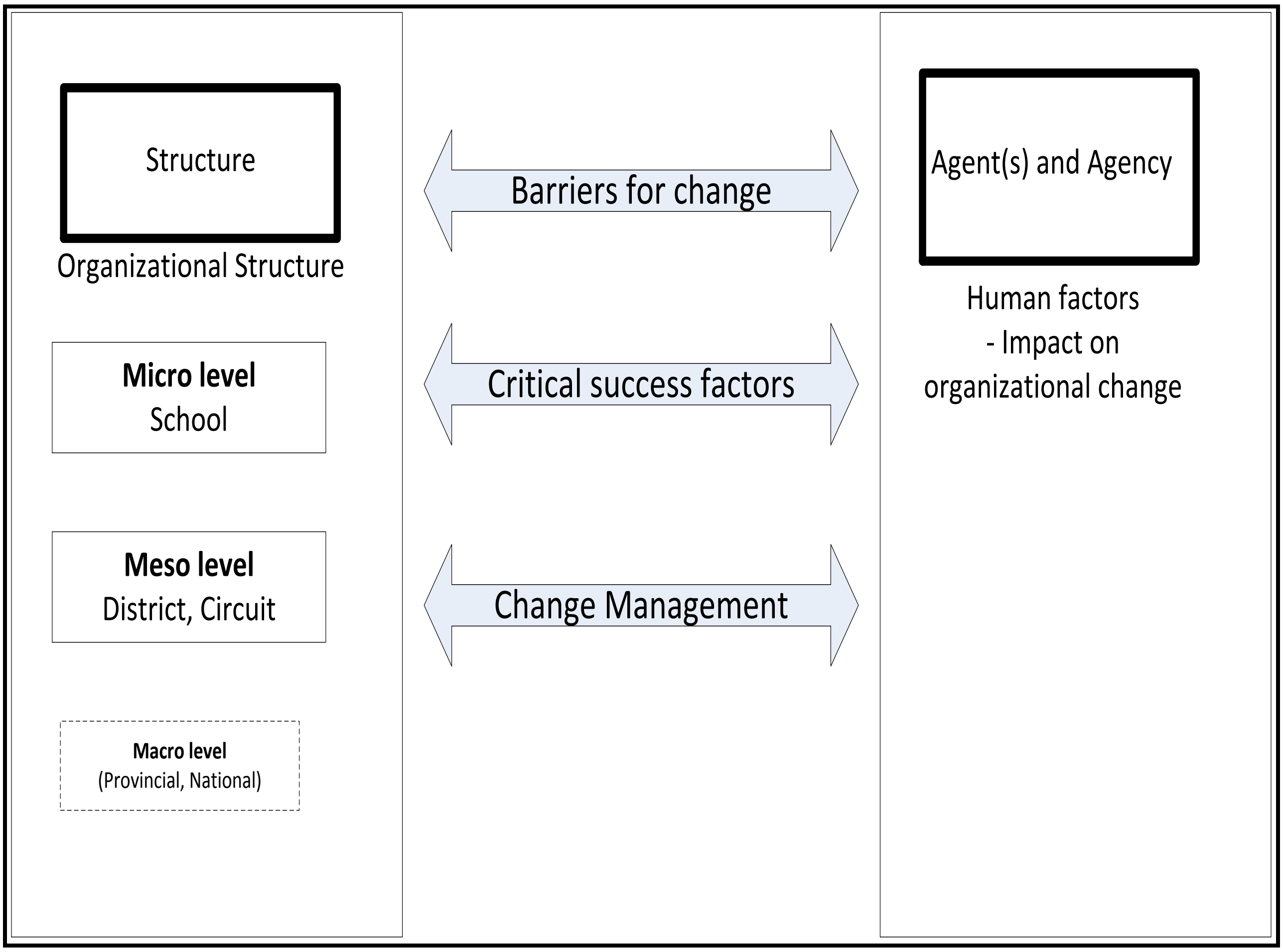


Figure 5.21: Structural considerations and factors affecting sustained tablet use

Figure 5.22 shows the organisational levels and barriers to change. Barriers that are *external* to the teachers such as infrastructure (hardware and software), availability of tablets, digital content, Internet access and Wi-Fi connectivity as well as barriers that are *internal* to the teachers such as teachers' beliefs, attitudes, knowledge and skills all affect mobile technology integration.

Figure 5.23 shows organisational structures (micro and meso levels) and dimensions affecting sustainability of mobile technology integration. Figure 5.24 shows the micro level (school) and mobile technology integration sustainability dimensions. The sustainability dimensions developed from the reviewed literature and demonstrated by the views of teachers and district officials in the case study are: financial/economic, political, social/cultural, technological, pedagogical and institutional sustainability.

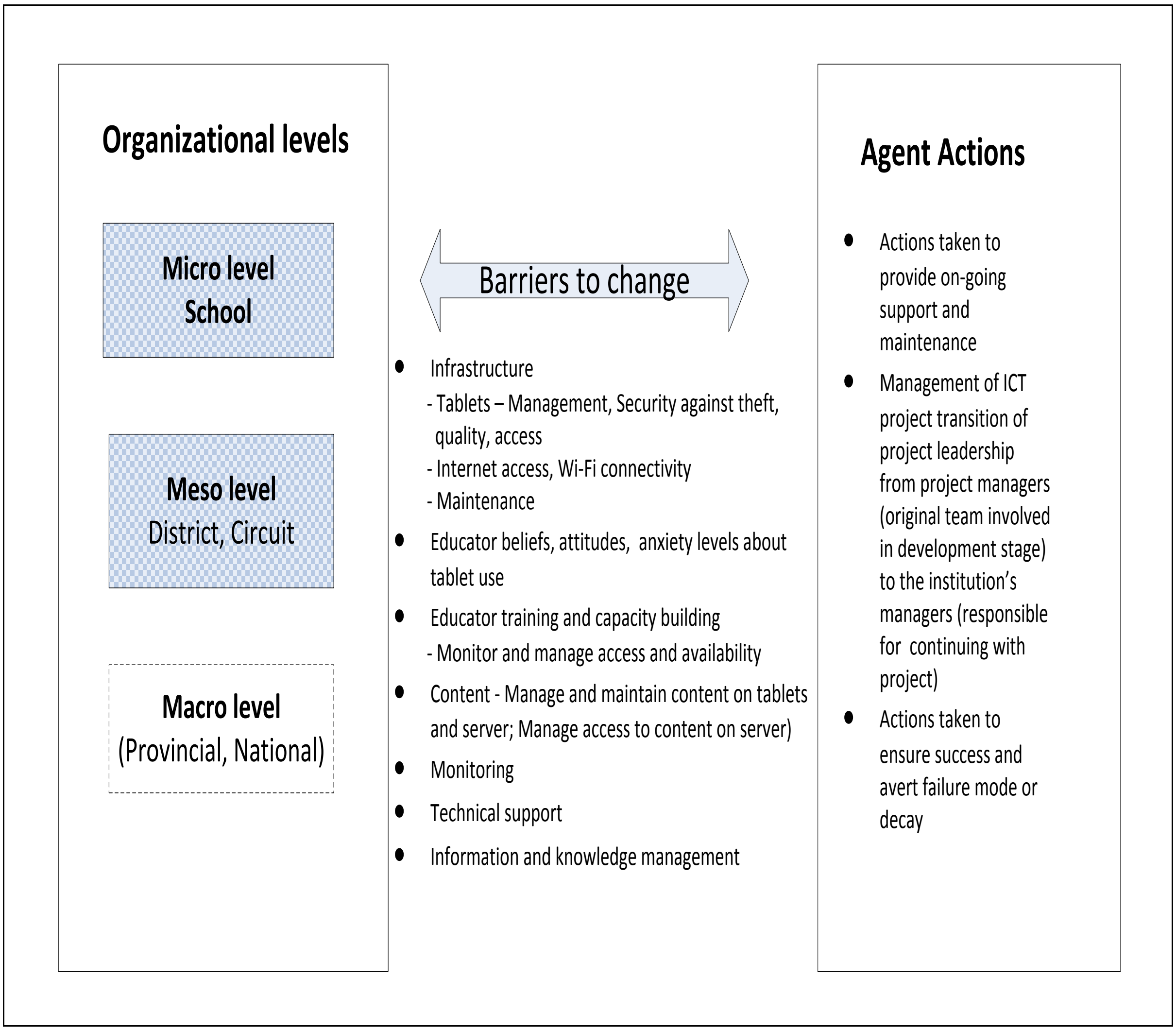


Figure 5.22: Organisational levels and barriers to change

The SFMTIS identifies aspects that should be addressed in order to enhance sustainable mobile technology integration. Access to digital content and ICT infrastructure require continuous support and maintenance. Institutional structures, tasked with monitoring and support functions, such as school management teams, school governing bodies and districts need to be well equipped and resourced to perform their functions effectively. Effective financial and technical support mechanisms must accompany the deployment of ICTs. Institutional systems and processes, at both school and district levels, which ensure continuous cooperation and coordination and which continue to inspire, drive, encourage and create awareness long after the project leadership has transitioned from the project managers to the institution's managers, should be identified. Institutional structures at school and district levels to support related communication, coordination and monitoring processes should function optimally. In addition to first-order barriers, second-order barriers should also be addressed.

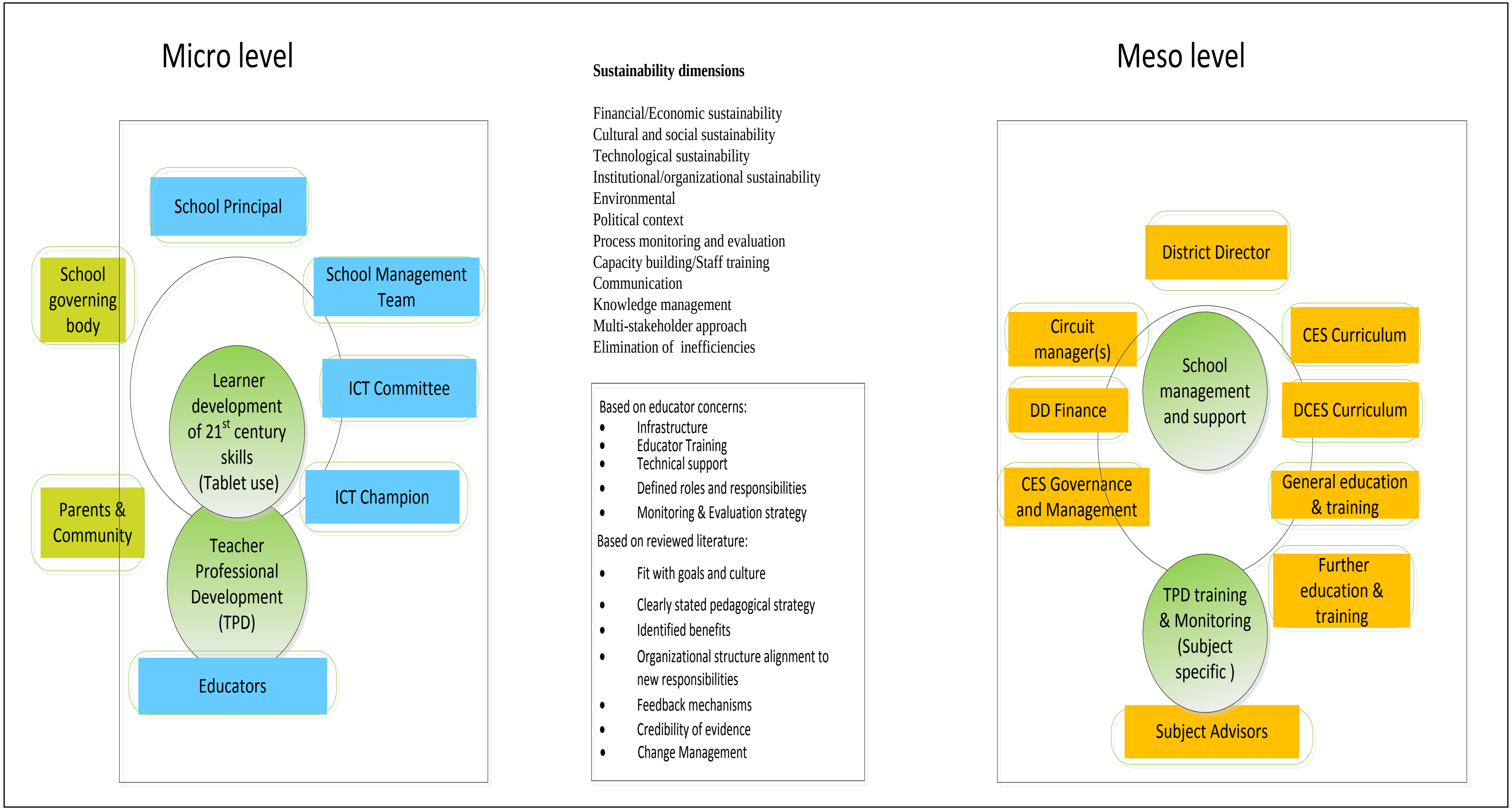


Figure 5.23: Structure and dimensions affecting sustainability of mobile technology integration

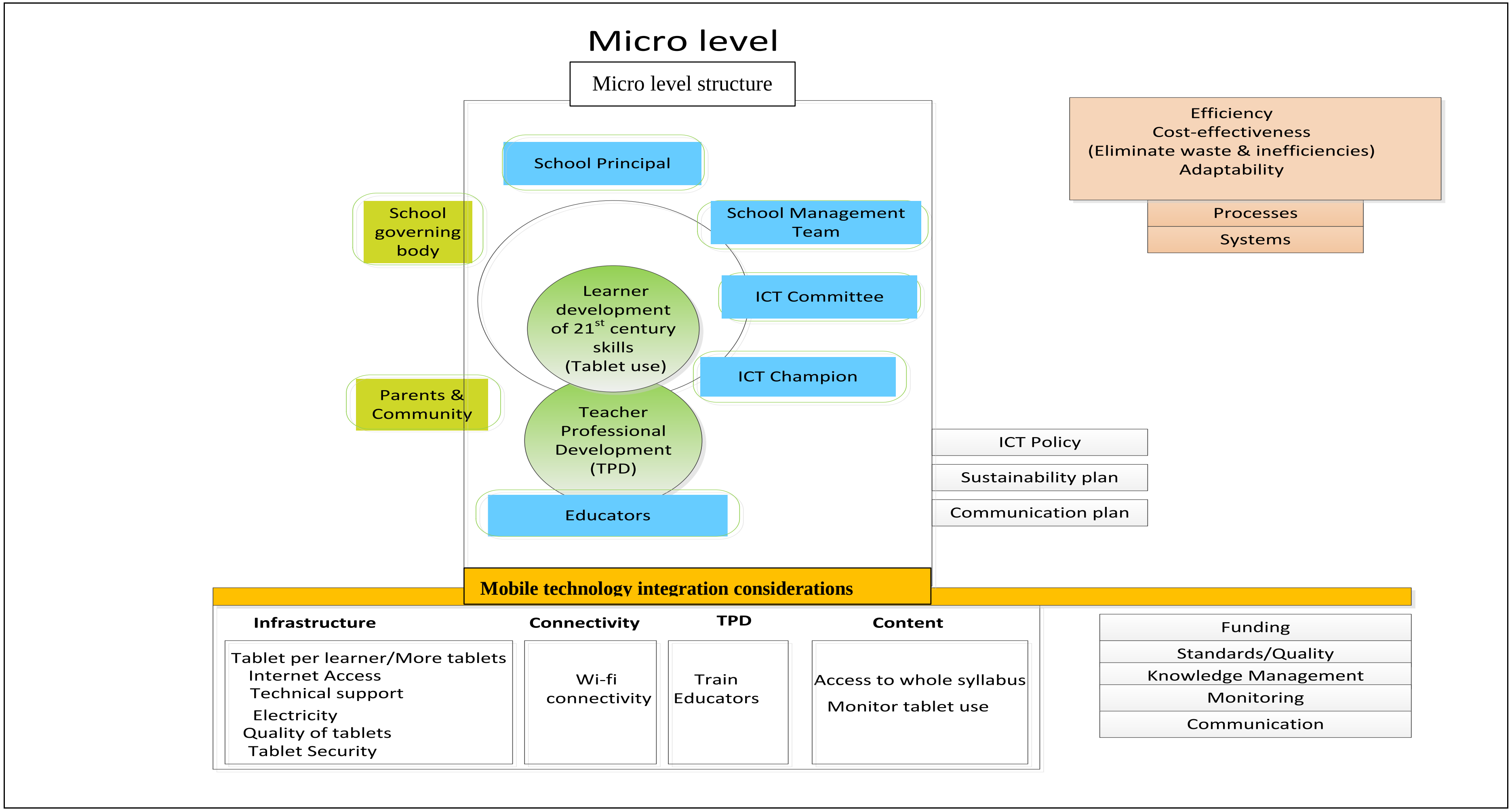


Figure 5.24: Micro level - mobile technology integration sustainability dimensions

In the preceding section, the intermediate framework was developed by reflecting on sustainability dimensions, as presented in the initial framework. The insights from teachers' views regarding the use of mobile technology at their schools were used to confirm the relevance of the sustainability dimensions identified from the literature reviewed. Figure 5.20 to 5.24 represent the Intermediate framework.

The intermediate framework was presented to district officials at Cofimvaba school district in order to obtain their perspectives in relation to information obtained from the teachers. District officials' viewpoints, which will be further discussed in Section 5.5, are significant because of the leadership role of the district in the education system, as discussed in Section 3.3.7.

5.5 RESULTS OF DISTRICT MANAGEMENT INTERVIEWS

The four district management officials interviewed in this study are all based in one of the school districts in the Eastern Cape Department of Education, in an environment considered as resource-constrained, and were involved in the ICT for rural education and development (ICT4RED) initiative. The purpose of interviewing the district officials was to ascertain their views regarding mobile technology integration in schools and to add value to the teachers' perspectives. Data was collected using semi-structured face-to-face interviews at the district offices in July and August 2016, a year after the implementation of the ICT4RED initiative. An interview guideline was used to ensure that interviews covered the main issues. Interviews lasted about one and half hours on average.

Thematic analysis was applied to analyse the data collected during the interviews with the district officials. Thematic analysis is discussed in the methodology chapter, in Section 2.6.3, and involves the examination of narrative data in search of themes and establishing commonality and contrasts (Teddlie & Tashakkori, 2012). Qualitative thematic analysis was conducted to capture participants' views and categorise them into themes that aligned to the dimensions of the framework for sustainable mobile learning. The sustainability dimensions used are: financial, technological, political, social/cultural, pedagogical and institutional. The views of the four district officials at management level in the Cofimvaba school district are referenced using Participant 1, 2, 3 and 4, in order to maintain anonymity and for ethical reasons.

Annexure 5.2 presents a summary of the district officials' views categorised into sustainability dimensions. These views are further discussed in the following section.

5.5.1 District management perspective - main themes

The main themes emanating from the analysis of interviews with district management officials are presented in the following sections using the sustainability dimensions: financial, technological, political, social/cultural, pedagogical and institutional.

5.5.1.1 Financial

Funding was stated as a major factor in ensuring sustained tablet use at schools. This is necessary because of expenses incurred. Participants remarked that there are financial commitments to providing physical security and that license fees are high. Responses from district officials indicated that the service level agreement for Wi-Fi access requires a specific amount to be paid per month for each of the schools that were involved in the ICT4RED project. A recommendation was made for reducing costs at macro level (provincial and national departments): *"Use economies of scale… then license fees will go down"*.

District officials' responses indicate that schools rely on financial resources from the department, and that schools were likely to struggle to maintain costs for Wi-Fi access after the limited three-year period that the ICT4RED initiative covered, without any financial support. Concerns that district officials raised regarding funding were that there are many needs in resource-constrained environments such as infrastructure, water, sanitation and maintenance. District officials suggested that other priorities, such as improving the basic conditions of school buildings, could be more urgent than costs associated with ICT integration.

Based on district officials' views, financial resources are important and the Department of Basic Education is responsible for providing funding to schools. It was suggested that corporate funding is needed to supplement funds that schools receive from the Department of Education. Examples of schools in the same province that had become "smart" schools as a result of strong school leadership, and funding sourced from private funders, were given. The emphasis was on strong school leadership and the need to supplement government funding.

District officials stated that there are norms and standards for funding and that schools are allocated funds based on stated criteria, including the number of learners. Schools are allocated funds for specific cost centres, for municipal services, electricity, maintenance, learner teacher support material (LTSM) and minimal sums of cash. The LTSM does not include a component which caters for maintenance of ICT equipment.

District management noted that schools can raise funds following departmental guidelines. Schools can also collect funds from parents to employ additional teachers paid by the school. The school management, school environment and schools' expectations are all important. It was observed that well managed schools tend to plan, budget, use maintenance funds appropriately and undertake fund raising activities. Social capital was also noted as important. A remark made was that *"a very serious principal can use the maintenance budget; it depends on how much the repair costs are, and, can ask for help from the district where necessary regarding expenditure".*

District officials' perspectives indicate that the quality of the school leadership (the principal, school management team and school governing bodies) and how the school is managed are major determinants to how schools integrate mobile technology.

5.5.1.2 Technological support

The district management officials were in agreement regarding the need for technical support to schools, noting that technicians should be assigned to each school and that they should be well trained in basic maintenance and access control administration. Participants noted that local people should provide technical assistance and that it would be easier if technicians were situated in the district. At present, ICT technicians based in the district are not assigned to service the ICT4RED project. Participants stated that there are currently no technicians at the schools and that ICT technicians are required to support schools. Participants remarked that *"teachers are not technicians"* and that *"a teacher's job is to teach".*

Based on district officials' responses, technicians could be assigned to support schools at district level. District officials stated that teachers need support when using tablets in a classroom environment because it takes time to set up ICT equipment and by the time the teacher finishes setting up, the lesson is finished. The views regarding tablet maintenance are varied. One perspective was that maintaining any equipment at school, including infrastructure, building and furniture is the school's responsibility and that there is a budget for maintenance, and this includes fixing and replacing tablets if stolen. Another view was that there is a need to *"create a line function for maintenance of tablets".* There were concerns raised regarding the quality of one of the brands of tablets, noting that charging ports are easily damaged.

5.5.1.3 Political

There were also concerns that *"when there are changes at provincial level, implementation of agreements made with previous provincial officers are often under threat"*. For instance, when a memorandum of understanding (MoU) is signed with a senior provincial officer and that officer then leaves and is replaced, there is no guarantee that the memorandum of understanding (MoU) will be retained, or upheld, because there may be new projects and priorities. To this extent it was noted that *"education is politicised"* and that *"there should be a way to ensure continuity"* despite political changes.

5.5.1.4 Pedagogical

The pedagogical reasoning behind tablet use relates to teaching and learning approaches. One of the district management officers stated that educators and school ICT Champions were trained regarding the use of digital content and that all schools in the ICT4RED project were given projectors. Although tablets had been supplied to the subject education specialists (subject advisors) who are based at the district offices, only a few had participated in the ICT4RED Teacher Professional Development (TPD) and Change management programmes. Training of teachers is based on personal growth plans. The district has a Human Resource Development (HRD) department. Teacher development is carried out by subject education specialists (subject advisors) for their credit, however resources should be provided by the provincial department (government).

5.5.1.5 Social/cultural

Parental support was considered to be minimal, and in some instances parents are absent from family homes, working in other cities. Sometimes the children live with grandparents, or only with the mother, or sometimes the children live by themselves. Parents may be too busy. As a result, it was commented that *"when you have parent meetings at schools, few attend"* which is an important consideration because *"in schools where parents are present, there is a big improvement."*

Annexure 5.2 also shows district management perspectives that can be considered as elements in the *institutional* sustainability dimension. The elements are categorised according to macro, meso and micro levels (provincial and national level, district and circuit and school levels, respectively).

5.5.2 Implications for SFMTIS

The findings from districts' perspectives confirm the sustainability dimensions that were identified in the initial SFMTIS, and further supported by teachers' views (as per Section 5.3) regarding sustaining mobile technology integration in schools.

District management emphasised the need for effective school *leadership*. Although subject education specialists were identified as the appropriate personnel to engage with schools in cluster and subject committee meetings regarding ICT integration, the guidelines regarding *how* subject education specialists should perform this function were unclear. The district's expectations of data to be collected from schools were unclear, which is expected given that the ICT4RED was a pilot in one circuit in the district and had not been implemented in all schools in the district. While district management stated the need for technicians to support schools, the district officials stated that it was the Province's role to provide funds for the "project" to move forward. Some concerns were raised regarding the political influence at provincial level and that provincial leadership changes affect the implementation of projects and decisions. District management articulated the need for funds and the requirement for more staff at district level in order to increase the district's capacity to implement policy and support schools. District management's views showed that district's interaction with the school affects the deployment of resources, like funding and technical support, particularly in providing technicians.

The insights from district officials' perspectives were applied to refine the initial framework. The refined intermediate framework is presented in Section 5.5.3, Figures 5.26, 5.27, 5.28 and Table 5.3. The refined intermediate framework will be presented to expert reviewers.

5.5.3 Refined SFMTIS

Figure 5.25 illustrates the components of the refined SFMTIS which comprise of:

Figure 5.26: Structure and factors affecting sustainability of mobile technology integration.

Figure 5.27: Factors affecting sustainability of mobile technology integration: Micro - meso interactions.

Figure 5.28: Visual representation of sustainability framework for mobile technology integration: context of resource-constrained environments in South Africa.

Table 5.3: The SFMTIS for resource-constrained environments in South Africa - dimensions and aspects to consider.

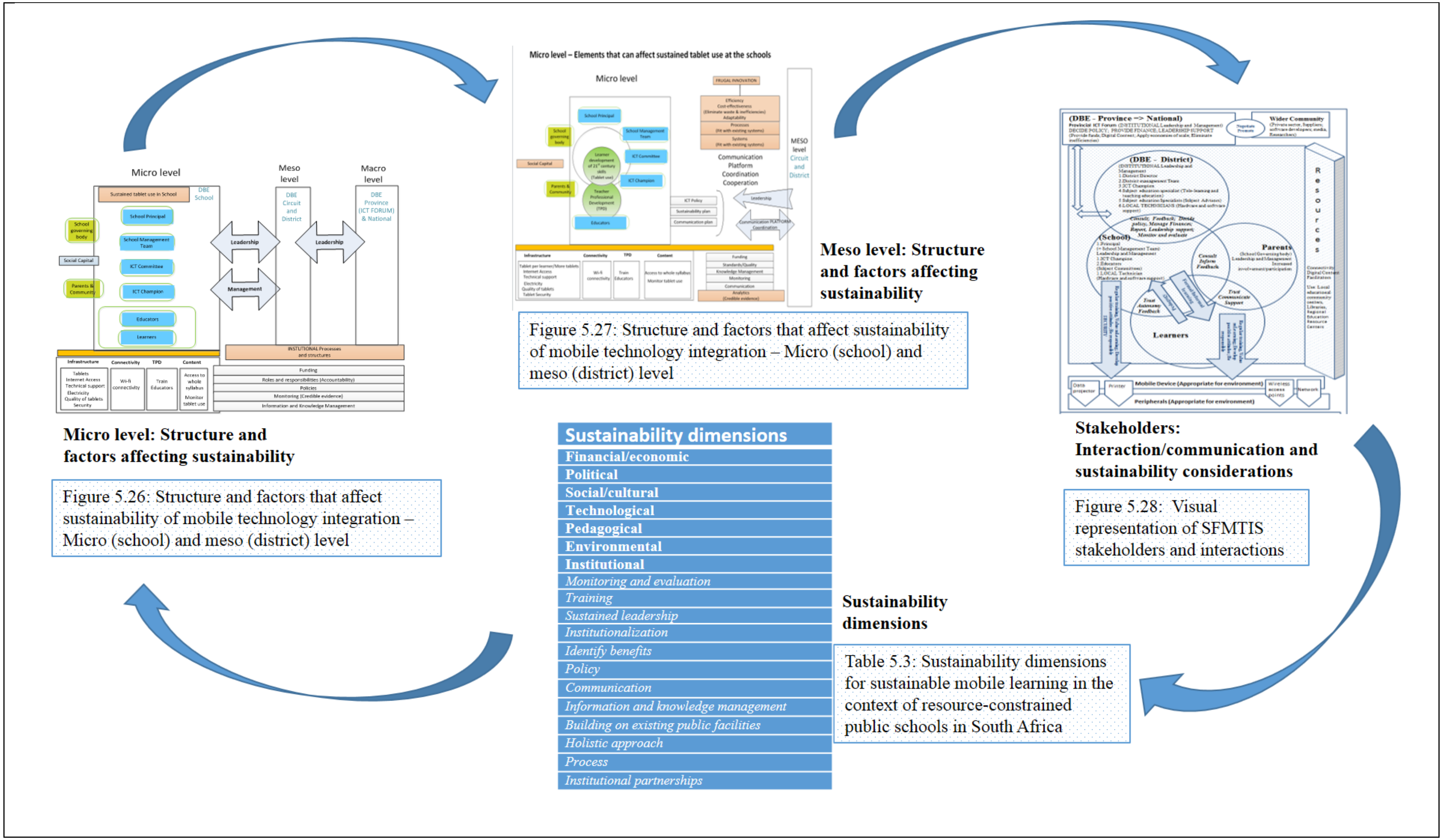


Figure 5.25: Intermediate SFMTIS components

5.5.4 Relating case study findings to the initial SFMTIS

In this section the initial SFMTIS, developed from analysing sustainability frameworks (as per Table 4.8), is related to findings of the case study in which the views of teachers and district officials regarding sustainability of mobile technology integration to support teaching were investigated and analysed. The value of the case study is to demonstrate and inform the initial SFMTIS that was developed from the reviewed literature. The initial SFMTIS, shown in Table 4.8, identified the following sustainability dimensions by examining general ICT4D sustainability frameworks: *financial, cultural, political, technological, environmental* and *institutional* dimensions. Other factors extrapolated by analysing the frameworks include: *monitoring* and *evaluation*, *training of staff*, ability to *identify benefits* through *credible evidence*, *information and knowledge management* and *leadership*. These factors were categorised within *the institutional* dimension (as per Table 4.2). Examination and categorisation of the critical success factors (CSFs) in the ICT4D sustainability framework specific to resource-constrained environments, were consistent with the sustainability dimensions that were identified in the general ICT4D sustainability frameworks. The exception is the environmental dimension that is not explicitly elaborated in these frameworks.

The terminology used for some elements varies from framework to framework. For example, *"leadership"* can be inferred from *"cultivating an influential project champion"* and *"monitoring and evaluation"*, the critical success factors (CSFs) of rural ICT project sustainability framework specifies. There are factors that are prominent in some frameworks, for example *"institutionalisation"* in the sustainability failure model and *"organisation"* and *"processes"* in the NHS sustainability model. "*Teacher professional development"* features prominently in the evidence-based ICT4RED framework, as well as factors such as *"management"*, *"change management"*, *"communication"* and *"coordination"*. The *pedagogical* sustainability is articulated in the Framework for sustainable mobile learning in schools.

The findings of the case study *confirmed* these aspects of the sustainability dimensions, and also indicate the relevance of *institutional structure* and *processes.* Figure 5.26 integrates the perspectives of teachers and district officials, showing the organisational structure micro level and factors that affect sustainability of mobile technology integration in schools. Leadership is critical at all levels of the education system, micro, meso and macro level.

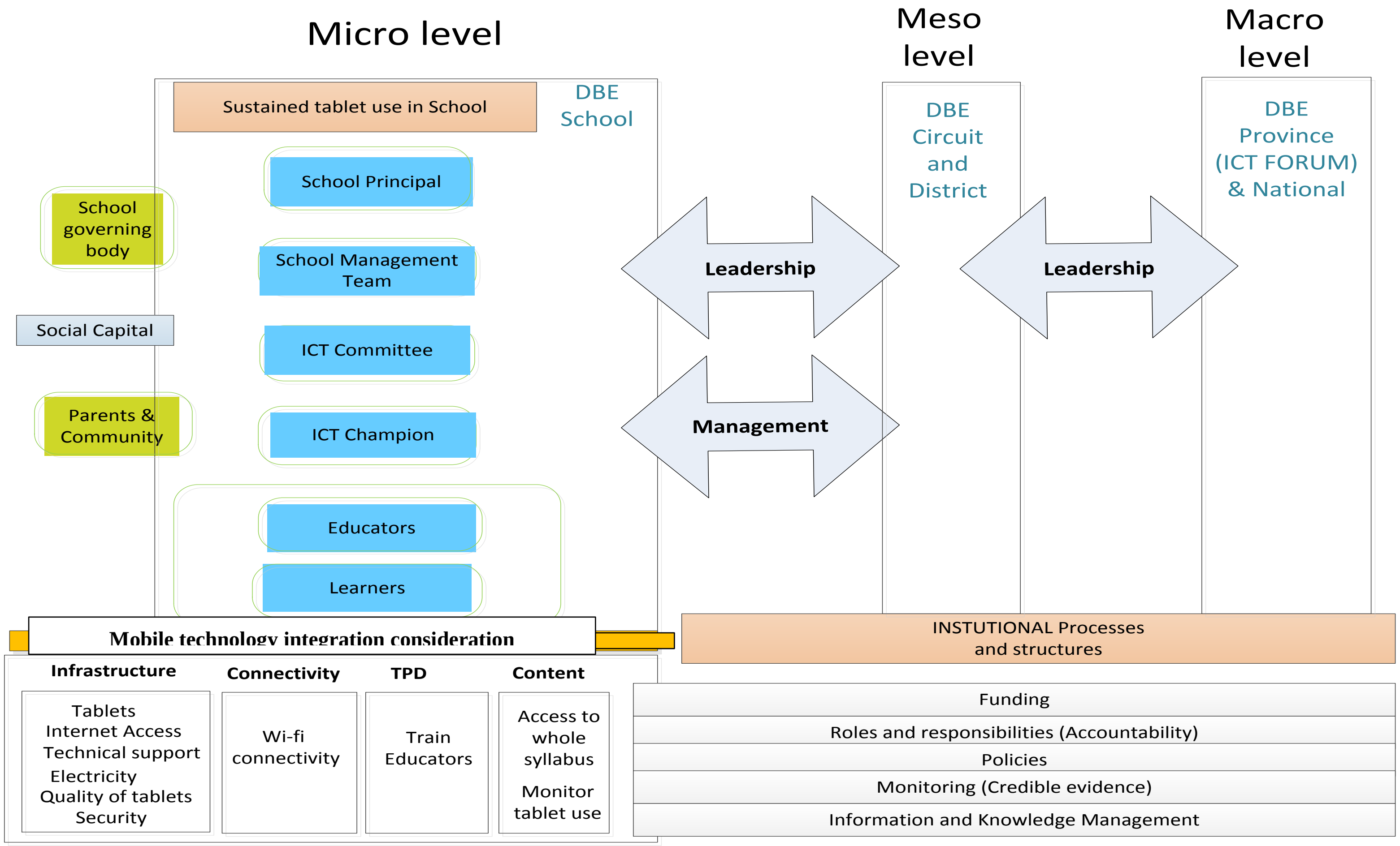


Figure 5.26: Structure and factors affecting sustainability of mobile technology integration

The sustainability dimensions identified in the initial SFMTIS were *confirmed* through analysis of the perspectives of teachers and district officials regarding sustainability of mobile technology integration in the schools. Table 5.2 presents the implications of teachers' views for the refinement of the SFMTIS and district officials' views are presented in Section 5.5.1 and implications for the SFMTIS in Section 5.5.2.

Teachers and district officials noted aspects that can be categorised in the *financial*, *institutional* and *technological* dimensions as main issues. Leadership, monitoring and evaluation, within the institutional dimension, were highlighted by teachers and district officials and this is reflected in Figure 5.26.

Figure 5.27 provides a detailed view of the school's dimensions which affect the sustainability of mobile technology integration. The strategy for sustaining the use of mobile devices can be enhanced by *action* supported by *financial resources*, *monitoring* and *evaluation* and *communication.* ICT policy, a sustainability plan and a communication plan can be developed by the school in line with strategies adopted at meso and macro levels.

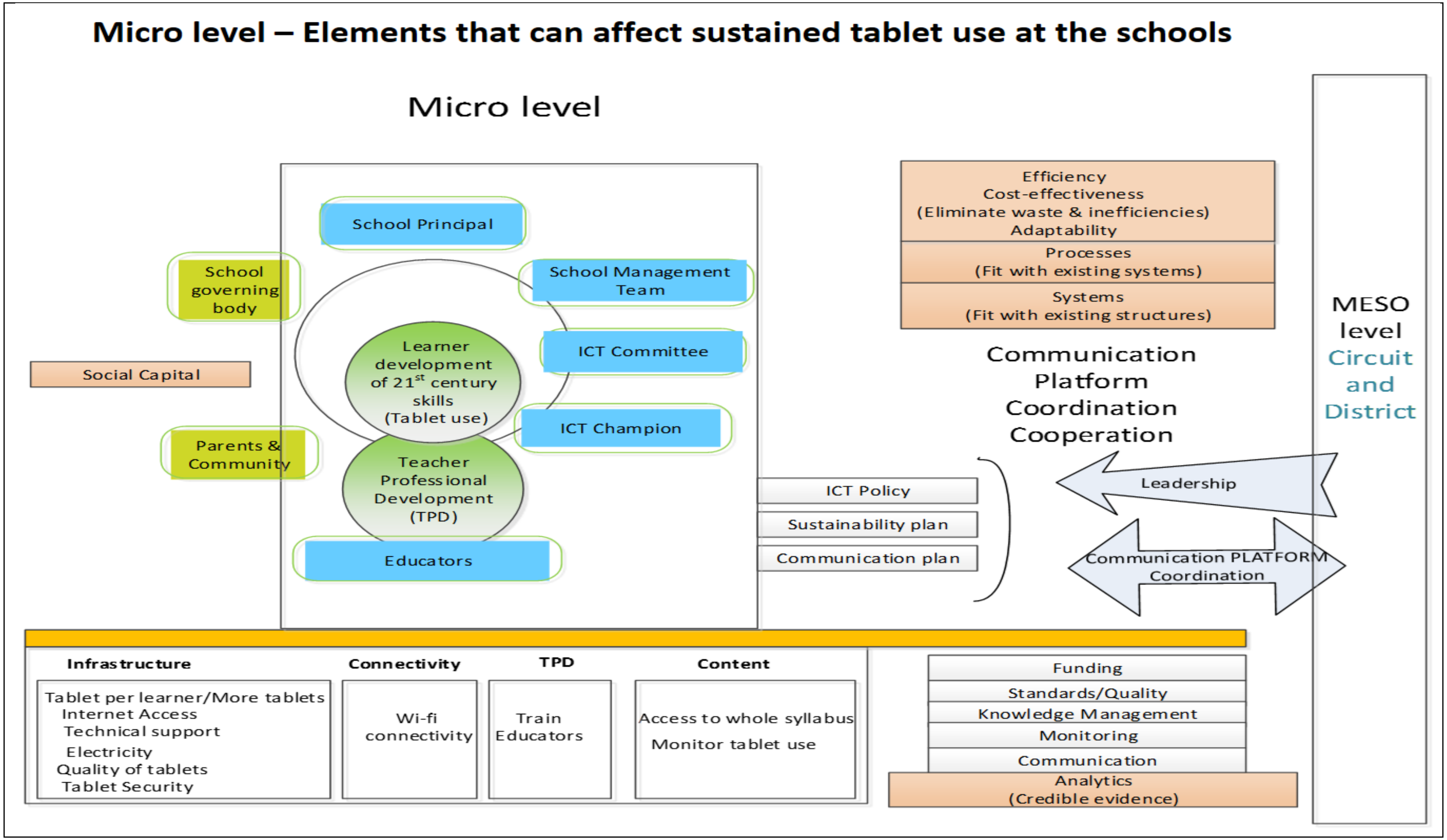


Figure 5.27: Factors affecting sustainability of mobile technology integration: Micro - meso interactions

Figure 5.28 is a visual representation of the SFMTIS. This illustration is adapted from the person-centred sustainable model for mobile learning to represent the context of resource-constrained environments in South Africa. The indicated stakeholders, their interactions and resources are essential components of the visual representation.

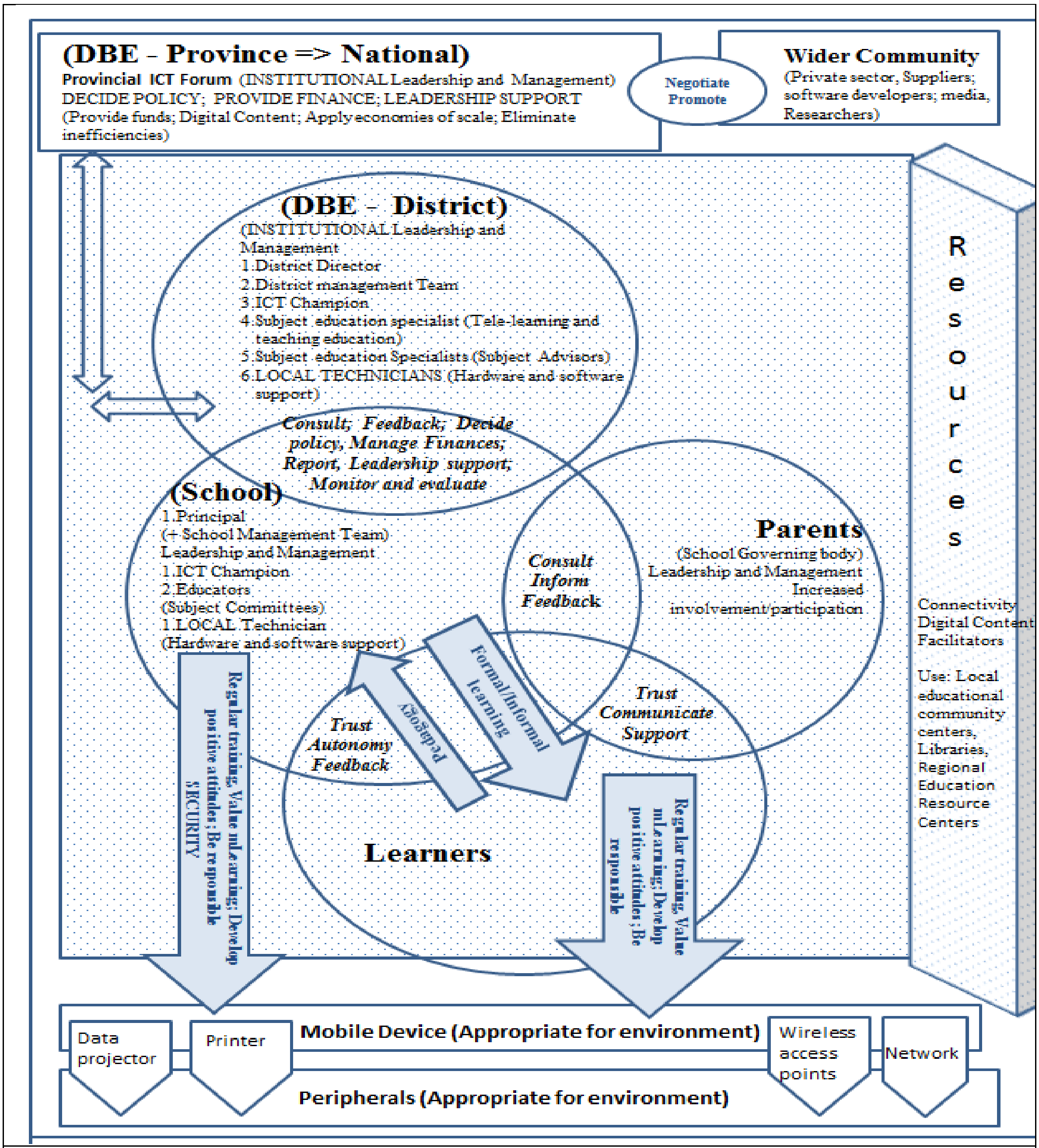


Figure 5.28: Visual representation of the SFMTIS
(Adapted from "Person-centred sustainable model for mobile learning" Ng & Nicholas, 2013)

Table 5.3 presents the sustainability dimensions and aspects for consideration in the SFMTIS.

Table 5.3: The SFMTIS for resource-constrained environments in South Africa – dimensions and aspects to consider

Sustainability dimension	Description	Aspects to consider
Financial/ economic	The financial capability of the educational institution to support ICT technology in the short and long term.	There is a need to focus on economic self-sustainability of mobile technology integration programmes. The LTSM structure needs to be examined to consider ICT related costs. Maintenance costs could be incorporated into expenditure planning. The use of a financial model, such as Total Cost of Ownership, could facilitate costing and financial planning. School Management Teams (SMTs) and School Governing Bodies (SGBs) need to be encouraged to be entrepreneurial in their approach and financial management of school funds. Explanation of what it means to be a section 20, or section 21, school needs to be communicated. Appropriate training and capacity building of SMTs and SGBs in planning and resource management is required. The involvement of the private sector needs to be aligned to the department's strategic goals.
Political	The role of leadership at different levels of the education system, micro (schools), meso (circuit and district) and macro (provincial and national) levels, towards guiding implementation and institutional policies required to adopt and maintain mobile technology integration programmes. This includes managing consultation and feedback with stakeholders.	People-related factors, such as interpersonal relationships between members of the leadership team, need to be functional to facilitate interaction and engagement. Engagement of senior leadership can be enhanced through appropriate communication, providing updates and enabling senior leaders' involvement. Plans can be formulated to raise senior leadership's awareness of the work required to sustain mobile technology use in schools. Specific roles for leadership involvement can be identified. The different levels of management and leadership in the education system needs to be acknowledged and appropriate communication mechanisms used to facilitate coordination and alignment in strategies, e.g. micro level (school), meso (circuit and district) and macro (provincial and national) levels. Roles and responsibilities need to be stipulated and accountability promoted. Existing structures and processes need to be assessed to identify strengths and weakness and action needs to be taken to reduce inefficiencies through change management.

Social/ cultural	Cultural and social context in which the project operates. Refers to the involvement and contributions of the community, parents, private sector and political leaders.	A culture of involvement can be promoted by communicating the benefits to and rationale behind the programme as well as encouraging the participation of parents, SGBs, SMTs, teachers and learners. When communities feel empowered by the ICT project they are likely to actively seek ways to sustain it. Capacity building needs to be considered by donors, funders, implementers and researchers. A culture of involvement can be demonstrated by an example at one of the schools where the ICT Champion assigns learners different tasks: charging tablets, taking the tablets to classes for use during lessons and collecting the tablets and ensuring that they are safely stored. This also helps in developing learners’ skills and teaches them responsibility. Schools and districts could involve parents, political leaders and funders in finding cost-effective solutions to security issues (economies of scale, schools working together) and to also seek innovative ways of raising funds. A culture of accountability can be encouraged in the school: teachers, principals, SMTs, learners, SGBs and the SGB Finance committee to be held accountable for their responsibilities. At district level district managers and subject education specialists should also be held accountable.
Technological	Refers to decisions made regarding the selection of appropriate technology, infrastructure and technical support in relation to the institutional needs and goals in the short and long term.	Tablet selection can be facilitated by using appropriate technology selection models. The cost of the technology, technical support, infrastructure and maintenance needs to be considered. Cost effective ways of implementation need to be investigated, for example, identifying existing facilities e.g. e-rate which enables schools to access the Internet at discounted prices. Communication and information management regarding facilities can support schools. Schools need technical support and financial resources are required to engage skilled technicians who would be locally available to support teachers and learners. District could assist schools by identifying cost-effective ways in which to engage technicians and support infrastructure maintenance at schools. District would thus aid schools by facilitating costing and coordination.
Pedagogical	Teaching, or learning, practices that support the long-term goals of the mobile learning programmes and the required roles at micro, meso, and macro levels of the education system.	Consideration of the infrastructure and e-resources that are required to facilitate teaching and learning using mobile devices. Long-term considerations regarding continuous updating of digital content on the school servers and mobile devices, maintenance of the infrastructure and associated costs. Minimising license costs associated with e-books through efficient use of resources, collaborations, application of economies of scale and identifying existing resources that can be accessed by teachers and learners. Different stakeholders can be involved in facilitating roles for long-term planning towards the maintenance of digital content.

		Consideration as to which structures and processes are available to institutionalise the process of maintaining digital content. Research institutions and universities could be involved in supporting the Department of Basic Education in developing, disseminating and maintaining digital content. It is necessary that the differences between open and proprietary digital content be understood and that the cost-benefits be analysed. Sustaining continuous use of mobile tablets to support teaching requires continuous professional training of teachers. The financial costs associated with this need to be accommodated within the education system.
Environmental	Involves making decisions regarding the provision of appropriate ICT infrastructure for the environment.	More robust ICT infrastructure is needed to cope with mountainous terrain which affects line of sight and Wi-Fi accessibility. Informed decisions need to be made regarding the appropriateness and safety of the tablets and Wi-Fi usage given aspects raised by researchers regarding radiation emitting devices. Appropriate plans are required to maintain damaged mobile devices and for eventual disposal, or reuse, of the increasing amounts of ICT equipment at the end of its effective life.
Institutional	Refers to alignment of institutional structures and processes at micro (school), meso (circuit and district) and macro (provincial and national) levels in relation to the ICT integration strategy and its implementation.	Management responsibilities required to implement changes need to be considered. Strategic considerations, such as development of ICT integration plans at provincial level, are required. Strategic considerations at provincial and district levels regarding integration across different divisions such as curriculum, ICT and e-learning, is required. Change management could be applied to manage changes associated with the introduction of new innovations to an organisation. Institutionalisation of processes and activities, such as use of mobile devices and e-resources, to become part of the day to day activities in the school and district. This requires consideration of everyday processes and practices in the organisation.
Monitoring and evaluation	Involves ongoing monitoring of progress and evaluation of the project and provision of credible evidence.	Roles and responsibilities should be well defined and communicated at strategic, tactical and operational levels (or macro/meso and micro levels): Who monitors what and why? What are teachers accountable for? What are teachers expected to use tablets for? What are subject education specialists responsible for? Data collection by schools and district: Who uses the tablets and what for? How many tablets are there, working/broken?
Training	Pertains to training and capacity building.	Staff training is required to support their involvement in sustaining the process. Plans can be formulated for determining how to recognise characteristics displayed by staff who feel a lack of involvement. Effective use of existing systems, such as the SACE continuous professional development (CPTD) system, which uses the professional point (PD) system to earn a target number of PD points within each three year successive cycle.

		Using available resources such as Teacher development centers effectively Financial resources are required to facilitate training.
Leadership	Refers to provision of management and professional support towards planning and providing oversight and accountability.	Develop and communicate a consistent ICT integration strategy. The roles and responsibilities of the district in providing monitoring, support and oversight for schools is essential. At school level principals, SGBs and SMTs should be accountable for integrating mobile technology to support teaching.
Institutionalisation	The routinisation of behaviours such as the use of tablets in day to day teaching activities.	Change management should focus on identifying structures and processes.
Identify benefits	Identifying benefits and strategic objectives.	The strategic rationale for mobile technology integration needs to be clearly stated and communicated at different levels of the education system. This facilitates alignment of strategies. For example, different strategies are required for implementing blended learning than when being fully online. There needs to be consistency in the information provided regarding the ICT integration strategy. Clear strategic objectives need to be provided.
Policy	Awareness of specific ICT policy influencing the project, developing appropriate policies.	Communicate relevant policies: e-rate; asset management; “section 21 schools” and their implications.
Communication	Understanding existing information channels and communication patterns between communities and relevant organisations.	Identify existing communication channels and their individual strengths and weaknesses. How do teachers report faults and related issues?
Information and knowledge management	Refers to how information is managed in the organisation. Involves identifying *which* information needs to be gathered, *how* it will be acquired, stored, retrieved and disseminated.	Information and knowledge management (KM) is important for sustainability. This assists in decision-making regarding the number of tablets at each school, how many of them require repair and how many schools use Internet. How will such data be collected, and by whom? What will this information be used for?
Building on existing public facilities	Available existing public resources (infrastructure, such as buildings, personnel, such as technicians) that can be appropriately utilised should be identified and maximised.	Existing facilities, such as Vodacom centres, should be used. Motivate/incentivise teachers to use ICT for self-development. Provide facilitators and encourage learners to identify and use existing facilities in the community.
Holistic approach	The broader needs of the community should be considered in line with the project and capabilities.	Identify other projects that support the initiative and decide how these can be leveraged.
Process	Refers to institutional procedures for reporting and management.	Requires assessment as to the effectiveness of current procedures and the elimination of inefficiencies in processes: e.g. reporting processes, fault logging procedures which should, for example, be followed when/if teachers require technical support. The actions required to map institutional processes to assess what is going well and what is not.
Institutional partnerships	Pertains to the long-term private and public-sector partnerships for infrastructure, digital content and teacher professional development.	Forming partnerships to increase capacity and improve economic sustainability. Key attributes necessary for successful ICT4D partnerships include trust, a clear focus, champions, focus on sustainability, investment of time in networking activities and transparency and sound ethics.

5.5.5 Summary

In this chapter the results of the case study were presented and analysed. Based on the responses of the teachers and district officials who participated in this study, *financial resources* are required to ensure that there is continuous educator training, monitoring, security of infrastructure, the provision of digital content and technical support. The findings support the need for long-term partnerships with the private and public sectors to aid financial sustainability as different stakeholders have varying competencies and capacities.

Teachers consider the use of tablets as beneficial in supporting teaching and learning. Teachers indicated that more tablets are required in the schools. There were suggestions to improve Internet and Wi-Fi access and to provide technical support to teachers and learners. Teachers' responses indicate that Internet access enables them to engage students in finding information online as well as accessing e-resources on websites such as Thutong and Quickmaths. This supports the *technological* sustainability dimension.

Teachers indicated that the learning and teaching support materials (LTSM) do not cater for ICT maintenance and that schools lack funds for technical support and tablet maintenance. District officials acknowledged the Department of Basic Education's responsibility in providing financial resources to schools. This supports the need for *financial* sustainability. The critical role of leadership was supported by examples of schools in the same province that had become "smart" schools, successfully integrating ICTs to support teaching, as a result of school leadership's efforts in raising funds from donors and funders to supplement funding received from the department.

Teachers' responses indicate that security of the tablets against theft is important, however, they seemed to consider it necessary for the department to play a more significant role in securing the ICT equipment. District officials, however, seem to place more responsibility on schools for the securing of ICT equipment. Communication between schools and the district regarding such matters is necessary to clarify roles and responsibilities.

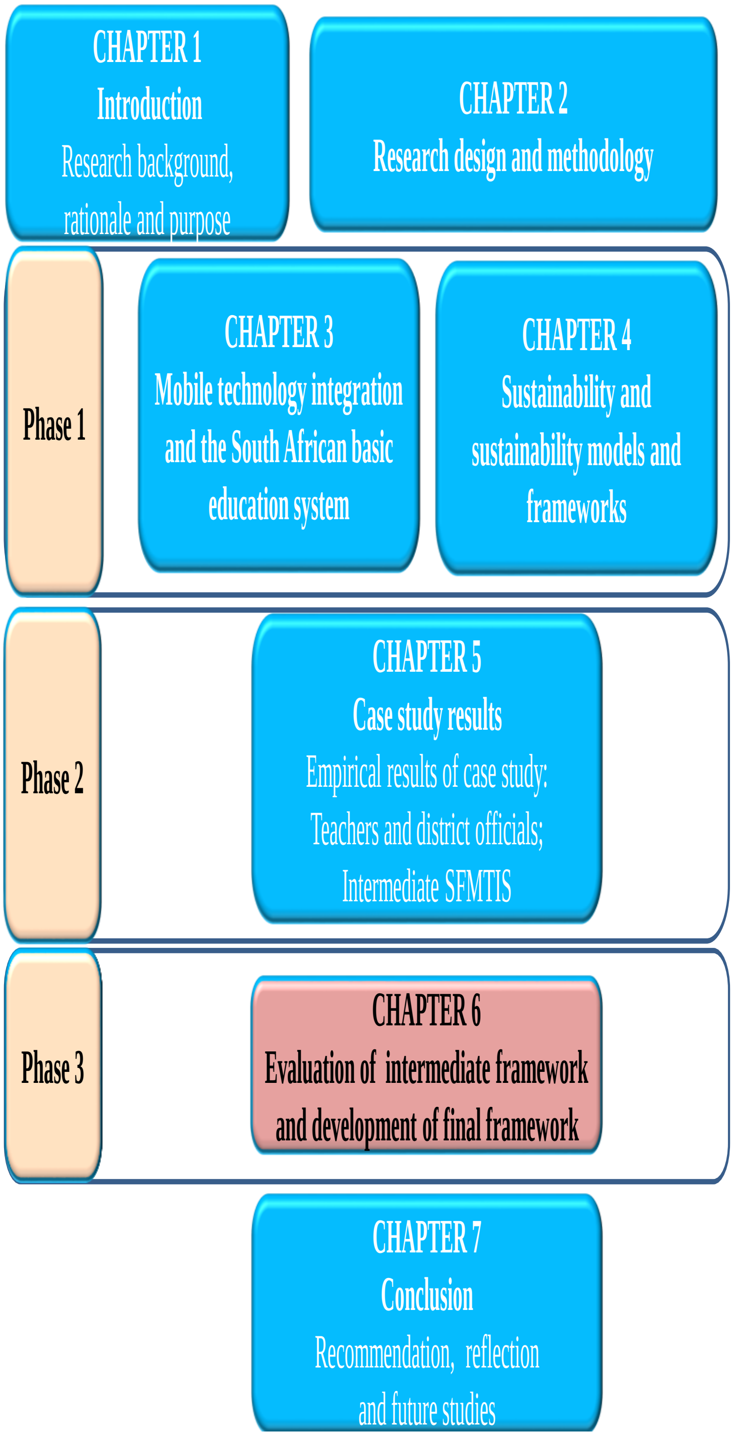
Based on the responses of teachers and district officials, institutional sustainability is integral in sustaining mobile technology integration. Teachers' responses indicate that ICT training of teachers is important in sustaining mobile technology integration. Teachers viewed leadership, monitoring and support by the district as essential, whereas district officials viewed school leadership (principal, school governing body and school management team) as critical.

The views of district management at Cofimvaba school district regarding mobile technology integration at the schools were discussed and categorised into sustainability dimensions. The significance of this categorisation is in confirming the sustainability dimensions that were synthesised in the initial SFMTIS. The findings from the interviews with teachers and district officials provide evidence to support the sustainability dimensions identified in literature. Reflection on the views of the teachers and district officials enabled the refinement of the initial SFMTIS which was developed into the intermediate SFMTIS, as presented.

Institutional factors, as identified from the responses of teachers and district officials, support the addition of the *institutional dimension.* This dimension represents the policies, procedures and practices, leadership, management, communication and coordination at different levels of the education system: micro (school), meso (circuit and district) and macro level (provincial and national) levels. Resources are required to support mobile technology integration.

Based on the responses of teachers and district officials, communication and coordination are mandatory at all levels of the education system. District management officials' responses support the need for clearly defined roles and responsibilities between schools and district in terms of: maintenance of ICT infrastructure, maintenance of tablets and the importance of leadership, particularly at school level. Leadership, management, communication and coordination are essential to sustaining mobile technology integration. The findings indicate that sound principles in school governance and management and effective leadership at school, district and provincial levels are required.

Chapter 6: Validation of the intermediate SFMTIS and development of final framework



Chapter 6: Validation of the intermediate SFMTIS and development of final framework

6.1 INTRODUCTION

In the preceding chapter, the intermediate SFMTIS was developed by applying the findings of the case study to refine the initial framework. This chapter presents Phase 3 of the DSRM in which the intermediate framework is evaluated by expert reviewers. This evaluation phase of the DSRM process (highlighted in red) is shown in Figure 6.1. The findings made were applied to refine the intermediate SFMTIS and to develop the final SFMTIS. The question that this chapter answers is: What constitutes a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa?

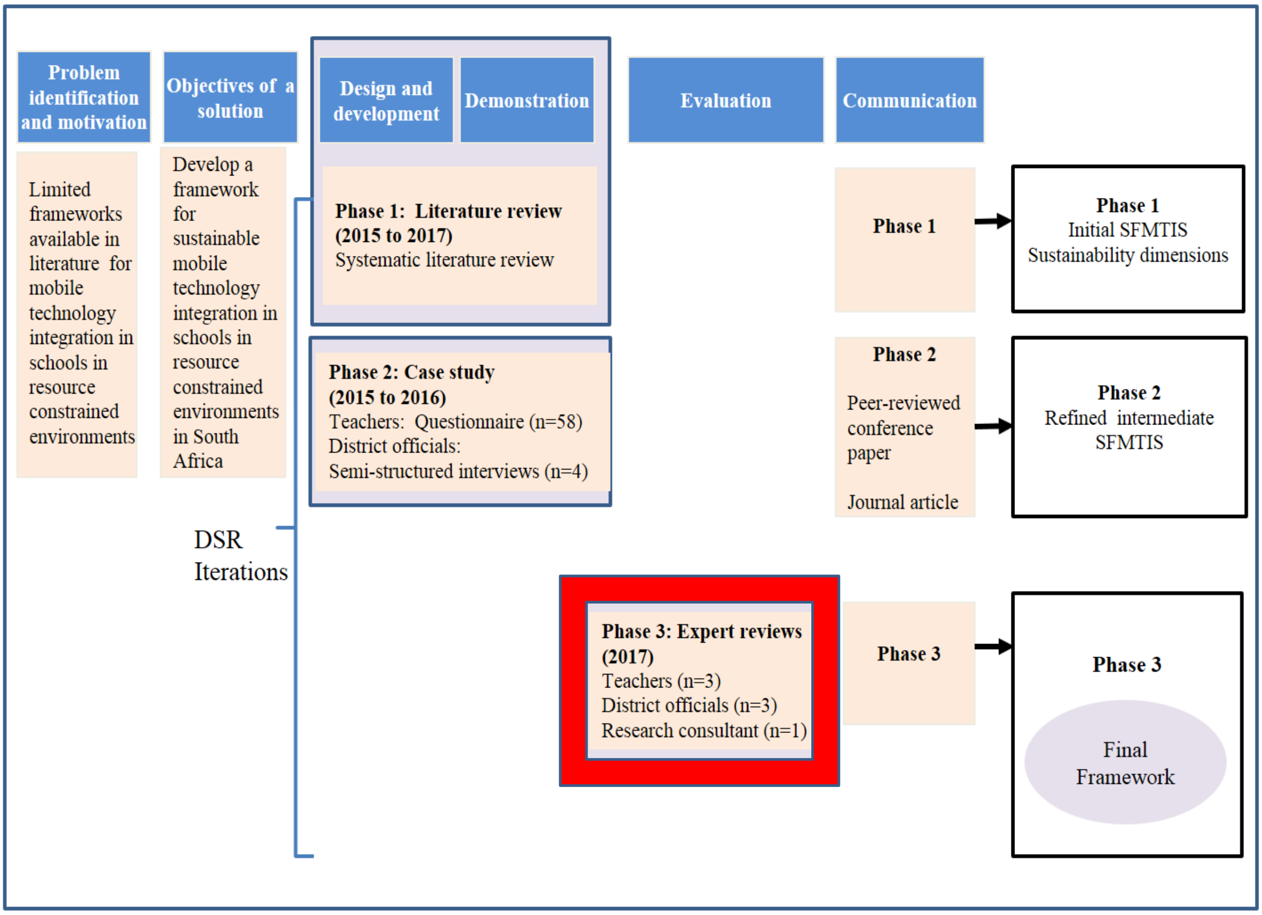


Figure 6.1: Application of DSRM process - Phase 3: Expert reviews

In the following section the significance of evaluation in DSR is discussed. The expert reviewers that were involved in the third phase of the research are presented in Section 6.3. The findings from the expert review of the SFMTIS are outlined in Section 6.4. Section 6.5

highlights the feedback from expert reviewers which was applied to the intermediate SFMTIS in order to develop the final SFMTIS presented in Section 6.6.

6.2 EVALUATION IN DESIGN SCIENCE RESEARCH

Evaluation is an essential activity in DSR (Hevner et al., 2004; Venable, Pries-Heje & Baskerville, 2012). DSR creates and evaluates IT artifacts intended to solve identified organisational problems. Utility is an important goal of DSR (Hevner et al., 2004) as evaluating the artifact's utility, in addressing the identified problems is essential, particularly where the artifact provides a type of solution, or development practices, for a particular class of user requirements (Markus et al., 2002: 180). The guideline for evaluation of utility in well-conducted DSR, as per Table 2.5 (Chapter 2), specifies that the utility, quality and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods. Venable et al. (2012) posit that the purpose of evaluation of the designed artifact, or the formalised knowledge about it, in DSR is to:

- Establish whether the developed artifact achieves its purpose and how well, that is, its utility and efficacy towards confirming, disputing enhancing the design theory;
- Compare it to other designed artifacts' ability to achieve a similar purpose; and
- Determine any adverse consequences, weaknesses and areas for improvement.

Design of evaluation in DSR distinguishes ex ante versus *post ante*, and *artificial* versus *naturalistic* evaluation, and may be f*ormative* or *summative*, however, each evaluation is specific to the artifact's purpose and the objective of the evaluation (Tremblay, Hevner & Berndt, 2010; Vaishnavi & Keuchler, 2015; Venable at al., 2012).

6.3 THE EXPERT REVIEWERS IN THIS RESEARCH

The intermediate SFMTIS (Figure 5.25) was evaluated by seven expert reviewers. The selected expert reviewers were requested to assess the intermediate SFMTIS. The reviewers signed the consent form (see Annexure 6.5) regarding their acceptance of the request. The data capturing was regulated by the University of South Africa's (Unisa) ethical guidelines. The clearance certificate is included in Annexure 2. The expert reviewers consisted of three teachers (one principal and two school ICT Champions) and three district officials. These expert reviewers had participated in the ICT4RED initiative and had given input as to the development of the SFMTIS during the DSR iterations (Figure 6.1). An expert reviewer from the agency which implemented the ICT4RED initiative, the CSIR, was also requested to assess the framework. The selection of the experts was based on their knowledge and expertise of the environment, context and involvement in the ICT4RED initiative. The following sections provide information regarding the expert reviewers' qualifications and knowhow that contributed to their selection to assess the framework as well as insights into how the evaluation was conducted.

6.3.1 Information about experts

Table 6.1 presents information on the expert reviewers, their current positions and academic qualifications.

Table 6.1: Expert reviewers

Expert reviewer and color ID	Current position	Highest academic qualification	Experience	Involved in ICT4RED?
Expert reviewer 1 - Teacher	Teacher at a school in Cofimvaba	BEd Honours (leadership and management)	Teacher for over 10 years and school ICT Champion	Yes
Expert reviewer 2 - Principal	Principal at a school in Cofimvaba	BEd Honours; Master's diploma (leadership and management)	32 years in basic education system	Yes
Expert reviewer 3 - Teacher	Head of department at a school in Cofimvaba	Primary teacher diploma; management and leadership programme	30 years in basic education system	Yes
Expert reviewer 4 - District	Senior subject education specialist (SES) at Cofimvaba district	BEd	Teacher (Maths & Science) 8 years; SES (9 years)	Yes
Expert reviewer 5 - District	Senior subject education specialist at Cofimvaba district	BEd Honours	Teacher (14 years); SES (10 years)	Yes
Expert reviewer 6 - District	Senior manager at Cofimvaba district	BEd	10 years in district, was also teacher in basic education system	Yes
Expert reviewer 7 - Academic	Research consultant	PhD	20 years	Yes

Expert reviewers 1 to 6 were all directly employed in the basic education system, 1 to 3 within schools and reviewers 4 to 6 at the district, while expert reviewer 7 had participated in the implementation of the ICT4RED as a research consultant at the CSIR, the implementing agency of the ICT4RED initiative. Thus, all the reviewers were well positioned to provide an informed assessment of the SFMTIS.

6.3.2 How the evaluation was conducted

Face-to-face interviews were conducted to present the intermediate SFMTIS to each of the teachers and district officials selected as expert reviewers. A PowerPoint presentation of the intermediate SFMTIS was used to explain the research process that lead to the development of the SFMTIS framework. The reviewers were then requested to respond to the questions in the questionnaire in Annexure 6.3 (teachers and district officials) and Annexure 6.4 (academic). The questions in the first section of the questionnaire sought to establish the reviewers' insights regarding the SFMTIS sustainability dimensions, while the open-ended questions related to relevance, rigour, validity and utility of the framework.

6.4 FINDINGS FROM EXPERT REVIEWS

Expert reviewers were requested to respond to questions regarding the sustainability dimensions of the SFMTIS. Section 6.4.1 presents the responses of the expert reviewers to the close-ended questions and Section 6.4.2 discusses the responses to the open-ended questions.

6.4.1 Responses to closed-ended questions

Table 6.2 shows the expert reviewers' responses to the closed-ended questions in assessing the significance of the sustainability dimensions towards ensuring the sustainability of mobile technology integration in schools in resource-constrained environments. The strongly disagree and disagree options were not selected by any of the expert reviewers.

Table 6.2: Expert reviewers' views on the significance of sustainability dimensions to ensure the sustainability of mobile technology integration					
	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Economic	-	-	-	-	100%
Cultural	-	-	-	-	100%
Political	-	-	-	30%	70%
Technological	-	-	-	30%	70%
Environmental	-	-	14%	-	86%
Pedagogical	-	-	-	30%	70%
Institutional					
School security, communication, coordination, technical support	-	-	-	-	100%
Leadership, monitoring and evaluation	-	-	14%	14%	71%
Policy	-	-	14%	29%	57%
Teacher professional development	-	-	-	14%	86%

All the expert reviewers strongly agreed that the economic and cultural dimensions are significant in ensuring the sustainability of mobile technology integration in resource-constrained schools in South Africa. Notably, one of the expert reviewers mentioned the importance of the district's role in financially supporting schools.

Most of the expert reviewers, 70% *strongly agreed* and 30% *agreed* that the political, technological and pedagogical dimensions are important for sustainability of mobile technology integration. The environmental sustainability dimension was supported by 86% of the experts who *strongly agreed* regarding the need for making plans for maintenance of tablets, replacing damaged mobile devices, planning for eventual disposal or reuse of ICT equipment. Fourteen percent of the experts *neither agreed nor disagreed.*

The institutional dimension examined aspects such as security, communication, coordination, technical support, teacher professional development, leadership, monitoring and evaluation, and policy. All the expert reviewers *strongly agreed* that school security, communication, coordination and technical support provided to teachers are important considerations for sustainable mobile technology integration. There were 86 % expert reviewers who *strongly agreed,* and 14 % *agreed* that professional development of teachers through ICT training is important. It is noteworthy that one of the reviewers specified that this training needs to be made available to all teachers in the circuit and not just limited to those who had participated in the ICT4RED initiative.

Seventy one percent *strongly agree*, 14 % *agree* and 14 % *neither agree nor disagree* responses for leadership and monitoring and evaluation. There were 57% *strongly agree*, 29% *agree*, and 14% *neither agree nor disagree* responses for policy implementation and the use of special available facilities such as e-rate for school Internet.

6.4.2 Responses to open-ended questions

The open-ended questions sought to establish the expert reviewers' views regarding the relevance, rigour and ease of use of the SFMTIS.

6.4.2.1 Relevance

Expert reviewers responded to the questions: Does the SFMTIS address a real problem/need? What three features of the SFMTIS would you consider as relevant? and Would you consider the SFMTIS reliable enough to apply in the environment?

All the experts agreed that the SFMTIS addresses a real problem/need and that it is reliable enough to apply in the environment. Expert reviewer 3 noted *"yes it is reliable, it can assist in enhancing sustainability in our schools and also the district"* and *"it also shows areas that need development"*. Expert 3's view is supported by expert reviewer 5 who stated *"yes (it addresses a real problem). It supports us and gives direction of continuity"*. Expert reviewer 7 elaborated that *"the concepts included in the framework are grounded in literature, and their application has been proven to be relevant in practice. The validity (reliability) of the framework is therefore implied"*. Expert reviewer 7 also explained that *"true validity would only be proven once it has been shown in a number of practical applications that sustainability has been influenced. To this end, clear indicators of sustainability would be required"*.

Financial sustainability was highlighted by expert reviewers 4 and 7. Expert reviewer 4 stated: *"Yes, it (SFMTIS) is needed for sustainability although there is a problem on its application due to financial problems"*. Expert reviewer 7 explained that: *"The loss of investment when interventions are not sustainable is significant. In addition, engaging communities in initiatives that fail could lead to fatigue and negativity with respect to development initiatives, thus preventing future access and potential positive impacts"*.

The expert reviewers also responded to the question: What three features of the SFMTIS would you consider as relevant? Table 6.3 lists each of the expert reviewers' selection, and Figure 6.2 represents this information graphically.

Table 6.3: Expert reviewers' top three features considered to be relevant			
	1	2	3
Expert 1	Pedagogical	Financial	Technological
Expert 2	Pedagogical	Institutional	Financial
Expert 3	Pedagogical *("Shows if tablets are used")*	Institutional: Security	Financial *("The maintenance of the tablets is a problem")*
Expert 4	Finance	Institutional: Security *("This also shows the security which is still a problem")*	Technological *("Digital content and connectivity")*
Expert 5	All seven sustainability dimensions	Institutional: Levels of communication	Institutional: ICT policies for schools
Expert 6	Finance	Institutional: Involvement	Technological: Selection of technology
Expert 7	All the sustainability dimensions are relevant and important	The tool used to score and discuss the dimensions (*Annexure 6.2) is relevant and potentially very useful	The SFMTIS visual representation (Figure 5.28) is useful and relevant to position the various role players

As Figure 6.2 shows, the financial sustainability dimension was considered to be important by all the expert reviewers. This was followed by the pedagogical and technological sustainability dimensions at 71%; institutional at 57% and the social, political and environmental dimensions at 29%. Expert reviewer 3 stated that the financial dimension is important because *"the maintenance of the tablets is a problem"*.

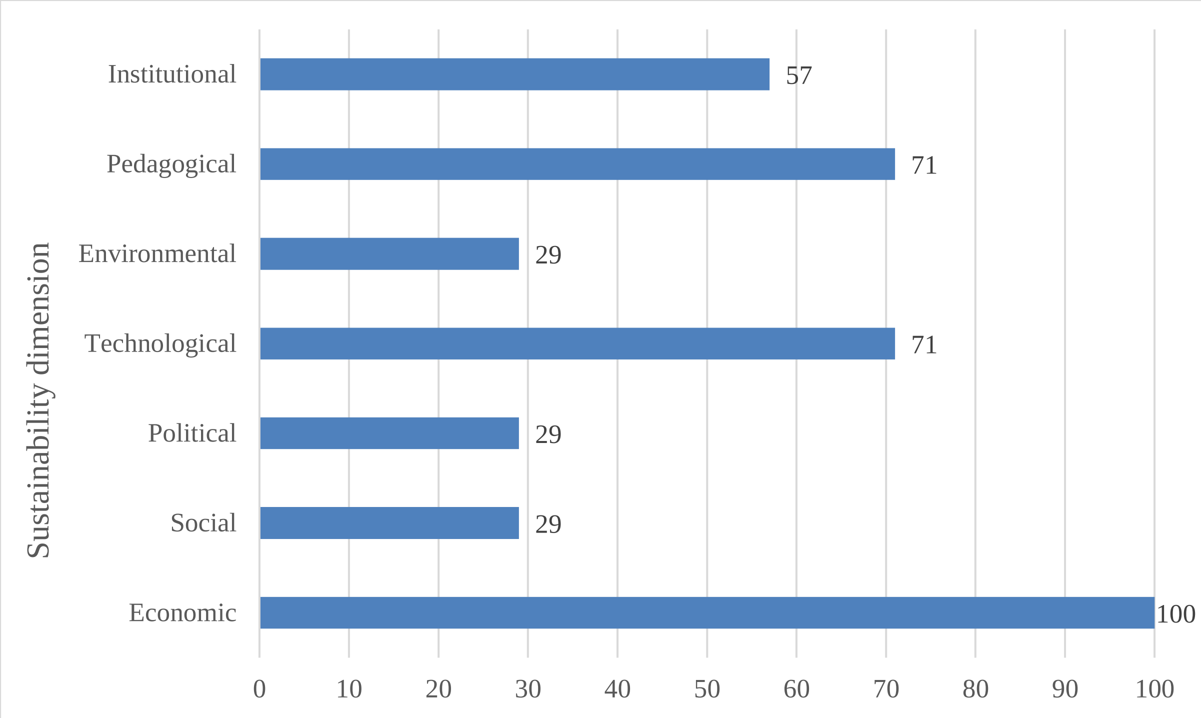


Figure 6.2: Percentage (%) of expert reviewers that considered the sustainability dimension as most relevant

Two of the expert reviewers, 5 and 7, viewed all of the sustainability dimensions as relevant and important. Expert reviewers 3 and 4 specified that security in the schools is a major problem. Levels of communication and involvement are aspects of the institutional sustainability dimension which expert reviewer 5 noted. The selection of appropriate technology was also indicated by expert reviewer 5 as important.

Expert reviewer 7 stated that: *"The SFMTIS tool used to score and discuss the dimensions (Annexure 6.2) is relevant and potentially very useful, and that the SFMTIS visual representation (Figure 6.4) is useful and relevant to position the various role players".*

6.4.2.2 Ease of use and application

The questions relating to ease of use and application were: Would it be easy to use the SFMTIS? How can the SFMTIS be applied? and What effect(s) can application of the SFMTIS have?

Affirmative responses were indicated by expert reviewers 1, 2, 3, 4 and 5 to the question: Would it be easy to use the SFMTIS? Expert reviewer 1 stated that *"following guidelines and applying relevant policies will ease the use of the SFMTIS"* and expert reviewer 2 expounded that "*it would be easy because all relevant stakeholders have been interviewed, also they contributed concrete evidence and inputs".* Expert reviewers 6 and 7 did not respond to the question regarding ease of use.

In response to the question: How can the SFMTIS be applied? expert reviewer 3 explained that: *"It would be used first at the school level, where the schools will be made aware that they need to sustain the project. The district and province, in supporting schools and also creating funding and providing workshops and technicians for the schools*".

Expert reviewer 6's response to the question: How can the SFMTIS be applied? was: *"Develop it as a policy guideline when implementing new projects"*. Expert 7's response was: *"Ideally, the framework should be applied at the outset of an ICT4D implementation (planning stage), with the purpose of highlighting the important aspects that could affect sustainability, creating awareness of key issues to manage, and influencing project planning. It could also be used as a tool for checking progress of the project towards sustainability at regular intervals during implementation and re-adjusting project implementation accordingly"*.

Expert reviewers' responses to the question: What effect can application of the SFMTIS have? are listed in Table 6.4.

Table 6.4: Expert reviewers' responses to the question: What effect(s) can application of the SFMTIS have?

Expert reviewer 1	It can improve the quality of integration of technology in resource-constrained schools.
Expert reviewer 2	It can have a positive effect on institutions if all the features of the programme can be integrated.
Expert reviewer 3	This will assist teachers, principals and districts into knowing what their role is, (and to be able to respond to the question:) How do they sustain the project?
Expert reviewer 4	Yes. (1) Motivation to all stakeholders, (2) Socio-economic factors.
Expert reviewer 5	Commitment to the project by all stakeholders; informed communities on ICT.
Expert reviewer 6	-
Expert reviewer 7	It could raise awareness of key sustainability issues and influence the management and implementation of an initiative towards sustainability.

Expert reviewer 1 stated that the effect of application of the SFMTIS is that *"it can improve the quality of integration of technology in resource-constrained schools"* and expert reviewer 7 responded that *"it could raise awareness of key sustainability issues and influence the management and implementation of an initiative towards sustainability"*.

6.4.2.3 Possible improvements

The questions posed to the expert reviewers in order to establish possible improvements to the SFMTIS framework presented to them were: What three features of the SFMTIS would you consider irrelevant? and What is missing in this framework?

Table 6.5 presents the expert reviewers responses to the question: What three features of the SFMTIS would you consider irrelevant? Two of the expert reviewers, 3 and 4, considered all of the features of the SFMTIS to be relevant. Three of the reviewers, expert reviewers 1, 2 and 4, stated that the political dimension is irrelevant. There were two expert reviewers who considered culture to be irrelevant. Expert reviewer 5’s view was that schools require the support of the department to provide finance for security and technical costs. Expert reviewer 7 suggested that two of the diagrams be integrated (Figures 5.26 and 5.27) and improvement to another diagram by reducing the details presented (Figure 5.28).

Table 6.5: Expert reviewers’ responses to: What three features of the SFMTIS would you consider irrelevant?

	1	2
Expert reviewer 1	Political	
Expert reviewer 2	Political	Culture
Expert reviewer 3	There was none that was irrelevant	
Expert reviewer 4	Culture	Political
Expert reviewer 5	Financing by schools without any departmental support for insurance, security, technical	
Expert reviewer 6	In my opinion all of them are relevant	
Expert reviewer 7	The two diagrams (Figures 5.26 and 5.27) are somewhat confusing in the sense that their immediate purpose is not clear. Could they be integrated into a single diagram?	The detail pertaining to the technology (Figure 4, bottom of the page) is very detailed and therefore potentially restrictive. Could this be made more generic to cater for any instantiation of technology (also considering potential future developments in technology)? For example, could ‘data projector’ and ‘printer’ be replaced with ‘data sharing devices’ or something similar?

In response to the question “What is missing in this framework?” expert reviewers 1, 2 and 3, considered the SFMTIS to be comprehensive. Expert reviewer 1 noted that *“all the relevant stakeholders are involved, as for me this is a comprehensive framework. Nothing is missing”* and expert reviewer 2 commented that *“as far as my opinion is concerned it has* *meaning, there is nothing that is missing".* Expert reviewer 3 stated that *"at the moment I do not see anything missing now"*.

Additions were suggested by expert reviewers 4 and 5. Expert reviewer 4 suggested inclusion of the directive approach and expert reviewer 6 stated: *"Asking sponsors from other companies to support the project e.g. Eskom, MTN, Vodacom, etc. financially to bridge gap not done by education and schools".* This perspective is supported by expert reviewer 7's remark that: *"The overall framework (Figure 4 on presentation) could make provision for funders, implementers, and commercial entities. These are often key to the intervention, and are not part of the education system or the other stakeholders listed in diagram"*.

Expert reviewer 7 suggested integration of the framework: *"The four different representations of the framework could be integrated into a single picture (with links between the elements, if necessary), so as to position the different ways in which the framework is implemented relative to each other, and to make the role of each clear".* In addition, expert reviewer 7 specified the need to emphasise the strategic aspect in the institutional dimension, and explained that: "*The Institutional dimension could include a strategy element (i.e., alignment between the strategic intent at micro, meso, and macro level). In addition, the strategic intent of the implementers and funders (who could reside outside of the education system) could also be considered".*

6.4.2.4 Rigour in development of SFMTIS

When expert reviewers were asked whether they would consider the process followed in developing the SFMTIS to be rigorous, 86% of the expert reviewers considered the process followed in developing the SFMTIS to be rigorous. Expert reviewer 3 indicated that *"we were consulted after each cycle was finished".*

Expert reviewer 7 consented that the process followed in developing the SFMTIS was rigorous because*: "The design science research process that was followed provided a framework within which concepts could be grounded in theory and tested in practice. Iterative application of concepts in practice provided the opportunity for rigorous testing and the development of well-grounded initiatives".*

6.4.2.5 Application in similar environments

When expert reviewers were asked whether they would consider the SFMTIS to be applicable in similar environments, 70 % of the expert reviewers considered the SFMTIS to be applicable in similar environments. Expert reviewer 3 explained that *"this can be used in* *any project because it is clear and specific".* Expert reviewer 1 indicated that it would be applicable *"as long as proper guidelines are followed"*.

6.5 EXPERT REVIEWERS' VIEWS APPLIED TO SFMTIS

Expert reviewers considered the SFMTIS to be relevant as it addresses a real problem, and *"It could raise awareness of key sustainability issues and influence the management and implementation of an initiative towards sustainability"*. The SFMTIS can also be applied in similar context. The following were incorporated based on the feedback from expert reviewers:

- Two of the diagrams representing the structure at micro and meso levels (Figures 5.26 and 5.27) were combined into one (Figure 6.5).
- The funders and implementers were given more prominence in the representation of stakeholder interactions.
- The alignment of the strategies within different levels of the department, in the institutional dimension were highlighted.
- The term *data sharing devices* was utilised in the SFMTIS visual representation diagram instead of *data projector* and *printer*.

6.6 THE FINAL SFMTIS FRAMEWORK

The components of the SFMTIS represented in Figure 6.3 that will be discussed in the following sections comprise of:

Figure 6.4: Visual representation of the SFMTIS stakeholders and interactions.

Figure 6.5: Structure and factors that affect sustainability of mobile technology integration - micro (school) and meso (district) levels.

Table 6.6: Sustainability dimensions for sustainable mobile learning in the context of resource-constrained public schools in South Africa.

Figure 6.6: Sustainability dimensions - practical example: Spider web.

Figure 6.7: Sustainability dimensions - practical example: Bar chart.

As discussed in Section 1.3, the SFMTIS is a conceptual framework. A conceptual framework is a visual (graphic) or written (narrated) product that explains the main things (factors, concepts or variables) and the presumed relationships among them (Huberman, 1994). Figure 6.4 shows the stakeholders and important interactions and relationships between the stakeholders. The structures, systems and processes of: the school (A), the district (B) and sustainability dimensions (C), are also indicated. Figure 6.5 shows the school (A) and district (B) structure, systems and processes. Making the structure explicit is important because all levels (micro, meso and macro) contain leadership roles and responsibilities that can be affected to support mobile technology integration (Section 3.2.7.1, School as a system, and Section 3.3.7, Leadership in the education system). This includes the roles and responsibilities of school governing bodies, the district and the provincial ICT Forum. The Department of Basic Education's information systems were discussed in Section 3.3.6. These systems provide digital resources to support teaching and enhance communication (e.g. DBE website, Section 3.3.6.1, and Thutong, Section 3.3.6.4). The SACE CPTD Management system (Section 3.3.6.5) supports the management of continuous teacher professional development.

In addition to the interactions and relationship between stakeholders, the alignment of structures, systems and processes of the school and district are an important factor in sustaining mobile technology integration. Table 6.6 (C) shows the sustainability dimensions. A practical example of application of the sustainability dimensions of the SFMTIS is presented in Figure 6.6. The spider web and bar chart scoring (Annexure 6.2) were developed to provide a practical exercise to facilitate discussion and communication of the sustainability dimensions of the SFMTIS.

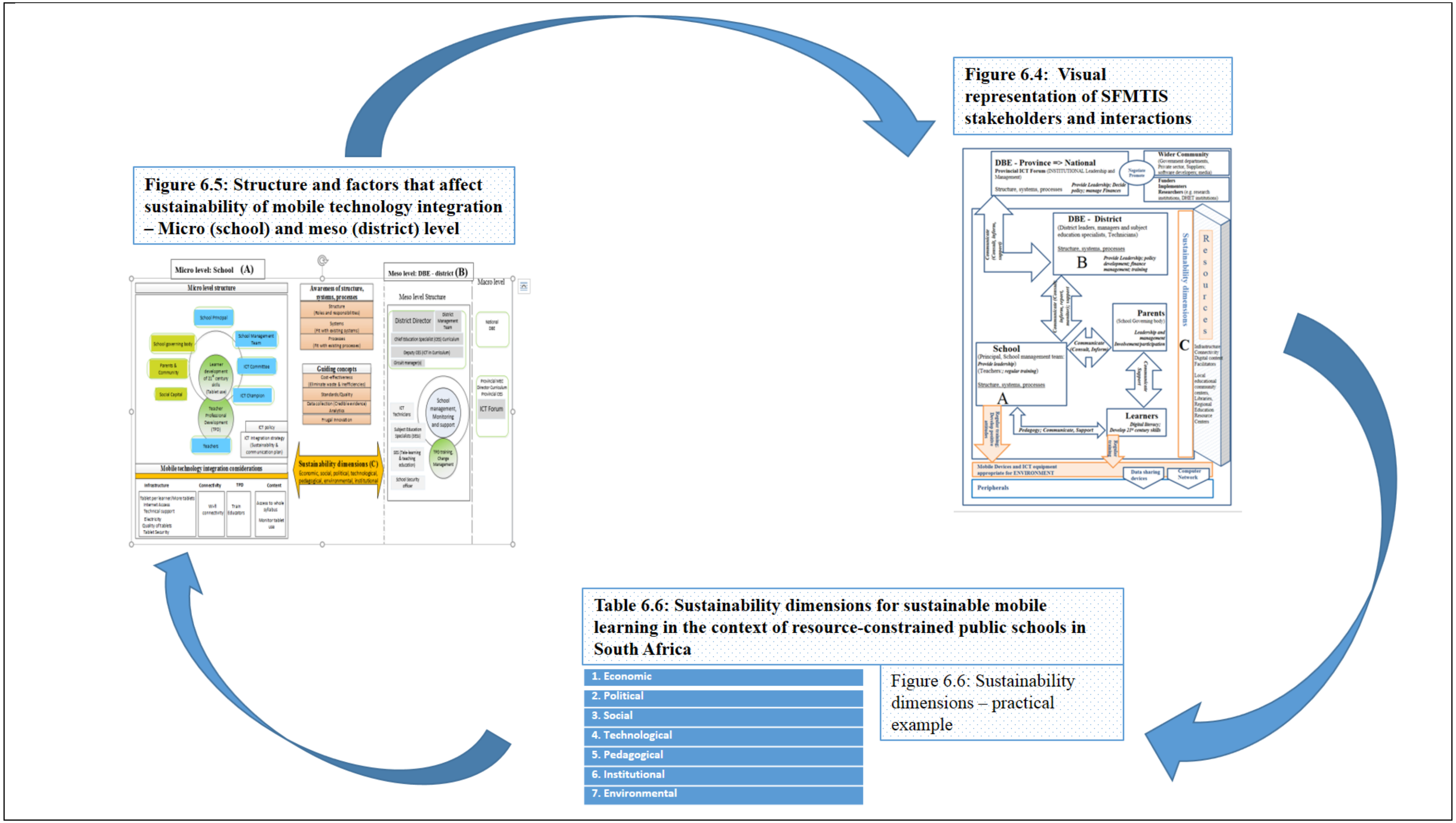


Figure 6.3: Final SFMTIS components

Figure 6.4 shows the stakeholders included in the SFMTIS context, the interactions between the stakeholders, their roles as well as interaction with the technology. Figure 6.4 is based on the "Person-centred sustainable model for mobile learning" (Ng & Nicholas, 2013), as discussed in Section 4.5.5 (Figure 4.6). The features indicated in Figure 6.4 include: institutional leadership micro (school), meso (circuit and district) and macro (provincial and national) levels; structures, systems and processes, particularly those of the school and district; and sustainability dimensions. The structure, systems and processes are important because the school is considered a system within the education system, as discussed in Section 3.2.7.1 (Figure 3.5).

The mLearn programme in the "Person-centred sustainable model for mobile learning" (Ng & Nicholas, 2013) was internally funded and therefore the discussion of leadership, management and interactions were internal to the school. The SFMTIS context considers the leadership and management at different levels of the education system because the school is reliant on funding allocated by the Department of Education based on pre-determined processes through the learning and teaching support materials (LTSM), as discussed in Section 5.5.1.1. The school and district, structures indicated as A and B in Figure 6.4, are depicted in more detail in Figure 6.5. The sustainability dimensions which are important for sustainable mobile tablet integration in the context of resource-constrained public schools in South Africa, shown in Table 6.6, are specified as C in Figure 6.4.

The coloured sections (peach colour) in Section 6.4 show the interaction that schools, including teacher and learners, have with the technology, the resources and sustainability dimensions. The sustainability dimensions, including the resources, support the interaction with the technology. Leadership at micro level (school), is provided by the principal, school management team and the school governing body, as previously discussed in Section 3.3.7. At district level, the district director and the district management teams have oversight of schools in their district, as per Section 3.3.7, while the province and national leadership is also important. The implications for the SFMTIS is the need for communication between and coordination of the systems and processes at the different levels of the education system.

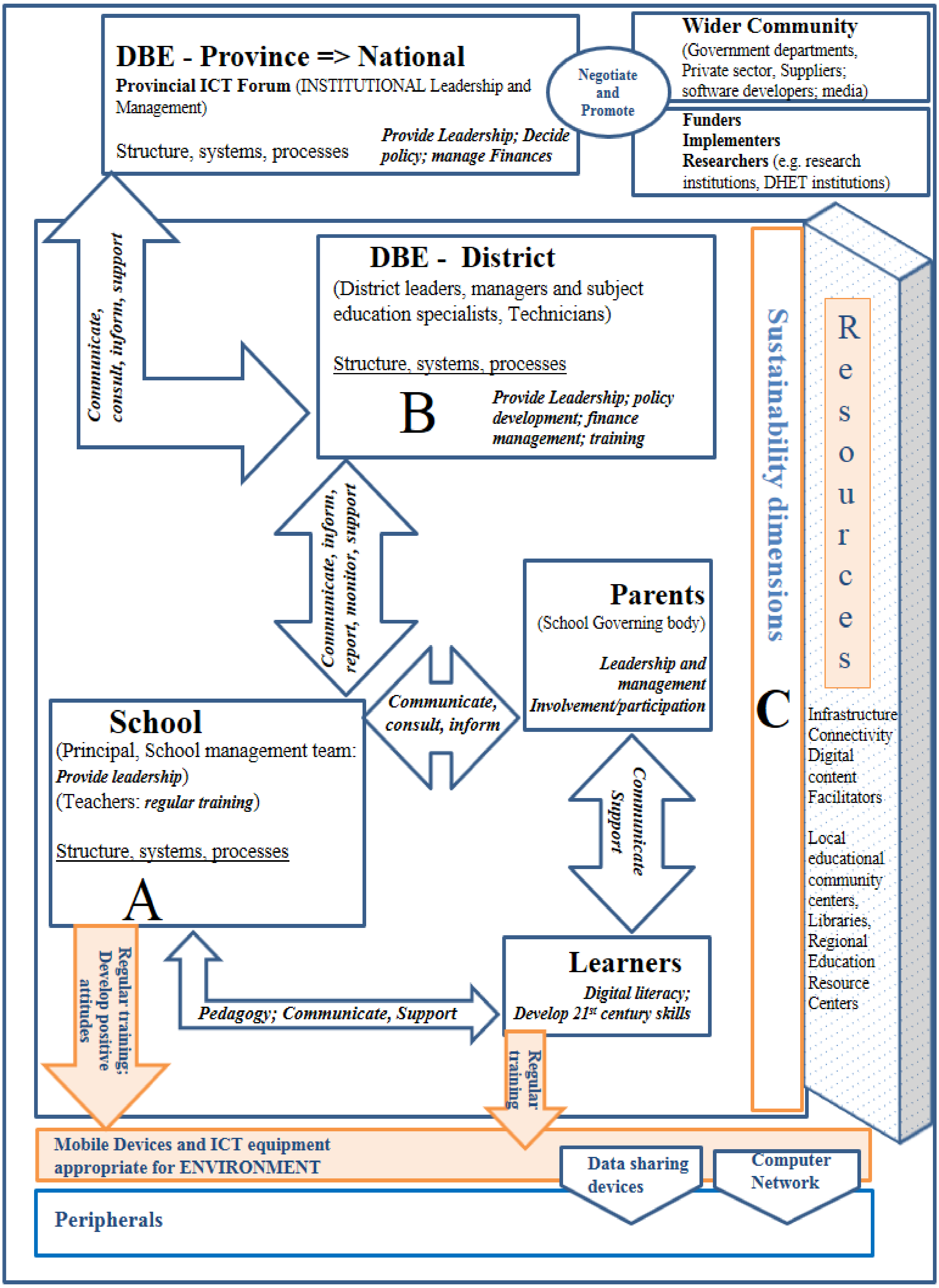


Figure 6.4: Visual representation of SFMTIS stakeholders and interactions

The findings in this research indicate the importance of the relationships between the stakeholders involved in the integration of mobile technology in the schools as well as the way in which they interact with the mobile technology, as shown in Figure 6.4. The leadership roles span across different levels of the education system, within the school, district, provincial and national levels. How leaders execute their roles and responsibilities, and are held accountable in managing and providing oversight, influences sustainability. The sustainability dimensions that were identified for the SFMTIS include: economic, political, cultural, technological, pedagogical, environmental and institutional dimensions. The institutional sustainability that this study proposes includes leadership, communication and coordination, training and security. Teachers noted that leadership and support by the DBE at national, provincial and district level is critical.

The availability of resources is an important aspect in the SFMTIS and forms part of the sustainability dimensions. The SFMTIS advocates financial support in various ways. Based on teachers' and district officials' responses, schools can engage the Department of Basic Education regarding the LTSM and how technical support and maintenance of mobile devices can be addressed. The findings also support involvement of the private sector in forming long-term partnerships to support mobile technology integration. Raising of funds and financial sustainability also supports parental engagement and the utilisation of social capital by engaging the community.

The need for alignment of the structure's systems and processes at micro, meso and macro levels, requires enhanced communication and coordination. Figure 6.5 provides a detailed view of the structure and factors that affect sustainability of mobile technology integration at micro and meso levels. When considering the school as a system within the educational system, as discussed in Section 3.2.7.1, the systems, structures and processes need to be well coordinated in order to efficiently implement mobile technology integration. Elimination of waste and inefficiencies, establishing and promoting standards, and appropriate quality levels in mobile technology integration would require relevant levels of reporting, data collection and analysis that can be supported by analytics.

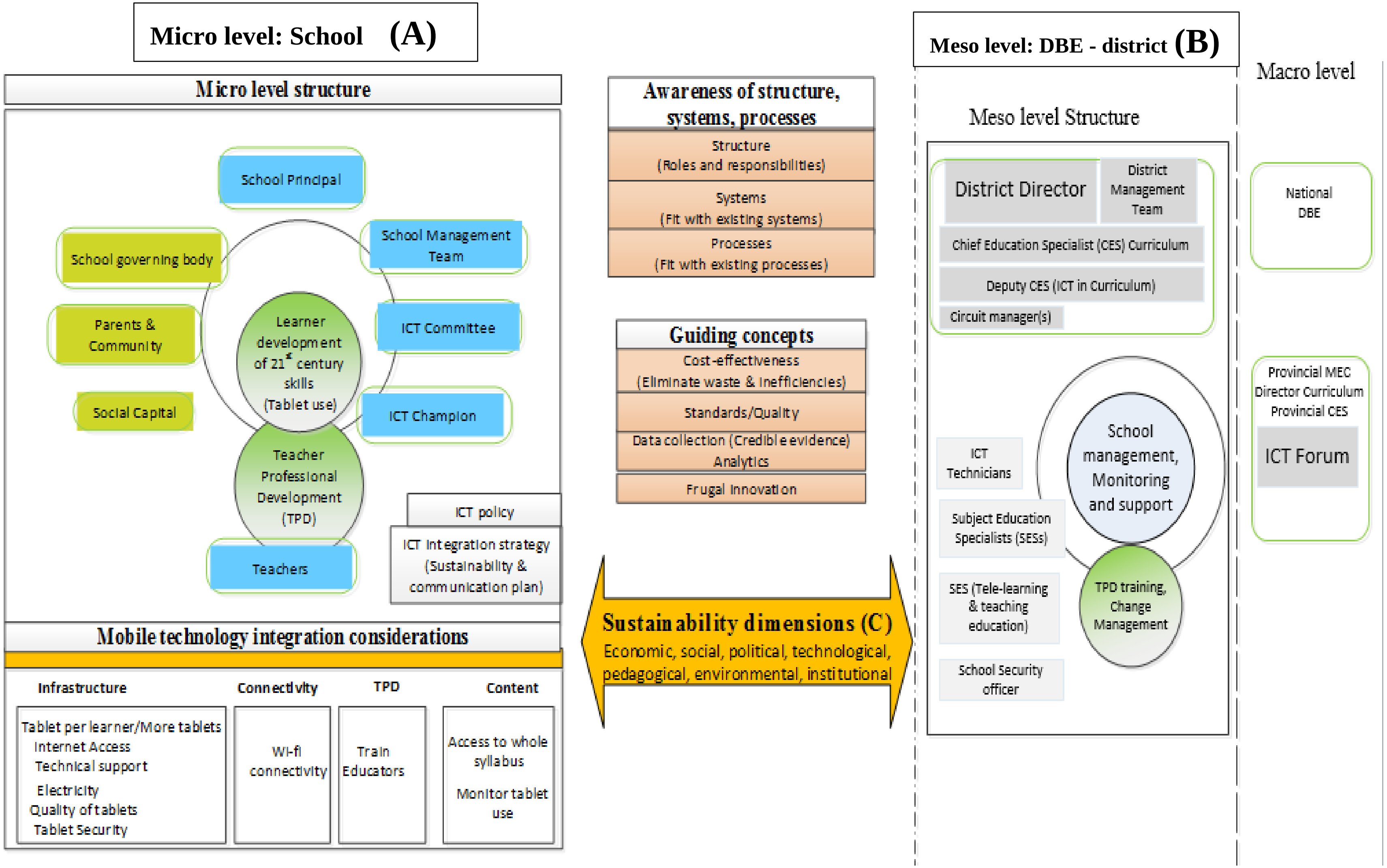


Figure 6.5: Structure and factors that affect sustainability of mobile technology integration – Micro and meso levels

Table 6.6 shows the Sustainability dimensions for sustainable mobile learning in the context of resource-constrained public schools in South Africa.

Sustainability dimensions - "C" in Figures 6.4 and 6.5	
Table 6.6: Sustainability dimensions for sustainable mobile learning in the context of resource-constrained public schools in South Africa	
1. Economic	The need for financial resources. Financial capability of the educational institution to support the ICT technology in the long term. Financial support from the government and the private sector for the financial requirements necessary for maintaining ICT infrastructure and equipment.
2. Political	The role of leadership and the institutional policies required to adopt, maintain and monitor the success of mobile learning programmes; consultation and feedback between different levels of the institution.
3. Social	Effective participation of social groups. Community involvement of parents, political leaders and partnerships with business partners, such as computer companies.
4. Technological	Informed technology selection based on institutional needs and mid to longer-term strategic goals. Consideration of technology and infrastructure access, maintenance, technical support and teacher professional development. Consultation and feedback between service providers regarding content, technical support and users (teachers).
5. Pedagogical	The roles of teachers in teaching and learning practices to support the goals of mobile learning programmes. Peer collegiality required to ensure best pedagogical practices. Formal and informal learning facilitated by mobile learning.
6. Institutional	Alignment of *strategy*, *processes*, *leadership support* and *policy* implementation at school (micro), district (meso), provincial and national level (macro) levels. The strategic intent of funders and implementers should also align to the Department of Basic Education's strategy.
7. Environmental	More robust ICT infrastructure is needed for hilly terrain that affects line of sight and Wi-Fi accessibility. Untarred roads can affect access to the schools and when it rains the roads become muddy. Plans to *maintain* damaged mobile devices and for eventual disposal, or reuse, of large amounts of ICT equipment when at the end of its effective life.

Table 5.3 provides a <u>detailed description</u> of the sustainability dimensions and aspects to consider for the SFMTIS for resource-constrained environments in South Africa.

The sustainability dimensions, as stated in Table 6.6, are further discussed in the following section.

Economic sustainability: Financial capability and economic self-sustainability are important aspect in the SFMTIS. The findings indicate a need for the educational institution to be able to provide the resources to support the continuity of the programme in the long-term. This includes costs associated with infrastructure, connectivity and cost of usage, hardware (additional tablets and maintenance of the tablets), ICT infrastructure and digital content in school servers. There are also costs associated with capacity building, professional development of teachers, Internet access and Wi-Fi connectivity as well as the technicians required to support teachers and learners.

Funding norms and guidelines that cater for financial support of new responsibilities arising from the introduction mobile devices could assist schools in maintaining mobile devices. The DBE’s planning and budgeting for schools’ LTSM could consider ICT related costs in its structure. The findings seem to suggest a need to train and support school SGBs, especially SGB financial committee members, regarding the management of school funds. An awareness with schools and SGBs, as to the implications of having been classified as a *section 21* school in relation to fund raising responsibilities, should also be established. Decision-support tools, such as the cost utility model and total cost of ownership model (TCO), can benefit the planning process.

The cost of learning and teaching support materials (LTSM), such as textbooks, could be assessed against the cost of utilising mobile technology and digital resources. The elimination of waste and inefficiency with a renewed focus on efficient, cost-effective operations should also be encouraged. Economies of scale and frugal innovation could be applied given that schools expressed the *lack of funds* as a major reason for not being able to afford the maintenance of tablets and the ensuing technical support. Schools could investigate different channels of funding, including public and private partnerships, as discussed in Section 4.5.3.2, towards finding cost-effective solutions that meet their developmental needs.

Economic sustainability is connected to the institutional, social and political dimensions of sustainability.

Cultural/social sustainability: Refers to stakeholder participation, including community involvement, and their roles and responsibilities in relation to mobile technology integration.

This includes stakeholders within the school, the community, and from outside the communities. Different stakeholders have varied competencies and capacities. The contribution made by different stakeholders could be *financial* or *non-financial* such as high-level support and advocacy, raising awareness of the advantages and importance of mobile learning, providing technological infrastructure and services.

Developing teachers' understanding of *how* and *when* to use technology for e-learning can change their practice of teaching. Providing opportunities for teachers to join communities of practice can provide a supportive work culture for teachers.

Interaction and communication within the school (teachers, parents, learners, school governing body, school management team and administration staff), and the district, province and broader community (community leaders, political leaders, business partners, funders, implementers and commercial entities) can be enhanced. Consultation and feedback with stakeholders can be beneficial in that it can lead to the identification of ways in which quality and cost-effective products and services, associated with different aspects of mobile technology integration, can possibly be provided.

A supportive culture in which individuals at all levels of the education system, thus macro, meso and micro levels, are held accountable for their assigned roles and responsibilities, could contribute to the effective integration of mobile technology to support teaching. A collaborative and supportive work culture can provide an enabling environment. Schools, and school districts, could cultivate a culture in which ICT related planning is prioritised whilst communication strategies are developed which, in turn, inform the DBE's approach regarding school ICT requirements, such as technical support. For example, one of the school ICT Champions suggested that schools' annual planning and budget, which are submitted to the Department of Education, could include ICT maintenance costs, technical support and content management costs.

School leadership, including SGBs' role and the extent to which the SGB hold teachers and principals to account, influence parents' involvement in finding solutions regarding security and funding. Strategies for increasing the involvement of parents, SGBs, SMTs and teachers in planning for, and actively participating in, activities to strengthen integration of mobile technology into teaching could be established.

The social dimension is interlinked with other dimensions such as political, institutional and financial.

Political sustainability: The findings in this study indicate that effective public leadership and sustained commitment can influence the success of mobile technology integration. Participation and commitment of public managers and political leaders can influence the sustainability of mobile learning programmes. This includes successful interactions between key players and the way in which interpersonal relationships are managed. Clarifying the roles and responsibilities of officials at different levels of the education system, thus at school (micro), district (meso), provincial and national (macro) levels, in relation to implementation of ICT programmes, can contribute to the sustainability of these programmes.

At district level the roles and responsibilities of subject education specialists (or subject advisors, in mobile technology integration in schools, particularly those responsible for e-learning, could be well communicated between schools and the district offices. Teachers expressed the need for increased involvement of the district, including the management and subject education specialists, in facilitating mobile technology integration.

At school level, the school ICT Champion, principal, school management team and school governing body, can contribute to the effective management of ICT programmes. At meso level (circuit and district), the district management team, District director, Chief education specialist (Curriculum), Deputy chief education specialist (ICT in Curriculum) and the subject education specialist (Tele-learning and teaching education) can facilitate monitoring, evaluation and oversight of schools and interaction, and reporting with the province. At provincial (macro) level, the provincial ICT Forum in the Eastern Cape Department of Education (ECDoE) can facilitate coordination of ICT related activities and so enhance communication and feedback on relevant matters. The role of the provincial ICT Forum also needs to be communicated.

How well these structures interact and function, and how they are resourced to effectively execute their functions, is also critical. Communication, consultation and feedback among stakeholders are required to facilitate planning, coordination, monitoring and evaluation. The political dimension is connected to the strategic alignment and intent at micro, meso and macro levels, as well as the strategic intent of funders and implementers. Cultivating influential ICT Champions thus seems to be essential for advocacy.

Communities of practice enable teachers to create a wider learning community and participation. Teachers could be supported in creating communities of practice that promote ICT integration into teaching. Analysis of e-learning impacts and best practices in developing countries shows that *"the most successful programmes also took advantage of the fact that* *informal leaders often emerged from schools and classrooms"* (Olson et al., 2011: 36). Peer-to-peer interaction by teachers in the ICT programmes often attract other teachers who may initially have resisted using technology (Olson et al. 2011). This is essential as teachers are important for successful e-learning (Section 3.2.5).

The effectiveness of current structures and processes could be assessed and appropriate structures and processes for planning, communication and coordination between the DBE and schools enhanced.

Technological sustainability: The findings in this research show that schools require durable high-quality tablets, and well-trained, qualified technicians, who can provide technical support to teachers and perform network administration functions. Technology selection could be informed by relevant models for the environment, such as the technology selection model (Meyer & Marais, 2014), to facilitate the choice of appropriate technology, based on institutional mid-to-longer-term strategic goals. Appropriate planning and budgeting is required to facilitate continued access to quality Internet and Wi-Fi connectivity, technical support for teachers and learners, ICT infrastructure and digital content maintenance.

Communication, consultation and feedback among stakeholders, as well as information and knowledge management, can support school processes. For example, information regarding facilities, such as the e-rate (Section 3.3.5.1), could be communicated to schools. Co-ordination and communication by districts can assist schools to leverage and maximise on the ICT infrastructure that has been established through the ICT4RED initiative.

This dimension is closely connected to the economic, institutional, political and pedagogical dimensions.

Pedagogical sustainability: Teachers' roles in facilitating learning with mobile devices, as discussed in Section 3.2.5, indicate the importance of this dimension. Professional training of teachers in the use of the devices, and teaching practices associated with technology-enabled learning, should be prioritised. This is associated with the professional training of subject education specialists (subject advisors) who are based at the district offices, and training of technicians, in order for them to provide relevant support to teachers. The role of subject education specialist in training teachers on *how* and *when* to use mobile technology when teaching specific subjects, needs to be clearly defined and communicated. Checks and mechanisms to identify inefficiencies in existing implementation, reporting, monitoring structures and processes also need to be put in place. Teachers' pedagogical practices to support mobile learning could be encouraged by supporting communities of practice which, in turn, facilitate peer collegiality and conversations that encourage teachers to apply best pedagogical practices.

A shared understanding of the pedagogical strategy by stakeholders could enhance collaboration. E-learning is a wide-ranging term and therefore it is useful to categorise the *type* of e-learning being referred to (represented in a continuum from no digital support to fully online), whether it is digitally supported, digitally dependent, internet supported, internet dependent or fully online. As Bates and Sangra (2011) argue, institutions' strategies and pedagogical models in relation to technology integration need to be clearly stated. It should also be clearly indicated whether courses are fully online or primarily text-based within the e-learning continuum. Planning and communication of the department's pedagogical strategy also relate to the funding formula of the learning and teaching support material (LTSM) applied.

The pedagogical strategy subscribed to by different stakeholders needs to be aligned at all levels. In the case of the ICT4RED initiative, a principal at one of the schools was quoted by Wild (2015) as saying: *"We have textbooks, but the tablets could replace them"*. This was not in alignment with the ICT4RED initiative objectives that sought to *"run in parallel with existing paper textbook and content models; it does not currently intend to replace the status quo"* (Botha & Herselman, 2014: 5). This was based on the approach of phasing in mobile devices to support teaching and learning as part of a *blended learning* environment in which various modes of teaching and learning material would co-exist comfortably.

A constructivist-based online delivery model requires planning in which teaching materials are appropriately designed for online teaching. Consequently, a need exists to build *institutional capacity*, and develop comprehensive pedagogy, course design and technological delivery programmes. Considerations to be made when developing and deploying e-resources to schools include: management of copyright issues, licence agreements and expiry dates and ensuring continuity of access to relevant e-resources. The differences between *open* and *proprietary* digital content, and their cost-benefits, need to be understood by policy makers in order to inform decisions regarding the setting of standards and procedures as to the cost-effective development, procurement and deployment of CAPS relevant e-resources. Creation and deployment of e-resources on tablets and servers need to support the long-term goals of the mobile learning programme.

Environmental sustainability: Refers to the existing conditions, including resource-constraints, within which the ICT programme is implemented, e.g. the physical terrain and handling of e-waste. More robust ICT infrastructure is needed in hilly terrains where line of sight and Wi-Fi accessibility is affected. Untarred roads can affect access to the schools as the roads can become muddy and slippery when it rains. Environmental sustainability also refers to the effects of the ICT equipment on the surroundings. Plans should be made which consider the effects of ICT equipment use on the environment, how damaged mobile devices will be handled and the eventual disposal, or reuse, of the ICT equipment at the end of its effective life. The environment is connected to other sustainability dimensions, institutional, environmental, political and cultural dimensions.

There are broader environmental issues at work in resource-constrained environments that teachers and district officials have to contend with. Some of these are covered in other dimensions such as those influenced by the financial, cultural and institutional dimensions. Environmental challenges require that tablets be designed to reduce the risks identified in this study. For example, the tablets need to be durable, easy to maintain and energy efficient.

The increase in the quantities of ICT equipment, including tablets that are supplied to schools, requires that the long-term effects of these devices on the environment be closely examined, for example, the way in which schools handle, maintain and dispose of ICT equipment.

The school system functions as an institution and as a component of the education system. Consequently, the school system interacts with social, political and economic factors in its environment which, in turn, affect the education system.

Institutional sustainability: This dimension pertains to the alignment of strategy, processes and policy at school (micro), district (meso), provincial and national (macro) levels and the relevant structures, systems, processes and policies which affect the implementation of the mobile technology integration programme. In the education system, integration may be required across disciplines such as: curriculum, ICT and e-learning. This would require the development of an ICT integration strategy with clearly defined objectives and measures to assess success. The articulation and communication of the roles and responsibilities of officials at different levels of the education system, in relation to the implementation of the mobile technology integration programme, is also required. Coordination and monitoring of the project by relevant officials fall within the institutional dimension.

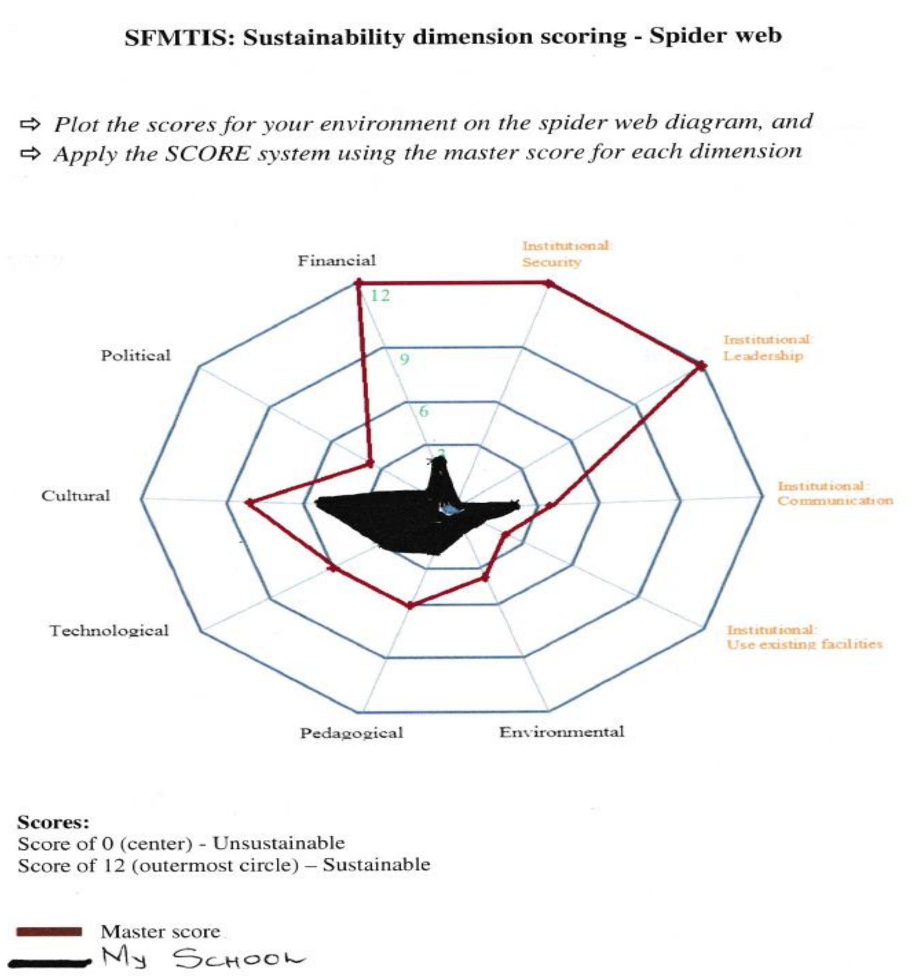
As stated by Meyer and Marais (2014), the findings in this research support the statement that *institutional readiness* and *capacity for uptake* are important factors. Teachers and district officials noted that at different levels (school, district and provincial) institutional processes, challenges, and governance issues affect mobile technology integration.
The ICT4RED initiative deployed technology, such as tablets, that require technical support. Institutional capacity also relates to personnel, processes and management capacity in the province, in this case the Eastern Cape Department of Education (ECDoE), and in the Cofimvaba school district which need to be aligned to the level of deployment of the ICT equipment. Leadership, communication and the capacity to manage the change are all important factors under the institutional dimension.

Sustainability dimensions - practical example

The practical example of the SFMTIS is an exercise that can be applied to enhance communication regarding sustainability dimensions (refer to Annexure 6.2). Figure 6.6 shows the perceived scores of the sustainability dimensions by two teachers from different schools. The two teachers were also ICT Champions for their different schools. This illustrates *how* the practical component of the SFMTIS can be applied to stimulate conversation, discussion and communication regarding actions that can be taken, by schools and districts, to enhance the sustainability of mobile technology integration. The two schools differed significantly in terms of leadership and security aspects, both considered to fall within the institutional dimension.

Applying the SFMTIS practical example enables teachers to assess their schools' positions in relation to the sustainability dimensions in the SFMTIS. This promotes teachers' ability to think about and generate solutions, as well as make decisions, in response to the challenges they face regarding mobile technology integration. This view is based on the premise of the basic tenants of *agency* and *structure* in the structuration theory discussed in Section 2.3.1. Agency, the human capacity to make a difference in one's situation, has transformative capacity and power (Giddens, 1984).

School X



School Y

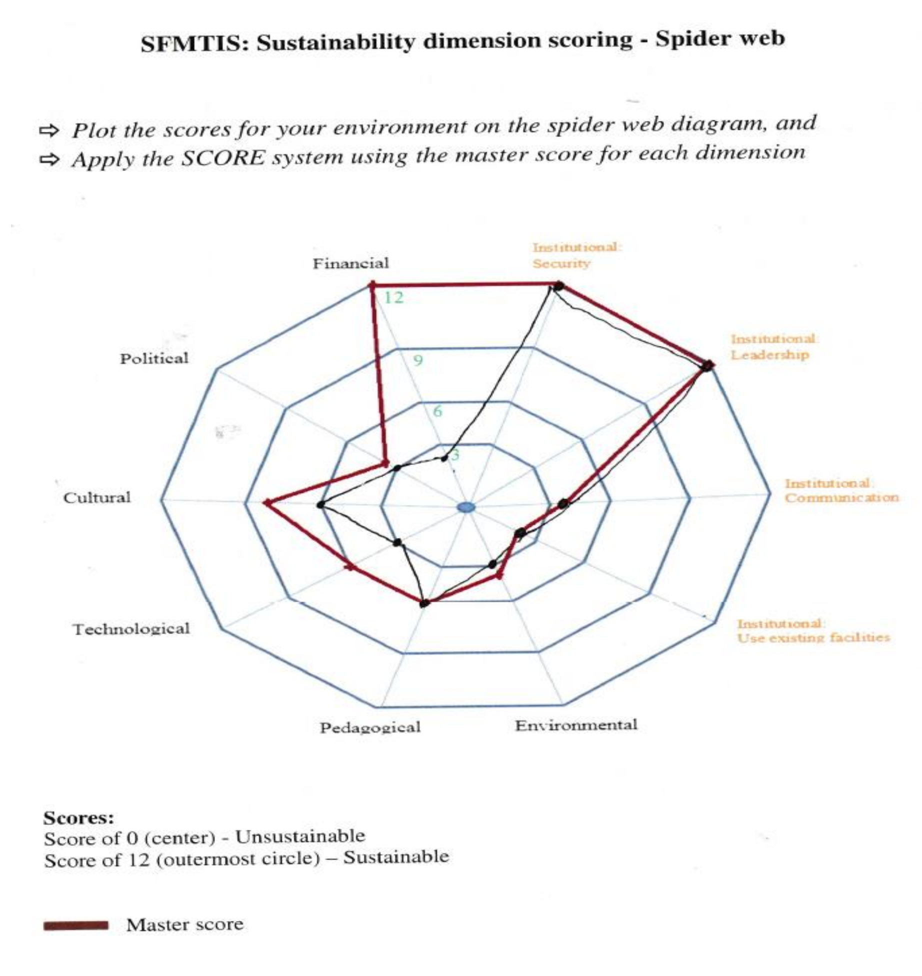
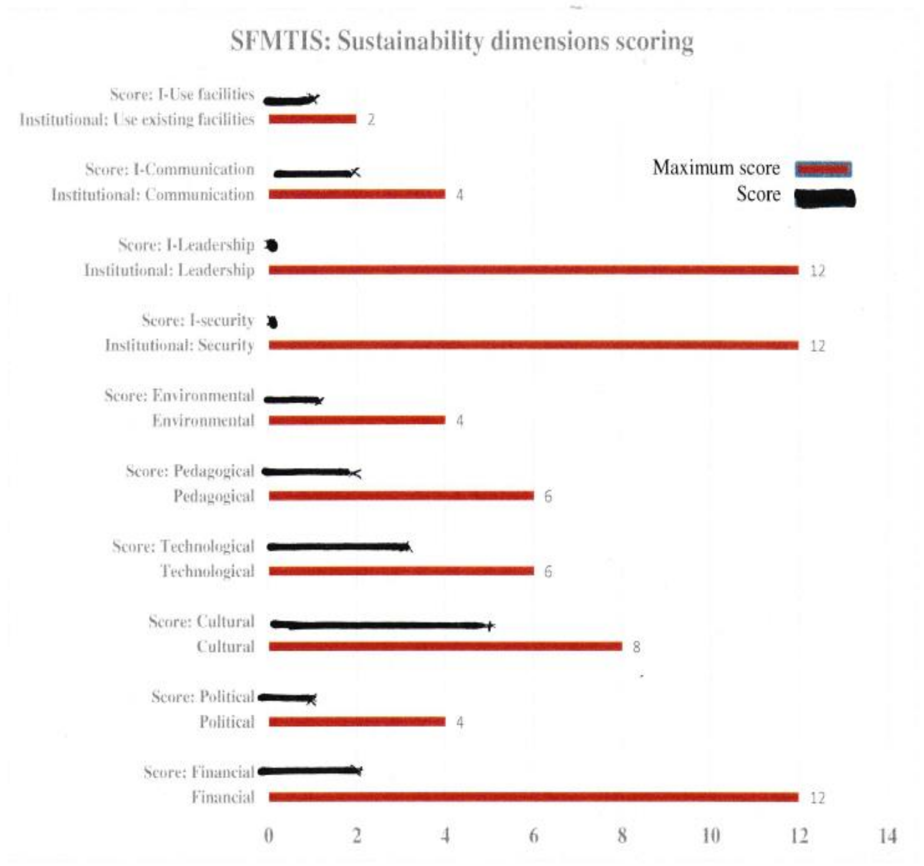


Figure 6.6: Sustainability dimensions – practical example: Spider web

School X

SFMTIS: Sustainability dimension scoring – Bar chart

⇨ *Plot the scores for your environment on the bar chart*



School Y

SFMTIS: Sustainability dimension scoring – Bar chart

⇨ *Plot the scores for your environment on the bar chart*

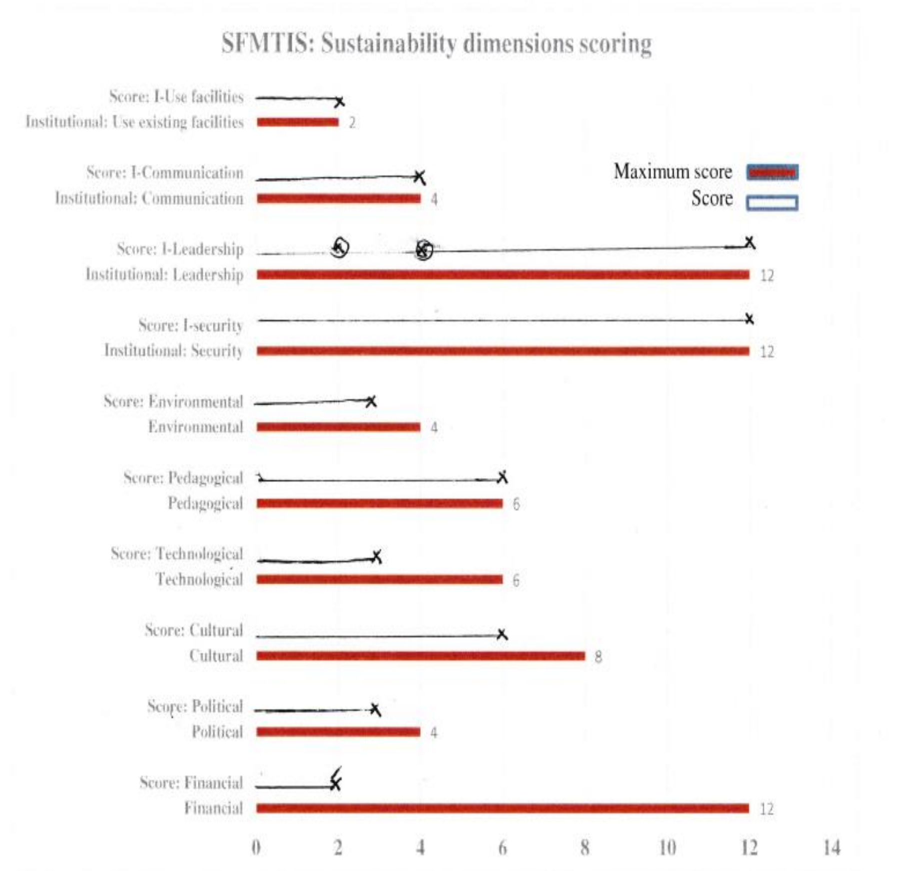


Figure 6.7: Sustainability dimensions – practical example: Bar chart

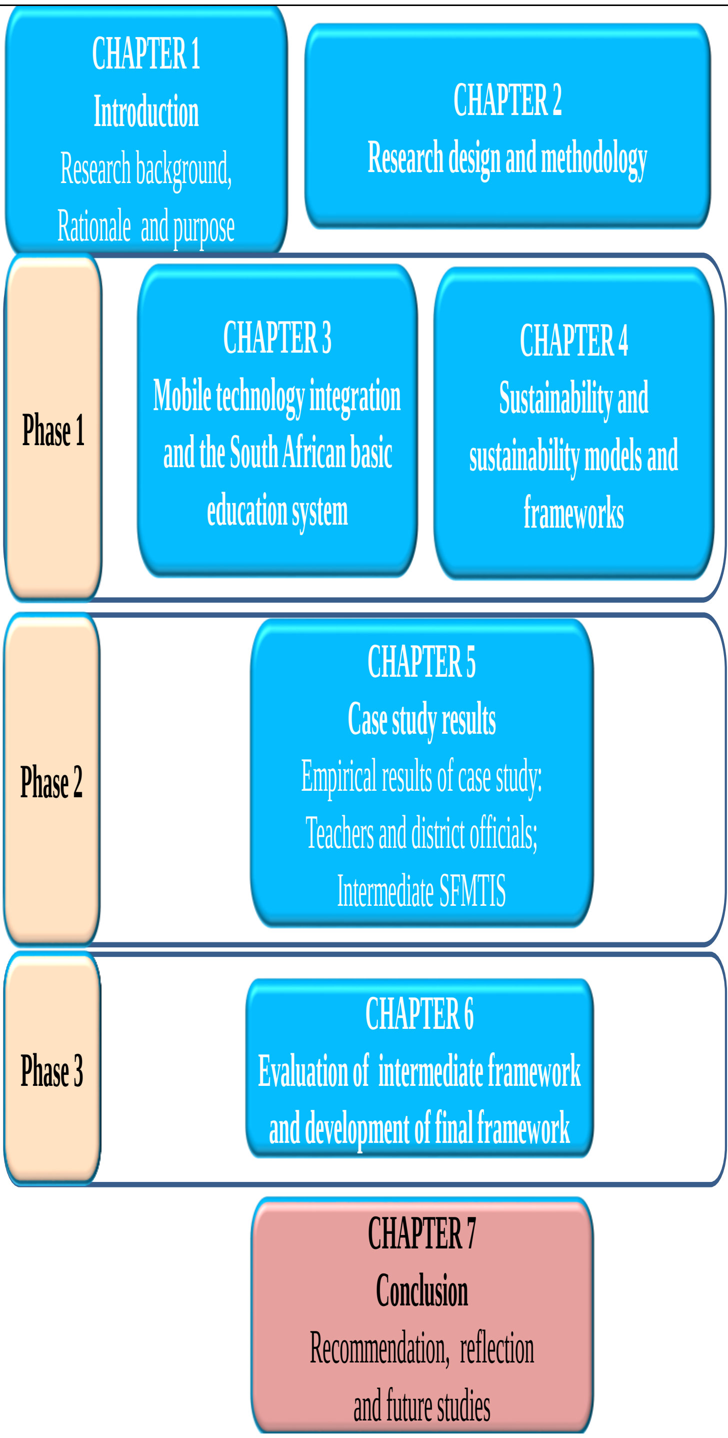
6.7 SUMMARY

The utility of the SFMTIS as an artifact, a product of the DSR process, was confirmed by the reviews provided by the expert reviewers. The evaluation of the intermediate SFMTIS by expert evaluators provided confirmation of the importance of the sustainability dimensions for mobile technology integration, namely: economic, political, social, technological, pedagogical, environmental and institutional sustainability. The research was also considered by the expert reviewers to address a real need for schools and the education system to sustain mobile technology integration. Insights that emanate from experts' reviews include the importance of the economic, technological and pedagogical dimensions, and institutional sustainability aspects, such as security. Expert evaluation of the intermediate SFMTIS echoed the need for frameworks, such as the SFMTIS, that can support the sustainability of mobile technology integration in resource-constrained environments.

The case study provided evidence to confirm the value of the sustainability dimensions identified in literature. The study highlighted the considerations that need to be made when developing and deploying mobile tablets and digital content to public schools in resource-constrained environments. Schools need technical support, regarding the repair of tablets, as well as for the maintenance of infrastructure, such as solving Internet connectivity problems. These skills should be locally available.

There is a need for clearly defined roles and responsibilities between schools and district in terms of the maintenance of ICT infrastructure and tablets. Interaction and communication between schools, district and the province regarding ICT issues need to be enhanced. Effective financial and technical support mechanisms must accompany the deployment of ICTs. Financial resources are required to ensure that continuous training and technical support is affordable to schools. Provision of digital content is closely related to other factors such as technical support, monitoring and economic sustainability. Long-term partnerships with the private and public sectors can contribute to sustainability as different stakeholders have varying competencies and capacities. Leadership is an important factor in mobile technology integration. More emphasis needs to be placed on sound principles in school governance and management and on efficient, effective leadership at school, district and provincial levels. The SFMTIS identifies aspects that need to be addressed to support sustainable mobile technology integration.

Chapter 7: Final discussion and conclusion



Chapter 7: Final discussion and conclusion

7.1 INTRODUCTION

The main objective of the research was to: *Develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa.* The SFMTIS contributes to theorisation and adds new knowledge to fill the gap in frameworks which guide the long-term sustainability of ICT4D projects. The design science research methodology was employed. This chapter presents a summary of the major research findings as well as recommendations and reflections emanating from conducting the study. The final conclusions regarding the research are then made.

7.2 RESEARCH PROBLEM AND RESEARCH GAP

The diversity, in both context and devices used, in practices and learning with mobile devices complicates a consolidated view of how to best sustain these practices (Ng, 2013). Ng and Nicholas (2013) developed the "Framework for sustainable mobile learning in schools" and the "Person-centred sustainable model for mobile learning". Prior to this there was "no model of sustainability for mobile learning in schools in the literature" (Ng & Nicholas, 2013: 3). This is supported by the categorisation and synthesis of mobile learning models and frameworks by Hsu and Ching (2015), as discussed in Section 4.5.4 and illustrated in Table 4.6. The framework for mobile learning in schools, developed by Ng and Nicholas (2013), was developed in the context of secondary education in Australia, and is based on data collected at an Australian school, which differs from the setting of this research. The context of this research is resource-constrained environments in South Africa.

While the importance of sustainability for ICT4D projects has been acknowledged, there is a shortage of frameworks that are suitable to guide the long-term sustainability of ICT4D programmes in resource-constrained environments (Mamba & Isabirye, 2015; Nawi et al., 2013). Sustaining the integration of ICTs to support teaching in schools in resource-constrained environments in South Africa remains a challenge (Meyer, Roux, Marais et al., 2016). There is a need for research to determine criteria that is significant for sustaining ICT4D projects in developing countries (Nawi et al., 2013). This study sought to investigate and develop *a sustainability framework for mobile technology integration in schools in resource-constrained environments in South Africa (SFMTIS).*

The main research question which the research sought to answer, as outlined in Section 1.4, is:

What constitutes a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa?

The following sub-research questions (SRQs) were investigated in order to answer the main research question:

SRQ1: What frameworks exist for sustainable mobile technology integration?

SRQ2: What are the perspectives of teachers on mobile technology integration in schools in resource-constrained environments?

SRQ3: What are the perspectives of school district officials on mobile technology integration in resource-constrained environments?

7.3 SUMMARY OF THE RESEARCH DESIGN

The methodology that was selected to develop the SFMTIS artifact in this research is Design Science Research (Drechsler & Hevner, 2016) as discussed in Section 2.4.6 and illustrated in Figure 2.9. The research was iteratively conducted through three phases by applying the DSRM process (Peffers et al., 2007) as per Section 2.5.1. Pragmatism is the main philosophy that guided the research, while interpretivism was applied within the DSRM process model, in order to synthesise sustainability factors from the findings of the teachers and district official's responses in the case study towards refining the framework. Phase 1 of the study involved the synthesis of an initial framework from a review of the existing literature. Mobile technology integration in the South African basic education system, and ICT4D sustainability models and frameworks were investigated by conducting a systematic literature review. The initial SFMTIS is depicted in Table 4.8.

In Phase 2 of the research, a case study was utilised to investigate the perspectives of teachers and district officials on mobile learning integration in the schools. The case study was used to demonstrate, inform, refine and add value to the initial SFMTIS that was developed in Phase 1 from the reviewed literature. The teachers and district officials involved in the case study were from schools that had formerly participated in the ICT for rural education and development (ICT4RED) initiative, part of TECH4RED (as discussed in Section 5.2). ICT4RED is a large-scale South African government research, development and implementation initiative that was carried out over three years, from 2012 to 2014, at Cofimvaba, in the Nciba school district in the Eastern Cape province of South Africa to investigated ways in which ICTs can be integrated into teaching and learning in rural areas. The teachers and district officials were selected through purposive sampling. The intermediate SFMTIS, the output from Phase 2 of the study, is depicted in Section 5.5.3.

Figure 7.1 illustrates how the findings of the case study were applied to refine the initial SFMTIS developed from reviewed literature in Phase 1 and how the final SFMTIS was developed.

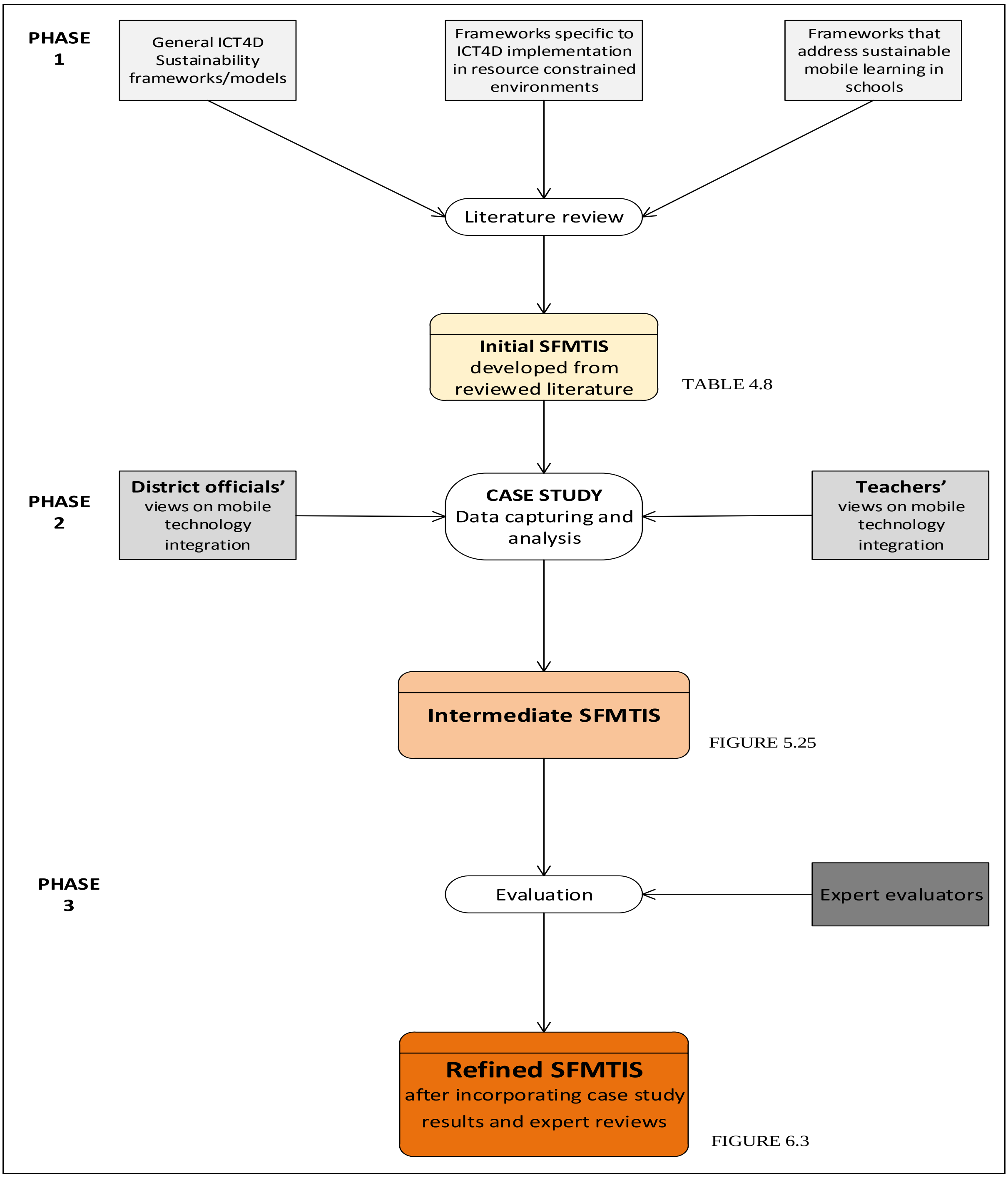


Figure 7.1: How the initial SFMTIS was refined to develop the final SFMTIS

Phase 3 of the research involved evaluation of the intermediate framework by expert reviewers, namely teachers and district officials who had formerly participated in ICT4RED, and who had been interviewed during the development of the SFMTIS. Additionally, an experienced research consultant who had been involved in the implementation of the ICT4RED initiative evaluated the intermediate SFMTIS developed in Phase 2, as discussed in Section 6.4. The final SFMTIS was developed by incorporating expert reviewers' feedback into the intermediate SFMTIS.

7.4 RESEARCH OVERVIEW

The research is presented in seven chapters. The first chapter described the research purpose, background and the rationale for the study. Chapter 2 discussed the design science research methodology that was selected for developing the *sustainability framework for mobile technology integration in schools* (SFMTIS) in resource-constrained environments in South Africa. In Chapter 3, literature on mobile technology integration and the South African basic education system is discussed to provide the knowledge base in the rigour cycle of the design science research methodology (DSRM) process applied in this research. This was part of the first phase of the three phases in the research. The concept of *sustainability* was defined and deliberated as it relates to systems and development. Sustainability ICT4D models and frameworks in general, and frameworks used in resource-constrained environments specifically, as well as mobile learning models and frameworks, were discussed in the light of which the initial SFMTIS was developed. In Chapter 5 the research findings of the case study, which were carried out in Phase 2 of the research to investigate the perspectives of teachers and district officials on mobile technology integration, were presented. The intermediate SFMTIS was developed by applying the findings of the case study to refine the initial framework developed in Phase 1. Chapter 6 presented Phase 3 of the DSRM in which the intermediate framework was evaluated by expert reviewers and the final SFMTIS was presented (Figure 6.3).

7.5 REFLECTION ON THE RESEARCH QUESTIONS

This section addresses each of the research sub-questions as well as the main research question.

7.5.1 SRQ1: What frameworks exist for sustainable mobile technology integration?

In Phase 1 of the research the initial SFMTIS was synthesised from reviewing extant literature on sustainability frameworks. Systematic literature review conducted in the first phase of the study answered the SRQ1. The frameworks and models examined were ICT4D sustainability frameworks in general, sustainability frameworks for ICT4D implementation specific to resource-constrained environments and frameworks that address sustainable mobile learning in schools. The initial SFMTIS was then developed.

Phase 2 of the study utilised a case study to demonstrate and refine the SFMTIS developed in Phase 1. Teachers' views regarding the integration of mobile technology in their schools were obtained and these responses were subsequently processed to inform the further development of the framework. The officials from the Department of Basic Education based at district offices were also interviewed to garner their views on the sustainable integration of mobile technology. The case study conducted in Phase 2 of the research addressed the two sub-research questions, SRQ2 and SRQ3.

7.5.2 SRQ2: What are the perspectives of teachers on mobile technology integration in schools in resource-constrained environments?

Teachers were positive about mobile technology integration and cited positive impacts for both teachers and learners. Teachers were, however, concerned about the future use of tablets at their schools and indicated that they require maintenance of infrastructure, Internet access and Wi-Fi connectivity, more tablets, technical support, electricity, quality tablets and that tablets should be secured against theft. The teachers also communicated the need for continuous ICT professional training, as well as the maintenance of digital content on tablets and servers, and for monitoring and support by the district officials.

7.5.3 SRQ3: What are the perspectives of school district officials on mobile technology integration in resource-constrained environments?

District officials considered leadership at school level, by principals, school management teams (SMTs) and school governing bodies (SGBs) to be essential for sustainable mobile technology integration. Teachers' responsibility to use tablets for teaching and school management's responsibility for maintaining the tablets and for providing security were also noted. Some of the district officials indicated that since the schools are "section 21 schools" they manage the schools' financial resources and that they could raise funds.

District officials indicated the need to apply economies of scale in the education system in order to reduce costs associated with Internet and Wi-Fi connectivity and the services of well-trained, qualified technicians. District officers indicated that there is a need for parental support and involvement.

District officers indicated that schools with tablets can make more use of e-books and that the DBE should develop strategies to reduce publishing and printing of the textbooks. District officials agreed that security at some schools is inadequate, especially for ICT integration. The findings of the case study were used to refine the initial SFMTIS.

7.6 RESEACH CONTRIBUTION TO KNOWLEDGE

The research contribution of the study is the SFMTIS artifact and the theoretical knowledge contribution.

7.6.1 Contribution of the SFMTIS as a DSR artifact to praxis

The practical contribution of the research is the framework for mobile technology integration in schools in resource-constrained environments in South Africa, the SFMTIS. The SFMTIS was developed by building on extant literature reviewed, focusing on sustainability frameworks in general, frameworks for ICT4D implementation in resource-constrained environments specifically, and frameworks for sustainable mobile learning in schools. Policies and strategic documents of the DBE and other government departments were analysed towards the development of the SFMTIS. The SFMTIS provides a mechanism on how the likelihood of sustainability of mobile technology integration initiatives in schools can be achieved. The SFMTIS can be applied as a guideline by schools, and the DBE and provincial ECDoE, when considering sustainability in integrating technology into resource-constrained schools in South Africa.

7.6.2 Potential of the SFMTIS for generalization

The SFMTIS is a framework based on solid, clear, and widely accepted contributions from the field. The SFMTIS thus has the potential for generalization as it allows for a larger scope that can provide a basis for application beyond the case of resource-constrained schools in South Africa. The SFMTIS thus has the potential for implementation beyond its immediate source.

7.6.3 Potential contribution of the SFMTIS in policy and decision-making

The lessons drawn from this dissertation could be useful for decision makers in South Africa and in other similar resource-constrained environments. The SFMTIS therefore has the potential to be relevant input into policy processes in South Africa and in countries with similar social and economic conditions.

7.6.4 Theoretical, knowledge contribution

The knowledge contribution of this research, in developing the SFMTIS as a DSR artifact, contributes to knowledge at levels 1 and 2 of the *DSR knowledge contribution framework*, as illustrated in the levels of knowledge contribution proposed by Gregor and Hevner (2013) (refer Section 2.4, Figure 2.4). As suggested by Gregor and Hevner (2013), research artifacts from a specific research project can be categorized in more than one level. The research provides *descriptive* and *prescriptive* knowledge, as previously discussed in Section 2.4.3.

In level 1 of the *DSR knowledge contribution framework*, the knowledge contribution of the artifact is the production of an *instantiation*, the SFMTIS output for situated implementation in a specific environment (refer Table 2.4 and Figure 2.4). Detailed description of the empirical findings of the research, and the SFMTIS artifact, provides *descriptive* knowledge, Ω (omega), the "what" knowledge regarding the sustainability of mobile technology integration in resource-constrained environments.

The knowledge contribution of this research at level 2 of the knowledge contribution is the SFMTIS as a conceptual sustainability framework that can be considered as nascent design theory (see Figure 2.4). This can be considered as the *prescriptive* knowledge, ^ (lambda), developed in the research. This research contributes to theory, through its contribution of the SFMTIS, which specifically addresses the integration of mobile technology in schools in resource-constrained environments. The framework contributes new knowledge towards the understanding of problems encountered when integrating mobile technology into teaching in schools situated in these environments as well as providing a theoretically grounded, evidence-based approach to addressing these problems.

Figure 7.2 positions the research contribution in terms of the DSR knowledge contribution framework as an improvement and as an exaptation.

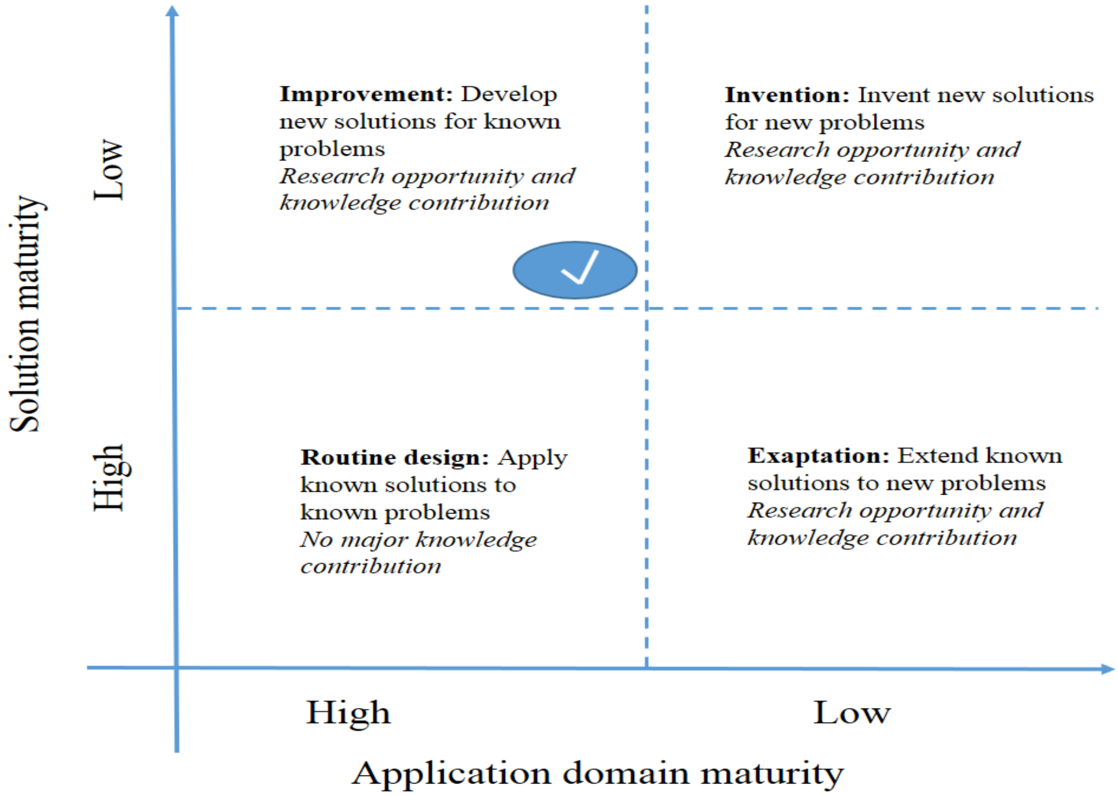


Figure 7.2: Research contribution in terms of DSR knowledge contribution framework

The development of the SFMTIS was based on existing frameworks, as discussed in Section 4.5, in order to address a known problem, as presented in Section 1.3. The research contribution is therefore in the high application domain level (known problem), and low solution (new solutions) maturity level: *Improvement* quadrant in Figure 7.2.

7.7 LIMITATIONS OF THE STUDY

The study applied the findings of a case study that included teachers in public schools located in the Nciba school district of Cofimvaba in the Eastern Cape province, South Africa, and district officials who had participated in the ICT4RED initiative. For the study purpose the research focused on teachers' perspectives of mobile technology integration, but excluded those of the learners and parents. Teacher organisations (unions) were considered to be beyond the scope of the study. Teaching and learning approaches are not the focus, as testing or measuring mlearning were beyond the study scope. The data are based on a single case study which limits the generalisation of the framework. The generalisability of this study can be improved through applying and evaluating the SFMTIS framework in other similar resource-constrained contexts.

7.8 FUTURE RESEARCH

The SFMTIS framework could in future be assessed for its relevance in similar contexts. The alignment of the Department of Education's pedagogical strategy for e-learning at different levels of the education system, that is, micro (school), meso (circuit and district) and macro (provincial and national) levels, could also be investigated. Future research can focus on the role of school districts, particularly subject education specialists (subject advisors), in mobile technology integration. The degree to which e-resources, such as digital content available to schools, are utilised, and the uptake of facilities, such as the negotiated e-rate for Internet access available to schools to facilitate e-learning, could be investigated. This would inform the Department of Education and facilitate the development of evidence-based policies and strategies.

Security at schools is an area that requires attention. It is necessary to investigate the type of security measures implemented in the schools, and to identify the forms of security that have been circumvented in some schools. Increased implementation of more stringent, yet affordable, security measures could be promoted through relevant decision-making in the education system. Research, coordination, and economies of scale can be applied in order to provide affordable and effective security in schools.

The use of tablets in *telematics*, especially virtual learning where "experts" support teachers and learners by providing lessons remotely, could be investigated. The SFMTIS's effectiveness could also be investigated in telematics. For example, the Eastern Cape Department of Education recently launched (September 2017) a "virtual teacher" platform in partnership with the private sector. The virtual teacher allows an individual teacher to deliver lessons and interact with learners in multiple remote classrooms. Telematics incorporates ICTs and multimedia, through the use of various combinations of telecommunications, television and information technologies (IT), to retrieve, store, process and communicate information as voice, sound, text, graphics, images and video. Investigating the applicability of the SFMTIS to the use of telematics, such as the "virtual teacher," to support teaching could inform and provide evidence of underlying issues to problems raised by teachers. For example, some schools have televisions and satellite infrastructure that is underutilised, or stored away, and in some schools tablets, which were sent in for repairs had, after several months, not been returned.

Future research is needed to focus more on learning and supporting the learning process when integrating mobile technology. Furthermore, the social, cultural, and contextual factors also warrant more research focus.

The SFMTIS allows for a larger scope that can provide a basis for application beyond the case of resource-constrained schools in South Africa, and therefore future research could focus on generalization of the framework.

7.9 LESSONS LEARNT

Institutional sustainability is an important aspect in the final SFMTIS. This is particularly important given the dynamic context in which the case study was conducted. Transitions emanating from the changes currently occurring in Cofimvaba in the Nciba school district, as part of the restructuring of school districts in the province, require a well communicated change management strategy. Communication and support structures are necessary to assist district management. For example, the new district director oversees two district offices that are more than 50 kilometres apart. Efficient information management and communication systems are required to ensure that there is continuity in the implementation of projects such as the ICT4RED initiative. School security needs to be addressed as a critical factor when ICT, such as tablets, are deployed. Schools need appropriate, effective and affordable security systems.

Successful integration of ICT at schools requires communication and coordination at all levels of the education system, micro (school), meso (school and district), and macro (provincial and national) levels. It is essential to enhance the capacity of the education system to engage in activities for continuous improvement, and collective problem-solving, and to develop institutional processes and structures that support teachers and district officials in integrating ICT into teaching.

7.10 PERSONAL REFLECTION

In this section I reflect on my personal experiences during the research, particularly my interactions with three teachers, one a principal (Principal X) and two school ICT Champions (Teacher Y and Teacher Z) and interactions with district officials.

I made my first trip to Cofimvaba in September 2014. I flew from Johannesburg in Gauteng to East London in the Eastern Cape, a journey of one hour, and then drove about 200 kilometres from East London to Queenstown, a journey of two hours, where I lodged at one of the guest houses. Cofimvaba, my destination, is about 80 kilometres, or another hour's drive, from Queenstown. I made seven such trips over the course of the research, 2014 to 2017, spending about a week or two for each visit. The first visit in September 2014 was timeous as I attended training workshops provided to teachers who were to become ICT4RED facilitators. The facilitators were trained in order to then provide training to other teachers on how to integrate mobile devices to support teaching. It was obvious to me that the teachers enjoyed the training and that they were positive about the implementation of ICT4RED, and the resulting changes to schools in Cofimvaba. I first met Principal X, head of one of the junior secondary schools, at one of the facilitator workshops. I interacted with her formally and informally over the course of the research.

Months later, during a courtesy visit in July 2016, Principal X explained that she was very concerned about the level of tablet use at her school that had declined. She added that tablets, which had required repair, had been collected by a company based in Queenstown, 80 kilometres away, and had still not been returned after several months. In addition, she commented that they had not been able to access the Internet for several weeks. The time I spent with teachers, and the casual conversations we shared, enabled me to understand the environment and issues which concern and impact them. This conversation occurred during a courtesy visit to Principal X at her “office”. Her “office” being a corner in one of the classrooms which she shares with over twenty pupils and their teacher. The same classroom also acts as a “safe room” where a storage facility had been built to store the toolkits and tablets.

Principal X’s main concern was that the ICT4RED initiative had infused enthusiasm into teaching by providing training, tablets and the ICT infrastructure, but she now felt discouraged because of the associated challenges and seeming lack of technical support. Worse still, in June 2017, Principal X’s “office” was broken into. This, despite the school having a night watchman. Tablets were stolen, together with a flat screen TV and projector, which had all been donated to the school. Principal X related how she, together with members of the SGB, had reported the incident to the local police. The principal complained that the police’s response made them feel as if they were reporting a “petty crime” in comparison with other crimes that the police had to deal with. Several months later there still has not been any news about the ICT equipment and TV screen.

My interaction with Teacher Y who was the ICT Champion at her school in July 2016 was thought-provokingly different to my interaction with Principal X. Teacher Y explained how she assigns different responsibilities to her students. Her students perform different tasks

- charging tablets, taking tablets to different classrooms and collecting them, as requested by teachers. Teacher Y explained that teachers at her school use the tablets and learners enjoyed using the tablets. When I asked her if they were able to access the Internet, she replied that they were. She continued to explain about the e-rate and the process that she had followed to load additional data units that enable Internet access when they ran out of data. Teacher Y proudly explained to me how competent one of her student was in using ICTs and how the student was outstanding as they used a tablet and projector during a regional competition.

Teacher Y's school was also burgled in 2016 and tablets and projectors were stolen. This occurred despite the presence of security cameras as well as the rapid response security company which the school pays monthly to provide security. Teacher Y explained that an investigation established that the cameras had been shifted so that no recording occurred during the incident. The school reported the matter to the local police and provided the names of suspects. Teacher Y was dissatisfied with the local police's response and handling of the reported case.

I noted the difference in Principal X and Teacher Y's reactions to the challenges e.g. the burglaries. Teacher Y was more focused on finding solutions. For example, Teacher Y was able to negotiate with an external funder for more tablets to replace the stolen ones. She explained how her school management had discussed security improvement that needed to be employed with their security company after the incident. Teacher Y's school has not experienced any more burglaries and the school continues to use tablets.

Based on my observations I concluded that the commitment of individual teachers can provide leadership and help their schools to use tablets, despite the challenges faced by schools. However, strong school leadership and support by the DBE and the private sector are required to assist schools towards ICT integration in various ways, for example, implementing effective security systems and managing digital content. This requires appropriate information management, coordination and leadership, especially at district and provincial levels. Developing a supportive ICT environment can nurture teachers, such as Teacher Z, an ICT Champion at a school that is 24 kilometres from Cofimvaba.

Teacher Z daily travels 104 kilometres to school, 80 kilometres on a tarred and 24 kilometres on a gravel road. This 104 kilometres is repeated after school as she returns home. Teacher Z is part of a lift club with several other colleagues in an effort to lower fuel expenses and minimise the wear and tear on her car. During my interaction with Teacher Z, I discovered that she is pursuing ICT related studies and is registered for a Master's degree at a

University in another province which she visits to consult with her supervisor. Teacher Z uses tablets to support her students. Her high self-efficacy, as well as her confidence in the use of ICTs, is apparent as she maintains a blog that encourages communication among teachers. Teachers Z is committed to using mobile devices to support teaching despite challenges that she faces in her environment.

Based on my interactions with the three teachers, I concluded that it is important to identify teachers, such as Teacher Y and Z, who are committed to using ICTs, and to provide them with appropriate support. It is equally critical to assists teachers who are dealing with challenges such as those related by Principal X.

My interactions with district officials revealed challenges that district officials are faced with. The school district in Cofimvaba, in which the schools in the case study are situated, is currently undergoing changes as a result of the restructuring of school districts in the province. A new district director has been appointed, however, the new director is responsible for two district offices that are over 50 kilometres apart. The subject education specialist for tele-learning and teaching education, who had also been involved with the ICT4RED initiative, has been transferred to another school district. After several months, a replacement had still not been appointed. My observation was that at district level, changes need to be managed in a way that considers the district's capacity to carry out its mandate.

During my last visit to Cofimvaba, in June 2017, I was interested to discover that both Teacher Y and Teacher Z were working together with district officials at the district offices, training a group of teachers in ICT use. This was encouraging to me because it indicates the positive impact that ICT4RED has had in this resource-constrained environment. I also thought about the many other facilitators that were trained during the implementation of the ICT4RED initiative that can be utilised by the district, and the infrastructure that was established, after all, it is said that:

"It is not what you have that matters, but rather what you do with what you have."

This resonates with the findings of this study and the SFMTIS that indicate the value of communication and coordination at all levels of the education system (micro, meso and macro levels), that are critical to the sustainability of schools' ICT integration programmes.

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Annexure 1.1: Ethical clearance

UNISA college of science, engineering and technology

Dear Ms. Jabulisiwe Mabila (32055242)

Date: 2015-07-26

Application number: 079/JM/2015

REQUEST FOR ETHICAL CLEARANCE: (Developing a sustainability model for tablet technology integration for teaching and learning in resource constrained environments)

The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your research study as set out in your proposal and application for ethical clearance.

Therefore, involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the CSET Executive or the CSET CRIC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Please note that the ethical clearance is granted for the duration of this project and if you subsequently do a follow-up study that requires the use of a different research instrument, you will have to submit an addendum to this application, explaining the purpose of the follow-up study and attach the new instrument along with a comprehensive information document and consent form.

Yours sincerely

Prof Ernest Mnkandla
Chair: College of Science, Engineering and Technology Ethics Sub-Committee

Prof IOG Moche
Executive Dean: College of Science, Engineering and Technology

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Annexure 1.2: Eastern Cape Department of Education permissions for ICT4RED (Research undertaken under the auspices of the ICT4RED initiative)

Province of the
EASTERN CAPE
EDUCATION

STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
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Enquiries: Dr Heckroodt Email: bernetia@iafrica.com

28 May 2013

Professor ME Herselman

CSIR Meraka Institute

P.O. Box 395

PRETORIA

0001

Dear Prof. Herselman

PERMISSION TO UNDERTAKE AN INDEPENDENT STUDY: eTEXTBOOK PILOT IN NCIBA CIRCUIT SCHOOLS IN THE COFIMVABA DISTRICT

1. Thank you for your application to conduct research.
2. Your application to conduct the above mentioned research in twenty six (26) Schools under the jurisdiction of Cofimvaba District of the Eastern Cape Department of Education (ECDoE) is hereby approved on condition that:
   a. there will be no financial implications for the Department;
   b. institutions and respondents must not be identifiable in any way from the results of the investigation;
   c. you present a copy of the written approval letter of the Eastern Cape Department of Basic Education (ECDBE) to the Chief Directors and Directors before any research is undertaken at any institutions within that particular district;
   d. you will make all the arrangements concerning your research;

PGDP EASTERN CAPE

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Page 1 of 2

Ilamva eliqaqambileyo!

e. the research may not be conducted during official contact time, as educator's programmes should not be interrupted;

f. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to the Director: Strategic Planning Policy Research and Secretarial Services;

g. the research may not be conducted during the fourth school term, except in cases where a special well motivated request is received;

h. your research will be limited to those schools or institutions for which approval has been granted, should changes be effected written permission must be obtained from the Director – Strategic Planning Policy Research and Secretariat Services;

i. you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis. This must also be in an electronic format.

j. you are requested to provide the above to the Director: The Strategic Planning Policy Research and Secretarial Services upon completion of your research.

k. you comply to all the requirements as completed in the Terms and Conditions to conduct Research in the ECDBE document duly completed by you.

l. you comply with your ethical undertaking (commitment form).

m. You submit on a six monthly basis, from the date of permission of the research, concise reports to the Director: Strategic Planning Policy Research and Secretariat Services.

3. The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in the Terms and Conditions to conduct Research in the ECDBE.

4. The Department will publish the completed Research on its website.

5. The Department wishes you well in your undertaking. You can contact the Director, Dr. Annetia Heckroodt on mobile number 083 275 0715 and email: annetia.heckroodt@edu.ecprov.gov.za should you need any assistance.

DR AS HECKROODT
DIRECTOR: STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES

Annexure 1.3: Consent form - Teachers

CONSENT FORM TO PARTICIPATE IN RESEARCH

Developing a sustainability model for mobile tablet integration to teaching and learning in resource-constrained environments

Your consent is requested for participation in this research. Your views regarding ICT use, particularly mobile tablets for teaching and learning, and the sustainability of the Information and Communications Technology for Rural Development (ICT4RED) project are important.

1. PURPOSE OF THE RESEARCH

The research seeks to develop a sustainability model for tablet technology integration for teaching and learning in resource-constrained environments. This is line with the Information and Communications Technology for rural development (ICT4RED) project objectives.

The ICT4RED initiative is part of the Technology for rural education and development (TECH4RED) joint initiative between South Africa's Department of Science and Technology (DST), the Department of Basic Education (DBE), the Department of Rural Development and the Eastern Cape Department of Education (ECDoE). It is focused on improving the quality of learning and teaching by integrating use of tablets in teaching mathematics and science in schools in the Nciba Circuit in Cofimvaba School District in the Eastern Cape. The objective is to use these technologies in a sustainable and replicable way.

2. PROCEDURE

Should you consent to participate in this research you will be requested to complete a questionnaire. The questionnaire will take about 30 minutes to complete. Questions asked relate to sustainable use of information and communication technology (ICT), particularly mobile tablets for teaching and learning.

3. CONFIDENTIALITY

Your individual responses obtained through this questionnaire will be kept confidential. You will not be personally identified. The information you give will be used for academic research purpose.

4. PARTICIPATION AND WITHDRAWAL

Participation in this research is voluntary. You have the right to withdraw from the study at any time without any negative or undesirable consequences to yourself.

5. POTENTIAL RISKS AND DISCOMFORTS

You will not be in any risk or discomfort because of your participation. Your responses will be kept confidential and will not be linked to your name or position as an individual. The questionnaires completed by different participants will be analysed collectively.

6. PAYMENT FOR PARTICIPATION

You will not be paid for participating in this research.

7. POTENTIAL BENEFITS TO SUBJECTS AND TO SOCIETY

Your opinion given in the questionnaire is valuable and will be used to develop a sustainability model for tablet technology integration for teaching and learning in resource-constrained environments.

8. IDENTIFICATION OF INVESTIGATOR

Should you have any questions or queries regarding this research you are welcome to contact Jabulisiwe Mabila (University of South Africa, School of Computing) on 0730137813 or mabiljp@unisa.ac.za

9. RIGHTS OF RESEARCH PARTICIPANT

You have the right to withdraw your participation in the research at any time without any penalty. Your participation does not relinquish any legal claims or rights. You can address questions regarding your rights as a research participant to the Research & Graduate Studies office in the UNISA College of Science Engineering and Technology 011 670 9225 or manalmp@unisa.ac.za

Participant consent

If you agree to participate in this study please complete the section below:

I hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I can withdraw from the research at any time should I so desire.

Signature: ___________________________

Date: _______________________

(Optional:) Surname: _______________________ Name: _____________________

Thank you!!

Annexure 2.1: Questionnaire - Teachers

ICT4RED

Developing a sustainability model for mobile tablet integration to teaching in resource-constrained environments

Name of School: ______________________________________ Date: ______________

DEMOGRAPHICS

Please provide the following information.

Where options are given, mark the appropriate option by crossing out the box next to it with an "X".

a) Gender

A	Male	
B	Female	

b) Age (years)

A	Less than 20	
B	Between 21-30	
C	Between 31-40	
D	Between 41-50	
E	Between 51-60	
E	Over 60	

c) Education

(i)What is your highest academic qualification category?

A	Matric (Grade 12)	
B	Diploma	
C	Bachelor degree (e.g. BSc)	
D	Postgraduate (e.g. Hons BSc or MSc)	
E	Other	

(ii) State the name of your highest qualification

____

(iii) Which year did you obtain your qualification?

____

d) (i) Are you currently studying?

A	YES	
B	NO	

(ii) If you are currently studying, what qualification are you registered for?

____

(iii) What is the main reason for selecting your current study direction**?**

____

A. USE OF TABLETS FOR TEACHING

1. How has the introduction of tablets at your school affected the way that you teach?

2. What is going well in terms of teachers using tablets for teaching at your school?

3. List three things, starting with the most important, of what should be done to make things even better?

B. FACTORS AFFECTING THE USE OF TABLETS

1. What are the main things that currently affect teachers' ability at your school to use the tablets for teaching?

2. What concerns you the most regarding the use of tablets at your school in future?

3. What are the steps that can be taken to reduce your concerns?

C. ONLINE TPD MODULES

1. A comment made by some teachers who participated in the ICT4RED Teacher professional development (TPD) earlier is:
"It has been a while, when are we going to have the workshops again?"

Do you think such comments are justified?

____

Please explain

2. Do you know about the ICT4RED Teacher Professional Development (TPD) modules which are online?

3. If the TPD was presented as an online course, would you recommend it for new teachers at your school that did not do the TPD course presented to you?

Please explain

For the following Section D:
Indicate your feelings about each statement by selecting a value between 1 and 5
(Show your selection by crossing it out with an "X") where: 1 is 'Strongly Disagree' and
5 is 'Strongly Agree'

D. SUSTAINING THE USE OF TABLETS

SUSTAINABILITY

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
Technological					
Connectivity					
1. Teachers at my school are able to connect to the Internet whenever they need to	1	2	3	4	5
2. I can access content on the server when I need to use it for teaching	1	2	3	4	5
3. I can use the content on the tablets when I work offline (e.g. without connecting to the Internet)	1	2	3	4	5
4. There are local people who are able to help solve issues quickly when the school ICT network gives problems	1	2	3	4	5
5. We have to wait for long periods to have connectivity problems solved	1	2	3	4	5
6. The computer systems installed at my school can be fully remotely managed online by a team of ICT experts (without physically coming to the school)	1	2	3	4	5
Devices					
7. Tablets are available for use whenever I need to use them with my learners	1	2	3	4	5
8. The computer systems at my school function well	1	2	3	4	5
9. Tablets are fixed quickly whenever they need to be fixed	1	2	3	4	5
Financial					
10. The Learning and Teacher Support Material (LTSM) funds are adequate for mobile tablet maintenance	1	2	3	4	5
11. The school can afford to pay for fixing the tablets when they are broken	1	2	3	4	5
12. It is cheaper to use e-books than normal print books (textbooks)	1	2	3	4	5
Organisational					
1. The role of the local subject advisors in supporting the ICT4RED project is clearly defined	1	2	3	4	5
2. The role of the ICT Champion is clearly defined	1	2	3	4	5
3. The role of NARYSEC (National Rural Youth Service coorps) in supporting the ICT use at the school is clearly defined	1	2	3	4	5
4. The role of Education Developmental Officers (EDOs) in supporting the ICT4RED project is clearly defined	1	2	3	4	5
5. There is capacity at district level to provide support for the ICT4RED project in the schools	1	2	3	4	5

CONTENT

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
1. I know what content is available to me on the school server which I can use for teaching	1	2	3	4	5
2. The e-books provided are aligned to the CAPS (National Curriculum and Assessment Policy Statement) curriculum	1	2	3	4	5
3. I can easily incorporate the e-books content in the server to my lessons	1	2	3	4	5
4. The e-books' content is relevant to our cultural context	1	2	3	4	5
5. I often find myself asking the question "how is the content on the server relevant to the CAPS curriculum?"	1	2	3	4	5
6. I know how to incorporate the content on the tablets to the CAPS curriculum	1	2	3	4	5
7. I know who to contact when I have questions regarding content on the server	1	2	3	4	5
8. I use the content on the server such as e-books in my daily teaching	1	2	3	4	5
9. I am concerned that in future the content in the server (e-books) will not be maintained (kept up-to-date)	1	2	3	4	5
10. The Department of Basic Education (DBE) will be able to keep the content on the server up-to-date even in the next 5 – 10 years	1	2	3	4	5

CONNECTIVITY

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
1. Teachers at my school are able to connect to the internet whenever we need to	1	2	3	4	5
2. I can access content on the server when I need to use it for teaching	1	2	3	4	5
3. I can use the content on the tablets when I work offline (without connecting to the Internet)	1	2	3	4	5
4. The computer systems at my school function well	1	2	3	4	5
5. The computer systems at my school are error-free	1	2	3	4	5
6. There are local people who are able to help solve issues quickly when the school ICT network gives problems	1	2	3	4	5
7. We have to wait for long periods to have connectivity problems solved	1	2	3	4	5
8. Tablets are fixed quickly whenever they need to be fixed	1	2	3	4	5
9. The systems installed can be fully remotely managed online by a team of ICT experts	1	2	3	4	5

INFRASTRUCTURE

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
1. Electricity is available for us to charge the tablets	1	2	3	4	5
2. There is good security at the school for the ICT equipment (e.g. tablets, servers, charging stations)	1	2	3	4	5
3. There have been attempts to steal ICT equipment (e.g. tablets, computers) at the school	1	2	3	4	5
4. I am concerned that the tablets can be stolen	1	2	3	4	5

TECHNOLOGY INTEGRATION

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
When teaching I use mobile tablets for:					
1. Presenting information to the whole class	1	2	3	4	5
2. Teaching learners in small groups	1	2	3	4	5
3. Assisting learners with activities where they make investigations (exploratory)	1	2	3	4	5
4. Assessing learners through tests or exercises	1	2	3	4	5
5. Managing my classes more effectively	1	2	3	4	5
6. Facilitating collaboration (learners' learning by working together) and team building among learners	1	2	3	4	5
7. Managing (organising, supporting and monitoring) collaborative work done by learners	1	2	3	4	5
8. Browsing the Internet for information related to teaching	1	2	3	4	5
9. Social media (e.g. Facebook or Twitter)	1	2	3	4	5
I am confident in my ability to:					
10. Use computers when teaching	1	2	3	4	5
11. Use word processing applications (e.g. MS Word)	1	2	3	4	5
12. Use presentations applications (e.g. MS PowerPoint)	1	2	3	4	5
13. Use mobile tablets for teaching	1	2	3	4	5
14. Send an e-mail to a given e-mail address	1	2	3	4	5
15. Attach a document to an e-mail and send it to a given e-mail address	1	2	3	4	5
16. To use the Internet to search for information	1	2	3	4	5

Learner development

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
The use of mobile tablets has a positive impact on learner development in terms of:					
1. Subject matter knowledge	1	2	3	4	5
2. Learning motivation	1	2	3	4	5
3. Information-handling skills	1	2	3	4	5
4. Problem-solving skills	1	2	3	4	5
5. Collaborative skills (learning together with others)	1	2	3	4	5
6. Communication skills	1	2	3	4	5
7. Developing learner's ability to use computers	1	2	3	4	5
8. Learner's ability to learn at their own pace	1	2	3	4	5
9. Reducing success gap among learners (gives learners equal chances of succeeding)	1	2	3	4	5
10. I can confidently explain to someone else what "21st century skills" are	1	2	3	4	5

KNOWLEDGE MANAGEMENT

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
1. I am able to show information such as records on how I use tablets in my lessons	1	2	3	4	5
2. There are records maintained in the school showing the usage of the tablets	1	2	3	4	5
3. There is an asset register at the school where information on the school tablets is maintained	1	2	3	4	5
4. The school maintains records of technical problems that are reported to the call center	1	2	3	4	5
5. Information regarding the content in the server is available to me	1	2	3	4	5
6. I know the minimum standards that the Department of Basic Education expects me to apply in teaching using computers	1	2	3	4	5

Annexure 5.1

Summary of results of closed-ended questions in questionnaire Percentage (%) of teachers who selected each option						
		Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
		1	**2**	**3**	**4**	**5**
TECHNOLOGICAL						
Connectivity						
1.1	Teachers at my school are able to connect to the Internet whenever they need to	14.04	10.53	5.26	56.14	14.04
1.2	I can access content on the server when I need to use it for teaching	9.09	5.45	12.73	65.45	7.27
1.3	I can use the content on the tablets when I work offline (e.g. without connecting to the Internet)	10.71	10.71	12.50	53.57	12.50
1.4	There are local people who are able to help solve issues quickly when the school ICT network gives problems	28.07	26.32	21.05	19.30	5.26
1.5	We have to wait for long periods to have connectivity problems solved	7.14	25.00	19.64	33.93	14.29
1.6	The computer systems installed at my school can be fully remotely managed online by a team of ICT experts (without physically coming to the school)	20.00	20.00	12.73	45.45	1.82
Devices						
1.7	Tablets are available for use whenever I need to use them with my students	0.00	3.57	7.14	39.29	50.00
1.8	The computer systems at my school function well	7.41	7.41	22.22	48.15	14.81
1.9	Tablets are fixed quickly whenever they need to be fixed	18.52	25.93	16.67	31.48	7.41
Financial						
1.10	The Learning and Teacher Support Material (LTSM) funds are adequate for mobile tablet maintenance	25.00	25.00	26.92	17.31	5.77
1.11	The school can afford to pay for fixing the tablets when they are broken	35.29	29.41	21.57	13.73	0.00
1.12	It is cheaper to use e-books than normal print books (textbooks)	1.92	7.69	21.15	53.85	15.38
Organisational						
1.13	The role of the local subject advisors in supporting the ICT4RED project is clearly defined	1.96	19.61	29.41	41.18	7.84

1.14	The role of the ICT Champion is clearly defined	1.92	5.77	23.08	53.85	15.38
1.15	The role of NARYSEC (National Rural Youth Service coorps) in supporting the ICT use at the school is clearly defined	3.85	19.23	30.77	36.54	9.62
1.16	The role of Education Developmental Officers (EDOs) in supporting the ICT4RED project is clearly defined	1.96	19.61	23.53	47.06	7.84
1.17	There is capacity at district level to provide support for the ICT4RED project in the schools	2.17	19.57	34.78	36.96	6.52
CONTENT						
2.1	I know what content is available to me on the school server which I can use for teaching	8.93	3.57	16.07	58.93	12.50
2.2	The e-books provided are aligned to the CAPS (National Curriculum and Assessment Policy Statement) curriculum	1.79	0.00	19.64	55.36	23.21
2.3	I can easily incorporate the e-books content in the server to my lessons	3.64	10.91	30.91	47.27	7.27
2.4	The e-books' content is relevant to our cultural context	5.45	0.00	47.27	38.18	9.09
2.5	I often find myself asking the question "how is the content on the server relevant to the CAPS curriculum?"	5.56	20.3	18.52	48.15	7.41
2.6	I know how to incorporate the content on the tablets to the CAPS curriculum	3.70	9.26	9.26	57.41	20.37
2.7	I know who to contact when I have questions regarding content on the server	1.89	7.55	15.09	58.49	16.98
2.8	I use the content on the server such as e-books in my daily teaching	3.85	19.23	25.00	50.00	1.92
2.9	I am concerned that in future the content in the server (e-books) will not be maintained (kept up-to-date)	3.77	22.64	28.30	32.08	13.21
2.10	The Department of Basic Education (DBE) will be able to keep the content on the server up-to-date even in the next 5 – 10 years	5.56	9.26	38.89	42.59	3.70
CONNECT-IVITY						
3.1	Teachers at my school are able to connect to the internet whenever we need to	9.09	16.36	16.36	41.82	16.36
3.2	I can access content on the server when I need to use it for teaching	7.27	7.27	23.64	47.27	14.55
3.3	I can use the content on the tablets when I work offline (without connecting to the Internet)	9.09	12.73	16.36	56.36	5.45
3.4	The computer systems at my school function well	12.96	3.70	24.07	50.00	9.26
3.5	The computer systems at my school are error-free	11.54	7.69	46.15	28.85	5.77
3.6	There are local people who are able to help solve issues quickly when the school ICT network gives problems	22.22	33.33	20.37	18.52	5.56

3.7	We have to wait for long periods to have connectivity problems solved	13.46	25.00	15.38	32.69	13.46
3.8	Tablets are fixed quickly whenever they need to be fixed	20.75	32.08	15.09	30.19	1.89
3.9	The systems installed can be fully remotely managed online by a team of ICT experts	11.11	11.11	16.67	55.56	5.56
INFRA-STRUCTURE						
4.1	Electricity is available for us to charge the tablets	9.09	7.27	5.45	30.91	47.27
4.2	There is good security at the school for the ICT equipment (e.g. tablets, servers, charging stations)	14.55	10.91	25.45	34.55	14.55
4.3	There have been attempts to steal ICT equipment (e.g. tablets, computers) at the school	11.11	22.22	14.81	35.19	16.67
4.4	I am concerned that the tablets can be stolen	10.00	8.00	20.00	28.00	34.00
TECHNOLOGY INTEGRATION						
When teaching I use mobile tablets for:						
5.1	Presenting information to the whole class	0.00	5.56	14.81	66.67	12.96
5.2	Teaching students in small groups	0.00	9.26	11.11	66.67	12.96
5.3	Assisting learners with activities where they make investigations (exploratory)	0.00	5.56	14.81	59.26	20.37
5.4	Assessing learners through tests or exercises	1.85	11.11	16.67	51.85	18.52
5.5	Managing my classes more effectively	0.00	13.21	18.87	58.49	9.43
5.6	Facilitating collaboration (learners' learning by working together) and team building among learners	0.00	3.92	7.84	62.75	25.49
5.7	Managing (organising, supporting and monitoring) collaborative work done by learners	0.00	3.70	7.41	66.67	22.22
5.8	Browsing the Internet for information related to teaching	3.70	18.52	5.56	51.85	20.37
5.9	Social media (e.g. Facebook or Twitter)	11.11	14.81	18.52	37.04	18.52
I am confident about my ability to:						
5.10	Use computers when teaching	1.82	16.36	29.09	36.36	16.36
5.11	Use word processing applications (e.g. MS Word)	5.56	7.41	24.07	37.04	25.93
5.12	Use presentations applications (e.g. MS PowerPoint)	7.41	7.41	29.63	35.19	20.37

5.13	Use mobile tablets for teaching	0.00	0.00	14.55	60.00	25.45
LEARNER DEVELOPMENT						
The use of mobile tablets has a positive impact on learner development in terms of:						
6.1	Subject matter knowledge	0.00	5.45	12.73	61.82	20.00
6.2	Learning motivation	0.00	1.82	3.64	70.91	23.64
6.3	Information-handling skills	0.00	1.85	7.41	75.93	14.81
6.4	Problem-solving skills	0.00	3.77	18.87	58.49	18.87
6.5	Collaborative skills (learning together with others)	0.00	1.89	1.89	77.36	18.87
6.6	Communication skills	0.00	3.77	11.32	67.92	16.98
6.7	Developing learner's ability to use computers	0.00	11.32	15.09	49.06	24.53
6.8	Learner's ability to learn at their own pace	0.00	9.43	15.09	50.94	24.53
6.9	Reducing success gap among learners (gives learners equal chances of succeeding)	0.00	3.70	20.37	55.56	20.37
6.10	I can confidently explain to someone else what "21st century skills" are	0.00	5.56	9.26	57.41	27.78
KNOWLEDGE MANAGEMENT						
7.1	I am able to show information such as records on how I use tablets in my lessons	0.00	5.56	18.52	53.70	22.22
7.2	There are records maintained in the school showing the usage of the tablets	0.00	5.56	20.37	53.70	20.37
7.3	There is an asset register at the school where information on the school tablets is maintained	0.00	5.66	13.21	52.83	28.30
7.4	The school maintains records of technical problems that are reported to the call center	1.85	1.85	20.37	55.56	20.37
7.5	Information regarding the content in the server is available to me	3.70	14.81	24.07	46.30	11.11
7.6	I know the minimum standards that the Department of Basic Education expects me to apply in teaching using computers	7.55	0.00	37.74	39.62	15.09

Annexure 5.2: District officials' views categorised into sustainability dimensions

Sustainability dimension	District management views
1. Economic	
Funds needed	D-Participant 1 : *"Funding must be set aside"* D-Participant 1: *"It is the department's responsibility to provide funding"* D-Participant 1: *"The District ICT4RED Champion is there for expertise and not to provide funds"* D-Participant 4: *"A very serious principal can use the maintenance budget. It depends on how much the repairs costs"* D-Participant 4: *"Schools can ask for help from the District where necessary regarding expenditure"* D-Participant 4: *"There are NORMS and STANDARDS for funding – allocation for schools: Each learner is funded at a specific amount"* D-Participant 4: *"A paper budget is allocated to specific cost centers, for example: funds are allocated for the learner, teacher, support management (LTSM), and municipal services cost center, and a specific minimal percentage (%) is provided as cash to schools"*
More corporate support needed (besides government funding)	D-Participant 1: *"Substantial external funding has contributed to some schools in the province becoming smart schools, and teachers use smart boards when teaching"*
Schools can raise funds	D-Participant 1: *"For fund raising schools must go through the relevant channels and inform the department when necessary"* D-Participant 1: Example *"Schools can collect a specific amount from parents per learner to employ an additional teacher"* D-Participant 1 : *"The principal's manual stipulates that so much budget, and schools can raise funds"*
Leadership	D-Participant 4: *"The school management is important"* D-Participant 1: *"The environment and expectations are important. If school is well managed, it tends to do these things (Planning and budgeting, use maintenance funds appropriately, raise funds"* D-Participant 1: *"Tapping into social capital is important"* D-Participant 4: *"A very serious principal can use the maintenance budget, it depends on how much repair costs are, and can ask for help from the District where necessary regarding expenditure"*
Use of allocated budget e.g. maintenance budget	D-Participant 4: *"There are Norms and Standards for funding, and schools are allocated funds based on stated criteria including the number of learners."* D-participant 4: *"A paper budget is allocated to specific cost centers, for example: funds are allocated for the learner, teacher, support management (LTSM), and municipal services (e.g. electricity) cost center, and only a specific minimal percentage (%) is provided as cash to schools"*
Economies of scale	D-Participant 1: *"Use economies of scale, and buy big, then license fees will go down."* D-Participant 1: *"Purchasing the license would enable us to get e-books"*
Concerns:	D-Participant 1: *"Consider the project expenses"* D-Participant 1: *"Wi-Fi and 'Mesh & Network' are only one component of the problem"*; D-Participant 1: *"The License fees are high"* D-Participant 4: *"Learners don't have a specific LTSM component to cater for broken computers/tablets"*. D-Participant 1: *"Connectivity /Wi-Fi are not working because there is no budget. The license period for Wi-Fi was 3 years. Service level agreement is about for a specific amount per school (multiply that by the number of schools in the ICT4RED project) and see cost per month per group of schools.*
Holistic approach	D-Participant 4: *"Schools have own needs and added responsibilities. Must have added funding for special projects (such as maintenance of ICT4RED)"* D-Participant 1: *"Consider the Infrastructure, there are many needs – water, sanitation… and all need maintenance"* D-Participant 1: *"There are many factors. The order of doing things is important, what about the basic conditions of school buildings?"*

2. Technological	**Technicians** D-Participant 1: *"There should be technicians assigned to each school;* D-Participant 1: *"Technicians should be well trained including in basic maintenance, and access control"* D-Participant 2: *Currently ICT technicians based at the district are not assigned to service the ICT4RED project"* D-Participant 4: *"It would be easier to have technicians in the district"* D-Participant 3: *"Local people should provide technical assistance"* D-Participant 3: *"There are currently no technicians at the schools"* D-Participant 4: *"ICT technicians required to support schools"* D-Participant 1: *"Teachers are not technicians, a teacher's job is to teach"* D-Participant 4: *"Technicians can be assigned to support schools at District level in the same way that districts do for "CAT" when there are exams at school"* **Training** D-Participant 1: *"Assistants should be provided to assist teachers in classroom set up, and also for tablet maintenance"* **Support** D-Participant 1: *"It takes time to setup ICT equipment and by the time the teacher finishes setting up the lesson is finished"* **Personal relationships** D-Participant 1: *"ICT Champion tries but teachers don't want to be ordered around"* **Maintenance** D-Participant 1: *"Must create line function for maintenance of tablets"*
Concerns:	D-Participant 1: *"Tablet quality- charging ports get easily damaged. A number of tablets have been reported as not working"* D-Participant 1: *"Maintaining any equipment at school, including infrastructure, building and furniture is school's responsibility*" D-Participant 1: *"There is a budget for maintenance, and this includes tablets if stolen or broken"* D-Participant 1: *"Normal channels through the circuit, and must be approved by the department where necessary"* D-Participant 3: *"What happens to new enrolments since tablets were only given to previous year's enrolled learners"*
3. Political	D-Participant 1: *"When there are changes at provincial level, agreements made with previous provincial officers may be threatened"* D-Participant 1: *"For example, when a MoU is signed with a provincial officer such as the SG, when that officer leaves and is replaced, there is no guarantee that the MoU will be retained. This depends on whether the new person is interested or not, because they may have new projects.* D-Participant 1: *"Education is politicised and different stakeholders may have varying agendas"* D-Participant 2: *"There should be a way to ensure continuity"*
4. Social/Cultural	D-Participant 1: *"When parental support is minimal, and parents' level of education may is low, or where parents are absent from family homes, working in other cities, children may be staying with grandmothers or only with the mother. Sometimes children are looking after each other"* D-Participant 1: *"Parents may be too busy. When you have parents meeting e.g. at schools and few attend there are problems. In schools where parents are present, there is a big improvement."*

5. Pedagogical	D-Participant 3: "*Teachers and ICT Champions were trained on the use of digital content"* D-Participant 3: *"All the schools were given projectors"* D-Participant 3: *"Training of teachers mainly happens at head office (Province)"* D-Participant 4: *"Human resource development (HRD) – Training of teachers is based on personal growth plans when IQMS has been carried out"* D-Participant 4: *"Teacher development is carried out by subject education specialists (subject advisors) for their credit. Resources should be provided by government, and provide incentives"* D-Participant 3: *Subject advisors (SESs) – Training should be subject specific* D-Participant 1: *"Schools with tablets can make more use of e-books"*
6. Institutional ***(Structures and processes)***	
STRATEGIC LEVEL – National and provincial level	
Provincial leadership	D-Participant 1: *"The provincial department needs to be supportive"*
Institutional processes	D-Participant 3: *There are processes to be followed in renewal of contracts and also for the "ICT rollout programme"* D-Participant 1: *"Wi-Fi license just expired. Contract must be taken over by DBE. The Department of Science and Technology (DST) contract (for Connectivity – Wi-Fi network) must be taken over by the Department of Basic Education (DBE), however a sustainability agreement/arrangement still needs to be agreed"* D-Participant 1: "*Departmental structures are rigid" ; Problems should be addressed in the "Sustainability Agreement"* D-Participant 2: *"There is a memorandum of understanding (MOU) and talks on sustainability are on-going, the issue is implementation."*
Economies of scale	D-Participant 1: "*Defining strategy at National/provincial level can leverage on economies of scale. Joburg (meaning Johannesburg city in the Gauteng province) has "Gauteng online", which is easier because schools are in close proximity and done at provincial programme. In Gauteng, the whole school is Wi-Fi enabled, and the provincial department has paid"*
Policy	D-Participant 2: *"The National strategy for learner attainment (NSLA) Section 9: ICT Support to curriculum is an important consideration"* D-Participant 2: *"There is 'Principal's manual'; There are policies that stipulate how budgets are allocated to schools"*
Textbooks, e-books	D-Participant 1: *"The DBE provides workbooks. Government should develop strategies on reducing textbook publish and print books costs"* D-Participant 1: *"Currently there are several book publishers and companies that are used by the DBE for textbooks"*.
Address other issues in the education system (Holistic approach)	D-Participant 1: *"Consider the infrastructure, there are many needs – water, sanitation… and all need maintenance"* D-Participant 2: *"People must sit down. And talk about the whole TECH4RED programme"* D-Participant 2: *"There are other barriers to learning, for example issues related to nutrition, scholar transport, remedial lessons, and "Teachers' motivation. Identify and address these factors"* D-Participant 1: *"The order of doing things is important, what about the basic conditions of school buildings?"; "There are many factors"*
Programme management	D-Participant 1: *"ICT4RED is based in another city, and that is where information is available if there are connectivity issues, and shows when the server is down"* D-Participant 1: *"It is all out- sourced. It should be in-sourced. For example out-sourced components include networking, monitoring"* D-Participant 3: *"Teacher Professional Development: In ICT4RED teachers were trained in order to 'earn' the Tablets, and badges are also earned"* D-Participant 3: *"The "Earn as you learn" approach used in ICT4RED, and the use of badges are good strategies"* **Define roles and responsibilities** D-Participant 3: *"It is important to identify where the 'rewards' such as tablets would be sourced. Would the DST or DBE provide these resources?"* D-Participant 3: *"Who would be responsible for the badge system?"* D-Participant 4: "*ICT4RED is a pilot and should be rolled out as part of ICT programmes"*

	D-Participant 4: "*Rolling out of ICT4RED to other circuits, the District could approach the province and indicate the number of facilitators trained through ICT4RED*" D-Participant 4: "*The facilitators who were trained during ICT4RED project could be compensate by the provincial office in a similar way that teachers who work for the 'Grade 12 intervention' are compensated*" D-Participant 4: *"Since ICT4RED was a pilot, it is important that it should yield tangible results, otherwise the province could decide to shelve it"* D-Participant 4: *"The question is, is there any performance improvement resulting from the project?"*
MESO LEVEL (District and circuit) and MICRO LEVEL (School)	
Support teachers	D-Participant 3: *"Extra work for teachers to charge tablets. Time and effort is needed"* D-Participant 3: "*If there is no support provided to the teacher, it is extra work for teachers to keep tablets in the office/strong rooms, make sure tablets are charged beforehand, and check that Wi-Fi is working*"
School Security	D-Participant 2: *"Tablets have been reported stolen or misplaced"* D-Participant 1: "*Can approach the department for a watchman*" D-Participant 1: "*Schools were informed through a circular. Lately schools are expected to insure their property, this includes ICT equipment*" D-Participant 2: "*Security at some schools is inadequate and tablets are targeted by thieves*" D-Participant 2: "*Burglaries have occurred at some schools and been reported to the district*" D-Participant 1: *"Tablets should be branded or in some to reduce theft"* D-Participant 2: *"Need to establish cost of security equipment"*
Information and knowledge management	D-Participant 4: *"If the district could be supplied with a list of the people (trained facilitators) it could help"*
Communication	**Subject Committee meetings** D-Participant 3: *"Specific groups such as subject committees, who meet regularly, monthly or quarterly per annum, provide a platform where issues can be raised. Active participation of teachers required in subject committee"* D-Participant 3: *"It is important that Subject education specialists (subject advisors) organise and set up subject committee meetings which are mandatory."* D-Participant 1: *"The scope of these meetings should be broadened to include ICT matters"* D-Participant 3: *"The circuit has clusters, and cluster meeting issues are reported at the subject committee meetings. Each cluster has a lead teacher, and meet quarterly"* **Continuous communication** D-Participant 1: *"Continuous contact with teachers about the project is required. Feedback from teachers now is different than during the project implementation."* D-Participant 1: *"When the project is active, there are workshops, conferences, and constant contact with project owners"* D-Participant 1: *"Inspiration is lacking because there is no activity"* D-Participant 1: "*When projects end teachers tend to go back to their little corners, to old habits. A handful of teachers are using it, but others need pushing."* **Communities of practice** D-Participant 1: *"Communities of practice for teachers are crucial for knowledge sharing and for learning. That is lacking"*
Reporting	D-Participant 3: *"CES Curriculum receives monthly reports from the District ICT4RED Champion monthly that are specific to ICT"* D-Participant 3: *"ICT4RED as a project must be reported by the district ICT4RED champion"*

	D-Participant 3: *"There are issues that need to be addresses such as the use of tablets by principals, or the return of tablets by teachers when they leave the schools. These must be reviewed together with the district ICT Champion"* D-Participant 3: *"Teachers and Principals interact directly with the Circuit manager and CES Chief Education Specialist"*
Human resources	D-Participant 3: "*More personnel are required at district"* D-Participant 1: *"More personnel are needed to assist teachers in setting up and for maintenance"*
District Leadership and management (Monitoring& oversight)	D-Participant 4: *"The District Management team is comprised of officials who perform different functions"* D-Participant 4: "*The Deputy Director (DD) Finance could assist in identifying funds, and sourcing funding required"* D-Participant 4: "*DD Supply Chain Management can help to with ICT problems, for example technicians would go through this channel. This means that technicians to assist schools could be accommodated at district level"* D-Participant 4: "*DD-Human Resources (HR): Could appoint someone to oversee training on mobile learning using departmental appointment processes, because HR issues appointment letters, just as it is done for Science Centers"* D-Participant 4: *"CES Curriculum: Responsible for content: Use, in class, use of correct materials, and CAPS compliance*. *There are officials in the district including Institutional development Support and governance (IDS & G), CES- HRD Human resource development, and CES Education Social Services"* D-Participant 1: *"For textbooks nobody asks for monitoring, so why ask for monitoring for tablets. This could mean that teachers are not comfortable or has to do with teachers' environment."* D-Participant 1: *"The circuit manager is like the general manager"* D-Participant 1: *"ICT Champions met with the district-based E-learning coordinator, but although this was started but now it is quiet."*
MICRO LEVEL (School)	
School Leadership (SGB, SMT)	D-Participant 2: "*School's leadership* (*Principal, School management team, School governing body) are responsible for school management and leadership"* D-Participant 1: "*There are some primary schools which are not in the ICT4RED project but have secured ICT equipment, bought the equipment and installed security systems for it that looks into strong room and classes."* D-Participant 2: "*Ensure school is functional and School governing body, School management team are functional"* D-Participant 3: "*There are (monthly) school formal meetings that should be used by teachers to communicate ICT related issues."*
Infrastructure: Provide appropriate equipment	D-Participant 1: "*Providing a 'full solution' such as trollies that teachers can use to transport tablets and projectors to class is meaningless if the trolley is too heavy or will not move easily on the gravel school terrain should be avoided"*
Mobility of teachers and Information and knowledge management	D-Participant 3: "*Teachers move to other areas, and teachers move from one circuit to another. Sometimes teachers leave with the tablets. There should be clear guidelines about what happens to teachers' tablets when they move to other schools"*

Annexure 6.1

RESULTS OF EXPERT EVALUATION OF SFMTIS – TEACHERS, DISTRICT OFFICIALS, ACADEMICS

(Purpose: Establish your opinions regarding the SFMTIS sustainability dimensions)

Indicate your assessment regarding the sustainability dimension by selecting a value between 1 and 5, and crossing your selection with an "X", where 1 is 'Strongly **Disagree**' and 5 is 'Strongly **Agree**"

Sustainability Dimensions in SFMTIS	**How strongly do you consider the sustainability dimension's significance in ensuring sustainability of mobile technology integration in schools in resource-constrained schools in South Africa?**	**Strongly Disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly Agree**
Financial/ Economic	Finance is required to support the ICT technology in the long term Cost of tablets, maintenance costs, access to infrastructure and technical support; Consultation and feedback between service providers regarding content, technical support	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
Social/cultural	Involvement, consultation and feedback by stakeholders at different levels of the institution-School: Teachers, learners, parents, SGB, SMT; District: District officials including managers and subject education specialists/advisors; Province: Provincial officials and Provincial ICT forum; National: DBE officials	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
Political	The role of leadership and the institutional policies required to adopt, maintain and monitor the success of mobile learning programmes;	1	2	3	4	5
		1	2	3	4	5

	Consultation and feedback between different levels of the institution	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
Technological	Informed technology selection based on institutional needs and mid-to-longer-term strategic goals; Need to consider how tablets selected, access to CAPS aligned digital content, and maintenance costs, access to infrastructure and technical support; Consultation and feedback between service providers regarding content, technical support and users (teachers)	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
Environmental	Making plans for MAINTENANCE of tablets (replacing damaged mobile devices); Making plans for eventual DISPOSAL or REUSE of the equipment (large numbers of servers and tablets) when they reach the end of their effective life	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
Pedagogical	Teaching and learning practices to support the goals of mobile learning programmes; The roles of teachers (and learners) in facilitating learning with mobile devices; Prepare and practice to facilitate learning with mobile devices; Peer collegiality required to ensure best pedagogical practices; Formal and informal learning facilitated by mobile learning	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5

		1	2	3	4	5
		1	2	3	4	5
Institutional	Alignment between PROCESSES, LEADERSHIP SUPPORT and POLICY IMPLEMENTATION at school, district (meso), provincial and national level (macro))					
HOW IMPORTANT IS EACH OF THE FOLLOWING?						
	School security	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
	Monitoring & evaluation	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
	Leadership	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5

	Communication and Coordination	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
	Policy implementation	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
	Use of special available facilities (e-rate for school Internet access)	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
	Technical support to teachers	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	
		1	2	3	4	
		1	2	3	4	5

		1	2	3	4	5
		1	2	3	4	5
	ICT teacher training	1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5 (all circuits in the district)
		1	2	3	4	5
		1	2	3	4	5
		1	2	3	4	5

Annexure 6.2

PRACTICAL EXAMPLE OF

Framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa

SFMTIS

Three reasons why using the SFMTIS sustainability scoring is beneficial:

1. The SFMTIS was developed with inputs from teachers and district officials who have experience in mobile technology integration in the environment

2. Teachers can be actively involved in identifying sustainability characteristics for their school and finding relevant solutions

3. Development of the SFMTIS followed a methodological process that involved analysis of reviewed literature and application of the case study

IMPORTANT TO NOTE: The SFMTIS applies relative scoring developed for the specific environment

How the SFMTIS sustainability scoring works:

1. SCORING

   For each of the SFMTIS sustainability dimensions TICK one of the three statements that best describes your school environment.

   Apply the SCORE system using the master score for each dimension (see example)

2. THE SPIDER WEB

   Plot the scores for your environment on the spider web diagram

   OR (or both)

3. BAR CHART

   Plot the scores for your environment on the bar chart

[See example]

EXAMPLE - SCHOOL A

1. Financial		
1.1 Tablet maintenance	Tablets that need to be repaired are maintained through funds allocated to the school by the Department of Basic Education (DBE)	4
	The school raises its own funds to maintain tablets and ICT infrastructure	2 ✔
	Tablets are not repaired because the school lacks funds for repairs	0
1.2 TPD - ICT training	The ICT training provided to teachers by DBE is adequate	4
	Teachers attend ICT training but it is inadequate	2 ✔
	Teachers are unable to attend ICT training because there are no time/funds available	0
1.3 Technical support	Teachers receive technical support from technicians through DBE support	4
	The school hires technicians to provide technical support to teachers	2
	Teachers do not have any technical support as the school cannot afford to pay technicians	0 ✔
Economic total score (Maximum 12)		

2. Political		
2.1 DBE district management	The DBE district management shares information and advice with teachers on how to sustain mobile technology integration in the school	2 ✔
	There is minimal DBE district management participation in activities to support the school's efforts to sustain mobile technology integration	1
	The DBE district management does not share information and advice with teachers on how to sustain mobile technology integration in the school	0
2.2 School management (principal, SGB, SMT)	The school management shares information and advice on how to sustain mobile technology integration in the school	2
	The school management's participation in activities to support the school's efforts to sustain mobile technology integration is minimal	1 ✔
	The school management does not share information and advice with teachers on how to sustain mobile technology integration in the school	0
Political total score (Maximum 4)		

3. Culture		
3.1 Parental involvement	There is a high level of parental participation in school activities	4
	There is minimal parental participation in school activities	2 ✔
	Parents do not participate in school activities	0
3.2 Community	There is a high level of community involvement	2
	There is minimal community participation in school activities	1

involvement	The community is unsupportive	0 ✔
3.3 Private sector involvement	The school receives financial support from the private sector	2
	Minimal financial support is received from the private sector	1 ✔
	The private sector does not financially supportive the school	0
Culture total score (Maximum 8)		

4. Technological		
4.1 Digital content	Digital content on the school server is frequently used by teachers	2
	A few teachers utilise the digital content provided in the school server	1 ✔
	Teachers do not use the digital content available in the school server	0
4.2 Connectivity	The Internet connectivity and Wi-Fi connectivity are very good	2 ✔
	The Internet and Wi-Fi connectivity need improvement	1
	The Internet and Wi-Fi connectivity are bad	0
4.3 Technical support	There are technicians that are locally available to provide technical support	2
	Technical support is available, however it is not provided timeously	1
	There is no technical support available to teachers	0 ✔
Technological total score (Maximum 6)		

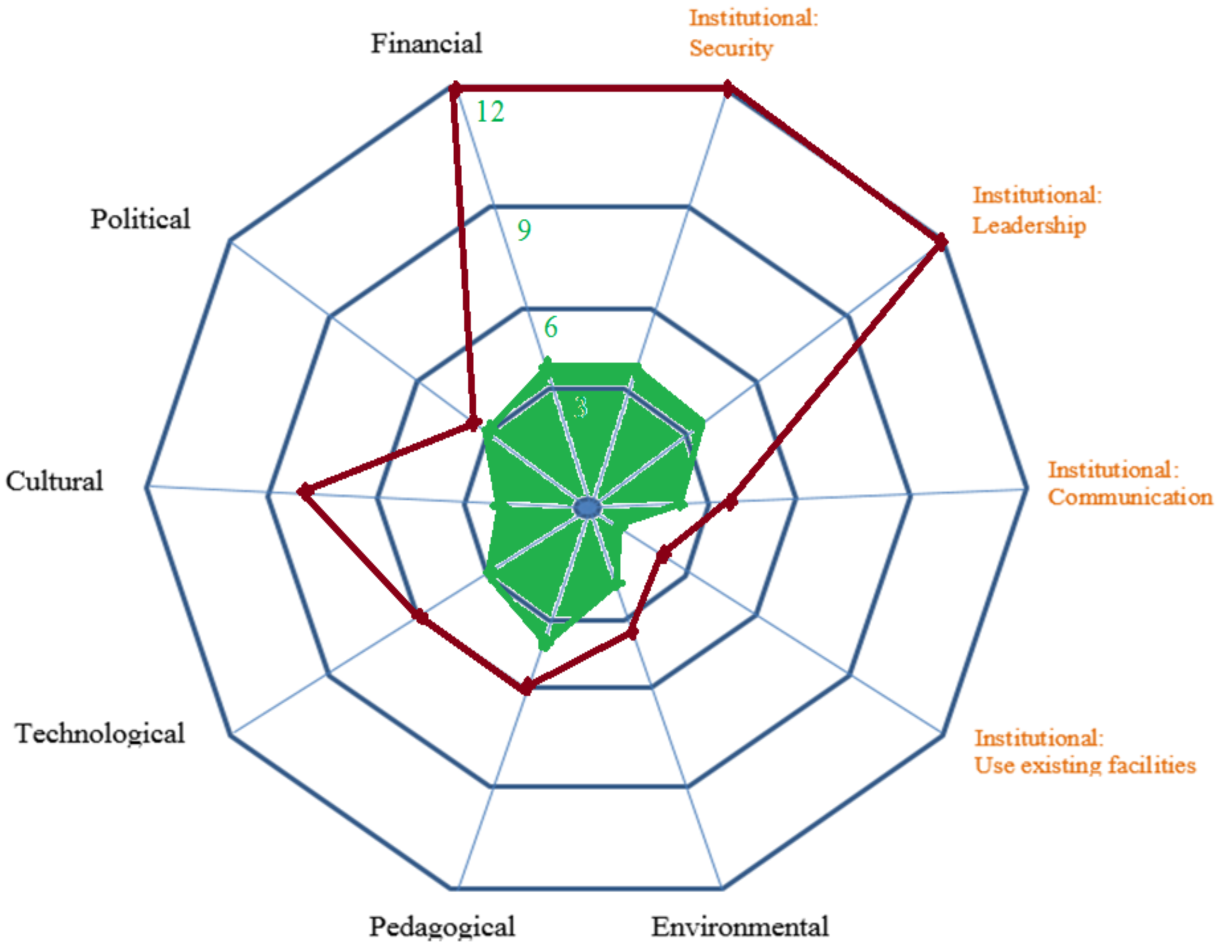
5. Pedagogical		
5.1 Tablet use	Teachers use tablets when they teach their classes	2 ✔
	There are few teachers who use tablets for teaching	1
	Teachers do not use tablet when they teach their classes	0
5.2 Credible evidence	Records are kept to indicate how or when teachers use tablets for teaching	2
	Records are maintained by some of the teachers	1 ✔
	No records are maintained to show when or how teachers use tablets for teaching	0
5.3 Benefits to teachers	The use of tablets makes teachers’ ability to teach easier	2
	Using the tablets adds extra pressure on the teachers	1 ✔
	Using tablets to teach is making the teachers’ work more difficult	0
Pedagogical total score (Maximum 6)		

6. Environmental		
6.1 Disposal/reuse of ICT equipment	The school has an ICT policy that explains how old tablets/ICT equipment will be disposed or reused	2 ✔
	The school has an ICT policy however it does not explain how old tablets/ICT equipment should be disposed or reused	1
	The school does not have an ICT policy	0
6.2 Reporting guidelines/processes: Maintenance of ICT	There are clear guidelines on how to report ICT equipment that require repairs	2
	There may be guidelines but I do not know them	1

equipment	There are no guidelines on what to do when tablets/ICT equipment need to be repaired	0
Environmental total score (Maximum 4)		

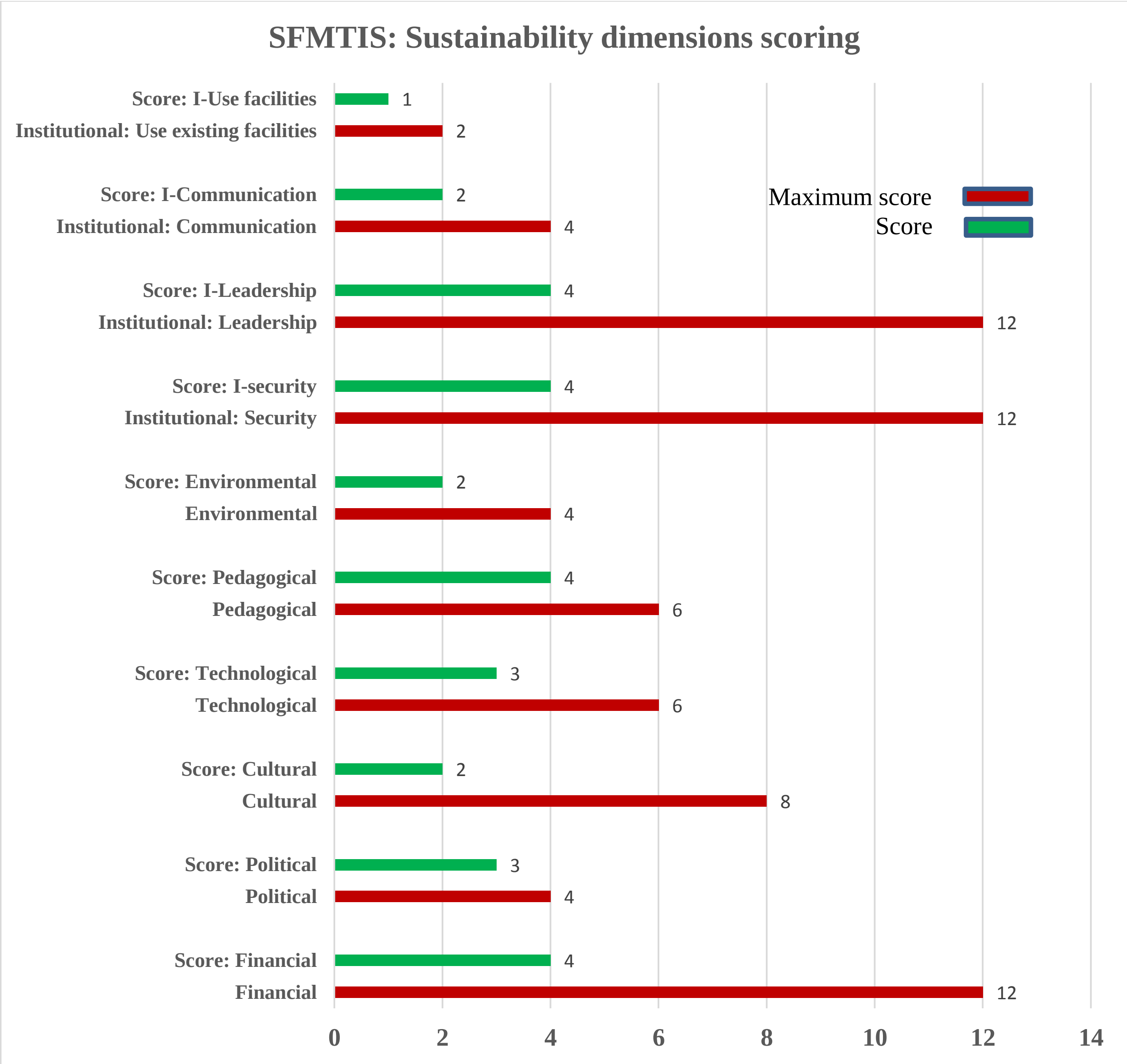
7. Institutional		
7.1 Security (against theft)	Strong security measures have been implemented at the school	12
	Security at the school is weak	4
	There is no security at the school	0
7.2 Leadership	Leaders at school level demonstrate strong leadership	12
	Leaders at district level demonstrate strong leadership	4
	Poor leadership is demonstrated at all levels	0
7.3 Communication	Clear guidelines on reporting, communication and recording procedures exist	4
	Reporting, communication and reporting procedures are unclear	2
	No guidelines on reporting, communication and recording procedures exist	0
7.4 Use of existing facilities	Existing ICT facilities and the subsidised Internet are utilised	2
	There are a few teachers that utilise available ICT facilities	1
	There is a lack of awareness/utilisation of available facilities	0
Institutional total score (Maximum 12)		

SFMTIS: Sustainability dimension scoring - Spider web (EXAMPLE)



Scores:
Score of 0 (center) - Unsustainable
Score of 12 (outermost circle) – Sustainable

Example
Example score
Master score



Example:
Insights into sustainability characteristics of school A in comparison to relative scores developed for SFMTIS include:

We will have to pay attention to how we finance the mobile technology integration programme

The school's security is inadequate, so what security features can we apply in order to enhance security and increase the likelihood of successfully integrating mobile technology into teaching?

Our political scoring is high, what characteristics enable our school to have this relatively high score, and how can we reinforce this?

Annexure 6.3

EXPERT EVALUATION OF SFMTIS – TEACHERS AND DISTRICT OFFICIALS

(Purpose: Establish your insights regarding the SFMTIS sustainability dimensions)

Indicate your assessment regarding the sustainability dimension by selecting a value between 1 and 5, and crossing your selection with an "X", where 1 is 'Strongly **Disagree**' and 5 is 'Strongly **Agree**'

Sustainability Dimensions in SFMTIS	**How strongly do you consider the sustainability dimension's significance in ensuring sustainability of mobile technology integration in schools in resource-constrained schools in South Africa?**	**Strongly Disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly Agree**
Financial/Economic	Finance is required to support the ICT technology in the long term Cost of tablets, maintenance costs, access to infrastructure and technical support; Consultation and feedback between service providers regarding content, technical support	1	2	3	4	5
Social/cultural	Involvement, consultation and feedback by stakeholders at different levels of the institution-School: Teachers, learners, parents, SGB, SMT; District: District officials including managers and subject education specialists/advisors; Province: Provincial officials and Provincial ICT forum; National: DBE officials	1	2	3	4	5
Political	The role of leadership and the institutional policies required to adopt, maintain and monitor the success of mobile learning programmes; Consultation and feedback between different levels of the institution	1	2	3	4	5
Technological	Informed technology selection based on institutional needs and mid-to-longer-term strategic goals; Need to consider how tablets selected, access to CAPS aligned digital content, and maintenance costs, access to infrastructure and technical support; Consultation and feedback between service providers regarding content, technical support and users (teachers)	1	2	3	4	5

Environmental	Making plans for MAINTENANCE of tablets (replacing damaged mobile devices); Making plans for eventual DISPOSAL or REUSE of the equipment (large numbers of servers and tablets) when they reach the end of their effective life	1	2	3	4	5
Pedagogical	Teaching and learning practices to support the goals of mobile learning programmes; The roles of teachers (and learners) in facilitating learning with mobile devices; Prepare and practise to facilitate learning with mobile devices; Peer collegiality required to ensure best pedagogical practices; Formal and informal learning facilitated by mobile learning	1	2	3	4	5
Institutional	Alignment between PROCESSES, LEADERSHIP SUPPORT and POLICY IMPLEMENTATION at school, district (meso), provincial and national level (macro)					
	HOW IMPORTANT IS EACH OF THE FOLLOWING?					
	School security	1	2	3	4	5
	Monitoring & evaluation	1	2	3	4	5
	Leadership	1	2	3	4	5
	Communication and Coordination	1	2	3	4	5
	Policy implementation	1	2	3	4	5
	Use of special available facilities (e-rate for school Internet access)	1	2	3	4	5
	Technical support to teachers	1	2	3	4	5
	ICT teacher training	1	2	3	4	5

Please indicate your views regarding the following:

1. Does the SFMTIS address a real problem/need (Relevance)

2. Would you consider the process followed in developing the SFMTIS to be rigorous? (Rigour)

3. Would you consider the SFMTIS reliable enough to apply in the environment in order to enhance sustainability of mobile technology integration? (Validity)

4. What three features of the SFMTIS would you consider as relevant? (Relevance)

5. What three features of the SFMTIS would you consider irrelevant? (Relevance)

6. How can the SFMTIS be applied?

7. Would it be easy to use the SFMTIS? (Ease of use)

8. Would it the SFMTIS be applicable in similar environments? (Generalisation)

9. What effect(s) can application of the SFMTIS have?

10. What is missing in this framework? (Comprehensiveness)

Annexure 6.4

EXPERT EVALUATION OF SFMTIS – Research consultant (CSIR)

(Purpose: Establish your insights regarding the SFMTIS sustainability dimensions)

Indicate your assessment regarding the sustainability dimension by selecting a value between 1 and 5, and crossing your selection with an "X", where 1 is 'Strongly **Disagree**' and 5 is 'Strongly **Agree**'

Sustainability Dimensions in SFMTIS	**How strongly do you consider the sustainability dimension's significance in ensuring sustainability of mobile technology integration in schools in resource-constrained schools in South Africa?**	**Strongly Disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly Agree**
Financial/Economic	Finance is required to support the ICT technology in the long term Cost of tablets, maintenance costs, access to infrastructure and technical support; Consultation and feedback between service providers regarding content, technical support	1	2	3	4	5
Social/cultural	Involvement, consultation and feedback by stakeholders at different levels of the institution-School: Teachers, learners, parents, SGB, SMT; District: District officials including managers and subject education specialists/advisors; Province: Provincial officials and Provincial ICT forum; National: DBE officials	1	2	3	4	5
Political	The role of leadership and the institutional policies required to adopt, maintain and monitor the success of mobile learning programmes; Consultation and feedback between different levels of the institution	1	2	3	4	5
Technological	Informed technology selection based on institutional needs and mid-to-longer-term strategic goals; Need to consider how tablets selected, access to CAPS aligned digital content, and maintenance costs, access to infrastructure and technical support; Consultation and feedback between service providers regarding content, technical support and users (teachers)	1	2	3	4	5

Environmental	Making plans for MAINTENANCE of tablets (replacing damaged mobile devices); Making plans for eventual DISPOSAL or REUSE of the equipment (large numbers of servers and tablets) when they reach the end of their effective life	1	2	3	4	5
Pedagogical	Teaching and learning practices to support the goals of mobile learning programmes; The roles of teachers (and learners) in facilitating learning with mobile devices; Prepare and practise to facilitate learning with mobile devices; Peer collegiality required to ensure best pedagogical practices; Formal and informal learning facilitated by mobile learning	1	2	3	4	5
Institutional	Alignment between PROCESSES, LEADERSHIP SUPPORT and POLICY IMPLEMENTATION at school, district (meso), provincial and national level (macro))					
	HOW IMPORTANT IS EACH OF THE FOLLOWING?					
	School security	1	2	3	4	5
	Monitoring & evaluation	1	2	3	4	5
	Leadership	1	2	3	4	5
	Communication and Coordination	1	2	3	4	5
	Policy implementation	1	2	3	4	5
	Use of special available facilities (e-rate for school Internet access)	1	2	3	4	5
	Technical support to teachers	1	2	3	4	5
	ICT teacher training	1	2	3	4	5

Please indicate your views regarding the following:

1. Does the SFMTIS address a real problem/need? (Relevance)

2. Would you consider the process followed in developing the SFMTIS to be rigorous? (Rigour)

3. Would you consider the SFMTIS to be reliable enough to apply in the environment in order to enhance sustainability of mobile technology integration? (Validity)

4. What three features of the SFMTIS would you consider as relevant? (Relevance)

5. What three features of the SFMTIS would you consider irrelevant? (Relevance)

6. How can the SFMTIS be applied?

7. What effect(s) can application of the SFMTIS have?

8. What is missing in this framework?

Annexure 6.5: Consent form - Expert reviewers

CONSENT FORM TO PARTICIPATE IN RESEARCH

Developing a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa

Your consent for participation in this research is requested in order for you to evaluate the *"Framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa"* (SFMTIS).

10. PURPOSE OF THE RESEARCH

The research seeks to develop a framework for sustainable mobile technology integration in schools in resource-constrained environments in South Africa. This is line with the Information and Communications Technology for rural education and development (ICT4RED) project objectives.

The ICT4RED initiative is part of the Technology for rural education and development (TECH4RED) joint initiative between South Africa's Department of Science and Technology (DST), the Department of Basic Education (DBE), the Department of Rural Development and the Eastern Cape Department of Education (ECDoE). ICT4RED focused on improving the quality of learning and teaching by integrating use of tablets in teaching mathematics and science in schools in the Nciba Circuit in Cofimvaba School District in the Eastern Cape. The objective is to use these technologies in a sustainable and replicable way.

11. PROCEDURE

Should you consent to participate in the research the SFMTIS will be presented to you (15 minutes). You will be requested to give your views regarding the presented framework (15 minutes), and to respond to specific questions some in writing (10 minutes).

12. CONFIDENTIALITY

Your responses will be kept confidential and you will not be personally identified. The information you give will be used for academic research purposes only.

13. PARTICIPATION AND WITHDRAWAL

Participation in this research is voluntary. You have the right to withdraw from the study at any time without any negative or undesirable consequences to yourself.

14. POTENTIAL RISKS AND DISCOMFORTS

You will not be in any risk or discomfort because of your participation. Your responses will be kept confidential and will not be linked to your name or position as an individual. The responses completed by different participants will be analysed collectively.

15. PAYMENT FOR PARTICIPATION

You will not be paid for participating in this research.

16. POTENTIAL BENEFITS TO SUBJECTS AND TO SOCIETY

Your inputs in evaluating the *"Sustainability framework for mobile technology integration in schools in resource-constrained environments in South Africa (SFMTIS)"* is valuable in the development of the framework. The SFMTIS will provide a mechanism that can be applied to increase the likelihood of sustainability of mobile technology integration initiatives in schools.

17. IDENTIFICATION OF INVESTIGATOR

Should you have any questions or queries regarding this research you are welcome to contact Jabulisiwe Mabila (University of South Africa, School of Computing) on 0730137813 or mabiljp@unisa.ac.za

18. RIGHTS OF RESEARCH PARTICIPANT

You have the right to withdraw your participation in the research at any time without any penalty. Your participation does not relinquish any legal claims or rights. You can address questions regarding your rights as a research participant to the Research & Graduate Studies office in the UNISA College of Science Engineering and Technology 011 670 9225 or manalmp@unisa.ac.za

Participant consent

If you agree to participate in this research, please complete the section below:

I hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I can withdraw from the research at any time should I so desire.

Signature: ___________________________

Date: _______________________

(Optional:) Surname: _______________________ Name: _____________________

Thank you!!