

**Designing and implementing an
Information Communication Technology for
Rural Education Development (ICT4RED) initiative
in a resource constrained environment:
Cofimvaba school district, Eastern Cape,
South Africa**



ICT4RED



TECH4RED
ENHANCING EDUCATION

Marlien Herselman and Adele Botha
2014



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ICT4RED

First published in December 2014

First Print December 2014

Design done by: Go Fish Designs



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Herselman, M. and Botha, A. (2014). *Designing and implementing an Information Communication Technology for Rural Education Development (ICT4RED) initiative in a resource constrained environment: Cofimvaba school district, Eastern Cape Province, South Africa*, 1 ed. 2014, CSIR Meraka: Pretoria, South Africa.

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ISBN: 978-0-7988-5618-8 (hbk) | ISBN: 978-0-7988-5619-5 (ebk)

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Designing and implementing an Information Communication Technology for Rural Education Development (ICT4RED) initiative in a resource constrained environment: Cofimvaba school district, Eastern Cape, South Africa

This book is a representation of the activities, which were recognised as essential components to consider, when implementing a certain ICT4D initiative in a resource constraint area in the poorest province of South Africa which is faced with significant educational challenges. This initiative was coined the ICT4RED initiative and was a research, development, innovation and implementation project that changed the way in which teachers teach with technology in their specific context over a period of 3 years (2012-2015).

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Herselman, M. & Botha, A. (2014). *Designing and implementing an Information Communication Technology for Rural Education Development (ICT4RED) initiative in a resource constrained environment: Cofimvaba school district, Eastern Cape, South Africa*. Pretoria, South Africa: CSIR Meraka.

ISBN: 978-0-7988-5618-8 (hbk)

ISBN: 978-0-7988-5619-5 (ebk)

We would like to thank Estee Wiese (estee.wiese@gmail.com) for her editorial support during preparation of this manuscript.

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Acronyms

CAPS	Curriculum Assessment Policy Statements
DBE	South African Department of Basic Education
DRDLR	South African Department of Rural Development and Land Reform
DSR	Design Science Research
DST	South African Department of Science and Technology
EAYL	Earn as You Learn
ECDoE	Eastern Cape Department of Education
ICT4D	Information and Communication Technology for Development
ICT4RED	Information and Communication Technology for Rural Education Development
ICTE	Information and Communication Technology in Education
IS	Information Systems
IT	Information Technology
LTSM	Learner Teacher Support Material
M&E	Monitoring and Evaluation
MoA	Memorandum of Agreement
MoU	Memorandum of Understanding
NDP	National Development Plan
NEIMS	National Education Infrastructure Management System
NGO	Non-Governmental Organisation
SGB	School Governing Body
SMT	School Management Team
Tech4RED	Technology for Rural Education Development
TPACK	Technological Pedagogical Content Knowledge
TPD	Teacher Professional Development

Executive summary

This book is a representation of the activities, which were recognised as essential components to be considered, when implementing a certain ICT4D initiative in a resource constrained area in the poorest province of South Africa which is faced with significant educational challenges. This intervention was coined the ICT4RED initiative and was a research, development and implementation project that changed the way in which teachers teach with technology in their specific context over a period of 3 years (2012-2015).

The book aims to provide an overview of the design and implementation of an *Information and Communication Technology for rural education development initiative* in a resource constrained environment.

Various frameworks, models, guidelines and tools were developed by adopting Design Science Research as the chosen methodology. Certain specific case study phases were applied within the Design Science Research process and lessons were learnt in each phase which was documented as the initiative moved from one phase to the other. Certain steps were followed during each phase. The book provides an overview of how each of the components, within the ICT4RED Implementation Framework (Section 2), were managed and how they were operationalised to provide specific deliverables or to reach certain aims.

The core team (one representative from each component) met once a week to track and trace progress and deliverables. What emanated from this ICT4RED initiative was far more than just frameworks, models, processes or tools, to be tested and refined, it was a *change* in the way 350 teachers (in 26 schools) applied technology and teaching strategies to support their teaching and learning and to improve their 21st century teaching skills. This initiative can be viewed as a successful intervention within a specific period of time involving specific people in a specific context where technology was deployed to support education.

What became evident from this initiative was that it was NOT about the technology, but about the PEOPLE who are empowered to use the technology in order to improve their lives and that of their learners!

New technology is common, new thinking is rare.
- Sir Peter Blake-

This book will guide readers through the journey of this initiative and it is hoped that it will inspire all new prospective students, teachers and academia to realise that the value of using technology does not lie in that it can ever replace the teacher, but that it can *enhance* teaching and learning and *transform* traditional teaching methods in a classroom. This transformation can only be successfully done where technology is earned and not just given away or provided free of charge.

The book is divided into Sections (1-9). **Section 1** provides the Introduction and Background to the ICT4RED initiative and describes how the ICT4RED Framework evolved and how it was adapted after every phase. The methodology, which underpinned the development of the framework, is also dealt with.

Section 2 delivers an overview of the ICT4RED implementation framework, as one of the key artefacts to describing the ICT4RED initiative.

Section 3 summarises how Teacher Professional Development (TPD) was developed and deployed.

Section 4 covers the importance of the Monitoring and Evaluation framework and how it was applied in the ICT4RED initiative, over a period of 3 years. It is not the intention to focus on results but to share *how* the M&E framework was used to obtain results and effect impacts.

Section 5 provides details regarding Initiative Management, Operations Management and School ICT. The focus is on *how* the ICT4RED initiative applied different processes, used certain tools and actioned suppliers to equip schools and teachers in the Cofimvaba school district.

Section 6 addresses the ways in which Change Management and Stakeholder Management contributed to the integration of technology in a resource constraint community in a specific context.

Section 7 focusses on Sustainability and how value is derived through improved decision-making. The issue of sustainability, and how it plays an important role in the ICT4RED initiative, is discussed. Total Cost of Ownership-, Cost utility- and Tablet selection-models, which were developed to address sustainability, are also discussed.

Section 8 deals with the use of social media in the management of the ICT4RED initiative. The Twitter and WhatsApp feeds (over a period of time)

were analysed and provided some interesting results.

Section 9 provides a synthesis in which the objectives and aims, and how these were achieved, are addressed. This last section also looks at changes, which were eminent in the context of the initiative, and ends with some recommendations for similar future endeavours.



Photo 1-1: TPD Phase 2

Acknowledgement

This work acknowledges the TECH4RED Initiative, and more specifically the ICT4RED component, which is supported by the Department of Science and Technology, the Department of Rural Development and Land Reform, the Department of Basic Education and the CSIR for allowing us to collect data from the participants in the Nciba district of Cofimvaba in the Eastern Cape Province of South Africa to inform this work. We also acknowledge the support provided by the Eastern Cape Provincial Department of Education, the ICT4RED core team, other outsourced companies and universities. Special recognition has to be given to the district officials, circuit manager, local suppliers, teachers, learners, parents and community of the Nciba circuit in the Cofimvaba School District who have enthusiastically embraced this initiative and have become co-creators of their own destiny and innovation.

It is not about the technology; it is about sharing knowledge and information, communicating efficiently, building learning communities and creating a culture of professionalism in schools. These are the key responsibilities of all educational leaders.

- Marion Ginapolis-

Initiative Participants

The following participants are recognized:

- CSIR Meraka Institute (Initiative Management and component championing)
- Department of Science and Technology (DST) and Department of Rural Development and Land Reform (DRDLR) (Initiative Sponsors)
- DST, DRDLR, Department of Basic Education (DBE) and Eastern Cape Education Department of Education (Initiative Stakeholders)
- Human Science Research Council (HSRC) (Monitoring and Evaluation of TECH4RED)
- Benita Williams Consultants (Monitoring and Evaluation)
- Impact Advantage (Modelling)
- CoZaCares Foundation (Content)
- Maskew Miller Longman (Content)
- Pearson (Content)
- SchoolNET SA (Teacher Professional Development)
- AfroFusion (Communication)
- Hive Holdings (Technology infrastructure design, Operations Management)
- Tipp Focus (Change Management)
- Nelson Mandela Metropolitan University Govan Mbeki Mathematics Development Unit (Content)
- Fort Hare, Rhodes, Nelson Mandela Metropolitan University, University of Pretoria, University of Johannesburg, University of the Free State, University of South Africa, University of Manchester, Monash University (Postgraduate students and Research)
- Faranani (Professional Services)
- University of Pretoria (Ethnography and Content)
- Lymmyl Technologies (ICT Infrastructure Implementation and Support)
- Liquid Telecom (Satellite Connectivity)
- Maggie Verster (Teacher Professional Development)
- Sandy Malapile (Stakeholder Management)
- Uys du Buisson (Operations Management)
- Redline (Wireless Mesh Networks and Wi-Fi Implementation)
- Google South Africa (Technology infrastructure)

Section 1. Designing and implementing an ICT4RED initiative

M. Herselman, A. Botha and M. Ford

This section covers the introduction and background to the ICT4RED initiative.

1.1 Introduction

The purpose of this book is to provide an overview of the design and implementation of an *Information and Communication Technology for rural education development initiative* in a resource constrained environment.

This intervention is coined the Information Communication and Technology for Rural Education Development (ICT4RED) initiative, which is a large-scale pilot (spanning a period of 3 years) that tested the use of tablets in 26 deep rural schools in the Nciba Circuit of the Cofimvaba school district in the Eastern Cape Province of South Africa.

The macro-economic perspective of the area is characterised by few economic opportunities, a high unemployment rate, low incomes, a shrinking population of economically active people and a growing number of school-going youth. This area is regarded as a resource constrained environment. A resource constrained environment, for the purpose of this book, is best described by Anderson, Anderson, Boriello and Kolko (2012) as an environment where there is low-income communities and low bandwidth. These environments provide unique constraints (e.g. cultures) where people are unfamiliar with, or afraid of, technology and/or environments where power and network connectivity are scarce and expensive.

The pilot included 3 senior secondary schools (Grades 10 to 12) and 23 junior secondary and senior primary schools (Grades R to 9) (Van Rensburg & Du Buisson, 2012). The challenge was to identify and introduce appropriate technology (devices and other supporting ICT infrastructure) in ways that would improve the teaching and learning engagement, support sustainability beyond the initiative and ensure true integration into existing education processes, whilst managing very real logistical and infrastructure

problems.

The ICT4RED initiative was part of The Technology for Rural Education Development (TECH4RED) research programme which aimed to contribute to the improvement of rural education via technology-led innovation. It was initiated by the Department of Science and Technology (DST) in collaboration with the Department of Basic Education (DBE), the Eastern Cape Department of Education (ECDoE) and the Department of Rural Development and Land Reform (DRDLR). TECH4RED is applying a range of technology-intensive interventions, including initiatives in ICT, nutrition, health, water, sanitation and energy to determine the extent to which the programme will enable positive contributions at all levels and spheres of influence in the school system.

The learning from this programme can contribute to the development of evidence-based policy related to ICT in education, within the government of South Africa. ICT4RED is thus part of TECH4RED, and within TECH4RED this component focuses on how ICTs can support teaching and learning, specifically towards a modern, 21st century school environment.

An envisaged intention of the ICT4RED initiative was to use the insights gained through the implementation, to aid in the development of appropriate contextual frameworks, models, guidelines and tools (as artefacts and outputs) and to thus inform and guide other similar initiatives before inception. The following objectives were envisaged for the ICT4RED initiative:

- Explore and design systemic and sustainable approaches to providing access to digital content in resource constrained rural schools in South Africa. This incorporated an investigation into new and evolving educational technologies, devices, platforms and processes that support the access to digital content for rural school environments.
- Explore and design approaches for Teacher Professional Development (TPD), towards the evolution of a more emerging teaching and learning engagement for the information age. This extends to the development of 21st century teaching practices of teachers and 21st century skills of learners, and to
- Use the evidence garnered from the research, within this context, to inform policy in an integrated and coherent manner.

The results of the ICT4RED initiative include elements pertaining to policy, research, practitioners and decision-support outputs.

The ICT4RED initiative applied a Design Science approach. It focused on continuous improvement and redesign based on the outcomes of each of the implementation phases.

This ICT4RED initiative can be regarded as one of the larger and more ambitious ICT for Education research initiative of its kind in South Africa. It incorporated ongoing and detailed measurement, monitoring and evaluation to integrate technology into teaching and learning.

The value of the initiative is its multi-focussed cross-disciplinary implementation in a rural educational environment. The ICT4RED initiative was designed by incorporating learning gained from similar global initiatives.

1.2 Background to the ICT4RED initiative

School education in South Africa, despite an investment of 19% of total government spending (Trading Economics, 2010), still faces serious challenges. South Africa's education system is currently ranked at 133 out of 142 countries in the world by the World Economic Forum and the quality of mathematics and science teaching is ranked even lower at 138 (ITWeb, 2012). The National Planning Commission's Diagnostic Report (2011) states that efforts to raise the quality of education for poor children have largely failed. Research evidence (Department of Basic Education, 2013; Consortium for Research on Education, Access, Transitions and Equity, 2009) highlights the significance of problems within the education system itself. These include ongoing changes to curricula, bureaucratic inefficiencies, teacher under-performance, lack of school leadership and management skills and the non-availability of learning and teaching materials such as textbooks, as highlighted by the recent textbook crisis in South Africa's rural provinces (Department of Basic Education, 2011). The complexity of the school system and the interaction with other socio-economic factors also significantly influence the performance of learners, particularly in under-resourced and rural schools (Bloch, 2009).

ICT is widely believed to have a transformational effect on the education system, however, many ICT for Education initiatives in South Africa and the

rest of the developing world have resulted in failure (Bytheway, Cox, Dumas & van Zyl, 2012; Were, Rubagiza & Sutherland, 2011). Teachers in rural areas are willing to use technology to support teaching and learning, but are not only under-qualified in terms of pedagogy and content knowledge, but are unable to integrate the technology into their teaching activities (Were et al., 2011). In those cases where ICT initiatives in schools do include some kind of training component, the focus is often on computer literacy, rather than *how* to use the technology as a tool to support teaching and learning (Were et al., 2011). There are many stories of unused, locked computer laboratories at schools throughout South Africa, examples of ‘technology push’, rather than embedding these tools within the local education needs and contexts.

Smartphones and tablets and their potential to provide digital content (e.g. in the form of e-textbooks) using one-to-one models have become popular in both the developed and developing worlds. The use of mobile technology can be seen as an increasingly feasible option to support teaching and learning. As the cost of these devices continue to drop, they are becoming more accessible on to the general public. The touch interface and form factor have also improved usability and mobility.

The original conceptualisation of ICT4RED was articulated as tablets would be used to provide e-textbooks to learners, in order to solve the logistical problems caused by the distribution of paper-based textbooks to schools in South Africa. This became the starting point for the project.

The ICT4RED initiative was rooted in the assumption that larger scale improvements to the South African education system are not limited to the domain of the Department of Basic Education alone, but require the combined efforts of public and private partners, together with civil society, at National, Provincial, District and Circuit levels. The targeted stakeholders included schools, government (at a provincial level), NGOs and applicable private sector organisations. Schools are regarded as a subsystem of the broader education system and an Education Circuit represents the smallest unit in this system.

The following diagram (Figure 1-1), attempts to outline the Education ecosystem at a high level in South Africa. Policy and leadership at a national level is the responsibility of the Department of Basic Education and day to day management and policy implementation occurs at a provincial level.

Each province is normally divided into districts, and each district into circuits. District Offices manage all the schools within a circuit. There are interactions at all levels of the eco-system between the various education stakeholders.

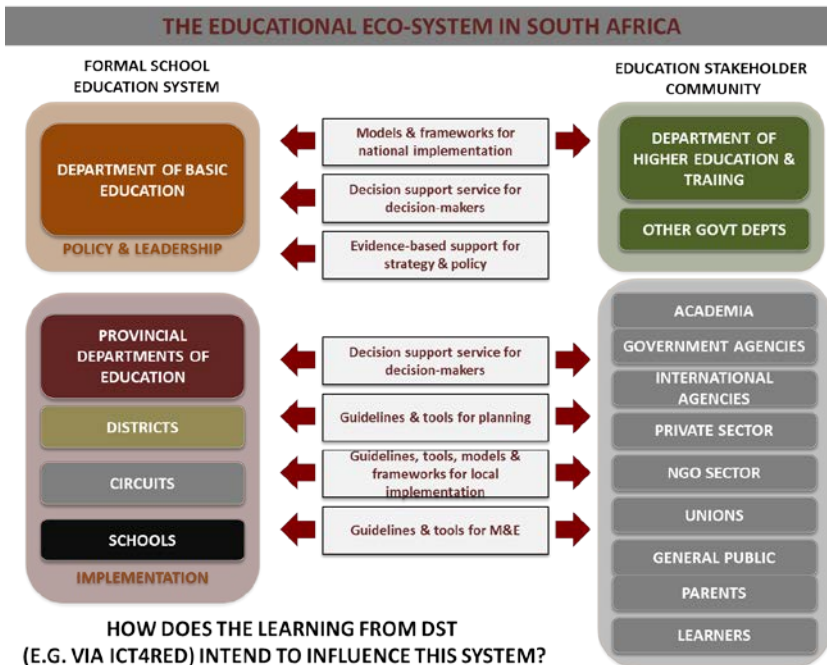


Figure 1-1: The educational eco-system in South Africa

The 26 schools targeted for intervention formed part of the Nciba Circuit of the Cofimvaba School District.

The following maps indicate the area where the initiative was implemented. The first map highlights the different provinces in South Africa.

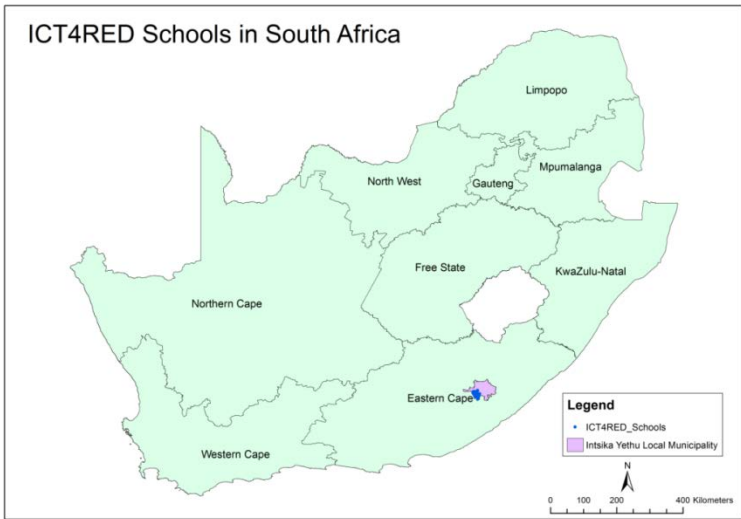


Figure 1-2: Map of South Africa showing the provinces and geographical locations of the ICT4RED schools



Photo 1-1: Striking vistas of the district (Photo credit F. Wallace)

The map below depicts the different South African district municipalities:



Figure 1-3: District municipalities in the various provinces of South Africa

These district municipalities can be found in the different provinces of South Africa. The ICT4RED initiative took place in the Eastern Cape Province of South Africa, and more specifically in the Chris Hani district municipality in which Intsika Yethu Local municipality is situated, as indicated by the purple area in the map above.

The schools involved are listed below in alphabetical order with the date of engagement given in brackets:

Phase 1:

- Arthur Mfebe Senior Secondary School (2012)

Phase 2:

- Bangilizwe Junior Secondary School (2013)
- Gando Junior Secondary School (2013)
- Gudwana Junior Secondary School (2013)
- Khwaza Senior Secondary School (2013)

- Mgcawezulu Junior Secondary School (2013)
- Mtimbini Senior Primary School (2013)
- Mvuzo Junior Secondary School (2013)
- Ntshingeni Junior Secondary School (2013)
- Siyabalala Senior Secondary School (2013)
- St Marks Junior Secondary School (2013)
- Zamuxolo Junior Secondary School (2013)



Photo 1-2: Ntshingeni J.S.S

Phase 3:

- Cube Senior Primary School (2014)
- Gqoboza Junior Secondary School (2014)
- Intlangano Senior Primary School (2014)
- Jongulwandle Junior Primary School (2014)
- Mbudlu Junior Secondary School (2014)
- Mpomvane Senior Primary School (2014)
- Sentile Junior Secondary School (2014)
- Sidubi Poort Junior Secondary School (2014)
- Thembisile Martin Hani Junior Secondary School (2014)
- Vukani Junior Primary School (2014)
- Zanendyebo Senior Primary School (2014)
- Zenzile Junior Secondary School (2014)
- Zigudu Junior Secondary School (2014)
- Zwelibangile Junior Secondary School (2014)

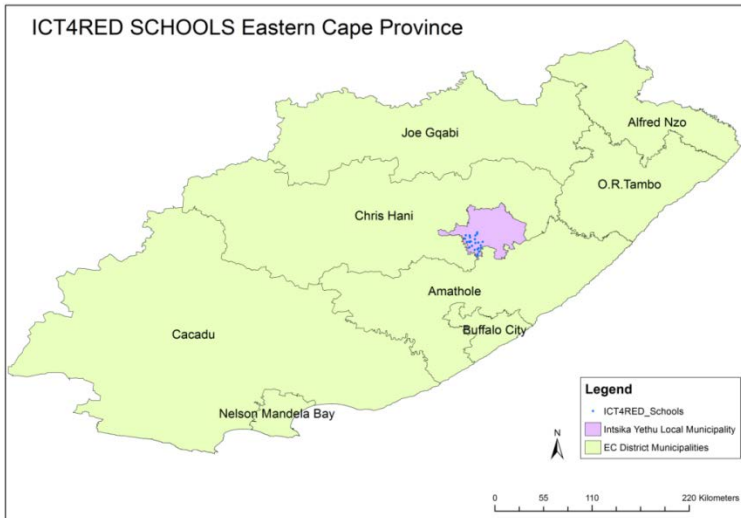


Figure 1-4: ICT4RED schools in the Intsika Yethu local municipality (Cofimvaba school district) in the Eastern Cape Province of South Africa

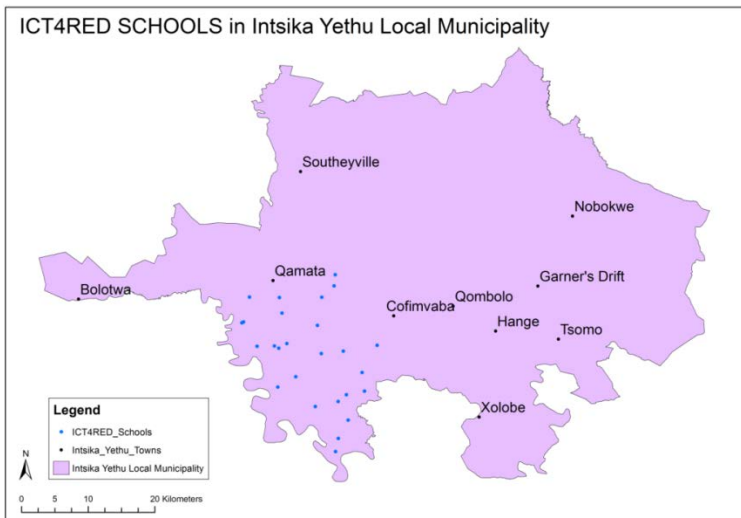


Figure 1-5: ICT4RED schools scattered between Qamata and Cofimvaba towns

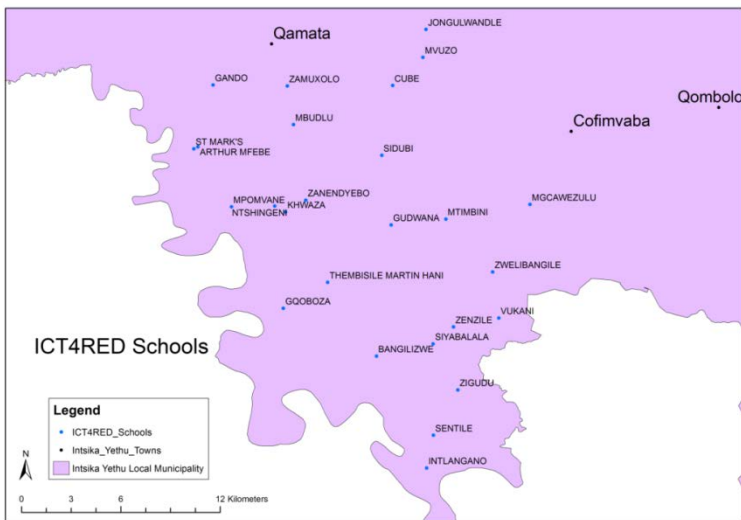


Figure 1-6: Twenty-six ICT4RED schools in the Intsika Yethu local municipality (Cofimvaba school district)

These schools are situated between two small towns: Qamata and Cofimvaba. Most of the schools are situated roughly 79 kilometres east of Queenstown on the route to Mthatha. Cofimvaba town, established in 1877, is the closest major settlement and has the distinction of being the hometown of Chris Hani, a South African political activist. The name, Cofimvaba, is derived from *cofa*, meaning ‘press’ and *mvaba*, translated as ‘milk-bag’ (made of goatskin) and the action describes the breaking up of lumps found in sour milk. Xhosa is the main spoken language in the district, although the final school exams in the senior secondary schools are undertaken in English. In addition, English is the language of instruction from Grade 4 onwards.

The population of the Intsika Yethu local municipality is estimated at 35500 inhabitants (StatsSA, 2011) and this area is famous for its beautiful unspoilt landscape. Small villages are scattered over hills and mountains and it is often quite an adventure to navigate the network of gravel roads in order to reach the villages. These meandering gravel roads also make it nearly impossible to reach some of these schools in the rainy season as the low water bridges, which are used to traverse the rivers, are often flooded. Teachers have reported that they opt to share transport in a bid to save on

costs such as petrol and wear and tear to their own vehicles. Unemployment and poverty are prevalent in this area and drug abuse has been identified as a recurring social concern.

Eastern Cape Education has consistently struggled to overcome infrastructural and educational legacy issues. An initial baseline survey (CSIR, 2012) in 2011/2 found that 66% of all the schools in the Cofimvaba school district (which consisted of more than 350 schools) had unreliable or no access to water, 40% unreliable or no access to electricity and sanitation remained a challenge. The 26 schools in the Nciba Circuit, at the time of the survey, comprised approximately 6 500 learners and 270 teachers. There were almost 30 learners per educator and the 2012 distribution of the schools were one junior primary school, 6 senior primary schools, 16 junior secondary schools and 3 senior secondary schools. In 2014, after reallocation and restructuring by the Eastern Cape Education Department, there were 3 primary schools, one secondary school, 13 junior secondary schools, 7 senior primary schools and 2 senior secondary schools. Access to the internet and communication infrastructure was nearly non-existent. These findings suggest that the schools can be classified as resource-constrained. As part of the bigger Tech4RED initiative, water, sanitation, electricity and toilet facilities, together with nutrition, would be addressed.

1.3 Implementation principles

The ICT4RED initiative was guided by pre-negotiated implementation principles which included:

- having minimum school disruption,
- flexibility within the school structure,
- developing local capacity,
- reflect, learn and improve,
- working within the system,
- positive reinforcement,
- create safe places and
- education-focussed.

These points will be further discussed in Section 2.2 of this book.

1.4 Scope of the ICT4RED initiative

The scope of the ICT4RED initiative was to provide tablets to teachers, learners and district officials and to explore and design various frameworks, models, guidelines and tools regarding:

- Infrastructure and Connectivity.
- Integration into the school.
- Operations, Logistics, Support and Maintenance.
- Costs (Total Cost of Ownership) and Sustainability.
- Content selection and organising content on servers.
- Tablets (selection and upgrades).
- Change Management.
- Teacher Professional Development.
- Other training needs.

The results of the ICT4RED initiative include the following artefacts as outputs:

- Evidence-based policy outputs (frameworks, models, guidelines, relevant standards, recommendations, policy briefs) to national and provincial governments.
- Practitioner outputs (planning and implementation guidelines, tools, templates, checklists) to various practitioners (schools, Non-Governmental Organisations (NGOs), provincial implementing agencies etc.).
- Research outputs (conference papers, books, journal articles) to the ICT4E and ICT4D research community.
- Decision-support tools (cost utility model, total cost of ownership model, Tablet selection model).

The purpose of the following section is to provide a narrative of the design and implementation of the Design Research Methodology that underpinned the exploration and design of the frameworks, models, guidelines and tools.

According to Lethbridge and Lananiere (2005), a framework can be defined as a generic solution to a generalised problem that provides common services to situations that are applicable and consists of a set of ideas or principles and the processes needed to control the implementation of

functionalities. Tomhave (2005) proposes that “[a] framework is a fundamental construct that defines assumptions, concepts, values, and practices, and includes guidance for implementing itself” (p.9). This concept, as well as that of an implementation framework, is further outlined and defined in Section 2.

Models can be viewed as conceptual and abstract. Tomhave notes that “[a] model is an abstract, conceptual construct that represents processes, variables, and relationships without providing specific guidance on or practices for implementation” (Tomhave, 2005, p.8).

Guidelines are viewed as systematically developed statements which assist and guide interpretation, implementation and use, while tools are items used for a specific purpose (Online Business Dictionary, 2014).

The frameworks, models, guidelines and tools were developed based on evidence and results during various phases of implementation in every component of the ICT4RED initiative.

1.5 The design (methodology) and implementation (phases) of the ICT4RED initiative

The ICT4RED initiative applied a specific methodology during its implementation. The implementation involved various phases and iterations in which different participants were involved.

1.5.1 Methodology

The methodology applied in the exploration and design of the various ICT4RED frameworks, models, guidelines and tools as artefacts was Design Science Research (DSR).

Design Science Research focuses on creation and the purpose of design being “to change existing situations into preferred ones” (Simon, 1996). Design science addresses ‘wicked problems’ in Information Systems or IS (Rittel & Webber, 1984) and is fundamentally a problem-solving paradigm. Wicked problems, as explained by Hevner and Chatterjee (2010, p. 11), relate to the ill-defined environmental contexts as well as the creativity and teamwork to produce effective solutions. There are compelling arguments to accept the educational exploitation of ICT within resource constrained environments, such as the Cofimvaba school district, as a

wicked problem.

The research methodology is grounded in the philosophy of pragmatism but the study has also applied interpretivism in the various case studies (See Figure 1.10). To a design science researcher, reality is socio-technologically enabled and knowledge is gained through the process of artefact creation (Vaishnavi & Kuechler, 2013).

Hevner and Chatterjee (2010) indicate that an artefact is a man-made object created to solve a specific problem, as opposed to naturally occurring objects. The artefacts created in DSR could be in the form of one of the following (Hevner & Chatterjee, 2010; Hevner et al., 2004; Vaishnavi & Kuechler, 2013):

- **Constructs:** A construct is the term that is used to describe a problem or solution. Constructs establish the specialised language and shared knowledge of a discipline that arises during the conceptualisation of a problem and they are refined throughout the DSR cycle.
- **Models:** A model is a set of propositions or statements that describes the relationships between constructs. It could also refer to an abstraction and representation of a problem or solution. The focus of models in DSR is on their usefulness or utility. It can also include frameworks and guidelines.
- **Methods:** A method is a set of steps that guides the performance of tasks. Methods also represent the plan of action aimed at achieving a goal. In DSR, a method that is aimed at solving a previously known problem in a more effective way, is deemed valuable.
- **Instantiation:** This is the actualisation of a construct, model or method. Instantiations demonstrate the feasibility and effectiveness of the constructs, models or methods in an environment. The ICT4RED implementation framework (Section 2) is an example of this.
- **Better theories:** DSR can contribute to the formulation of better theories, or to the development of new ones. The development or evaluation of an artefact, which results in a better understanding of the relationships between its elements, could potentially lead to the development of a new design theory for the artefact (as was done to validate the ICT4RED implementation framework).

The research and development implementation was operationalised through a Design Research engagement informed by 12 components. Each of the components (units of analysis) had been investigated through the use of case study research. The results informed the development of the various frameworks, models, guidelines and tools which were also how these artefacts were refined and improved based on evidence and results. During each phase of the ICT4RED initiative, each of the 12 components tested their different artefacts. Some of these will be discussed in other sections of the book.

Hevner, March and Park (2004) were the first authors to provide an Information systems framework to show where Design Science Research fits in. This framework was later improved by Pirinen (2009) as well as Wang and Wang (2010). The following figure, adapted from Hevner et al., (2004) and Pirinen (2009), indicates the relevance and rigour of Design Science Research in Information systems. It is also used as the theoretical framework which informs this initiative.

Figure 1-7 borrows the IS research framework found in Hevner et al., (2004) and overlays a focus on three inherent research cycles: relevance, rigour and design with creativity and how each of these contributes to the knowledge base of foundations and methodologies. People, organisation and technology are three components of the environment of design research. Business needs are the driving force for design research so that it remains relevant. Design Research must add to the knowledge base so that it can be rigorous. The specific IS Design Science Research cycles which have been applied in this initiative are illustrated in Figure 1-8.

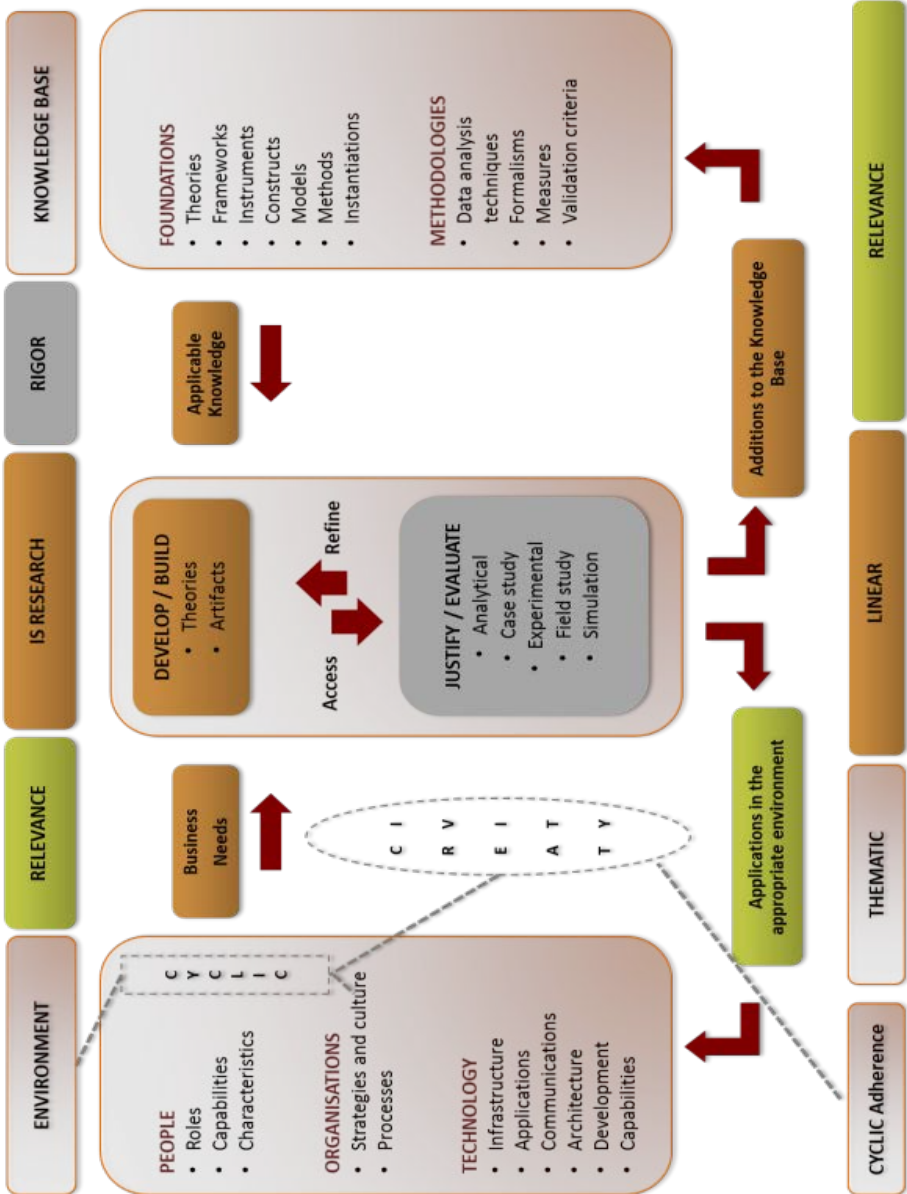


Figure 1-7: Information System Framework (Hevner et al., 2004; Pirinen, 2009)

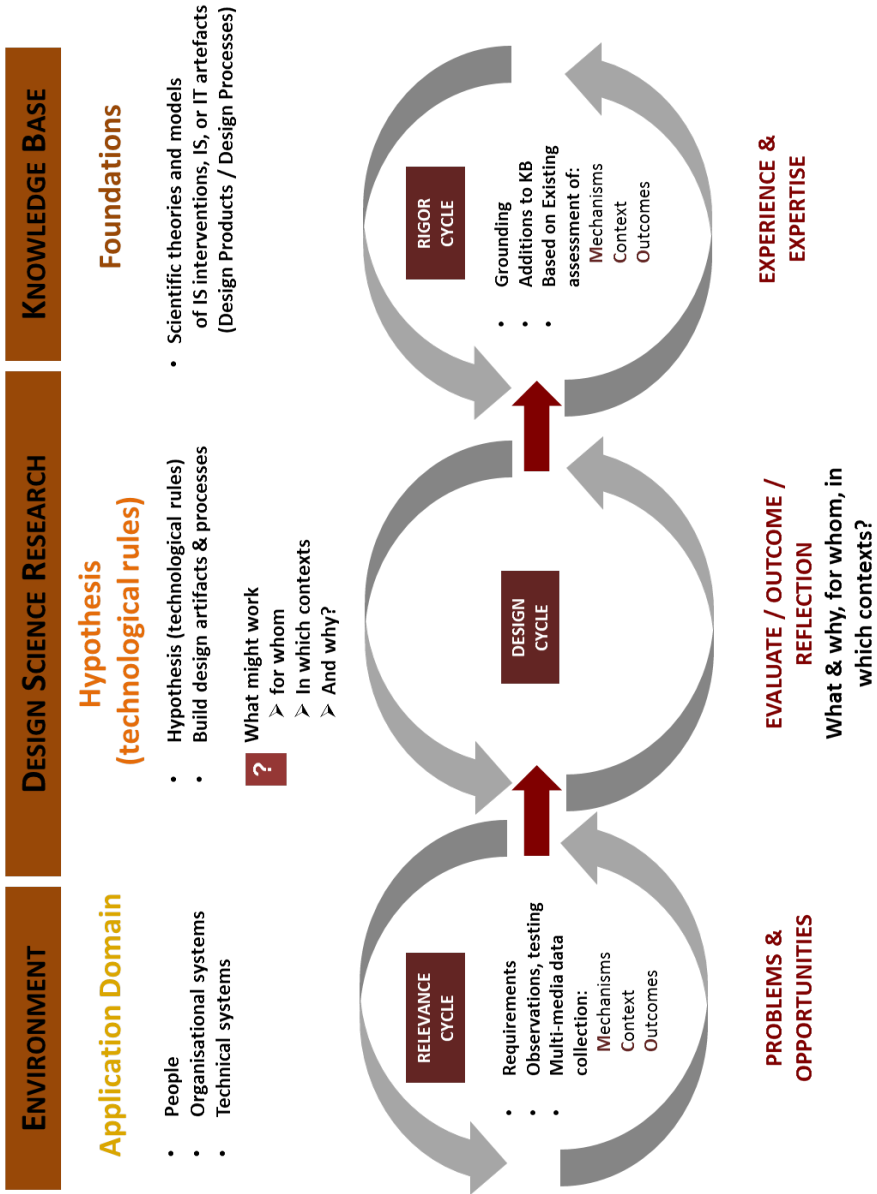


Figure 1-8: Information Systems Design Science Research Cycles (adapted from Carlsson, 2010, and Hevner, 2007)

1.5.1.1 *Relevance Cycle*

The *Relevance Cycle* initiates Design Science Research with an application context that not only outlines the requirements for the research (e.g. the opportunity/problem to be addressed) as inputs, but also defines acceptance criteria for the ultimate evaluation of the research results. The output from the Design Science Research must be returned into the environment for study and evaluation in the application domain (Hevner, 2007).

The ICT4RED initiative envisaged the development of appropriate contextual frameworks, models, guidelines and tools to inform other similar initiatives where appropriate.

Each of the resulting artefacts would be developed for the resource constrained context as contextualised by individual literature studies of relevant case studies and position papers. Identified requirements were peer reviewed by experts, or in peer reviewed publications, for validation and to ensure the artefact designs had a solid foundation (this is discussed in Section 9.8). The individual component requirements provided the input for the Design Cycle and were used to collect data and evaluate the artefact.

1.5.1.2 *Rigor Cycle*

The *Rigor Cycle* provides existing knowledge to the research initiative in order to ensure its innovation. It is contingent on the researchers to thoroughly research and reference the knowledge base in order to guarantee that the designs produced are research contributions and not routine designs based upon the application of well-known processes (Hevner, 2007). Additions to the knowledge base, as results of Design Science Research, will include any extensions made during the research, the new artefact (design products, tools, processes, frameworks, models and guidelines) and all experiences gained from performing the research and field testing the artefact in the application environment (Hevner et al., 2004; Hevner, 2007).

For the knowledge base this study applied relevant scientific theories, methods and meta-artefacts found through literature reviews, together with the expertise and experience of the researcher or research teams, in each of the 12 components in the ICT4RED initiative.

1.5.1.3 Design Cycle

The internal *Design Cycle* of research activities iterates more rapidly than the *Relevance* and *Rigor Cycles* between the development of technological rules, the construction of an artefact, its evaluation and subsequent feedback to refine the design further (Carlsson, 2006; Hevner, 2007). Simon (1996) describes the nature of this cycle as generating design alternatives and evaluating the alternatives against requirements until a satisfactory design is achieved. In this study, the design cycle involves the development and evaluation of the artefacts.

1.5.1.4 Design Science Research Guidelines

The seven guidelines to perform Design Science Research in an Information Systems discipline, as described by Hevner et al., (2004), follow and include: design as an artefact, problem relevance, design evaluation, research contributions, research rigour, design as a search process and communication of research (Wang & Wang, 2010).

Table 1-1: Design-Science Research Guidelines (Hevner et al., 2004)

Guideline	Description	Application for each artefact
Guideline 1: Design as an Artefact	Design-science research must produce a viable artefact in the form of a construct, a model, a method or an instantiation.	Research-related artefacts (frameworks, models, guidelines and tools) were developed based on knowledge gained from the application of technologies and resources in the 26 schools in Cofimvaba school district.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.	Technology-based solutions have been created to support the teaching and learning at the schools.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.	The artefacts were evaluated by the ICT4RED core team and relevant peer reviewed platforms after each phase. Monitoring and Evaluation (M&E) processes have been applied to evaluate the different artefacts in progress.
Guideline 4: Research Contribution	Effective design-science research must provide clear and verifiable contributions in the areas of the design artefact, design	The relevant frameworks, models and guidelines and tools are novel contributions to assist schools to use technology enhanced learning resources to support teaching and learning. In each

Guideline	Description	Application for each artefact
	foundations, and/or design methodologies.	case there is a theoretical, methodological and practical contribution.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.	Rigor will be achieved through the use of the different component artefacts by new researchers or practitioners from industry and academia. Additions to the knowledge base as well as determining through M&E what worked and what not, with reasons, have assisted in the development of the individual contributions.
Guideline 6: Design as a Search Process	The search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.	Guided by the research outcome, each unit of analysis developed a research question and scoped the appropriate deliverables and methods applied.
Guideline 7: Communication of Research	Design-science research must be presented effectively, both to technology-oriented as well as management-oriented audiences.	A communication strategy in consultation with the DST, DBE and DRDLR was developed. Various presentations at various forums, conferences and workshops were done to communicate the formative results of the different iterations.

1.5.1.5 Design Science Research Process (DSRP)

The Design Science Research Process (DSRP) applied in this research is consistent with prior literature (Hevner et al., 2004; Hevner, 2007; March & Storey, 2008) and include the following six steps: problem identification and motivation, objectives for a solution, design and development, evaluation and communication. The iterative nature of the Design Science Research Process, as introduced by Peffers et al., (2008) and adapted for this study, is illustrated in the following figure by the arrows between the various steps.

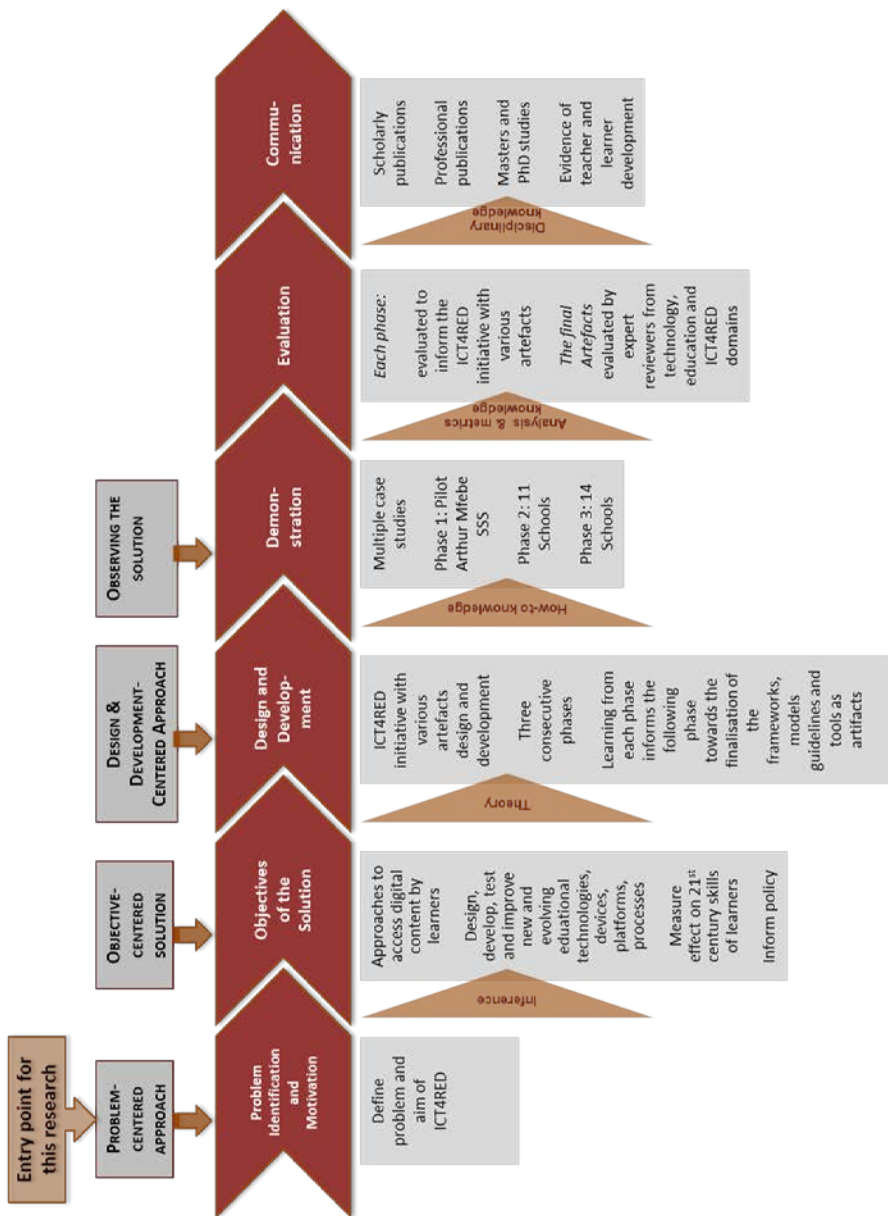


Figure 1-9: Design Science Research Process adapted from Peffers et al., (2008).

The following figure depicts the phased implementation as iterations.

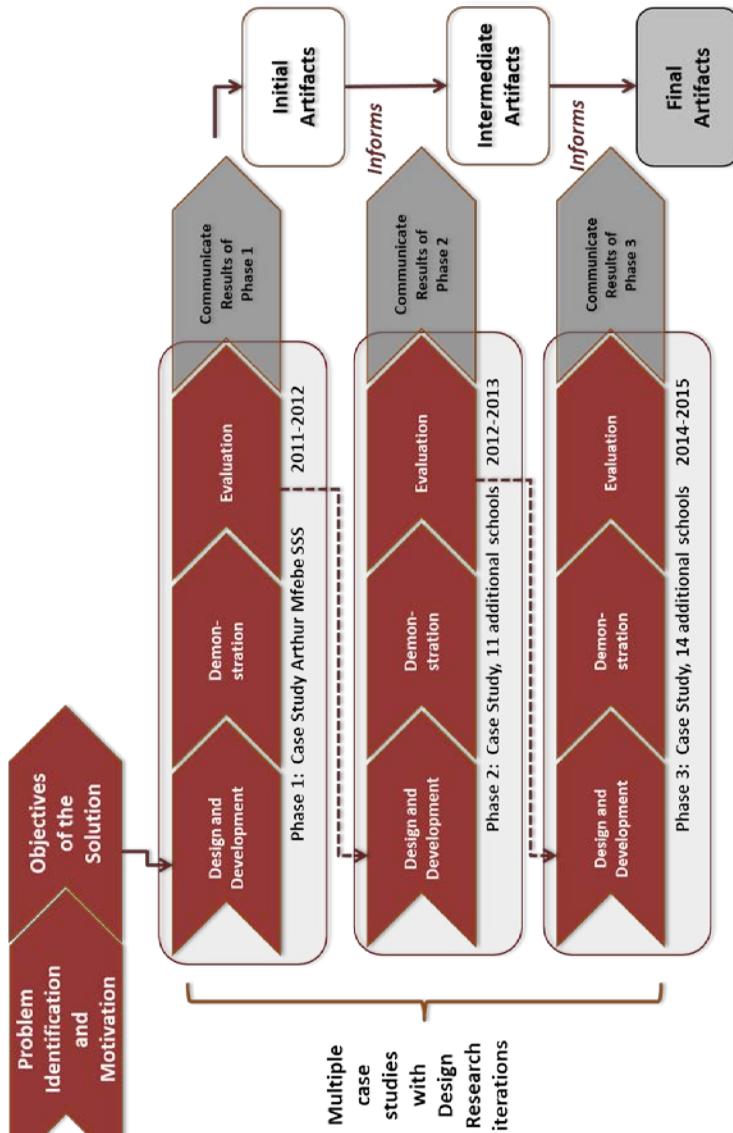


Figure 1-10: Design Science Research process with the multiple case studies and the deliverable from each iteration.

1.5.1.6 Data collection

In order to ensure accuracy of data, a variety of data sources were used. These included observations, interviews (both one-on-one and focus groups), audio-visual material (photographs, text- and video recordings), anecdotal stories, feedback from the M&E questionnaires, ethnographic reports, Twitter and WhatsApp feeds and from the implementation of the various components in each phase.

1.5.1.7 Sampling

The participants were selected using purposive and snowball sampling. With *purposive sampling* the researcher uses her/his judgment to select specific participants who can contribute to an understanding of the research problem and phenomena central to the investigation in order to meet the purpose of the research (Creswell, Plano & Clark, 2011; Oates, 2006). *Snowball sampling* identifies research participants through a chain reaction as a result of word of mouth. Researchers find one person who comes from the target group and then ask him/her to recommend additional participants who can contribute to the study. Having gathered data from these participants, the researchers then asks them to recommend additional participants (Creswell, Plano & Clark, 2011; Oates, 2006).

1.5.1.8 Data verification

To ensure accuracy of data, corroborate the findings and enhance their validity, various types of triangulation were used (Oates, 2006):

- Data triangulation involves the use of a variety of data sources in a study. In this study the sources included: participants (teachers and learners at the 26 schools as well as community representatives and leaders and Department of Basic Education's district officials and Nciba circuit manager) and existing documentation relevant to the study and external experts in ICT4D, technology and education domains;
- Theory triangulation in which multiple theoretical perspectives were used to interpret the data collected. These are critical theory and design theory; and

- Method triangulation entailed the use of multiple data-generation methods, namely ethnographic reports, observations, interviews, photographs, video clips, anecdotal stories as well as Twitter and WhatsApp feeds.

1.5.1.9 Data analysis techniques

As interpretivism is the philosophy which has been applied under the different case studies of each phase of the initiative, the Hermeneutic analysis technique was applied. Hermeneutics is based on the interpretative paradigm (Walsham, 1995). Gadamer (1998, p. 196) points out that the hermeneutic analysis is “logically a circular argument in so far as the whole, in terms of which parts...” or otherwise put “we must understand the whole in terms of the detail and the detail in terms of the whole” (Gadamer, 1998). Hermeneutics therefore analyses the various sections of the text whilst considering the complete picture. It also analyses the complete picture while looking at the various separate texts that contributed to the whole picture. This is done through the hermeneutic circle.

1.5.2 Hermeneutic cycle

The hermeneutic circle is based on the hermeneutic rule of understanding of meanings from individual parts based on the whole and the understanding of the whole based on the individual parts as described by Gadamer (1998). The analysis of this research was based on four stages, which make up the hermeneutic circle. They are the following:

- Stages 1 and 2: Study of the literature review based on the hermeneutic cycle in order to produce initial artefacts.
- Stage 3: Conducting multiple case studies at the various schools to improve on the artefact.
- Stage 4: Develop and interim evaluation.
- Stage 5: Evaluate the artefacts through expert reviews.

Klein and Myers (1999) propose a set of principles to conduct and evaluate interpretive case research, which are based on the philosophical perspective of hermeneutics and which mostly apply to studies of this nature. Table 1-2 indicates these principles and how they guided the research study as a whole.

Table 1-2: Principles for conducting and evaluating interpretive research

Fundamental principle for conducting and evaluating interpretive studies	How and where applied in this study
<p>1. The Fundamental Principle of the Hermeneutic Circle. This principle suggests that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form. This principle of human understanding is fundamental to all the other principles.</p>	<p>Data analysis using Creswell's (2007, p. 75) within-case, cross-case and holistic-case analysis template. Triangulation.</p>
<p>2. The Principle of Contextualisation. Requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged.</p>	<p>Applied when highlighting the background history of the multiple case studies (26 schools within the Cofimvaba school district).</p>
<p>3. The Principle of Interaction Between the Researchers and the Subjects. Requires critical reflection on how the research materials (or 'data') were socially constructed through the interaction between the researchers and participants.</p>	<p>The role of the researchers and component champions was to reflect on field visits to the schools, observed the physical conditions of the schools and interacted with the participants (all stakeholders).</p>
<p>4. The Principle of Abstraction and Generalisation. Requires relating the idiographic details, revealed by the data interpretation, through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action.</p>	<p>It is envisaged that the resulting artefacts will be able to be replicated and applied in other provinces thus generalisation will be possible if the context specifics are taken into consideration.</p>
<p>5. The Principle of Dialogical Reasoning. Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ('the story which the data tell') with subsequent cycles of revision.</p>	<p>The interpretations of the data were done in light of the literature.</p>
<p>6. The Principle of Multiple Interpretations. Requires sensitivity to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. Similar to multiple witness accounts, even if all tell it as they saw it.</p>	<p>Various impact stories were collected by the M&E team in each phase and this informed the improvement of the artefacts.</p>

Fundamental principle for conducting and evaluating interpretive studies	How and where applied in this study
7. The Principle of Suspicion. Requires sensitivity to possible ‘biases’ and systematic ‘distortions’ in the narratives collected from the participants.	Data collected from participants were done anonymously. Multiple sources for data collection and multiple measures for data collection were employed.

The principle of the hermeneutics circle and multiple interpretations requires the researcher to understand and examine situations in parts, and as a whole, and to assign explanations to them.

1.5.3 Ethical considerations

Ethics are the “norms and standards of behaviour that guide moral choices about our behaviour and our relationships with others” (Cooper & Schindler in Saunders et al., 2009). What is regarded as acceptable, moral or ethical depends on the particular community involved (Babbie, 2005; Brydon-Miller & Greenwood, 2006; Pimple, 2008; Zimbardo, 1973). It is important for researchers to be aware “of the general agreements shared by researchers about what is proper and improper in the conduct of scientific inquiry” in the Information Science (IS) and social science domains (Babbie, 2005, p. 62).

The ICT4RED initiative followed the ethical guidelines laid down by the CSIR ethics committee as well as the Eastern Cape Department of Basic Education, in order to protect the rights of all participants and to ensure that good research is conducted in a just and fair manner. The welfare and interest of all the participants and their communities will at all times be of the utmost importance. Ethical approval for conducting the research was received from the CSIR ethics committee as well as from the Eastern Cape Department of Basic Education (further discussions on ethics can be found under Section 4.10).

In summary, the following was applied to guide the development of the artefacts:

- **Philosophy:** The philosophy that has been chosen for the study is mainly *pragmatism* to guide the design and development of the artefacts, but *interpretivism* was also applied to the results from the multiple case studies (of each of the 26 schools) which were part of the phase iterations of the design science cycle.

- **Methodology:** The methodology used was *Design Science Research* (DSR), which was informed by qualitative multiple case study methodology.
- **Approach:** The data was analysed through both *inductive* and *deductive* means.
- **Research strategy:** The strategy used in the study is the *multiple case study approach*.
- **Data collection techniques used:** The data collection techniques used included *primary data*, in the form of the validations from the experts and *secondary data*, sought from literature reviews.
- **Data analysis:** Employed hermeneutics, descriptive statistics techniques to make meaningful examinations of the collected data as well as within-, cross and holistic case analysis. *Triangulation* of results was therefore applied.

The methodology section explained the design of the ICT4RED initiative. The next section explains the implementation through the different iterative phases.

1.6 Evolution of the ICT4RED phases

The ICT4RED initiative aimed to identify and introduce appropriate technology (devices and other supporting ICT infrastructure) in ways that would improve the teaching and learning engagement, support sustainability beyond the initiative and ensure true integration into existing education processes, whilst managing very real logistical and infrastructure problems in 26 schools to deliver contextual frameworks, models, guidelines and tools.

This was done through the iterative phases of DSR. The different phases of the initiative are described in the following table:

Table 1-3: Phases in the ICT4RED initiative

	PHASE 0 (2011/12)	REVIEW AND DESIGN
	This phase consists of desktop research, in order to learn from initiatives around the world, taking into account the particular context of the schools. This feeds into the design of the initiative. Best case scenarios (literature review), what others are doing, pragmatically choosing what works.	
	PHASE 1 (2012/13) – 1 SCHOOL	EXPLORE AND EXPERIENCE
	This phase tests designs so that the results and relevant insights can be used to guide the next iteration.	
	PHASE 2 (2013/14) – 1 +11 SCHOOLS	DESCRIBE AND SUPPORT
	This phase takes into account the learning from PHASE 1, and essentially goes through a redesign process in order to implement the insights in a new iteration. This iteration is the first attempt to scale the initiative to additional schools, in different contexts (e.g. testing the model in junior secondary schools). At this stage, some general findings could be documented. Initial data and evidence presented to implementers and policymakers.	
	PHASE 3 (2014/15) – 1+11+14 SCHOOLS	ADVISE AND EMBED IN SYSTEM
	This phase allowed for a final redesign of artefacts, based on the learning from PHASE 2. Advance insights gained around both process and scaling. Summative recommendations, based on data and evidence as input to implementers and policymakers.	
	PHASE 4 (2014/15) REFLECTING	EXPLAIN, ADVISE, TRANSFER AND TRANSFORM
	This phase facilitated reflection and articulation of formal research findings to provide design heuristics. These design heuristics need to be implemented with caution as it is highly contextualised in a specific rural resource constrained environment. The limitation and future recommendations for replication or scaling of the frameworks, models, guidelines and tools are provided. This is a snapshot in time as technologies evolve and many of the applications and designs were based on a limited timeframe.	

Each phase represented a specific point in time and the objective was to create a platform to enable widespread participation and collaboration between multiple stakeholders (private, public, academic, civil society, community) to implement a large Technology for Education Demonstrator in this rural school district that had the buy-in of key stakeholders and demonstrable impact on education and quality of life in the region.

The development of frameworks, models, guidelines and tools as artefacts was directly linked to the iterative phases. After each phase the artefacts, as outputs, were adapted to accommodate the new gained insights.

The Phases can be shown diagrammatically as follows:

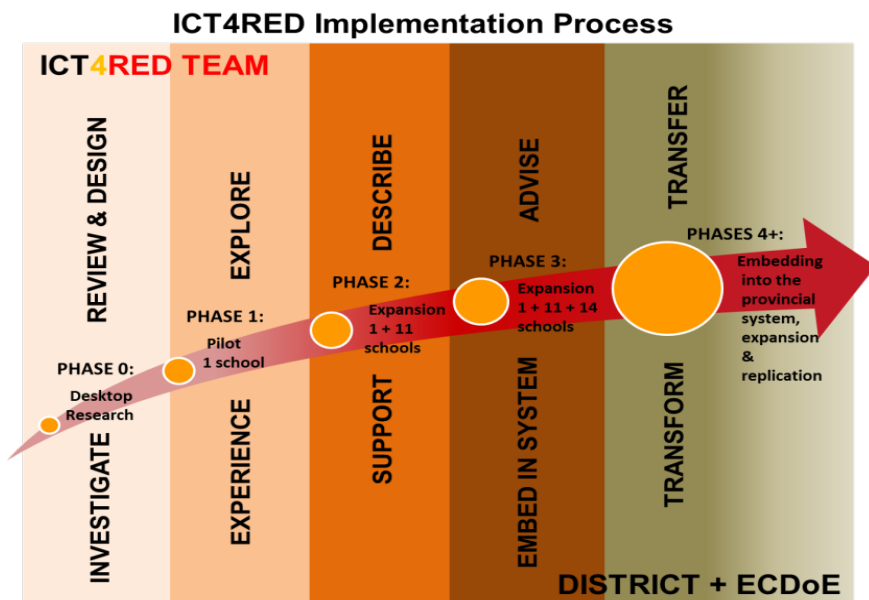


Figure 1-11: ICT4RED Phased implementation process

The phased approach is evident in the following figure:

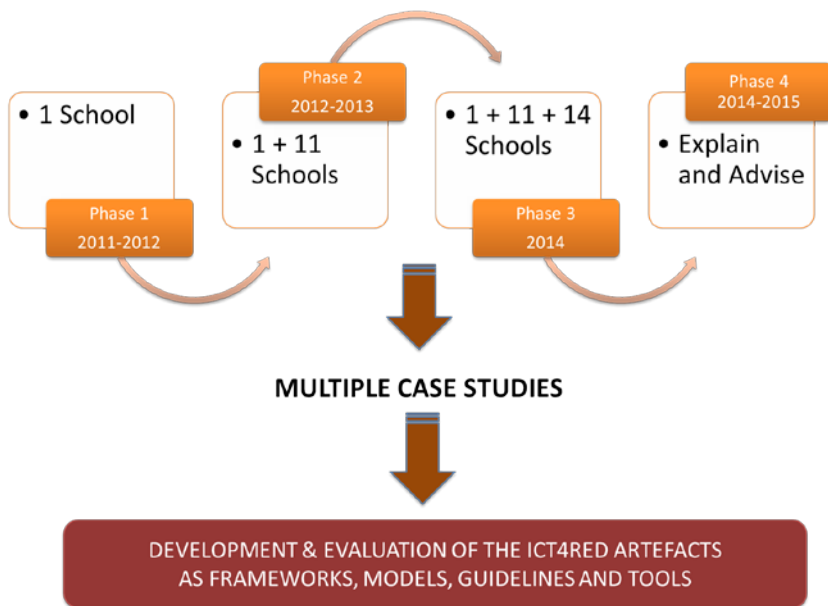


Figure 1-12 Phases and development of the ICT4RED artefacts:

Each phase will now be discussed and there will be an explanation of *how* the artefacts were developed through the different phases.

1.6.1 Phase 0

	PHASE 0 (2011/12)	REVIEW AND DESIGN
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Phase 0 included a thorough literature review which was done in order to understand why some ICT4D educational initiatives, where technology was deployed, have failed and why some have been successful all over the world. In the case of successful endeavours, the researchers determined which useful elements or components could be incorporated into the ICT4RED initiative and framework.

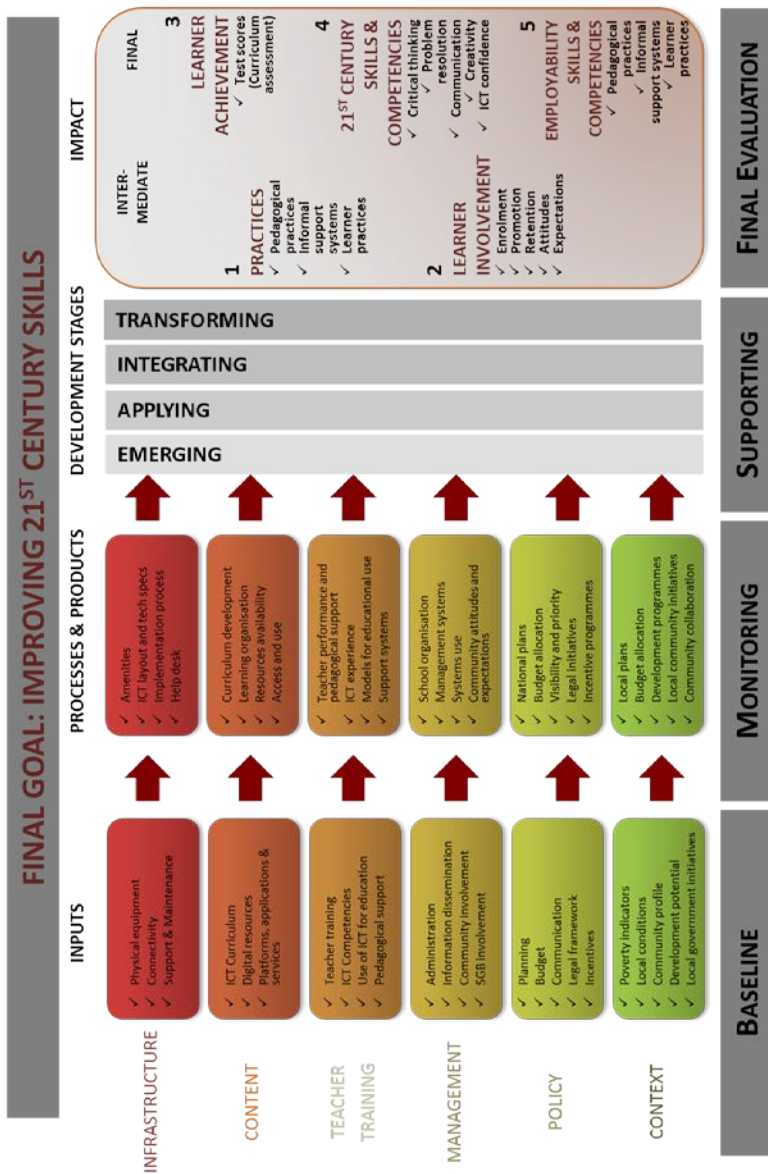
The ICT4RED core team had to determine if other relevant frameworks, models, tools and guidelines existed which could be used to guide the development of the ICT4RED artefacts. Lessons were also learnt by the

ICT4RED core team from previous successful initiatives and the deployment of technology in rural communities. All these played a crucial role during the initial phase. In Phase 0 the artefacts were designed based on a thorough literature overview and components were selected to guide the operationalisation and implementation of the initiative.



Photo 1-3: TPD Module 4. Teachers listening to a podcast.

It was found that components from the Inter-American Development Bank (IDB) Conceptual Framework, which focussed on Initiatives for the use of Information and Communication Technologies in Education (Eugenio, 2010), would be most suitable to adapt for the purpose of the ICT4RED initiative. The IDB Conceptual Framework was developed into the initial ICT4RED components:



*Amended Inter-American Development Bank (IDB) Conceptual Framework
(Projects for the use of Information and Communication Technologies in Education (Eugenio, 2010))*

Figure 1-13: Initial basis for the ICT4RED components

Looking at the Inter-American Development Bank (IDB) Conceptual Framework, it is evident that various important input components relating to infrastructure, content, human resources, management, policy and context, lead to processes and products. These are then subjected to different developmental stages of emerging, applying, integrating and transforming to provide an impact in the end on practices, learner involvement, learner achievement, 21st Century and employability skills and competencies of everyone involved in the eco-system. The final goal was set to improve the 21st Century skills of teachers and learners and to have intermediate and final evidence of impact. This has to be supported by the bottom layer where inputs are measured through a baseline study, the processes and products are monitored, developmental stages are supported and a final evaluation of the impacts is done.

Note that this Inter-American Development Bank Conceptual Framework was later expanded to become the ICT4RED Monitoring and Evaluation Theory of Change Framework and was updated to include all the final ICT4RED components.

The basic enablers needed to create the required pre-conditions for learning in any school include a functional school environment, an adequate infrastructure and a supportive home environment. A functional school environment is one where there is competent leadership and educators together with informed parents. Access to ICT, which resonates under adequate infrastructure, is also regarded as important in the effort to reach the final goal of improving educational outcomes, of which the 21st century skills and competencies are the most important. This can be achieved through support for access to digital content, and thus the ICT4RED initiative. On each side of the central picture are the focus areas (red and green blocks) which include learners, teachers, schools, government and policy which can be influenced. The desired 21st century school environment can be achieved if ICT complements and enhances teaching and learning.

To reach the ultimate goal of creating a modern 21st century schooling environment, certain crucial components were identified from various literature sources, engagement with educational experts and role players, implementation learning from previous initiatives in rural areas and from the initial framework supplied above. The following initial model was developed based on the understanding at the beginning of the initiative

and improved upon during the various phases. At this stage the focus was more on the content aspects of the initiative with the movement from traditional learner and teacher support materials (LTSM) towards digital and multimedia materials on mobile devices such as smartphones and tablets taking centre stage.

The changes should be focussed on the learner and his/her home, the teachers and the school as well as on government and policies relating to ICT in schools. The components identified to inform the final framework, and its evolution throughout the initiative, have formed the basis for all work within the initiative. The context of the ICT4RED schools and the complex and unique problems that have to be solved, lend themselves well to this approach. This is illustrated in Figure 1-14 below.

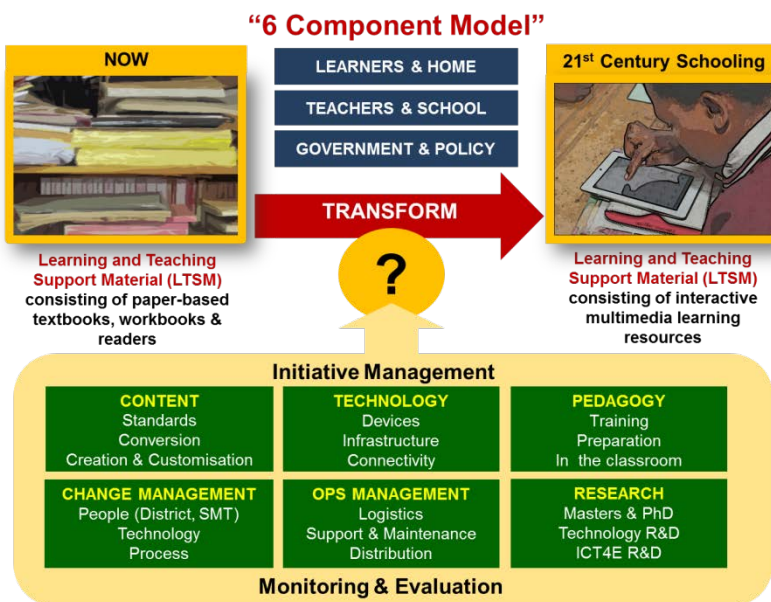


Figure 1-14: ICT4RED “6 Component Model” (Ford, 2013)

The initial components were:

Table 1-4: Components after Phase 0

Component	Purpose and elements
Initiative Management	Financial Management, Procurement and Implementation management which managed the budget and reporting on the initiative.
Monitoring and Evaluation	Forms the basis of the initiative, monitors and evaluates the impact on learners, teachers and schools as well as on each component within the initiative.
Technology	Decide on devices, provide infrastructure to support use and provide connectivity to schools.
Content	Standards, Conversion, Creation and Customisation on tablets and the servers at the schools.
Operations Management	Logistics, Support and Maintenance Distribution of tablets, security measures and charging stations.
Pedagogy	Training of teachers to use the devices and preparation of the classrooms.
Change Management	Support and training for the teachers, district, circuit and community as well as change management processes for the technology use in schools.
Research	Academic Research with academia and post graduate students. Research and development on ICT4Education.

A champion was selected for each of these components and this made up the core ICT4RED team, which was given the responsibility (with support from the Initiative Managers) to conceptualise, design, plan, manage and implement their component. Regular weekly meetings were used to manage the progress and feedback from each component and to integrate activities where necessary.

This was the first artefact which was designed, based on literature and through the application of DSR process (Figure 1-9).

1.6.2 Phase 1

	PHASE 2 (2013/14) – 1 +11 SCHOOLS	EXPLORE and EXPERIENCE
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Phase 1 comprised an exploration at a single senior secondary agricultural

school, Arthur Mfebe Senior Secondary school. In 2012, when the pilot took place, the school comprised a principal, 12 teachers and approximately 240 learners in Grades 10, 11 and 12. Of these, 39 learners were in Grade 12.

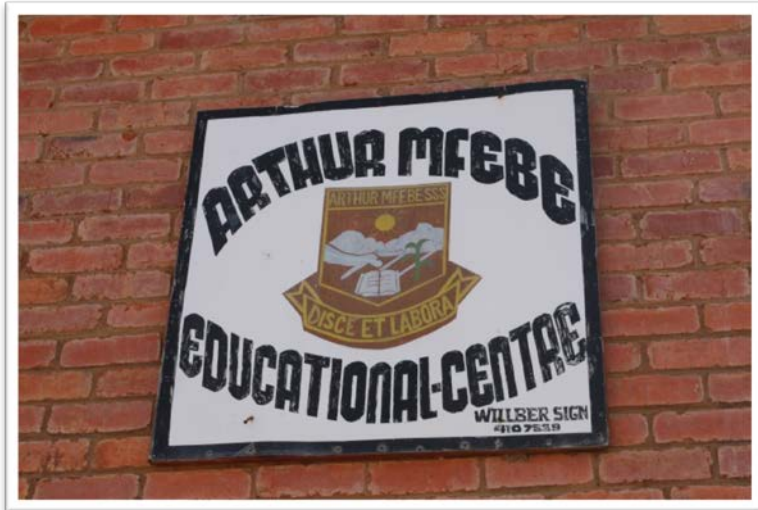


Photo 1-4: Arthur Mfebe S.S.S (Photo credit: Danielle Botha)

Arthur Mfebe S.S. offers the following subjects: Mathematics (no Mathematical Literacy), Accounting, Consumer Studies, Agricultural Science, Physical Science, Life Sciences, Economics and Business Studies. The school is accessible by a gravel access road and, even though the school is situated in a remote area, there is intermittent mobile phone reception available. This reception does not necessarily extend to stable 3G or 4G receptions. The school is situated on a 17 hectares plot and consists of the following:

- 1 Vegetable garden
- 1 Soccer field
- 1 Netball court
- 2 044 m² of plastered brick buildings with pitch metal roofs made up of separate rooms that vary in size between 5.6m² and 83m² per room
- 5 Offices

- 1 Staff room
- 14 Classrooms
- 6 General stores/ safes
- 1 Kitchen
- 1 Laboratory
- 1 Library
- 1 Food preparation centre

Site security consists of a wired fence and a main gate, which is partly functional, but 25%-50% of the fencing is in need of refurbishment. The school makes use of a borehole/well on site as a source of water and there are 3 taps used for drinking water. According to the DBE NEIMS assessment forms, dated 2006, the overall condition of the water supply systems has been graded as fair.

There is no municipal method of disposing sewage and the school makes use of 24 pit toilets. Two pit toilets are allocated for male and female teachers respectively, and the male and female learners each have 11.

The school makes use of a grid connection to obtain electricity, which is reticulated to some of the buildings and, as per the 2006 NEIMS assessment form, the condition thereof is good and functional with only corrective maintenance required.

The school library has been converted into a staff room where teachers can relax and attend to administrative tasks. There is a nutrition program at the school and during break time learners line up for the one prepared meal they receive per day at the school. Learners participate in sport after school, although there are no formal sports grounds. Evening classes, which are compulsory for Grade 12 learners and optional for Grades 10 and 11, are offered at the school. Arrangements were made with Grade 12 learners who stay far from school to be accommodated closer in order that everyone can attend the evening classes. Arthur Mfebe SS is a functioning school with good leadership and discipline. The governing body of the school, at the time of the pilot, was very involved with the running and welfare of the school and was chaired by Mr Mfebe, nephew of the school founder.



Photo 1-5: Arthur Mfebe School as seen from a distance (Photo credit: Vivian Naidoo)

In order to implement the ICT4RED initiative, the following process was followed (Ford, 2013):

- Step 1: Explaining the ICT4RED initiative to district officials so their cooperation for the initiative could be secured.
- Step 2: Meeting the Principal, Deputies and school governing bodies in order to create buy-in. This stage mainly consisted of meetings. Upon buy-in, the Principals, Deputies and allocated ICT champions attended a workshop focused on explaining ways to support the roll out of the tablets in order to ensure integration and sustainability.
- Step 3: Continued Teacher Professional Development during which teachers were equipped with skills aiding them in the use of ICTs in teaching. Teachers were expected to complete homework and show how they would integrate the tablets in their classroom. Teachers, who completed their courses and graduated, earned technology for their schools.
- Step 4A: This step consisted of the installation of Mobikits (kits

where tablets are charged and kept for safety), a Mobihub (wifi hub and small content server), local Wi-Fi and local content (see photos below).

- Step 4B: After Step 3, the learners were given tablets while their teachers continued with training. At this stage, once Wi-Fi was installed in the school, the school could be linked with other schools. Technical as well as pedagogy support was also appointed within the school. It is hoped that Communities of Practice will evolve, based on teachers sharing lessons, content and new ways of teaching with tablets.
- Step 5A: This step expanded the initiative to provide tablets to Grade 12s and then to Grades 10 and 11s on a one-to-one basis.
- Step 5B: The operational management of the school was supported with the election of an ICT committee to determine the operational management and technical support.
- Step 6: Expansion to new schools and taking the lessons learnt from this phase to improve the framework for the next phase.

The following figure outlines the steps that were taken in implementing the ICT4RED in Phase 1 at Arthur Mfebe Senior Secondary School.

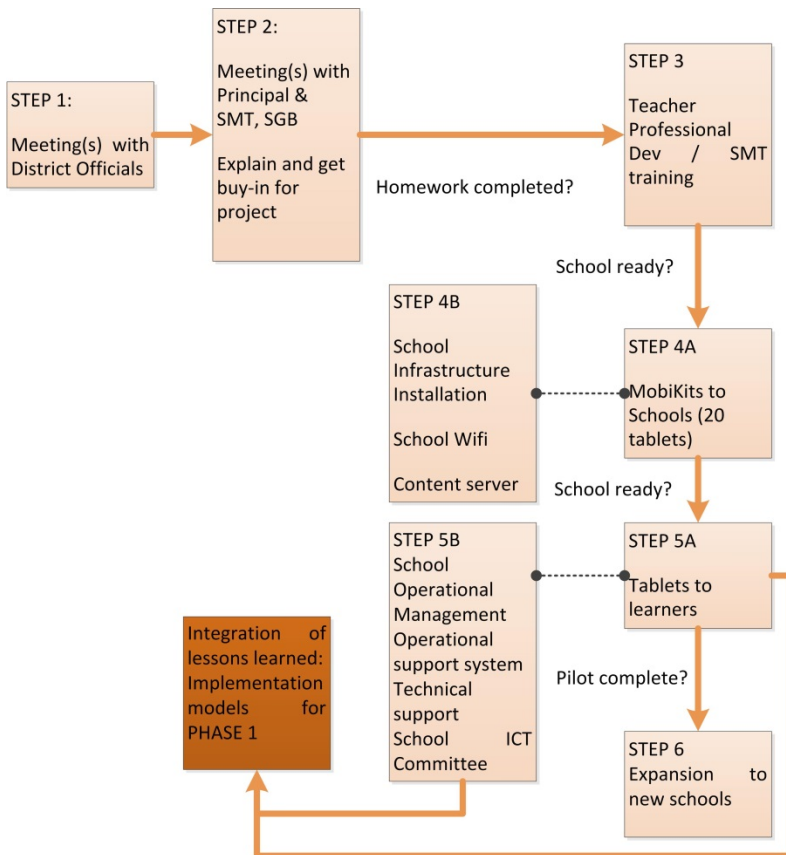


Figure 1-16: Step-by-step process in Phase 1 (Ford, 2013)

Before the pilot started, a technology scan was undertaken in order to decide whether the initiative should employ tablets or dedicated e-readers. The pros and cons of each technology were taken to the Department of Basic Education and they made the decision to deploy tablets.

The decision was made to focus on the teachers and they were thus provided with tablets first. Initially, low cost tablets were loaned to the teachers and a system was introduced to measure their attendance at TPD sessions. Only teachers who attended all TPD sessions would be able to ‘earn’ the tablets as their personal property. Various training modules,

which focused on modern teaching methods that could be supported by technology, were put together. Teachers had to complete 'homework' between sessions. Sessions were 3 hours long and were held in the afternoons.

Change management was not formalised or provided for separately but was incorporated as part of the TPD programme. An ICT committee was established and it takes decisions relating to the use of the tablets per grade, class and subject. A dedicated ICT technical support person was appointed to support teachers with charging the tablets, booking them as well as loading information from the server.

Additional supporting hardware installed consisted of:

- charging station and safe room,
- satellite connectivity,
- a school Wi-Fi network, and
- a server with content.

TECH4RED infrastructure at the school consisted of:

- a Biogas alternative energy system,
- a hydrogen fuel cell alternative energy system,
- outbuildings to host the piggery and chicken section were erected, and
- new toilets were installed.

Evidence gathered after the implementation of Phase 1 was analysed and informed the conceptual design going forward:

- An ethnographic study was undertaken before and one year after the tablets were introduced. It identified many clear positive behavioural changes, in both the teachers and learners at the school, as well highlighting the gaps that still exist.
- A self-evaluation report was developed by the Monitoring and Evaluation (M&E) team for Phase 1 of the initiative in which interviews with teachers, district officials, learners, community leaders and implementers were undertaken. The feedback from this report was invaluable in helping to cement the design components.

Lessons learnt that influenced the adaption of the components:

Lessons were learned which informed the adaption of the components with the elements. These lessons included the following:

- All of the teachers were exposed to 21st century teaching and had the opportunity to develop their digital literacy skills as a result of the ICT4RED intervention at the Phase 1 School (Arthur Mfebe). It was confirmed that some of the teachers did in fact show changes in their 21st century skills that translated into a change of how their classes were run (Botha, 2013).
- The most significant change, however, relates to the fact that the availability of the tablets made a greater variety of Learning and Teaching Support Material (LTSM) available to more learners.
- The school's informal support systems have been enhanced by a greater involvement of parents and there are claims that learners' attitudes and expectations may have been impacted positively.
- Besides making learning texts, question papers and videos more available to the learners at Arthur Mfebe, greater expectations have also been imposed on the staff.
- The district and initiative implementers provided an opportunity for these rural teachers to develop themselves, and expected them to rise to the occasion. Most educators did, and although it cannot be expected that all teachers' practices have now been transformed to always include technology, there certainly was more experimentation of this kind in the school.
- The initiative directly impacted on teachers, district officials and learners, whilst also providing an opportunity for the implementing staff to learn and develop their thinking about the ICT4RED initiative.

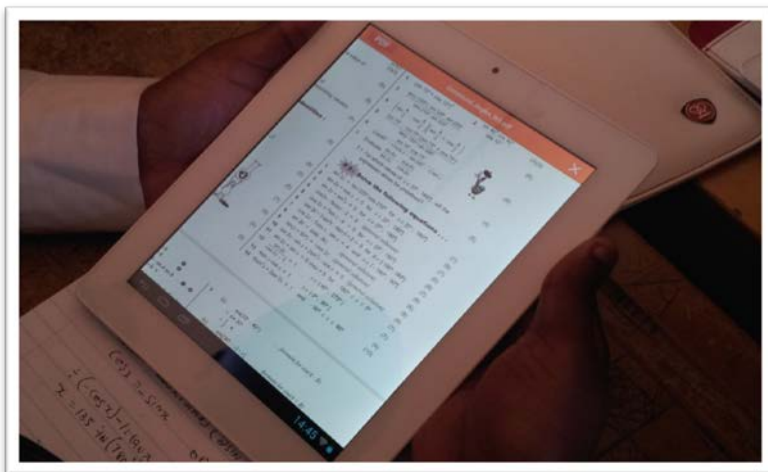


Photo 1-6: Active use of tablets to support Mathematics

Important technology learning also occurred during this pilot phase, as is outlined as below:

- **Tablets:**

The decision to use low cost tablets was not a good one. There were problems with battery power and the overall quality of the tablets. In addition, the teachers struggled to interact with the small 7-inch form factor. Although the tablets were 3G compliant, there were compatibility issues. The tablets were replaced with 10-Inch branded Android devices, supporting 3G connectivity. This led to a renewed emphasis on supporting tablet decision-making at schools and the tablet selection model that was developed for this. All teachers in the initiative were given 10-inch branded Android 3G-compatible tablets for Phases 2 and 3.

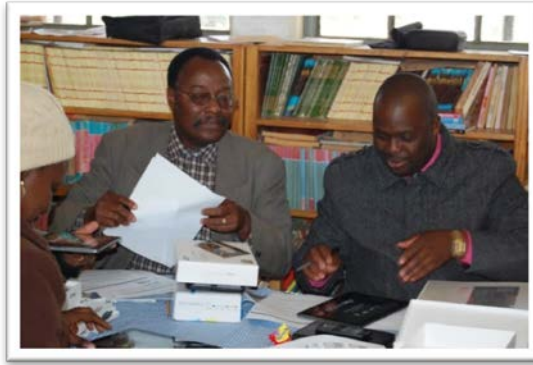


Photo 1-7: Hand-out of the new 10-inch tablets to Arthur Mfebe teachers

- **MobiKits and charging lockers:**

The MobiKits worked well and the school offered some valuable inputs for improving their design. The external charging lockers that were installed for the learners to use, were not as successful and eventually became multi-purpose lockers for the teachers.



Photo 1-8: Multi-purpose charging lockers

- **Charging room:**

The charging room consisted of lockers with charging drawers. Although the school is a one-to-one tablet implementation, they made the decision to only allow Grade 12 learners to take tablets home with them.

Unfortunately, the logistical challenges in handing out tablets to the rest of the schools in the morning and then collecting them in the afternoon severely limited the use of tablets in other grades. In addition, there were problems with the design and sizing of the lockers and charging drawers. This resulted in a total re-think and redesign of tablet storage and charging for Phases 2 and 3.



Photo 1-9: Secure charging station used in Phase 1

- **School Wi-Fi:**

The initial school Wi-Fi design and implementation in 2012 was problematic. The equipment was not robust enough to handle 300 devices connecting to the network every day. In addition, there were severe weather issues with equipment hit by lightning. The Wi-Fi was replaced with more modern equipment in 2014.

By April 2013 the following people were impacted:

Table 1-5: People who were impacted in Phase 1

14 – 16 teachers	All of the staff at Arthur Mfebe received tablets and participated in the training.
1 – 2 District officials	District officials were observers and supporters of the Phase 1 school: Arthur Mfebe.
341 Learners benefitted from more resource	302 learners, enrolled in Arthur Mfebe during

enriched teaching and learning	2013, as well as the 39 learners that wrote the senior certificate in 2012.
32 Grade 12 learners benefited from sharing the Mobikit devices - 1 device between two learners.	

All teachers fulfilled the criteria and graduated in May 2013.



Photo 1-10: A major project milestone: Graduation of all Arthur Mfebe teachers (Photo credit: Danielle Botha)

This phase involved the implementation of the first artefact (6-component model) and the feedback, lessons learnt and other evidence informed this model to be adapted before the start of phase 2.

1.6.3 Phase 2

PHASE 2 (2013/14) – 1 +11 SCHOOLS	EXPLORE and EXPERIENCE
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The learning during this first phase resulted in adapting the components

and also in changes in the technology and processes. Midway through Phase 2 the model had undergone 2 additional iterations, initially creating 9 and then finally 12 operational and implementation-focused components, with INITIATIVE MANAGEMENT taking on more of a leadership and facilitating role.

A dedicated Project Manager was appointed to take over the day-to-day implementation management, procurement and financial management of the initiative, creating a PROJECT MANAGEMENT component. The TECHNOLOGY component was expanded into SCHOOL ICT INFRASTRUCTURE (to make provision for the unique ICT needs within a school) and into NETWORK (to cover different technology challenges in providing connectivity between schools and to the internet). The initiative also did not make enough provision for obtaining buy-in from the parents and the wider community, so COMMUNITY ENGAGEMENT was the result. There was also a need to ensure ongoing engagement with the District Office, the provincial education department and the national government departments, so STAKEHOLDER MANAGEMENT was added. The components, with the elements, were underpinned by the constant monitoring and evaluation of every aspect and phase.

It was also realised that, to adequately cater for the transformation of the schools into '21st century school environments', the improvement of teaching practise was needed. The concept of PEDAGOGY was thought to be too vague and this eventually became TEACHER PROFESSIONAL DEVELOPMENT, one of the primary drivers in the initiative. The importance of changing pedagogy, while introducing technology was a critical learning point and needed to be emphasised in the new model. The emphasis on RESEARCH also evolved into the specific needs identified by government, that of EVIDENCE-BASED POLICY support. There was also a lack of a COMMUNICATION strategy, as it became increasingly important to share the learning gained through the initiative and to relay the correct message to the media and other interested parties. Thus, after completion of Phase 1 and halfway through Phase 2, the names of the components, as well as the focus of these components changed and this resulted in the following *ICT4RED 12-Component model*:

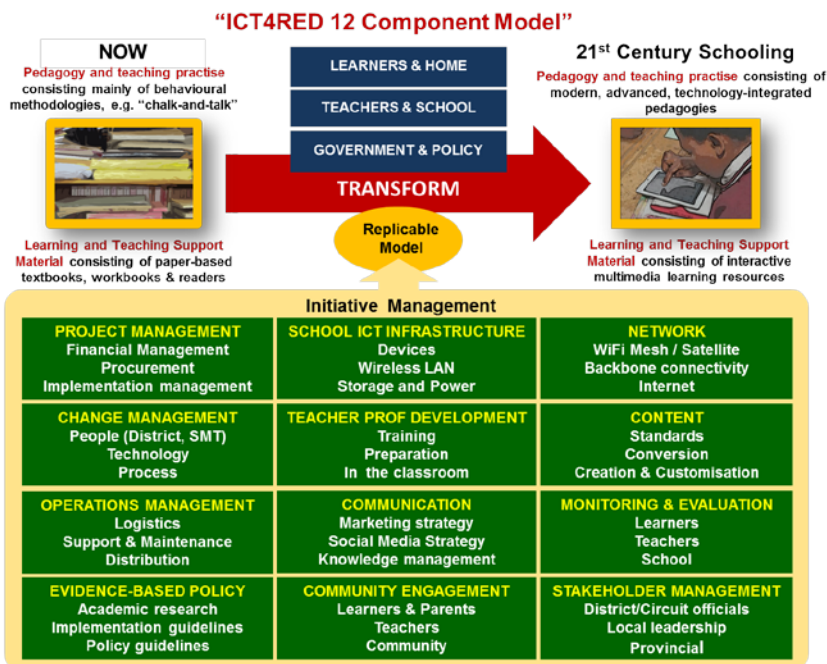


Figure 1-15: Updated model after Phase 1 for Phase 2

The following components were thus applicable in Phase 2:

Table 1-6: Components used during Phase 2

Component	Purpose and elements
Project Management	Financial Management, Procurement Implementation management.
School ICT Infrastructure	Devices, Wireless LAN, Storage and Power.
Network	Wi-Fi Mesh, Satellite, Backbone connectivity, Internet.
Change Management	People (District, School Management Teams), Technology Processes, teachers teaching innovatively. All part of the exit strategy for the schools and school district to take over the sustainability and future of this intervention.
Teacher Professional Development	Training teachers to use mobile devices to enhance their teaching and learning. They apply their trained knowledge as evidence in the classroom with their learners to earn their devices.

Component	Purpose and elements
Content	Standards, Conversion, Creation and Customisation.
Operations Management	Logistics, Support and Maintenance, Distribution.
Communication	Marketing strategy, Social Media Strategy, Knowledge Management.
Monitoring and Evolution	Learners, Teachers, Schools
Evidence-Based Policy	Academic Research, Implementation guidelines, Policy guidelines.
Community Engagement	Learners and Parents, Teachers, Community.
Stakeholder Management	District/Circuit officials, Local Leadership, influential and decision-makers from the community, Provincial leadership.

These components were developed to identify elements that needed to be considered to facilitate the transformation of a prevalent traditional pedagogy to a technology-enhanced emerging pedagogy for the information age.

To make Phase 2 a reality it was decided to apply the following operational methodology:

- **Apply, learn and develop ‘best practice’**

There was a lot of reflection on what worked and what did not work in Phase 1. The learning was then used to inform the processes and approaches for Phase 2 and to adapt the ICT4RED model as one of the artefacts.

- **Ensure long-term sustainability by working within the system**

Informal discussions and meetings with the principals, teachers, district officials and government stakeholders helped to inform and improve the design of the initiative. A Memorandum of Understanding was facilitated between government stakeholders that outlined roles and responsibilities. A decision was made to support local capacity development and district officials were included in decision-making and as resources on the initiative.

- **Education-focused versus technology-focused**

Content was sourced, based on the gaps identified by Phase 1 teachers. The teacher professional development plan and courseware were amended and formalised. Change Management became a separate focus

and consisted of separate courseware. In addition, training was provided to officials at the District Office.

- **Empower the teachers first**

Since the teachers are the gatekeepers in the classroom, it was critical to get their support and active engagement. In addition, teachers have the ability to affect generations of learners. Teachers needed to demonstrate competence in using the tablets to teach and the schools needed to prove readiness, before tablets were provided to learners (Botha & Herselman, 2015).

- ***Prepare the schools***

There was a big focus on change management, in terms of preparing and empowering the school to manage the technology in their environment. In addition, the physical preparation of the school infrastructure received a lot of attention. This included provision for adequate power and securing storage and charging environments.

- ***Technology must be earned***

It was felt that by 'giving' technology to the schools, teachers and learners, it would send out the wrong message. Teachers and learners needed to feel part of the initiative and they had to be prepared to work to develop the necessary skills. Therefore an 'Earn as You Learn' approach was developed, where progress was measured by using a badging system as a form of assessment and micro-accreditation (Botha, 2013).

The expansion to the other schools for Phase 2 process and status is demonstrated below. This phase built in the lessons learned from Phase 1 and developed an amended strategy and plan. The District Office was much more actively involved and became participant collaborators and resources for the initiative. This resulted in additional steps in the implementation process as identified in the figure below.

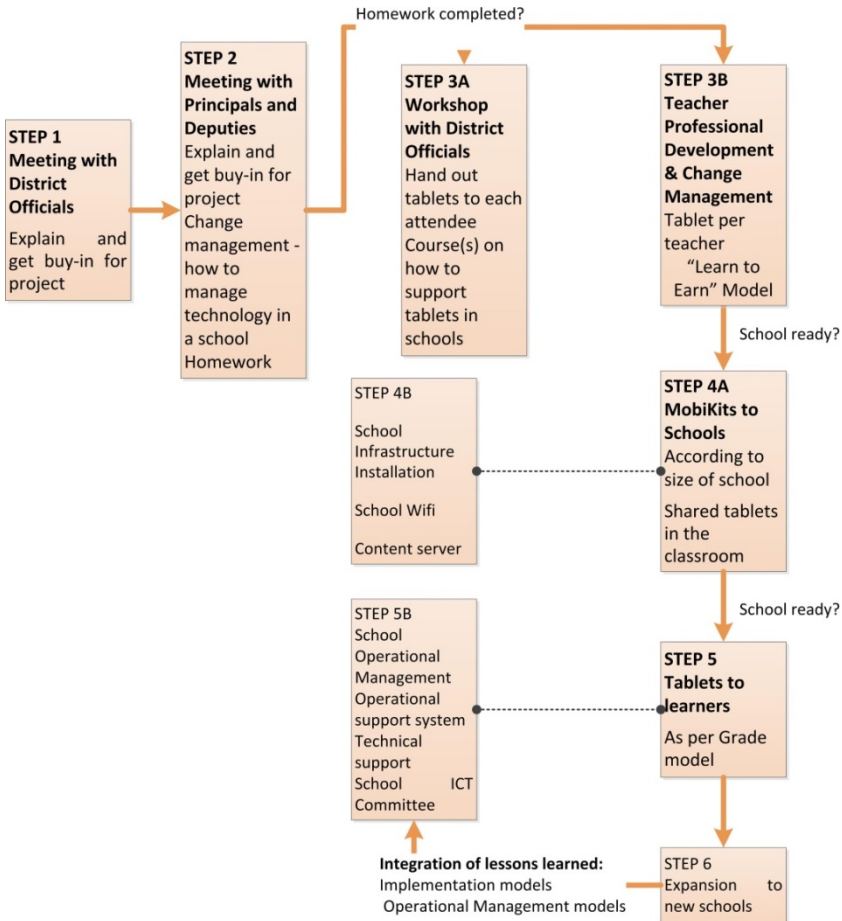


Figure 1-16: Step-by-step process followed in Phase 2 (Ford, 2013)

Phase 2 gave the opportunity to test the model for a larger number of schools that were very different from Arthur Mfebe. There were 9 junior schools in this phase and 2 senior schools. Early on it became apparent that the 2 senior secondary schools were quite dysfunctional, despite the fact that the building infrastructure was of a very high quality for both.

Reflection and Learning after Phase 2

The following high-level learning points emerged:

- **Initiative Management:**

The decision to start small and expand into the circuit, then potentially into the district and province was a good one, as it enabled the system to absorb the changes, develop the skills and capacity to manage the technology and provide accessible support systems (e.g. school to school support). Sustainability becomes probable.

The model based on empowering the teachers (tablets and professional development) and preparing the schools (change management and supporting infrastructure) before involving learners worked in most schools. However, there was a problem with dysfunctional schools – they were struggling with too many educational and management issues to effectively integrate the technology into their schools.

- **Teacher Professional Development (Botha, 2013):**

The model that was developed was education-focused NOT technology-focused. Teacher professional development modules enabled teaching strategies with technology as a tool. Many of these could be used in the absence of technology as well. The expected outcome in the long term is better teaching.

The Earn as You Learn (EAYL) badge system was very successful. The decision not to give technology to anyone, but to earn it by working for it, is something that can be widely replicated. It led to impromptu study groups by teachers after school, as they worked together to earn badges as individuals and as schools, so that they could get the rewards (such as technology for the school). All Phase 2 teachers successfully graduated and 100% of the teachers earned the 13 compulsory badges with many earning 15+ badges.

The ease-of-use and multimedia capability of tablets lent themselves perfectly to environments where people are mostly comfortable with mobile phones as ICT devices. The learning curve is minimal – about 3 hours to full comfort with the devices. It was due to the usability of the devices that the focus could change to teaching *with* the devices, rather than the ‘computer literacy’ challenges of the past.

- **Evidence-Based Policy:**

The outputs of ICT4RED and the possibilities for the technology were better understood. There was the recognition that academic-focused research outputs (e.g. books, papers, Masters and PhD theses) needed to be supplemented by practitioner-based outputs (e.g. a practitioner's guide) and policy outputs (e.g. policy guidelines). All these are artefacts which were provided and developed from the other 12 crucial components.

- **Stakeholder Management:**

Excellent buy-in, a trust relationship and support from various district officials were a major contribution to success. There was a need to expand a broad understanding of the project to all district officials and to integrate activities that they were involved in into their day-to-day activities.

- **Content:**

It was possible to effectively use tablets in an offline mode (i.e. no connectivity), as long as there is sufficient useful preloaded content on the tablets. Connectivity was gradually provided to all schools and not all at once. By the end of the initiative, all schools were connected but during Phase 2 and 3 training, limited connectivity was available as procurement of the right suppliers and ordering of equipment took longer than expected.

Appropriate curriculum-aligned content was still a major challenge, especially for younger learners. There is a need to get South African based contextual content developed that is designed for mobile devices. A renewed definition of *content* also needs to be made in order to make provision for digital and multimedia content.

Content ONLY in the cloud was NOT a viable solution in the short to medium term. The bandwidth challenges would be impossible with the current network infrastructure shortfalls - a study in the UK has specified that you would need 100mbps minimum bandwidth for a school of 700 learners. The solution being tested in Cofimvaba consisted of a local content server, that is synchronised to a central server when traffic is low (e.g. at night). Teachers and learners have an 'internet-like' experience by accessing the local content server containing the cached content.

- **School ICT Infrastructure:**

It was difficult to select good tablets – there were even problems with the so-called reputable companies. In addition, the rapid development of tablets, in terms of hardware and software, made selection complex. The team developed a multi-criteria decision-making tablet selection tool (as an artefact) to support schools and the decision was made to test all tablets in the lab.

There was a need to revisit specifications every 3-6 months as the technology improves.

It was critical to develop standards-based criteria and not product-based criteria for tablets – theoretically it should not matter what brand tablet is selected, as long as it conforms to the standards. This gives decision makers a choice based on budget and prepares the way for a ‘Bring Your Own Device’ scenario.

The biggest challenge experienced with tablets was battery power. Tablets did not perform to specifications and lasted 4-5 hours maximum. This points very strongly to a replacement policy of every 2-3 years as the technology becomes obsolete and unusable due to battery age.

There was a lot of complexity in selecting hardware, software and network solutions. In one of the Request for Proposal (RFP) process to provide satellite connectivity to schools, there were orders of magnitude differences in pricing between vendors, even though they were provided with a very specific template. This will be a huge problem for the uninformed.

It was critical to make provision for secure charging in the school environment – this has implications on power needs and costs in the schools. Most schools were not comfortable in allowing learners to take tablets home due to the high crime rate in the area.

Based on the lessons learnt as mentioned above, new adjustments were made to all the artefacts as part of Phase 2. The following diagram represents how the 12 components can guide implementation and which components are seen as enablers and drivers in the ICT4RED implementation framework. The model was converted into a framework after the implementation of Phase 2. This conceptual framework has been improved upon and expanded on the initial model to show the

relationships between the various components through every phase of implementation and as evaluation lessons were learned.

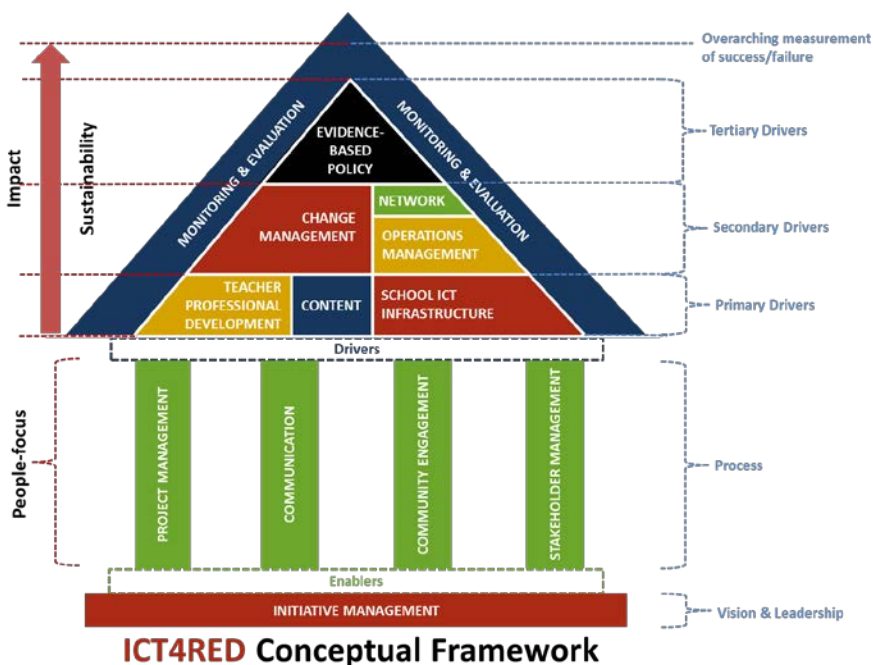


Figure 1-17: Conceptual framework emanating from the 12 components after Phase 2

Although INITIATIVE MANAGEMENT is not strictly one of the 12 components, it is critical that someone takes overall responsibility for the initiative, in terms of coordination of the various components, leadership, vision, decision-making, relationship-building and networking. Inspirational and supportive INITIATIVE MANAGEMENT becomes the foundation for the whole initiative. In the context of a school, this role would typically be fulfilled by the principal.

The Enablers are process-driven activities needed to support the initiative and these include:

Enablers:

- **Project Management:**

A good project manager is critical to the success of a complex initiative of this nature. If the initiative is being undertaken in an environment characterised by uncertainty and change, it is important to design the initiative so that flexibility is built into the plan.

- **Communication:**

Communication is critical to the success of any initiative of this type – whether it is between team members, to stakeholders (e.g. parents) or to the press. There is also a need to include knowledge management as an important element of this communicative strategy.

- **Community Engagement:**

In a school environment, there are many important community stakeholders – the teachers, the school governing body, the parents, the learners and the local community itself. In addition, in rural areas, there may also be traditional leadership structures that may need to be informed or involved. One needs to make provision for extensive communication to garner support from the community.

- **Stakeholder Management:**

Identify your most important stakeholders. For the purposes of our initiative, we identified stakeholders as government officials, ranging from district officials and the local municipality to the province (ECDoE) and on a national basis (DBE, DST and DRDLR). This will differ from one initiative to the next. Another important aspect to consider is that there is a protocol involved with interventions in schools – it is necessary to get the go-ahead, or even better, active support and participation from the District Office (or the Provincial Department if it is a research initiative).

Drivers can be divided into primary, secondary and tertiary drivers:

Primary Drivers:

- **Teacher Professional Development (Botha & Herselman, 2015):**

It was decided that teacher professional development would be the ‘golden thread’ that runs through the initiative. All the other activities are

were planned around this component. In order to integrate technology into a school environment, you need to get the teachers on board, particularly in a rural school environment with very entrenched hierarchies. We also decided to focus on ‘developing teaching strategies supported by technology’ as opposed to ‘developing technology skills that can support teaching’ – this is very different to current approaches and it proved to be successful, exposing teachers to modern teaching methods that could be employed, with or without the use of technology.

- **Content:**

Making provision for content, particularly curriculum-based content, is extremely important. In the digital world it is important to expand the concept of *content* to include all kinds of content types – video, audio, animations etc. Do not discount the value of content created by teachers and learners themselves – it is not always necessary to look for external content when there is a rich source of locally-created content (co-creation). Tablets are multimedia devices, and combined with the latest teaching strategies (such as role-play, story-telling, podcasts etc.), they become very easy content creation tools.

- **School ICT Infrastructure:**

It is important to design your infrastructure according to the needs and context of a particular school environment. Because, in this case, we were implementing Android tablets in schools and internet connectivity is expensive (and non-existent in many cases), we designed an individualised school ICT infrastructure plan that suited the environment.

Secondary Drivers:

- **Change Management and Leadership:**

This component was renamed to acknowledge the need for Change Leadership as well as the day-to-day process oriented activities that need to be put in place when you provide technology to a school. It is important not to underestimate the impact of change in ICT for Education initiatives, particularly when intervening in a school from a zero-base exposure to ICT. Enough time needs to be spent on preparing the school for the intervention. In addition, it is critical to include district officials in the change management and leadership activities in order to ensure longer term sustainability.

- **Operations Management:**

Making provision for day-to-day support for technology in a school environment is critical. Teachers are already overburdened and, even with the best will in the world, cannot take responsibility for the technology as well. Unemployed youths from the community will provide first line basic technical support in the schools (see Section 5).

- **Network:**

Internet connectivity is expensive, particularly in rural environments where there is often a lack of even 3G access. It is possible to provide an ‘internet-like’ experience to schools by at least providing local Wi-Fi-connectivity and access to a content server. Even if there is internet connectivity, it is a good idea to try and keep traffic local as much as possible, in an effort to save bandwidth. In a similar initiative in the UK, the minimum bandwidth suggested for schools with about 500 – 900 learners with tablets is 100MB/s (Tablets for Schools Project, 2014).

Tertiary Drivers:

- **Evidence-Based Policy:**

Whether your intervention is being undertaken on a large scale (for a district/province/country) or a small scale (for a school or small group of schools), it is important to incorporate your learning into policies and processes to support the implementation in your context. On a national scale, this translates into policies such as the ICT for Education White Paper and content standards. On a school scale, it translates into Acceptable Use Policies, School ICT Policy, ICT management processes etc.

Over-Arching Measurement of Success/Failure:

- **Monitoring and Evaluation:**

Every initiative needs to have some kind of monitoring and evaluation process in order to assess and measure whether or not you have reached your goal(s) and to inform decisions and processes as you go along. It is also important to share your learning with others, so that the same mistakes are not repeated. M&E also informed the evolution of the various artefacts based on results in each phase.

- **Impact and Sustainability**

By including all the drivers and ensuring that enabling activities are ongoing, the ICT4RED 12-Component Framework, as it became known after Phase 2, attempted to identify all the components involved in an initiative of this nature. It provides and summarises guidelines to support similar rollouts, in order to maximise the potential for success, and addresses the areas of implementation, sustainability and impact. It has been developed by incorporating ongoing feedback loops, so that learning is translated into new and improved designs going forward.



Photo 1-11: Graduation Phase 2

At this stage of the ICT4RED initiative, each of the 12 components have also developed their own specific frameworks, models, guidelines and tools.

1.6.4 Phase 3

PHASE 3 (2014/15) – 1+11+14 SCHOOLS	ADVISE and EMBED IN SYSTEM
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The expansion to other schools, actioned in PHASE 3, adapted the process

below. It was based on the new lessons learned from PHASE 2 and developed an amended strategy and plan. A decision was made to involve district officials more directly and actively in teacher professional development, change management and ongoing monitoring and evaluation of the tablet use in the schools.

The ICT4RED initiative undertook a very flexible, but process-driven implementation approach. In Phase 3 District Officials were designed to be an integral part of the initiative. This is reflected in the step-by-step implementation process for Phase 3, as shown in Figure 1-19 below.

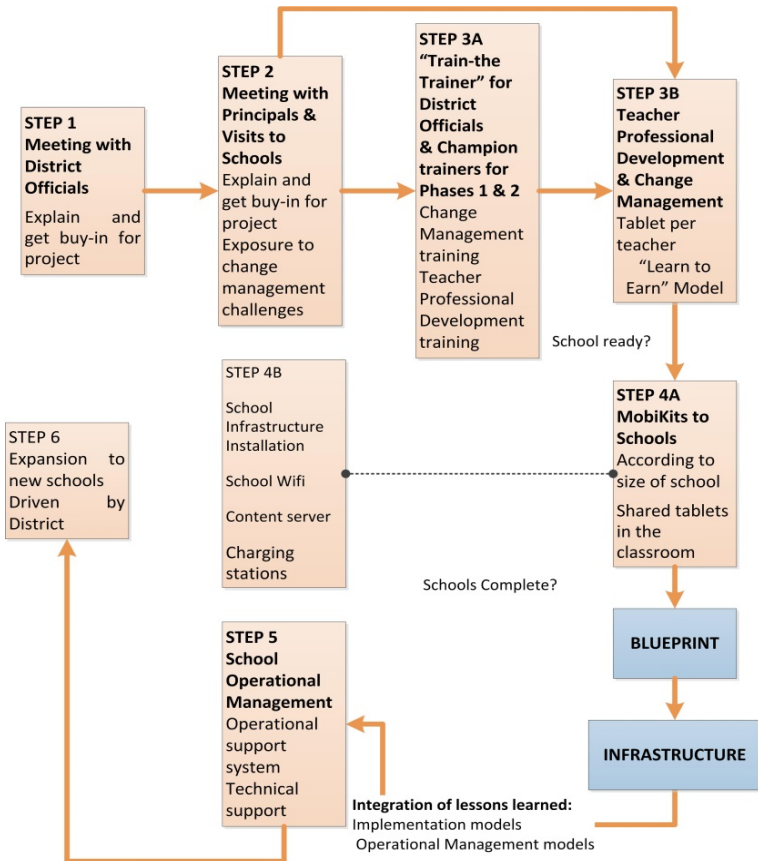


Figure 1-19: Step-by-step process followed in Phase 3. (Ford, 2013)

Within Phase 3 it was important to address the aims and objectives of the ICT4RED initiative and to re-address the artefacts. The following important lessons were learnt in Phase 3:

- **Teacher Professional Development**

At the centre of this initiative was the teachers' engagement with the Teacher Professional Development Component (Section 3). This component is what made this initiative a success. Attendance was high and teachers started their own co-creation of content, lessons plans and sharing this in communities of practice with similar teachers in their area. The extra support provided by the facilitators, participating teachers and the badge collectors towards the end of the programme, was likely a contributing success factor. It created opportunities for teachers to exchange ideas about teaching with technology, it highlighted the possible value of ICT for teaching and learning, and it created some level of support through the establishment of school-based ICT committees. Teachers have also gained more knowledge through leadership and change management courses and were using their tablets to complete administrative tasks as well. Supporting and refresher courses for Phases 1 and 2 teachers, who successfully earned their technology, is important. What teachers now did was to teach learners by using videos, accessing information from the content servers and doing Online Assessments. Some respondents also noted that these changes in teaching and learning led to a significant change in learners' attitudes and the level of attention they paid in the class.

Almost all teachers reported that they were becoming more comfortable using their technology, and there was evidence that the initiative contributed towards more positive attitudes towards the use of technology by teachers.

- **Stakeholder Engagement**

A sustainability plan and strategy needs to be developed by various stakeholders in the Cofimvaba school district. These stakeholders include the circuit manager, district officials and Eastern Cape Department of Education officials who support ICT champions at schools and address other ICT infrastructure issues like tablet upgrades, tablet problems, Internet and Wi-Fi connection problems and training of new teachers after the ICT4RED initiative ends.

Schools also reported a change in the way the district interacted with them after the initiative had commenced in their school. The officials involved in e-learning and institutional development visited schools more frequently and assisted with tasks such as co-ordinating training, assisting in incorporating tablets into teaching, providing moral support, boosting teachers' confidence and suggesting strategies on how to keep tablets safe. It seems, however, that there was a change in behaviour even at organisational level.

- **Evidence-Based Policy**

The ICT4RED initiative is contributing towards the Department of Science and Technology's Human Capital Development goals with the number of active postgraduate students and other academics who are using the initiative in their studies.

The ICT4RED initiative is influencing practice in the ICT4E field through sharing its learning via the ICT4RED blog (ICT4RED.blogpost.com), engagements at gatherings of practitioners and by producing specific outputs (artefacts) targeted for use by practitioners.

For practitioners, the ICT4RED TPD Course (as discussed in Section 3 of this book) was made available online under a Creative Commons Attribution-Non-commercial-Share Alike 3.0 licence.

The team members were also invited to practitioner focused gatherings with stakeholders involved in the field of Education, both locally and internationally, in publishing and also in ICT4E work.

The initiative has also had some fairly high level interactions with policy makers and implementers. Other provinces (North West, Gauteng Education Department and Northern Cape) are engaging with the ICT4RED team to incorporate the training modules for their teachers.

The feedback and experiences of the ICT4RED team in Phase 3 have not led to major adaptations of the evidence-based ICT4RED Implementation Framework, but have led to changes in the purpose and elements of each component as understanding of the issues and needs became clearer. As Wolske indicated in a keynote address (2014):

[E]xpertise in technology should never be the answer, only a possible tool, when appropriate and collaboratively crafted. We must remain people-centred. This is difficult if the conversation is techno-centric. Wolske(2014)

This is clearly evident in the ICT4RED implementation framework (version 1) below. It is critical that an all-encompassing approach is undertaken, with a focus on each of the components identified. Much of the work includes working with people and securing buy-in from all the educational stakeholders, including the schools and local communities. The focus on the technology component itself (in ICT4RED’s case, the introduction of tablets into 26 schools) is a small fraction of the overall initiative.

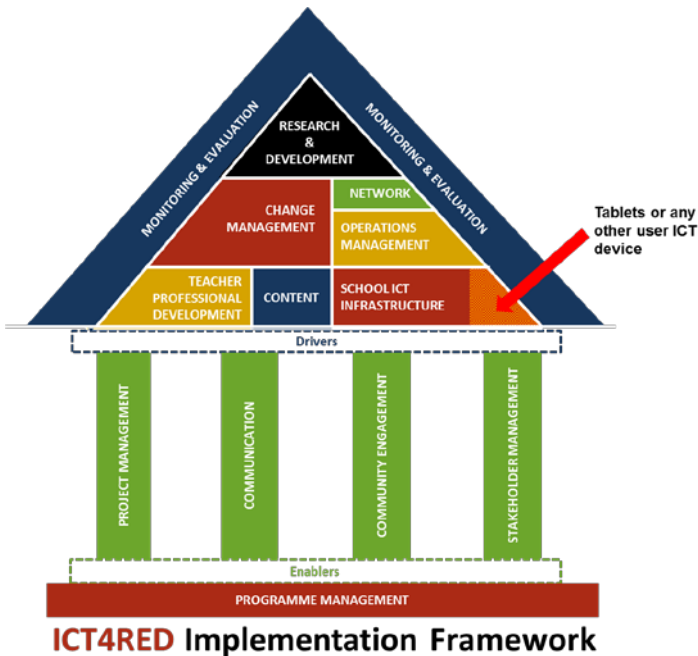


Figure 1-18: ICT4RED Implementation framework v1. Tablet focus vs all other components

This artefact was thus used to explain the ICT4RED initiative based on its implementation at various schools and also based on results and evidence gained from the feedback from all the 12 crucial components. This was thus the most important artefact to use when explaining this initiative at various forums.

1.6.5 Phase 4

PHASE 4 (2014/15) REFLECTING and EXPANDING	EXPLAIN and ADVISE, TRANSFER and TRANSFORM
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This last phase is the handover of the initiative to the stakeholders, so that they can manage the 26 schools and investigate further options of expanding the initiative throughout the district and province. The final ICT4RED Implementation Framework emerged and this will be discussed in more detail in Section 2.

In the ICT4RED initiative the main contributions can be divided into theoretical, methodological and practical contributions which were:

- **Theoretical contribution**

The design theory recalibrated the Design Science Research approach to better accommodate the needs of the ICT4RED schools. This approach will allow for the formulation of explicit instructions in terms of methods, techniques, principles of form and function for the creation of an appropriate artefact. For the purpose of this initiative, the resulting artefacts can guide the implementation of similar initiatives in similar contexts.

- **Contribution to research methods**

The challenging environments, in which the ICT4RED schools are situated, are environmental, community and physical challenges. Making use of an in-depth comparative case study, within the design science iterations with a limited ethnographic component, this initiative applied multiple data-gathering methods as well as multiple data sources. Data-gathering methods included expert and participant interviews, focus groups, observations, anecdotal stories and audio-visual material. Following an iterative data-gathering process over a period of three years enabled an in-depth understanding of the social reality of the participants. Combined with previous experiences in conducting initiatives in rural communities, this initiative could provide guidelines on *how* to interact with communities in order to obtain maximum buy-in and useful research data. An important contribution of this initiative was the unique combination of using case study design within Design Science Research to collect data and to inform the development of the artefacts (frameworks, models,

guidelines and tools).

The monitoring and evaluation of the initiative, through developmental evaluation, informed this approach and it was done from the initiation of the initiative until its completion (Section 4 of this book). This was an important contribution to the implementation of the initiative as it allowed for constant monitoring and evaluation of every phase. This provided rich evidence which could support the development of the various artefacts like the ICT4RED framework and many other decision-support tools (as tablet selection and total cost of ownership as discussed in Section 7).

- **Practical contributions**

On a practical level, this initiative provided the following:

- Refined frameworks, models, guidelines and tools were adapted to specifically suit the requirements of the rural education system.
- Processes, operational and procedures with guidelines.
- Recommendations and advice at policy level (Section 9).
- A better understanding of the role mobile technologies can play in developing 21st century skills in rural schools.

1.7 Conclusion

Section 1 of the book provided an overview of *where* the ICT4RED initiative originated from and *how* it was approached from an operational, as well as a scientific methodological perspective. The initial ICT4RED Implementation Framework as well as the envisaged contributions of this initiative were also discussed.

The rest of the book will cover the most important drivers of the initiative. Some overviews, results of the enablers and other models, guidelines and tools will also be shared.

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Herselman, M. and Botha, A. (2014). *Designing and implementing an Information Communication Technology for Rural Education Development (ICT4RED) initiative in a resource constrained environment: Cofimvaba school district, Eastern Cape Province, South Africa*, 1 ed. 2014, CSIR Meraka: Pretoria, South Africa.

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ISBN: 978-0-7988-5619-5 (ebk)



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