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

This book is a representation of all 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 with significant educational challenges. This initiative was coined the ICT4RED initiative and was a research, development and implementation project that changed the way teachers teach with technology in their specific context over a period of 3 years (2012-2015).

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Contents

Executive summary

This book is a representation of all 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 with significant educational challenges. This initiative was coined the ICT4RED initiative and was a research, development and implementation project that changed the way teachers teach with technology in their specific context over a period of 3 years (2012-2015).

The book aims to provide insight into how this initiative was implemented and how the components were adapted to form an Evidence-based ICT4RED Implementation Framework in the end. This framework was developed by adopting design science research as the 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 final Evidence-based ICT4RED Implementation Framework, were managed and how it was operationalised to provide specific deliverables or to reach certain aims.

There was a core team (one representative from each component) that met once every week to track and trace progress and deliverables. What emanated from this ICT4RED initiative was far more than just processes or models which were 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 to improve their lives and that of their learners!

"New technology is common, new thinking is rare." – ***Sir Peter Blake***

This book will take the reader through the journey of this initiative and share best practices as well as lessons learnt. It is envisaged that it will inspire all new prospective students, teachers and academia to realise that the value of using technology is not to think that it can ever replace a teacher, but that it can enhance teaching and learning and transform traditional methods of teaching in a classroom. This can only be successfully done where technology is earned and not just given or provided for free.

The book is divided into Sections (1-8). In section one the introduction and background to the ICT4RED initiative is provided as well as how the *Evidence-based ICT4RED Implementation Framework* evolved and was adapted after every phase. The methodology which underpinned the development of the framework is also provided. Section 2 is an overview of how the Teacher Professional development (TPD) was developed and deployed.

Section III 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 which was applied was used to get to the results and to show impact.

Section IV is where all the detail about Programme management, Operations Management and School ICT is provided. It was decided to focus on how the ICT4RED initiative applied different processes, tools and suppliers to equip schools and teachers in the Nciba school district.

Section 5 addresses how Change Management and stakeholder Management all contributed to the integration of technology in a resource constraint community in a specific context.

Section 6 is a chapter on Sustainability and how value is derived through improved decision-making. The issue of sustainability is covered and how it plays an important role in the ICT4RED initiative. There is also a focus on Total Cost of Ownership, Cost utility and Tablet selection models which were developed as part of addressing sustainability.

Section 7 is a chapter on 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 8 is a synthesis where the objectives and aims are addressed and how these were achieved. This last section also covers the changes, which were eminent in the context of the initiative and end 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, 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 from the Eastern Cape Provincial Department of Education, 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 district of Cofimvaba who have embraced this initiative and have become co-creators of their own destiny and innovation.

> *"It is not about the technology; it's 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 & Evaluation of TECH4RED)
- Benita Williams Consultants (Monitoring & Evaluation)
- Impact Advantage (Modelling)
- CoZaCares Foundation (Content)
- ICT4Champions (Teacher Professional Development)
- SchoolNET SA SA (Teacher Professional Development)
- AfroFusion (Communication) CONTRACT COMPLETED FEB 2014
- Hive Holdings (Technology infrastructure design, Operations Management) CONTRACT COMPLETED 31 MARCH 2014
- Tipp Focus (Change Management) CONTRACT COMPLETED JAN 2014
- NMMU Govan Mbeki Mathematics Development Unit (Content)
- Fort Hare, Rhodes, NMMU, UP, UFS, UNISA, University of Manchester, Monash (Postgraduate students and Research)
- Faranani (Professional Services)
- University of Pretoria Business Enterprises (Ethnography)
- Lymmyl Technologies (ICT Infrastructure Implementation and Support)
- Liquid Telecom (Satellite Connectivity)
- Maggie Verster (Teacher Professional Development)
- Redline (Wireless Mesh Networks and Wi-Fi Implementation)

SECTION 1: Introduction, background and the evolvement of the ICT4RED framework

M. Herselman, A. Botha & M. Ford

This section covers the introduction and background to the ICT4RED initiative. It outlines the development of the Evidence-based ICT4RED framework as it was developed through various phases of implementation.

1.1 Introduction

The purpose of this book is to provide an overview of how a specific framework guided the way in which one type of technology (mobile tablets) can support and enhance teaching and learning in a specific resource constraint environment in South Africa. This intervention is coined as the Information Communication and Technology for Rural Education Development (ICT4RED) initiative, which is a large-scale pilot (over 3 years) that tested the use of tablets in 26 deep rural schools in the Nciba school district in the Eastern Cape Province of South Africa.

The macro-economic perspective of the area is one of few economic opportunities, high unemployment, low incomes, a shrinking population of economically active people and a growing number of school-going youth. This area is regarded as a resource constraint environment. A resource constraint environment, for the purpose of this book, is best described by Anderson, Anderson, Boriello & Kolko (2012) as environments 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, environments where power and network connectivity are scarce and expensive.

The pilot extends to include 3 senior secondary schools (Grades 10 – 12) and 23 junior and senior primary schools (Grades R to 9) (Van Rensburg & Du Buisson, 2012). The challenge is to introduce technology (in this case tablets and other supporting ICT infrastructure) in ways that will improve teaching and learning, support sustainability beyond the initiative and ensure true integration into existing education processes, whilst managing very real logistical and infrastructure problems. This is a challenge that can be seen as the *Holy Grail* of ICT in Education initiatives in rural areas.

This initiative was part of The Technology for Rural Education Development (TECH4RED) research programme which aims 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) in South Africa. 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 (Bloch, 2009). The learning from this programme will enable evidence-based policy development within the government of South Africa. ICT4RED is thus part of TECH4RED and is the component within TECH4RED which focus only on how technology can support teaching and learning.

The intention was to use the learning while implemented technology and to develop a conceptual framework, which can be applied in other similar initiatives before inception. This use and application of this framework can ensure that other tablet initiatives in the country have a better chance of success. This framework, in addition, would be well-suited to influence policy on how technology enhanced teaching and learning can be introduced to schools in resource constrained contexts. The following objectives were envisaged:

- Design systemic and sustainable approaches to providing access to digital content by learners at resource constrained rural schools in South Africa;
- Design models for teacher professional development that focus on “how to teach with a tablet”, rather than “how to use a tablet”;
- Design, develop, test and improve new and evolving educational technologies, devices, platforms and processes that support the access to digital content for rural school environments;
- Measure the effect of this initiative on the 21st century skills of learners; and
- Use the evidence from the research within this context to inform policy in an integrated and coherent manner.

The learning from this initiative is being designed to feed into the system in a multi-dimensional way, to a variety of stakeholders in the educational eco-system:

- Evidence-based policy outputs (guidelines, models and frameworks, standards, recommendations, policy briefs) to national and provincial governments
- Practitioner outputs (planning and implementation guidelines, tools, templates, checklists) to various practitioners (schools, 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)

This initiative involves both research and implementation, using a design science approach, focused on continuous improvement and redesign based on learning, in each iteration. It is also the largest and most ambitious ICT for Education research initiative of its kind in South Africa in terms of ongoing and detailed measurement, monitoring and evaluation of the efficacy of the approach to integrate technology into teaching and learning. The value of the initiative lies in the fact that it is being implemented in "real-world" conditions, in a rural educational district and that it was designed by incorporating learning from initiatives of a similar nature from around the world. The fact that it is collaboration between four government departments bodes well for future sustainability.

The success thus far of the initiative also points to the need for a mechanism/structure to continue this kind of ICT for Education research for government.

1.2 Background

School education in South Africa, despite an investment of 19% of total government spending (Trading Economics, 2010), still faces 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) highlight 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 in 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 performance of learners, particularly in under-resourced and rural schools (Bloch, 2009).

ICT is seen as having 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, A., Cox, S., Dumas, C., & van Zyl, I., 2012; Were, E., Rubagiza, J., & Sutherland, R., 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 for teaching and learning (Were et al. 2011). There are many stories of unused, locked computer laboratories at schools in South Africa, examples of "technology push", rather than embedding these tools within the local education needs and contexts.

The emergence of 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. Using mobile technology can be seen as an option as the use of mobile technology to support teaching and learning are found to be cheaper and more usable than for instance a PC, which helps people to get access to the learning materials, the facilitators and the fellow learners. Educational tablet initiatives have been announced around the world (Tablets for schools, 2012), however none of these initiatives have developed a framework based on implementation and lessons learnt, which can inform other or new initiatives.

The ICT4RED initiative is rooted in the recognition that larger scale improvements to the education system are not limited to the domain of education departments alone, but require the combined efforts of public and private partners, together with civil society at National Provincial, and at District and Circuit level. The target market includes schools, government (at a provincial level), NGOs and private sector organisations (who are currently engaged in similar rollouts). The focus on schools is fixed in the notion that the school system is a subsystem of the broader education system and that a focus at the level of the Education Circuit represents the smallest Unit of this system.

The following diagram attempts to identify the ICT for Education ecosystem at a high level and shows some preliminary thinking regarding the types of tools and services for the different role players.

The scope of the ICT4RED initiative was to provide tablets to teachers, learners and district officials and to test various models, in terms of:

- Infrastructure & Connectivity
- Integration into the school
- Operations, Logistics, Support & Maintenance

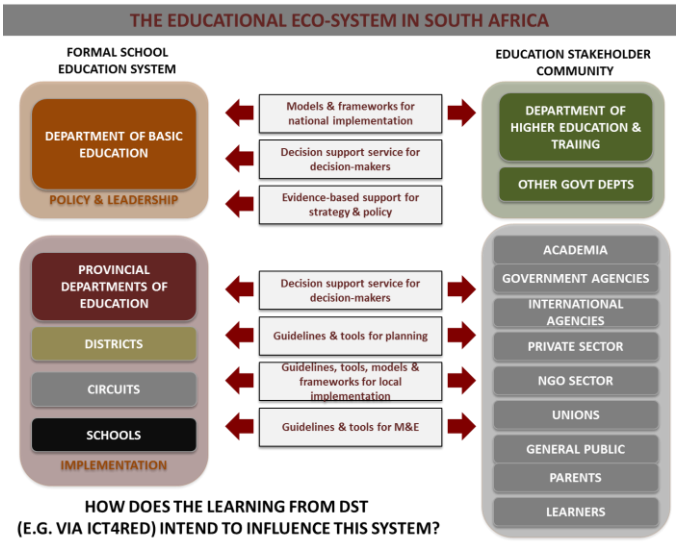


Figure 1-1: The educational ecosystem in South Africa

- Costs (Total Cost of Ownership) & Sustainability
- Content selection and organising content on servers
- Tablets (selection and upgrades)
- Change Management
- Teacher training and professional development

The scope was used to understand digital Content issues such as:

- Open Content vs Proprietary
- Changing role of traditional publishers
- Various eBook formats
- Paradigm shift from text- to *media*books

Also to investigate the following distribution issues:

- Content distribution
- Device distribution
- Connectivity options
- Models that will work in worst case scenarios

And finally to investigate device options like:

- Dedicated LCD-based eReaders (Nook Color, Kindle Fire) / Dedicated e-ink based eReaders (Kindle, Nook Touch) / Tablets (iPad, various Android tablets) / Smartphones
- Power requirements, form factors, ruggedness, colour vs monochrome, costs, expandability, upgradability, usability
- Cost/Ownership/Support and maintenance models
- Training needs

All of these investigations and models resulted into understanding the type of technology best suitable to support the education eco-system in the Nciba school circuit and to use feedback from 6 500 learners, 350 teachers and 16 district officials to develop an *Evidence-based ICT4RED Implementation Framework* which can inform policy decision makers and other initiative managers who want to embark on similar intervention.

A few maps will now follow which indicate the area where the initiative was implemented. The first map highlights the provinces in South Africa.

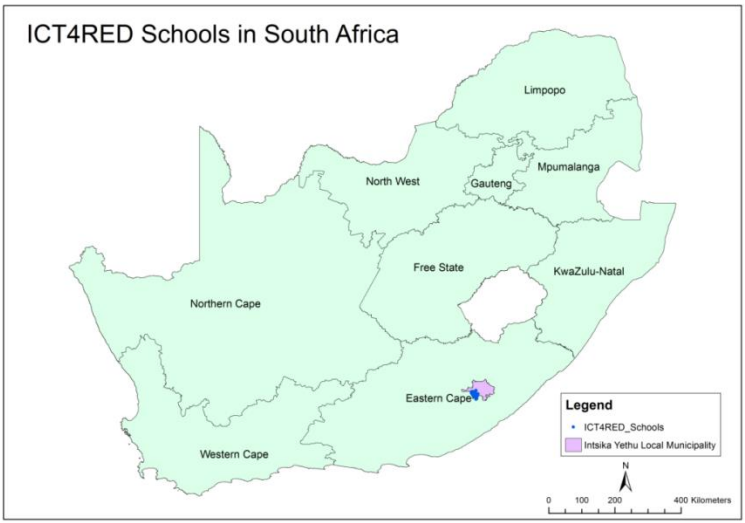


Figure 1-2: Map of South Africa with the provinces and where the ICT4RED schools are situated

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

In the map below, the different South African district municipalities are evident:

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

These district municipalities can be found in the different provinces in 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 in the pink area in the map above.

The schools are in alphabetical order with the date of engagement 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)

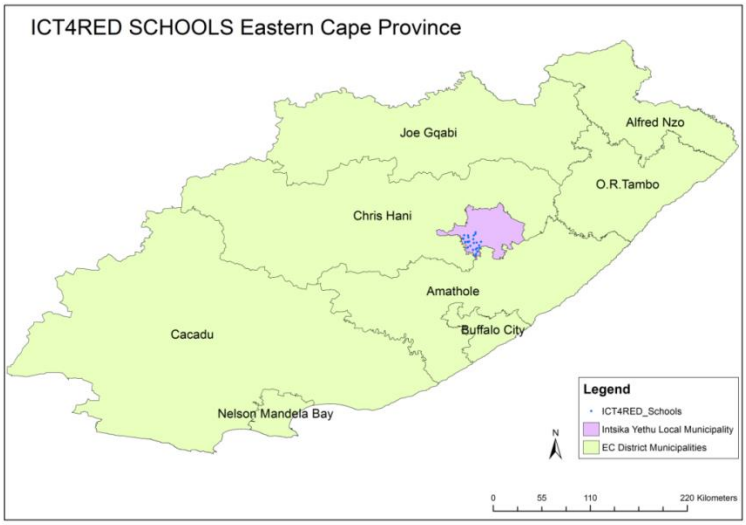


Figure 1-4: ICT4RED schools in the Intsika Yethu local municipality (Nciba school district) in the Eastern Cape Province of South Africa

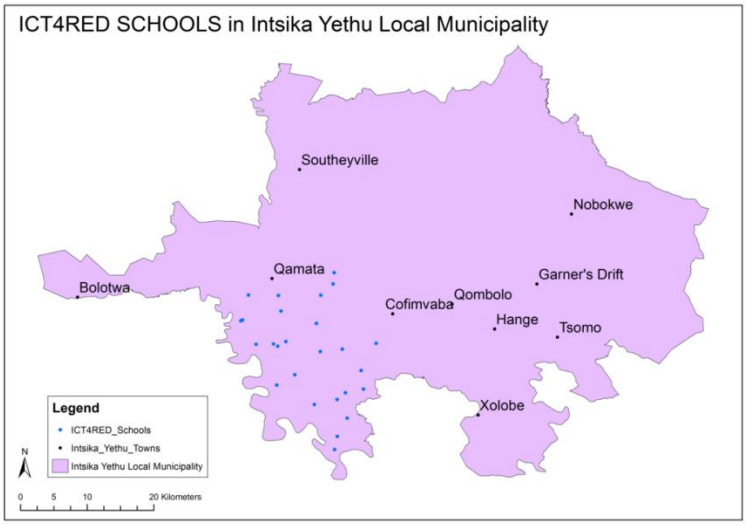


Figure 1-5: ICT4RED schools scattered between Qamata and Cofimvaba towns

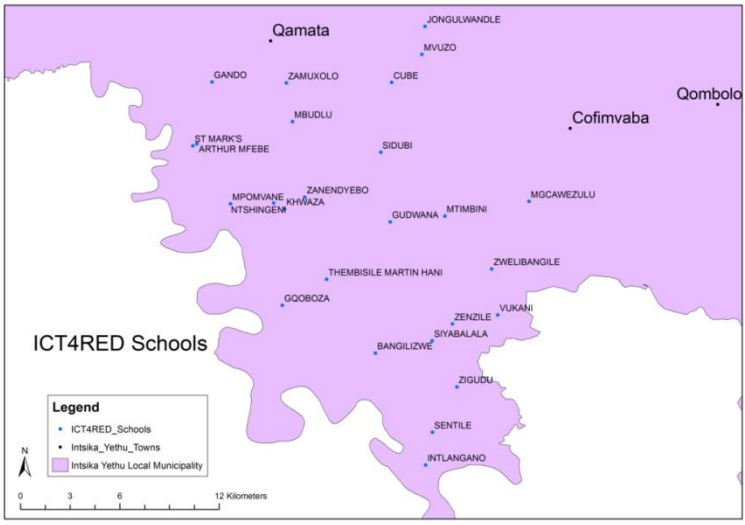


Figure 1-6: ICT4RED 26 schools in the Intsika Yethu local municipality (Nciba school district)

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 Butterworth, in Thembuland. Cofimvaba town, established in 1877, is the closest major settlement and has the distinction of being Chris Hani, a South African political activist's, home town. The name, Cofimvaba, is derived from *cofa*, meaning "press", and *mvaba*, translated as "milk-bag" (of goatskin). This action is associated with breaking up lumps of sour milk. Xhosa is the main spoken language in the district although the final school exams in the senior secondary schools are taken in English. In addition, English becomes the language of instruction from Grade 4 onwards.

The population of the Intsika Yethu local municipality is estimated at 35500 inhabitants (StatsSA, 2011) and is famous for its beautiful unspoilt landscape. Small villages are scattered over hills and mountains and it is often quite an adventure to reach these villages as a network of gravel roads needs to be navigated. The meandering gravel roads make some schools nearly impossible to reach in the rainy season, as the roads often traverse rivers by way of low water bridges. Teachers have reported that they opt to share transport in a bid to save on costs such as petrol and wear and tear on 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 this Nciba school district had unreliable or no access to water, 40% unreliable or no access to electricity and sanitation remained a challenge. The 26 schools, at the time of the survey, comprised of approximately 6500 learners, 350 teachers and 16 district officials. There were almost 30 learners per educator and a distribution of the schools in 2012 were one junior primary school, 6 senior primary, 16 junior secondary and 3 senior secondary schools. In 2014, after reallocation and restructuring by the Eastern Cape Education Department in a bid to conform, there were 3 primary schools, one secondary school, 13 junior secondary, 7 senior primary and 2 senior secondary schools. Access to the internet and communication infrastructure was nearly non-existing. These findings suggest that the schools can be classified as resource constrained. As part of the bigger Tech4RED initiative sanitation, electricity and toilet facilities together with nutrition would be addressed.

The ICT4RED initiative opted to embrace some important principles which included using only open standards, having minimum school disruption, striving for sustainability after the end of the initiative, providing inclusivity, being transparent and being practical and hands-on. These values set the stage for developing local capacity and supporting local suppliers. At school level the initiative endeavoured to develop 21st century schooling towards creating an educational engagement that would incorporate technology into the classroom.

To make this a reality the ICT4RED initiative had to develop a framework which could be replicated to other provinces or areas (of similar context) and to inform policy makers on deployment of ICT in schools. In order to develop a framework it is necessary to define what it is. According to Lethbridge and Lananiere (2005) a framework can be defined as a generic solution to a generalized problem that provides common services to situations that are applicable and consist of a set of ideas or principles and the processes needed to control the implementation of functionalities. ‘A framework is also defined as a fundamental construct that defines assumptions, concepts, values, and practices, and which includes guidance

for implementing the specific framework' (Tomhave, 2005:9). The Evidence-based ICT4RED Implementation Framework mainly involved the following knowledge domains, namely:

- theories and practices on the development of an ICT4RED framework;
- policies, procedures and government documentation on use of technology in rural schools; and
- theories and practices on using technology in the ICT4RED schools.

1.3 The development of the A Evidence-based ICT4RED Implementation Framework

The ICT4RED initiative was designed to go through very specific phases. Each phase was used to develop and adapt the framework in order to have a final framework. The phases are indicated after the methodology.

1.3.1 Methodology

It was already indicated that the methodology which was applied to develop the *Evidence-based ICT4RED Implementation Framework* has been Design Science research. Design science research, focuses on creation and the purpose of design is "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 & Chatterjee (2010:11) relate to the ill-defined environmental contexts, 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 and has applied the deductive reasoning approach, which will be operationalized through a Design Research engagement informed by the ICT4RED Component of which each component has been viewed as a unit of analysis towards the development of the *Evidence-based ICT4RED Implementation Framework.* Each of the components (units of analysis) have been investigated through the use of case study research and these results informed the development of the framework which has been the designed by Design science research. This is illustrated in the figures below.

Hevner, March & Park (2004) were the first authors to provide an Information systems framework to show where design science research fits. This framework was later improved by Pirenen (2009) as well as Wang & Wang (2010). The figure below is adapted from Hevner et al. (2004) and Pirenen (2009) and indicates the relevance and rigour of design science research in Information systems and is also used as the theoretical framework for 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. In this framework people, organization and technology are three components of the environment of design research. Business needs are the driving force for design research so that design research can be relevant. Design research must add knowledge to the knowledge base so that it can be rigorous. The specific IS design science research process which has been applied in this initiative is illustrated in figure 1-8 below:

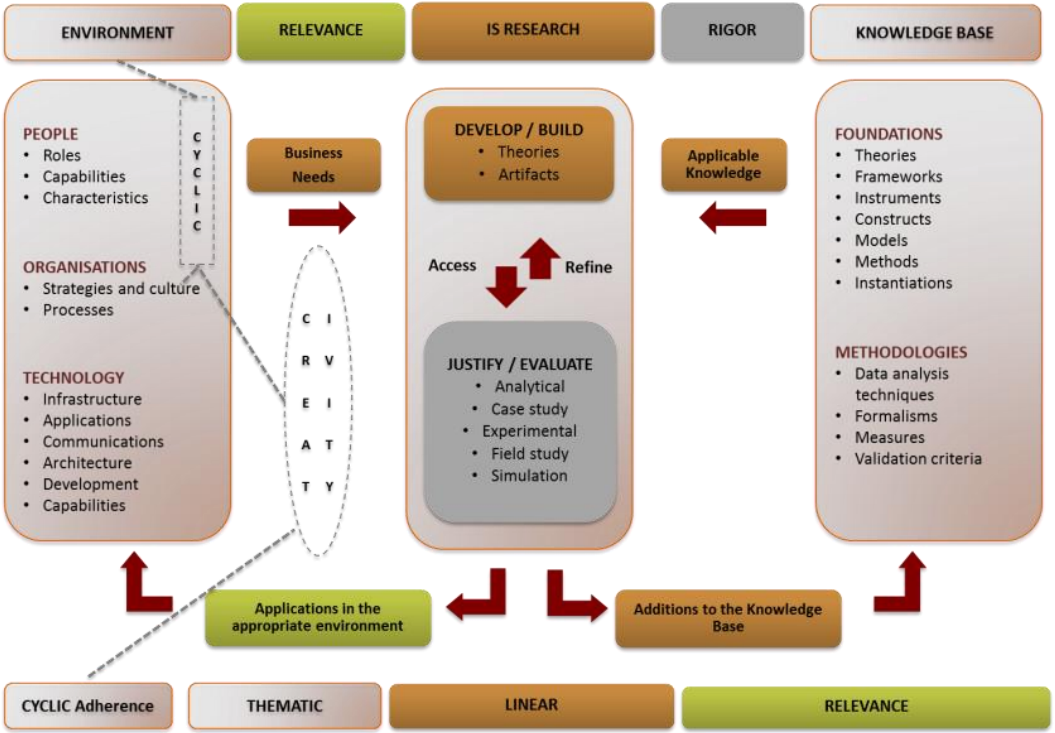


Figure 1-7: Information System Framework (Hevner et al., 2004; Pirenen, 2009)

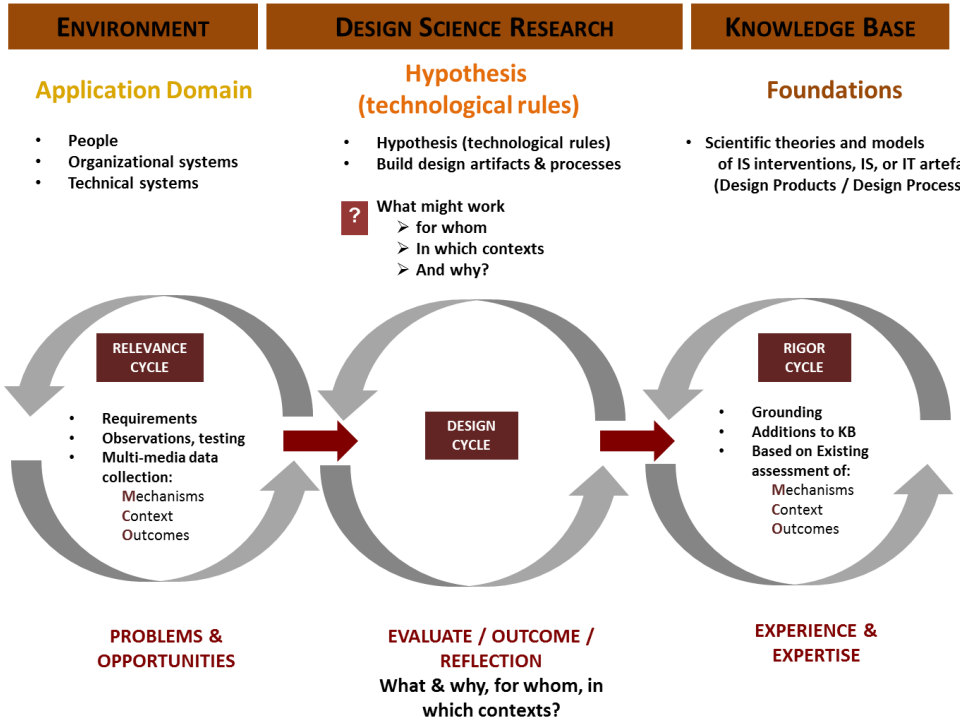


Figure 1-8: Information Systems Design Science Research Cycles (adapted from Carlsson, 2010, and Hevner, 2007)

1.3.1.1 Relevance Cycle

The *Relevance Cycle* initiates design science research with an application context that not only provides 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).

This initiative has identified a potential research opportunity as the lack of a framework for the development of 21st century school environments, which support access to digital content. A list of requirements as outlined in the relevance cycle will be developed for the resource constrained context as contextualized by the literature study of relevant case studies and position papers. The requirements will be reviewed by experts for validation to ensure the design is built on a solid foundation. The requirements will provide the input for the *Design Cycle* and will be used to evaluate the developed framework as an artefact and collect data on the mechanisms, context, and outcomes.

1.3.1.2 Rigor Cycle

The *Rigor Cycle* provides existing knowledge to the research initiative 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 to the original theories and methods made during the research, the new meta-artefacts (design products and processes), 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 has applied:

- scientific theories, methods, and meta-artefacts found through literature review;
- the researcher's expertise and experience; and

- the 12 component inputs of the model in the areas of mobile technology access and use for 21st century school environments.

1.3.1.3 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 framework which will be replicated to other provinces.

1.3.1.4 Design Science Research Guidelines

The seven guidelines to perform design science research in Information Systems discipline described by Hevner et al. (2004) will be followed 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 in this initiative
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	A Research-related operational ICT4RED framework has been developed as an artefact based on knowledge gained from the application of technologies and resources in the 26 schools.
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	The framework has been evaluated by the ICT4RED core team after each phase before replication and Monitoring and Evaluation (M&E) processes have been applied to evaluate the different

Guideline	Description	Application in this initiative
	methods	components of the framework.
Guideline 4: Research Contribution	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies	The elements of the framework have been able to contribute to new processes and artefacts which can assist schools to use technology enhanced learning resources to support teaching and learning. 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 framework 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 strengthening the elements of the framework.
Guideline 6: Design as a Search Process	The search for an effective artefact requires utilizing available means to reach desired ends while satisfying laws in the problem environment	Each component has developed their own research question, deliverables and methods which they applied to add to the knowledge base of the elements of the framework.
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, conference and workshops were done to communicate the framework.

1.3.1.5 Design Science Research Process (DSRP)

The proposed Design Science Research Process (DSRP) is consistent with prior literature (Hevner, et al. 2004; Hevner 2007; March and Storey 2008) and includes 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 is represented by the arrows between the various steps. The Design Science Research Process introduced by Peffers et al. (2007) was adapted for the design of the framework as depicted in the following figure:

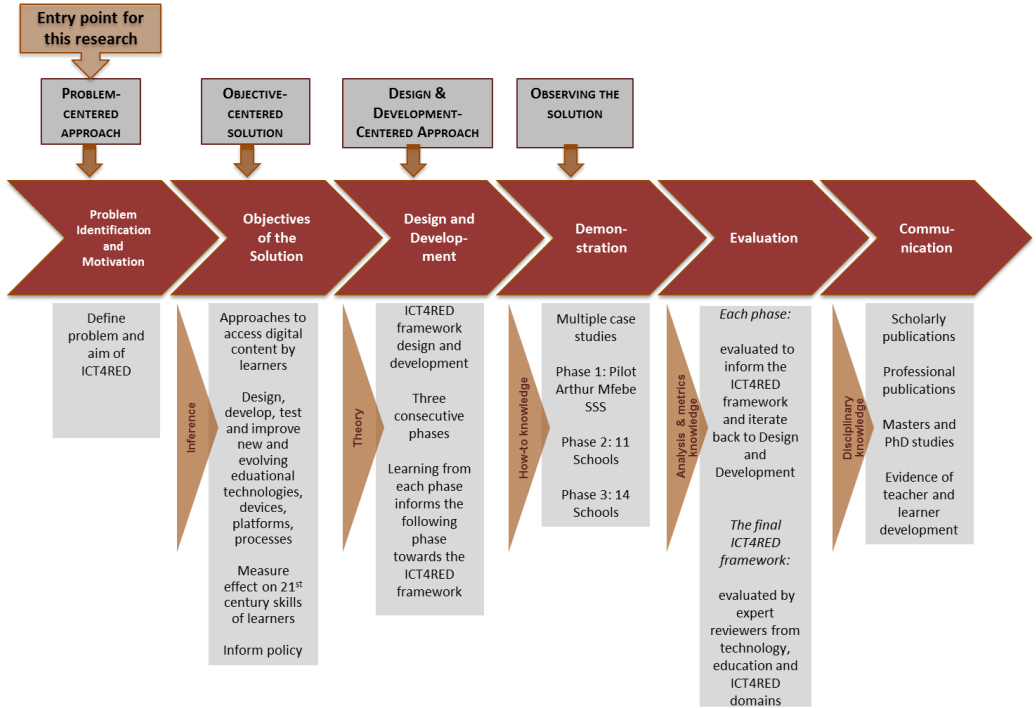


Figure 1-9: Design Science Research Process adapted from (Peffers et al, 2007)

The following figure explains how the final *Evidence-based ICT4RED Implementation Framework* was developed through the different phases as iterations and where the multiple case studies are included:

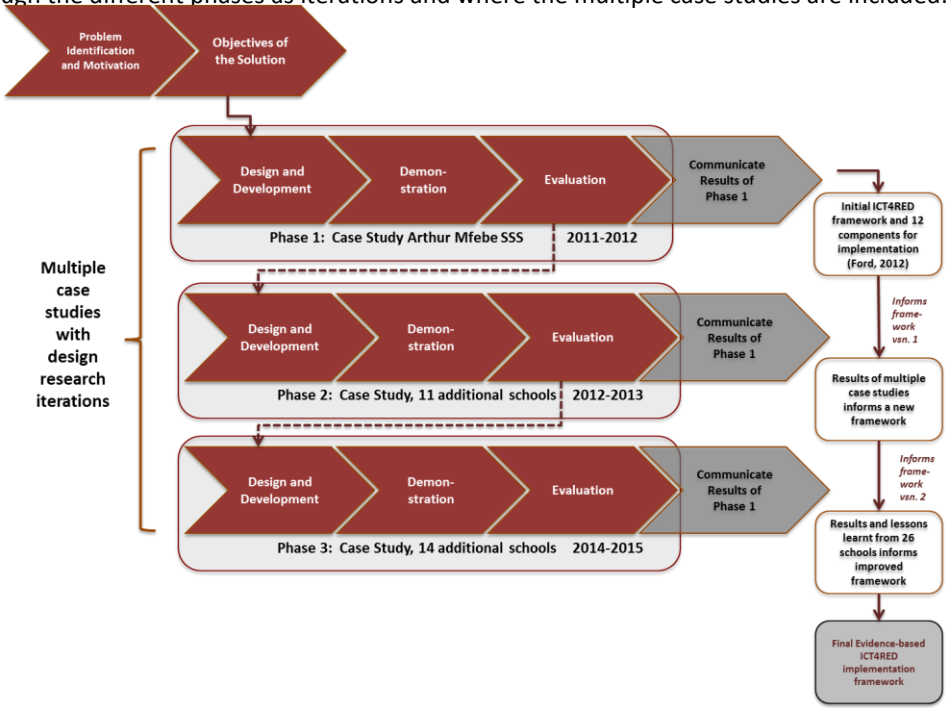


Figure 1-10: Design science research process with the multiple case studies and the deliverable from each

1.3.1.6 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, twitter and WhatsApp feeds and from the implementation of the various components.

1.3.1.7 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 them 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).

Experts from industry, government and academia were involved to validate the final framework.

1.3.1.8 Data verification

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

- Data triangulation which involves the use of a variety of data sources in a study. For this it will be the participants (teachers and learners at the 26 schools as well as community representatives and leaders and Department of Basic Education's district officials and circuit manager), existing documentation relevant to the study and external experts in the 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 observations, interviews, photographs, video clips, anecdotal stories as well as twitter and WhatsApp feeds.

1.3.1.9 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) points out that the hermeneutic analysis is "logically a circular argument in so far as the whole, in terms of which parts…" in other words "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 while looking into the complete picture. It also analyses the complete picture while looking at the various separate texts that contributed to the whole picture. This will be done through the hermeneutic circle.

1.3.2 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 is based on four stages which will make up the hermeneutic circle. This consists of the following:

- Stage 1 and 2: Study of the literature review based on the hermeneutic cycle in order to produce an initial framework for the components
- Stage 3: Conducting multiple case studies at the various 26 schools to improve on the initial framework
- Stage 4: Develop and evaluate the elements with their processes and artefact of the framework at three different levels: Macro, meso and micro to theoretical framework from literature.
- Stage 5: Evaluate the framework 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 2 indicates these principles and how they have been applied to this research study.

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
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.	Applied in data analysis using Creswell's (2007:75) within-case, cross-case and holistic-case analysis template. Triangulation as well.
2. The Principle of Contextualization 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	Applied when highlighting the background history of the multiple case studies (26 schools within the Nciba school district).
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	The role of the researchers and component champions to reflect during field visits to the schools, observed the physical conditions of the schools and interacted with the participants (all stakeholders)
4. The Principle of Abstraction and Generalization 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.	It is envisaged that the framework will be able to be replicated and applied in other provinces thus generalization will be possible if the context specifics are taken into consideration.
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.	The interpretations of the data were done in light of the literature.
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.	Expert review inputs into the framework.

Fundamental principle for conducting and evaluating interpretive studies	How and where applied in this study
Similar to multiple witness accounts even if all tell it as they saw it.	
7. The Principle of Suspicion Requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants.	Data collected from participants was done anonymously. Multiple sources for data collection were employed 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 to assign reasons to them.

1.3.3 Ethical considerations

Ethics are the "norms and standards of behaviour that guide moral choices about our behaviour and our relationships with others" (Cooper and 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 IS 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 IS and social science domains (Babbie, 2005:62; University of Pretoria, undated).

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 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.

In summary the following was applied to guide the development of the final framework:

- **Philosophy:** The philosophy that has been chosen for the study is mainly pragmatism, but interpretivism was also applied on the results from the multiple case studies (of each of the 26 schools)

which were part of the iteratives of the design science cycle above.

- **Methodology**: The methodology used was Design science research, which was informed by qualitative multiple case study methodology.
- **Approach**: The data was analysed through both inductive and deductive means
- **Research strategy**: The strategy that has been undertaken to be used in the study is the multiple case study approach.
- **Data collection techniques used**: The data collection techniques that were used included primary data in form of the validations from the experts and secondary data that were sought from the 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 explained the how in research-related terms. The next section explains how the framework developed through the different phases.

1.4 Evolution of the Evidence-based ICT4RED Implementation Framework based on the phases

The ICT4RED initiative aimed to investigate the application and deployment of tablets, supported by other technologies (which include school infrastructure, network connectivity, E-textbooks and other electronic resources) in 26 schools to build a framework. The different phases of the initiative are depicted in the following table:

Table 1-3: Phases in the ICT4RED initiative

	PHASE 0 (2011/12)	REVIEW & 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
This phase tests the design and enables the initiative to try and test various things, so that the learning and research can be used to enhance the next iteration.		
	PHASE 2 (2013/14) – 1 +11 SCHOOLS	DESCRIBE
This phase takes into account the learning from PHASE 1, and essentially goes through a redesign process in order to implement the learning 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 can be documented and data and evidence can already be produced that is useful to implementers and policymakers.		
	PHASE 3 (2014/15) – 1+11+14 SCHOOLS	DEVELOP GUIDELINES
This phase does a final redesign, based on the learning from PHASE 2 and enables the initiative to improve the learning around both process and scaling. It is here where the initiative can make final recommendations, based on data and evidence as input to implementers and policymakers.		
	PHASE 4 (2014/15) REFLECTING	EXPLAIN & ADVISE
This phase reflects and articulates formal research findings to provide design heuristics of the initiative. These design heuristics need to be implemented with caution as it is highly contextualised in a specific rural resource constraint environment. The limitation and future recommendations for replication or scaling of the framework and models are provided. This is a snapshot in time as technologies evolve and many of the applications and designs are based on this timeframe.		

Each phase represents 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 has the buy-in of key stakeholders and has demonstrable impact on education and quality of life in the region.

Linked to the phases is the development of the *Evidence-based ICT4RED Implementation Framework* as after each phase the framework was adapted to accommodate new lessons learnt.

The phased approach is evident in the following figure:

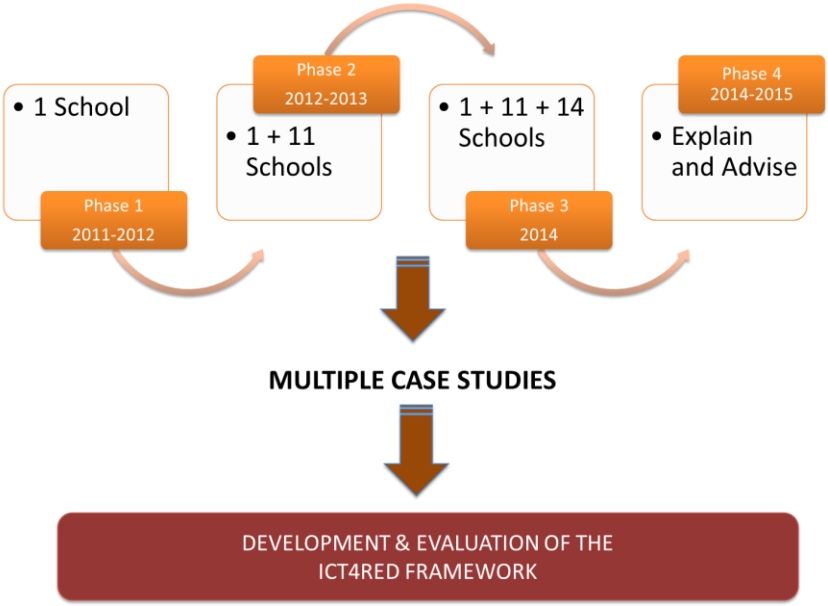


Figure 1-11: Phases and development of the Evidence-based implementation framework

Each phase will now be discussed.

1.4.1 PHASE 0

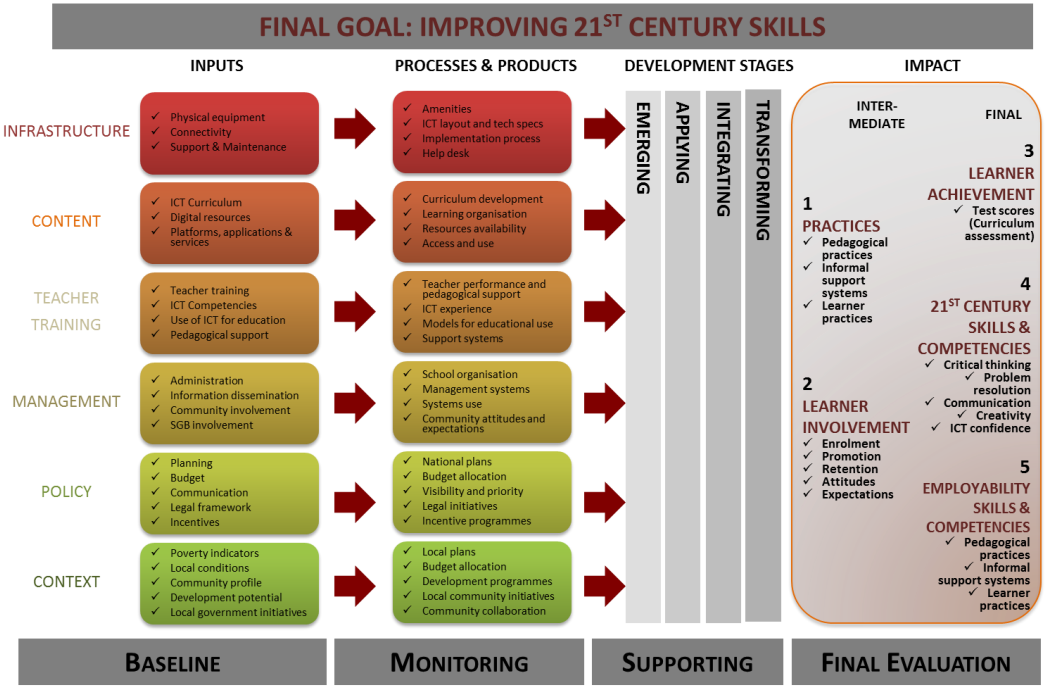
	PHASE 0 (2011/12)	REVIEW & DESIGN

Phase 0 included a thorough literature review to understand why some ICT4D educational initiatives where technology was deployed have failed and why some were successful all over the world. Also to determine which elements or components in those that were successful can be useful to incorporate into the ICT4RED initiative and framework. The ICT4RED core

team had to determine if other frameworks existed which could be used to guide the development of our own context-based framework. Lessons were also learnt by the ICT4RED core team in previous successful initiatives and deployment of technology in rural communities. All these played a crucial role during the initial phase.

In Phase 0 the framework had to be designed based on a thorough literature overview and components had to be selected to guide the operationalization and implementation of the initiative. 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 the most suitable to adapt for the purpose of the ICT4RED initiative. This developed into the initial ICT4RED framework as indicated in the following figure:

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



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

Figure 1-12: Initial ICT4RED framework

From the framework it is evident that various important input components about infrastructure, content, human resources, management, policy and context, leads to processes and products for each of the input components. These are then put through 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 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, the developmental stages are supported and final evaluation is done on the impacts.

The basic enablers 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 are competent leadership and educators together with informed parents. Access to ICT which resonates under adequate infrastructure were also regarded as important to reach the final goal to improve educational outcomes of which the 21st century skills and competencies are the most important to improve 21st century schooling. This can be achieved through the 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 the learners, teachers, schools, government and policy which can be influenced while the desired 21st century school environment can be achieved if ICT support teaching and learning and support are provided for informed and "smart" ICT decision-making.

To reach this ultimate goal, certain crucial components were identified from various literature sources, engagement and implementation of previous initiatives in rural areas and from the initial framework above. These components were necessary to change the current less of "traditional pedagogy" to 21st Century Classroom where there is more of an "emerging pedagogy for the information age". The changes should be focussed on the learner and his/her home, the teachers and the school as well as on government and policies on ICT in schools. The components which were 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. These 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 & Evaluation	Forms the basis of the initiative and to monitor and evaluate 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 & 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, who was given the responsibility (with support from the Programme and 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.

1.4.2 PHASE 1

	PHASE 1 (2012/13) – 1 SCHOOL	EXPLORE

Phase 1 comprised of an exploration at a single senior secondary agricultural school, Arthur Mfebe Senior Secondary school. In 2012, when the pilot took place, the school was comprised of a principal, 12 teachers and approximately 240 learners in grades 10, 11 and 12. Of these, 39 learners were in Grade 12.

Arthur Mfebe SS 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 m^2 of plastered brick buildings with Pitch Metal roofs made up of separate rooms that vary in size between 5.6m^2 and 83m^2 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 it is in need of refurbishment. The school makes use of a borehole/well on site as a source of water supply, there are 3 taps used for drinking water and as per 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. 2 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 for 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 library of the school has been converted in a staff room for the teachers where they attend to administrative task and for relaxation. 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 not any sports grounds. Evening classes are offered at the school, these classes are compulsory for the Grade 12 learners and optional for Grade 10 and 11. Arrangements were made with the Grade 12 learners who stay far from school to be accommodated closer to school in order for everyone to 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, grandson of the school founder.

In 2013, Arthur Mfebe SS has been converted to a secondary school for grades 6-12 and has received additional staff and learners. Related to the ICT4RED initiative, an ICT committee has been established and is taking 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 consists of:

- charging station and safe room,
- a server with content,
- a Biogas alternative energy system,
- outbuildings which host the piggery and chicken section were erected,

- a satellite connection was installed to provide for Internet access,
- multiple Wi-Fi points linked to the server and internet has been installed to connect the whole school, and
- new flush toilets were installed.

In order to implement the ICT4RED initiative the following process was followed:

Step 1: This step focuses mainly on explaining the ICT4RED initiative to district officials

Step 2: Meeting with the Principal and Deputies and school governing bodies in order to create buy-in. This stage mainly consists of meetings. Upon buy-in the Principals, Deputies, and allocated ICT champions attend a workshop focused on ways to support the roll out of the tablets in order to ensure integration and sustainably.

Step 3: This step focuses on continued Teacher Professional Development where teachers are equipped with skills on how to use ICTs in teaching. Teachers are expected to complete homework and show how they would integrate the tablets in their classroom. Teachers who graduate and complete their courses earn technology for their schools. This model is known as "Learn to earn".

Step 4A: This step consists of the installation of Mobikits (kits where tablets are charged and kept for safety), Mobihub, local Wi-Fi, and local content (see photos in Section IV below).

Step 4B: After Step 3, the learners are given tablets while their teachers continue with training. At this stage, once Wi-Fi is installed in the school, the school is linked with other schools. This will allow the teachers to share content. Technical support is also appointed within the school as well as pedagogy support. 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 expands the initiative to other schools to provide tablets to grade 12 and then to grades 10-11.

Step 5B: The operational management of the school is supported with the election of an ICT committee and to determine the operational management and technical support.

Step 6: Expansion to new schools and take the lessons learnt from this phase to improve framework for next phase.

The figure below outlines the steps that were taking in implementing the ICT4RED in Phase 1 at Arthur Mfebe Senior secondary school.

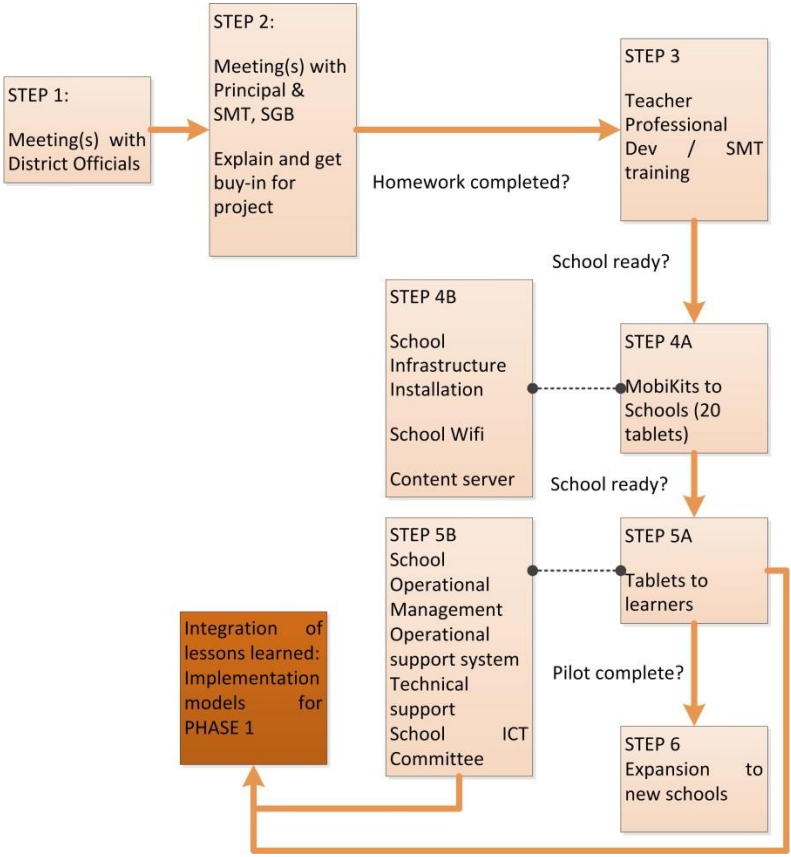


Figure 1-13: Step-by-step process in Phase 1

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

- An ethnographic study one year after the tablets were introduced to the first school identified many clear positive behavioural

changes in both the teachers and the learners at the school as well as gaps that still existed;
- A self-evaluation report was developed by the Monitoring & Evaluation (M&E) team for Phase 1 of the initiative, where interviews were undertaken with teachers, district officials, learners, community leaders and implementers. The feedback from this report was invaluable in helping to cement the design components.

Lessons learnt that influenced the adaption of the components:

The following lessons were learned which informed the adaption of the components with the elements and these were that:

- All of the teachers who 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 their 21st century skills that translated into a change in which classes are run.
- The most significant change, however, is related 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 schools 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, there have also been greater expectations 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 rise to the occasion and although it cannot be expected that all teachers' practice has now been transformed to always include technology, there certainly was more experimentation of this kind, going on in the school.
- The initiative directly impacted teachers, district officials and learners, whilst also providing an opportunity for the implementing staff to learn and develop their thinking about theICT4RED initiative.

By April 2013 the following numbers of 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 enriched teaching and learning	302 learners enrolled in Arthur Mfebe during 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	

This resulted in adapting the components with their elements of phase 0. 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 getting buy-in from the parents and 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 added as an understanding of what it would take to transform these schools. 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 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 of the initiative and to get the correct message out to the media and other interested parties. Thus after Phase 1 the names of the components, as well as the focus of these components changed and

this resulted in the following figure which was used to explain the updated framework:

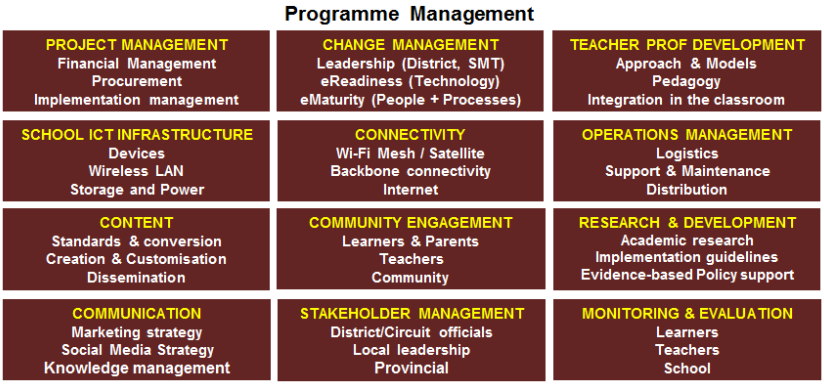


Figure 1-14: Updated framework after Phase 1

1.4.3 PHASE 2

	PHASE 2 (2013/14) – 1 +11 SCHOOLS	DESCRIBE

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 resources on the initiative.

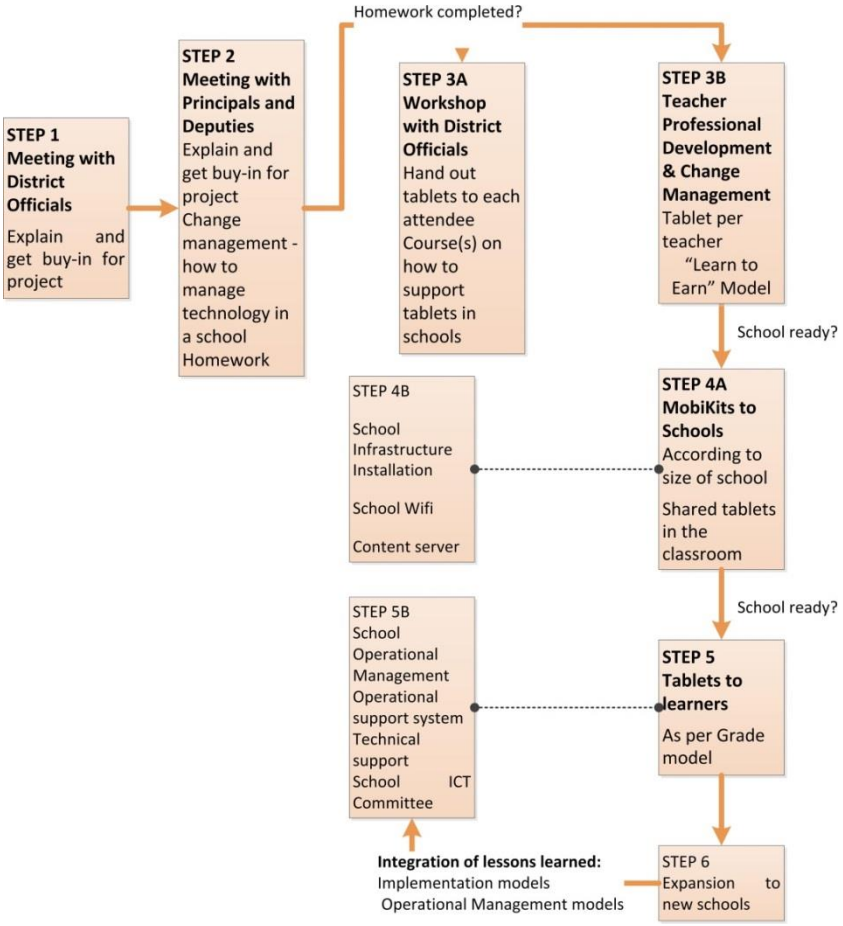


Figure 1-15: Step-by-step process followed in Phase 2

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

Apply, learn and develop "best practice"

In-depth desktop research was undertaken to gather information and learning from similar initiatives, particularly the One-Laptop-Per-Child (OLPC) initiatives in Peru and Venezuela. Experience from similar large

scale ICT for Development initiatives undertaken by the initiative team was gathered (covered in Phase 0)

- ***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 the design of the initiative. A Memorandum of Understanding was facilitated with each government stakeholder 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. A technology scan was undertaken in order to decide whether the initiative should employ tablets or dedicated e-readers and the pros and cons of each technology were taken to the Department of Basic Education. They made the decision to deploy tablets (covered in Phase 0).

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

An ethnographic study of Arthur Mfebe, the first pilot school, was undertaken to understand the educational challenges and practices before the provision of tablets to teachers and learners at the Phase 2 and 3 schools. The teacher professional development plan and courseware was then designed based on the results of this study. The courseware aims to expose the teachers to various teaching strategies that can be enhanced by tablets (covered in Phase 1)

- ***Empower the teachers first***

Since the teachers are the gatekeepers in the classroom, it was critical to get buy-in and active engagement of the teachers. Teachers needed to demonstrate competence in using the tablets to teach and the schools needed to prove readiness, before tablets were provided to learners (covered in Phase 1 and 2).

Prepare the schools

There was a big focus on change management, in terms of preparing the school to be empowered 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 (covered in Phase 1, 2 and 3).

- ***Technology must be earned***

It was felt that by "giving" technology to the schools, teachers and learners, it would give the wrong message. The teachers and learners needed to feel part of the initiative and 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 (covered in all the phases).

The following components were applicable in Phase 2:

Table 1-6: Components used during Phase 2

Component	Purpose and elements
Initiative 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.
Content	Standards, Conversion, Creation & Customisation
Operations Management	Logistics, Support & Maintenance Distribution
Communication	Marketing strategy, Social Media Strategy, Knowledge Management
Monitoring & Evolution	Learners, Teachers, Schools
Evidence-Based Policy	Academic Research, Implementation guidelines, Policy guidelines
Community Engagement	Learners & 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 need to be considered to facilitate the transformation of a prevalent traditional pedagogy to a technology enhanced emerging pedagogy for the information age.

Reflection and Learning after Phase 2

The following high-level learning points have emerged:

- The decision to start small and expand into the **circuit**, then potentially into the **district** and **province** was a good one, as it enables the system to absorb the changes, develop the skills and capacity to manage the technology and provides accessible support systems (e.g. school to school support). Sustainability becomes probable.
- The model being developed is **education-focused** NOT technology-focused. Teacher professional development modules enable teaching strategies with technology as a tool. Many of these can be used in the absence of technology as well. The expected outcome is better teaching.
- The **Earn as You Learn (EAYL) badge system** is incredibly successful. The decision is not to give technology to anyone, but for them to earn it by working for it, is something that can be widely replicated. It has led to impromptu study groups by teachers after school, as they work together to earn badges as individuals and as schools, so that they can get the rewards (such as an initiative for the school). All the Phase 2 teachers successfully graduate and 100% of the teachers earn 15+ badges (only 13 were compulsory).
- The outputs of ICT4RED are being understood better. There will still be strong **academic-focused research outputs** (e.g. books, papers, Masters and PhD theses), but there also needs to be **practitioner-based outputs** (e.g. a practitioner's guide) and **policy outputs** (e.g. policy guidelines).
- Excellent buy-in, trust relationship and **support from district** – from the top, all the way through to the officials – is a major contribution to success.
- It is 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 will be 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.

- The **ease-of-use** and **multimedia capability of tablets** lend 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 is due to the usability of the devices that the focus can change to **teaching with the devices**, rather than the "computer literacy" challenges of the past.
- Appropriate curriculum-aligned **content is still a major challenge**, especially for younger learners. There needs to be a push to get South African based contextual content developed that is designed for mobile devices. There also needs to be a renewed definition of content to make provision for digital, multimedia content types (or else you get the typical "textbook behind glass" syndrome).
- Content ONLY in the **cloud is NOT a viable solution**. The bandwidth challenges would be impossible – a study in the UK has specified that you would need 100mbs minimum bandwidth for a school of 700 learners. The solution being tested in Cofimvaba consists 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.
- The current model is based on **empowering the teachers** (tablets and professional development) and **preparing the schools** (change management and supporting infrastructure) before rolling out to the learners. This is working in most schools. However, there is a problem in dysfunctional schools – we will be testing a **learner-centric model** in one of these schools.
- It is difficult to select good tablets – there are problems even with so-called reputable companies. There are also MANY disreputable. We have developed a **multi-criteria decision-making tool** to support schools and test all tablets in the lab.
- There is a need to **revisit specifications every 3-6 months** as the technology improves
- Important to **develop standards-based criteria** and NOT product-based criteria for tablets – theoretically it shouldn't matter what brand tablet is selected, as long as it conforms to the standards –

gives parents/government choice based on budget and prepares the way for a "Bring Your Own Device" scenario.

- Currently the biggest challenge experienced with tablets is **battery power**. Tablets do not perform to spec and last 4-5 hours max. This points very strongly to a replacement policy of every 2-3 years as the technology becomes obsolete and unusable due to battery age.
- Urgent need to investigate **new network infrastructure opportunities** – TV Whitespace, LTE, 3G, etc. These issues are technically solvable!
- In a recent 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 can be a huge problem for the uninformed.
- It's critical to make provision for **secure charging** in the school environment – this has implications on power needs and costs in the schools

Photo 1-4: Secure charging station used in Phase 2

Based on these above lessons that were learnt, new adjustments were made to the initial framework under Phase 1. The following picture represents how the 12 components can guide implementation and which components are seen as enablers and drivers. This was the framework as it was viewed after the implementation of Phase 2. This conceptual

framework has been improved and expanded to show the relationships between the various components through every phase of implementation and as evaluation lessons were learned.

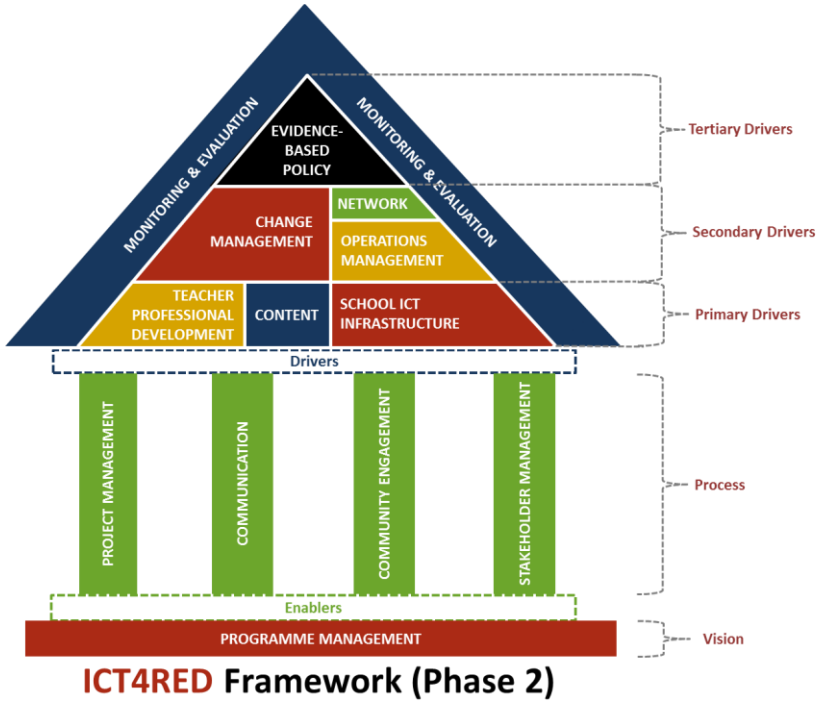


Figure 1-16 Conceptual framework emanating from the 12 components after Phase 2

At the bottom of the framework, the vision is that although programme 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. In the context of a school, this would typically be the principal.

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

- Initiative Management:

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

- Communication:

Communication is key to the success of any initiative of this type – whether it is between team members, to stakeholders (e.g. parents) or to the press.

- 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 that may need to be informed/involved. Make provision for extensive communication to get buy-in 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, through to the province (ECDoE) and on a national basis (DBE, DST and DRDLR). This will differ from initiative to initiative. Another important thing to remember 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:

A decision was made that teacher professional development would be the "golden thread" that runs through the initiative. All the other activities are 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 has paid off in a big way, exposing teachers to modern teaching methods that can be employed with *or* without technology.

- Content:

Making provision for content, particularly curriculum-based content is extremely important. In the digital world it's 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 that is 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. 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 came up with a school ICT infrastructure plan that suited the environment, rather than using the cookie-cutter approach.

SECONDARY DRIVERS:

- Change Management:

It is important not to underestimate the issue 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.

- 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. We are in the process of training young unemployed youth from the community, who will provide first line basic technical support in the schools.

- 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 to keep as much traffic local as possible, 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 [14].

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, content standards, etc. 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 you have reached your goal(s) or not and to inform decisions and processes as you go along. It's also important to share your learning with others, so that the same mistakes are not repeated.

The ICT4RED 12-Component Framework, as it was known after Phase 2, attempted to identify all the components for an initiative of this nature. It packages together and provides guidelines to support similar rollouts, in order to maximise the potential for success - in terms 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 1-5: Graduation Phase 2

1.4.4 PHASE 3

PHASE 3 (2014/15) – 1+11+14 SCHOOLS	DEVELOP GUIDELINES

The expansion to the other schools for PHASE 3 has adapted the process below. It is based on the new lessons learned from PHASE 2 and developed an amended strategy and plan.

The ICT4RED initiative undertook a very flexible, but process-driven implementation approach.

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

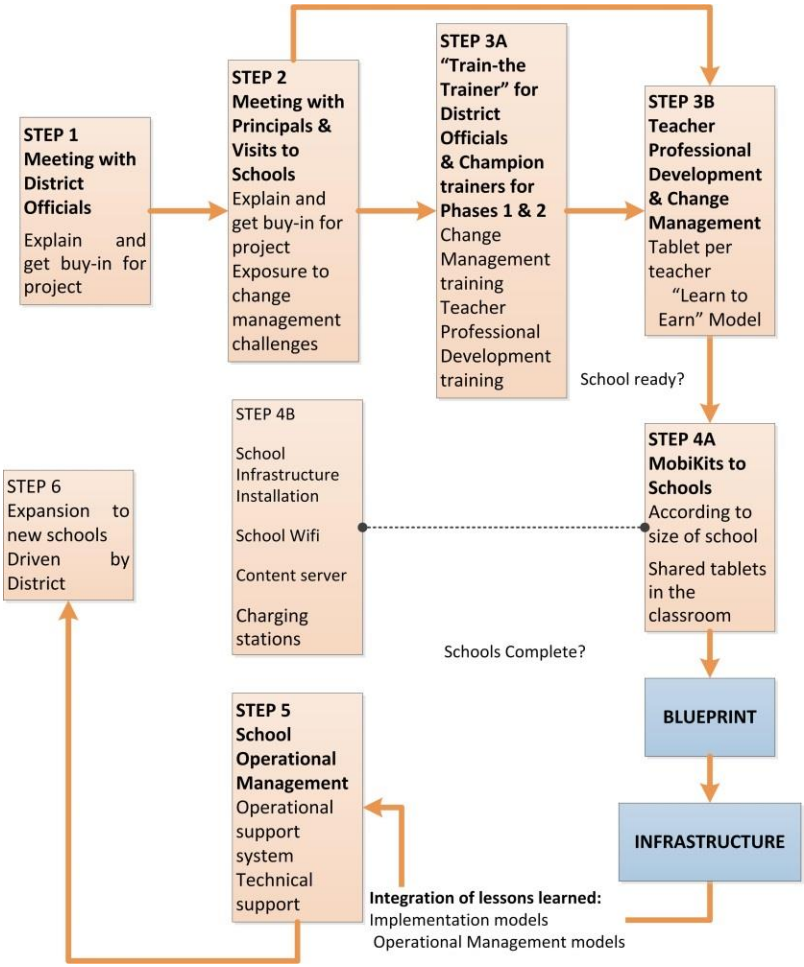


Figure 1-17: Step-by-step process followed in Phase 3

- At the centre of this initiative is the teachers' engagement with the Teacher Professional Development Component. This component is what makes this initiative a success. Attendance is high and teachers are starting 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, is 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 are using their tablets now for administrative tasks as well. Supporting and refresher courses for the Phase 1 &2 teachers who have successfully earned their technology is important. What teachers now did included teaching learners using videos, accessing information from the contents provided by ICT4RED, doing Online Assessments. Some respondents also noted that these changes in teaching and learning have led to a significant change in learners' attitudes and attention in the class.

- A sustainability plan and strategy have to be developed by various stakeholders in the Nciba school district like the circuit manager, district officials and Eastern Cape Department of Education to support ICT champions at schools and address other ICT architecture issues like tablets upgrades, tablets problems, Internet and Wi-Fi connection problems and training of new teachers after the ICT4RED initiative ends.
- Schools also report a change in way the district interacts with them after the initiative commenced in their school. Especially the officials involved in e-learning and institutional development are visiting schools more frequently and assisting with tasks such as co-ordination of training, assisting in incorporating tablets into teaching, providing moral support and boosting teachers' confidence, suggesting strategies on how to keep tablets safe. It seems, however, that there is a change in behaviour even at organizational level.
- Almost all teachers reported becoming more comfortable with their technology, and there is evidence that the initiative contributed towards more positive attitudes towards using technology for teachers.
- 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.

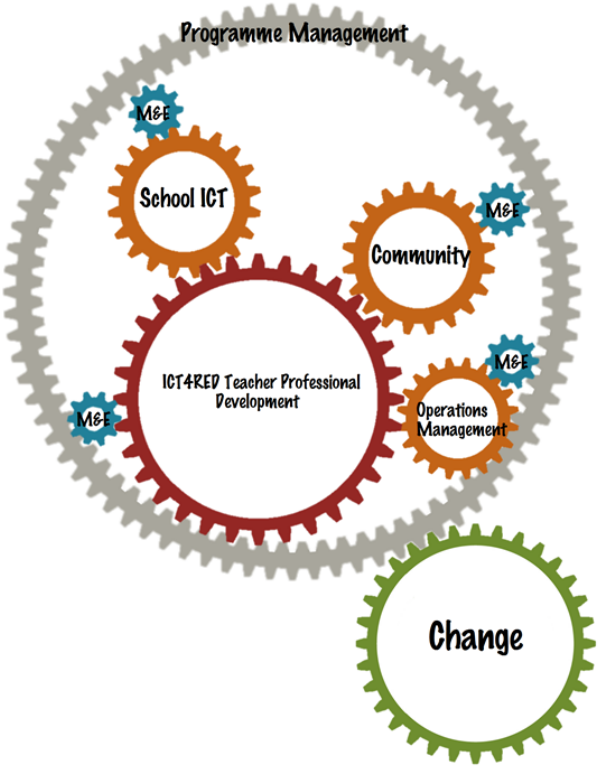
- The ICT4RED initiative attempts to influence practice in the ICT for Education field, by sharing its learning via the ICT4RED blog (ICT4RED.blogpost.com), engagements at gatherings of practitioners and by producing specific outputs targeted for use by practitioners.
- For practitioners, the ICT4RED Teacher Professional Development Course (as discussed in section II of this book) is made available online under a Creative Commons Attribution-Non-commercial-Share Alike 3.0 licence. There was also some interest from persons located in the government departments associated with the initiative, and two education department officials from provincial education Departments downloaded the material in order to influence their own thinking on teacher training. This resource, therefore, has the potential to have a real impact in how different stakeholders actually approach their own work in ICT or Education.
- The team members have also been invited to practitioner focused gatherings with stakeholders involved in Education locally and internationally, in publishing, and also in ICT for Education work.
- The initiative has also already had some fairly high level interactions with policy makers and implementers. Other Provinces (North West, Gauteng Education Department) are engaging with the ICT4RED team to incorporate the training modules for their teachers.

This feedback and own experiences of the ICT4RED team have resulted in adapting the components to develop the final *Evidence-based ICT4RED Implementation Framework*. The components which have to be adapted are mainly the drivers as TPD has now become the centre around which everything else happens and supported or influences or enables the TPD component. 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 difficult if the conversation is techno-centric.*

Other changes to the components involve the evolvement of PROGRAMME MANAGEMENT to incorporate evidence-based policy, a different community as well as managing the communications about the initiative to external parties. OPERATIONS MANAGEMENT should also include the management of content, devices, infrastructure and support and maintenance. ICT ARCHITECTURE becomes SCHOOL ICT component and it hosts all the school related ICT hardware, software and infrastructure decisions and issues. A new central focus has to be provided to COMMUNMITY ENGAGEMENT which now becomes the community consisting of people and organisations internally to the specific context. MONITORING AND EVALUATION still stays the overarching component which measures success and failure but also impact. It is now on the periphery and overseas the whole initiative including programme management.

Based on these adaptions the new and final ***Evidence-based ICT4RED Implementation Framework*** can be found on the following page:



Programme Management
Stakeholder/partners
Ethics
Evidence-based policy
Community
Universities
Domains (Education, ICT4D)
Communication
Budget allocation
Project knowledge Management
Talks
Blog, social media, conferences
Workshops
Publications

School ICT
Software selection
Server
Tablets content
Hardware selection
Tablets
Mobikit cases
Infrastructure
Connectivity
Local network
Wi-Fi
ICT committee
Social media
Storage
Mobikits
Charging stations

M&E
Developmental Evaluation
Impact
Theory of change
Theory of Action
Lessons Learnt
Sustainability

Operations Management
Project management
Infrastructure management
Storage
Hardware installation
Procurement
Device management
Support & maintenance
Content management
Curriculum content curation
Program content artifact

Community
Internal stakeholders (district, circuit, principals, teachers, learners, parents, local businesses)
Schools change in vision and mission
Funding & graduations
Co-creation

Change
Emergent pedagogy
Impact
Sustainability
Ownership
Uptake &use

ICT4RED TPD
ICT4RED TPD 10 Modules
Gamification
Earn as you Learn
TPACK

Figure 1-18: Evidence-based ICT4RED Implementation Framework after Phase 3

After the Phase 3 implementation of the ICT4RED initiative it was realised that **PROGRAMME MANAGEMENT** is necessary to manage, coordinate and support the other components of the initiative. It drives the whole initiative and its function is crucial for the high level implementation and feedback to stakeholders.

In this component it is important to engage with high level stakeholders and partners which involves the Government departments (DRDLR, DBE, DST), Research councils (HSRC), CSIR management (for reporting), province managers (Eastern Cape Department of Basic Education officials), community managers (Tribal leaders, chiefs) and publishers. This component report to DST and DRDLR (main funders) on impacts and results and receives inputs from component champions. Through this component applications for ethical approval is gained and in this component advice is given on evidence-based policy to high level stakeholders. This component recommends actions that have to be taken for long term sustainability. The community in this component will include negotiations with universities to collaborate and to influence the domains of Education and ICT4D. Initiative knowledge management in this component deals with the channels through which information on the initiative is communicated to the outside. This involves the talks on radio shows or to newspapers on the initiative, the website initiation and maintenance, Blogs, Social media feeds, conference and workshop presentations as well as publications on the initiative. This component is discussed in more detail in Section IV of this book.

OPERATIONS MANAGEMENT is also a support function to allow for Teacher professional Development to take place through technology. TPD needs this component as it cannot function without it. This component involves the initiative management through Prince 2, infrastructure management like selection and provision of storage facilities at schools, oversees installations of hardware at schools. Procurement is done in this component of the entire technological infrastructure needed to implement this initiative in all schools with the same process and procedures. Device management (log calls) and support and maintenance falls in this component. Content management is also done in this component which involves curation and organisation of curriculum content on the server and tablets. Selection of applications for the tablets and loading these onto the tablets is managed from this component. Distribution of hardware to the

circuit manager, contracts with local and other suppliers and logistics support are also managed within this component. This component is discussed in more detail in Section IV of this book.

SCHOOL ICT component enables TPD at school level as it pertains to all decisions which are school specific. It involves the software selection for the tablets, server and content on these), hardware selection like the tablets selections and what should a Mobikit contain and how should the cases for these be designed. This component also involves the infrastructure decisions on connectivity (3G, Satellites) and how the local area network will look like and where it will be installed. The Wi-Fi and the type of security for the storage units as well as the types of charging stations for the tablets are decided within this component. The School ICT committee selection for each school resides in this component and more detail on this is provided in Section IV of this book.

TEACHER PROFESSIONAL DEVELOPMENT is the main driver and involves the training of the teachers and district officials on how to use the technology to support their teaching and learning. This is done through a 10-module training course and completion of each module involves the reward of earning a badge associated with the specific module. If the teacher can provide proof on how the module was applied in his/her classroom a badge is awarded (by independent assessors). If a teachers earns 10 badges he/she has successfully earned their technology. This component is built around principles of gamification and rewards as well as teaching strategies and not skills development. The aim is to support teachers to change their ways of teaching by using mobile tablets to enhance their teaching. Through implementing this component it was realised how important it is to empower teachers to feel confident in using technology and to open up minds on new creative ways of teaching. Learners are not trained but they benefit as they too can work on tablets with the teachers in groups or as individuals depending on decisions taken by the ICT Committee at each school. This component is discussed in more detail in Section II of this book.

This component needs the SCHOOL ICT and OPERATIONS MANAGEMENT to be applied. It also empowers and disrupts organisations like schools, provincial Departments of Education and internal stakeholders of the initiative in the community. This influence the following component: **COMMUNITY ENGAGEMENT** which are the community itself in Nciba

school district as its context. People and organisations which are affected by this initiative include internal stakeholders which are the district and circuit managers, subject advisors, principals, teachers, learners, parents and local businesses. All of these stakeholders have to be managed differently from the stakeholders who are under programme management as a component. These internal stakeholders all have to undergo change management training and support as schools have changed their operations and this can affect their vision and missions as well as funding allocations. The community has to become part of celebrations like graduation ceremonies when teachers earn their tablets or fun days are held to showcase the initiative. Teachers also form their own communities of practice based on the subjects they teach and sharing of lessons plans and success stories. Co-creation takes place with teachers as they apply different teaching strategies in their own classrooms (which were in the modules) in their own subjects and grades and they provide evidence of how they have applied it. This component is discussed in more detail in Section V of this book.

MONITORING AND EVALUATION is done from initiation of the initiative until its end. Throughout the initiative it was documented what worked, what did not and why. Based on the evidence collected some recommendations are made. Learning brief, impact stories and successes with failures are documented and shared with funders. All of these were done through the application of specific data collection instruments (as outlined in Section III of this book). The impact of the initiative can thus be provided over a period of 3 years and based on these evidence-based results, informed recommendations and advice can be provided to influence policies on technology integration in resource deprived schools and environments. From our experience of operating as change agents and researchers, we are suggesting that successful implementation is a function of the relation between the nature of the evidence, the context in which the proposed change is to be implemented, and the mechanisms by which the change is facilitated.

The effect of these above main components results in **CHANGES, which affect impact and sustainability.** There is a change in the emergent pedagogy of the 26 schools after the initiative. The 21st century skills of teachers and learners have been influenced. Impact is also seen on the community as they can now use technology to improve their lives (internet

banking and access to information which was previously only obtainable in libraries). Learners have access to more resources on the servers to assist them in preparing for examinations. Teachers were empowered with knowledge on how to use technology in their classrooms and to apply new teaching strategies; they also could use Applications on the tablets, which are linked to their subject, to support their teaching. The principals can now communicate via e-mail and not just over the phone or in meetings. The province and circuit manager have developed a sustainability plan to support teachers and learners after the initiative and to plan ahead for updates. Schools are better equipped with electricity, security, storage and charging of mobile devices and with satellites and Wi-Fi for Internet access and for downloading content from servers. Access to content from well-known and reputable publication houses is free on the servers. Schools all have an ICT committee which takes decisions about the use of the technology in their school. All schools have an ICT support person to assist with bookings and maintenance and support of the technology at their schools. Other provinces are duplicating the training material for their teachers. Universities are developing the training material to offer short courses to industry and other academia. Overseas universities are translating the training content into Arabic to use in Morocco. Advice is provided to other schools and lessons are shared at conferences, workshops and at forums. The overall changes are mostly positive and initiative is well received both nationally and internationally. The uptake and use of the technology have affected every person who was part of the initiative. There is ownership and use which all affect impact.

The final framework can be referred to as an Evidence-based framework as all the evidence that was collected and lessons which were learnt as the ICT4RED initiative was implemented in every phase provided a better understanding of how the final framework should be portrayed. It cannot be portrayed as a house with pillars anymore (phase 2) as the cohesion of components are lost and the essence of what the evidence indicated in every Design science cycle showed that TPD has to be the main focus around which all the other components should be rotating to form a whole and to see impact and changes over a 3 year period. The other components are all drivers to support and enable TPD to empower teachers to use technology to innovate themselves and their classrooms.

1.4.5 PHASE 4

	PHASE 4 (2014/15) REFLECTING	EXPLAIN & ADVISE

This last phase is where the final *Evidence-based ICT4RED Implementation Framework* is subjected to experts for review both internally (Participants and core team) and externally (policy-making stakeholders and funders). This is also the phase where the ICT4RED team can use to reflect and complete final deliverables like the following which was also articulated under the initiative aims and objectives:

- Sustainable approaches to providing access to digital content by learners at resource-constrained rural schools in South Africa;
- Design models for teacher professional development that focus on "how to teach with a tablet", rather than "how to use a tablet";
- Present final tested educational technologies, devices, platforms and processes that support the access to digital content for rural school environments;
- Measure the effect of this initiative on the 21st century skills of teachers and learners; and
- Use the evidence to inform policy.

The learning from this initiative is being designed to feed into the system in a multi-dimensional way, to a variety of stakeholders in the educational eco-system and resulted in the following outputs:

- Evidence-based policy outputs (guidelines, models and frameworks, standards, recommendations, policy briefs) to national and provincial governments
- Practitioner outputs (planning and implementation guidelines, tools, templates, checklists) to various practitioners (schools, NGOs, provincial implementing agencies, etc.)
- Research outputs (conference papers, books, journal articles) to the ICT4E and ICT4D research community
- Decision-support tools

If the Design Science process applicable to this initiative is re-visited it is evident that this last phase is where the last two blocks (Evaluation and

Communication) are the focus as illustrated on the Figure on the following page.

This book is evidence of how the communication aspect (last part of process) can be supported.

The final framework was send to 6 experts (5 have PhDs) with the following background and expertise:

Table 1-7 Expert reviewers and their expertise to evaluate the framework in Phase 4

Expert and field of expertise	Experience
Two from Education	One has been an established researcher in the field of Education for 17 years and has worked with many NGOs and industry partners to deploy technology in resource constraint environments. The other one has 12 years lecturing experience at an established South African university and has been working with teachers on a daily basis.
One from Informatics	This person has 8 years' experience in developing models and frameworks for business analysis field and works at an established South African university as a Research Professor.
Two (one national and one international) from ICT4D implementation in rural areas	One person is from a well-known UK university who has written numerous publications on ICT4D implementations and the impact of technologies in rural communities. The other expert is from a research council (with a PhD) who has been deploying and testing technology products in rural communities for over 10 years.
One teacher who are teaching in a resource constraint school	This teacher holds a Master's Degree and has been teaching at a resource deprived school for 9 years now.

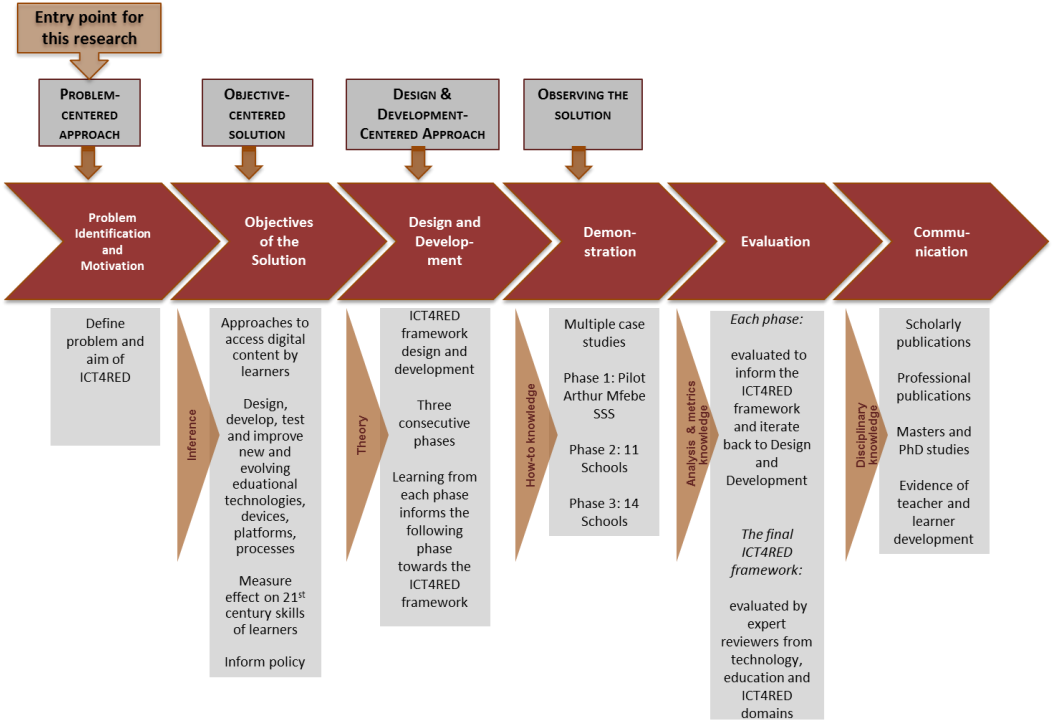


Figure 1-19: Design science process applicable to ICT4RED

The diversity of experts is important as it provided credibility to the final framework. Experts provide a higher level of feedback which validates an idea as their inputs are regarded as trustworthy and valuable.

From the feedback the following was indicated:

- The framework can work well in the specific resource constraint environment if replicated.
- This is valuable to any ICT4D initiative, which wants to start with deployment of technology to support teacher development through ICT.
- This should be shared to a wider audience and tested in other environments as well.
- I will not change it! It works well and provides insight into the importance of empowering people first before providing technology. Monitoring and evaluation of everything is also important.
- For sustainability it is important to have operations management, School ICT and programme management separately as they operate on different levels to support the TPD.
- This is an implementation framework with enough evidence of how it was improved through different phases. This is valuable to anyone, from Education to ICT4D practitioners and industry.
- I wish every initiative of this nature; can have this before they embark on providing technology to schools.
- It provides a high level view of all the most important things to consider before embarking on deployment of technology in schools in this context where schools are under-resourced.

The feedback from the experts was all positive. Their feedback first and foremost supports the layout and focus of all components in the framework. It highlights the importance of context, schools, ICT management, development of teachers and the monitoring and evaluation of all of these from beginning until end to affect change. All components should be supporting Education in an ICT4D context to have impact and sustainability in the long term. It is a wish from this initiative that this framework can inform innovation initiatives in schools through ICTs and that government departments apply this whenever they want to deploy any type of technology to support teaching and learning. It can be cost

intensive, but it indicates what should be considered before deploying technology in schools.

The NDP vision 2030 (2011) emphasizes that South Africa needs knowledge that equips people for a society in constant social change. It believes that quality education encourages technology shifts and innovation that are necessary to solve present-day challenges. The NDP argues that education, training and innovation are not a solution to all problems, but society's ability to solve problems, develop competitively, eliminate poverty and reduce inequality is severely hampered without them. Thus, schools are the building blocks for learning and socialization and the quality of the schooling system impacts significantly on further education and society's ability to innovate. However, UNESCO Bangkok asserts that in order to make successful use of ICT in enhancing the reach and quality of teaching and learning, policy makers need to be aware of how ICT can be of best value in their country's education system, and need to develop a supportive policy environment and framework at the national level for the integration of ICT into their education systems.

In the ICT4RED initiative the main contributions can be divided into theoretical, methodological and practical contributions and 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 artifact. For the purpose of this initiative the artefact will be a framework, which can guide the implementation of similar initiatives in similar context.

- ***Contribution to research methods***

The challenging environments where the ICT4RED schools are situated are plagued by dire poverty, traditional hierarchical and patriarchal community structures, language barriers and low literacy levels. 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 experience 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 Evidence-based ICT4RED Implementation Framework. 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. 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 framework and many other decision-support tools (tablet selection, Total cost of ownership).

- ***Practical contributions***

On practical level this initiative provided the following:

- A refined framework adapted to specifically suit the requirements of the rural education system with crucial elements which has to be considered if applied in other contexts. Processes (Operational and procedures with guidelines will also be provided on how to implement such a framework.
- Recommendations and advice at policy level.
- A better understanding of the role mobile technologies can play in developing 21st century skills in rural schools.

1.5 Conclusion

The Section I of the book provided an overview of the where the ICT4RED initiative originated from and how it was approached from an operational as well as from a scientific methodological perspective. The different models which will be investigated of which some will be provided in this book have been indicated. The proposed *Evidence-based ICT4RED Implementation Framework,* which was developed, was also provided as well as what the envisaged contributions were of this initiative.

The rest of the chapters in the book will cover the most important drivers of the initiative. Some overview and results of the enablers will also be provided.

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SECTION 2: Teacher Professional Development

A. Botha

2.1 Introduction

The development of the Evidence-based ICT4RED implementation framework was indicated in Section 1. In this framework the importance of the Teacher Professional Development component was explained and it became evident that the classroom interaction in the participating rural schools had to change in a way that would accommodate the introduction of appropriate ICT's. The 21st century teaching and learning engagement was identified as the most appropriate interaction that would facilitate this need. A curriculum was conceptualised based on the Mobile Learning Framework. The framework was essentially a domain effort to articulate the current understanding of how mobile learning can contribute to educational gains (Botha, Batchelor, Traxler, de Waard, & Herselman, 2012). This resulted in the *ICT4RED Teacher Professional Development (ICT4RED TPD) Course* as an instantiation of the Mobile Learning Curriculum Framework, which was piloted at one school in 2012, and refined through the two further iterations. The second iteration scaled to 11 schools and the third to 14 additional schools. In total therefore the engagement extends to 26 schools. This engagement will encompass 6 500 learners, 350 teachers and 32 district officials.

The rest of the chapter aims to share the methodology used, the main findings from the literature that guided the *ICT4RED TPD Course* design, the use of the TPACK model as a theoretical framework, design decisions that were made, design strategies that were used and the resulting design heuristics

2.2 Methodology used

The TPD Course aimed to guide the development of relevant teacher knowledge and proficiency to enable classroom practice to portray a 21st century teaching and learning engagement.

In creating the modules for the Teacher Professional Development component, the design science methodology was applied. This

methodology was also explained in Section 1 and from figure 8 in Section 1 the same Design Science process was followed to develop the TPD course. Design Science research focuses on creation and the purpose of design is "to change existing situations into preferred ones" (Hevner & Chatterjee, 2010).

The phases were:

	PHASE 0 (2011/12)	REVIEW & 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
This phase tests the design and enables the initiative to try and test various things, so that the learning and research can be used to enhance the next iteration.		
	PHASE 2 (2013/14) – 1 +11 SCHOOLS	DESCRIBE
This phase takes into account the learning from PHASE 1, and essentially goes through a redesign process in order to implement the learning 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 can be documented and data and evidence can already be produced that is useful to implementers and policymakers.		
	PHASE 3 (2014/15) – 1+11+14 SCHOOLS	DEVELOP GUIDELINES
This phase does a final redesign, based on the learning from PHASE 2 and enables the initiative to improve the learning around both process and scaling. It is here where the initiative can make final recommendations, based on data and evidence as input to implementers and policymakers.		
	PHASE 4 (2014/15) REFLECTING	EXPLAIN & ADVISE
This phase reflects and articulates formal research findings to provide design heuristics of the initiative. These design heuristics need to be implemented with caution as it is highly contextualised in a specific rural resource constraint environment. The limitation and future recommendations for replication or scaling of the framework and models are provided. This is a snapshot in time as technologies evolve and many of the applications and designs are based on this timeframe.		

The phases were also explained in the development of the evidence-based ICT4RED implementation framework. These will now be used to explain

how the TDP modules evolved over the last three years during each of the iterations.

2.3 Phase 0

2.3.1 Criteria from Literature

Literature abounds with case studies and reports that highlight the opportunities as well as the challenges of implementing ICT in the classroom. Both challenges and opportunities seem to magnify when considering ICT in the resource-constrained classroom environment. A resource constrained environment for the purpose of this chapter is best described by Anderson, Anderson, Borriello, and Kolko (2012) as environments where there is low-income communities and low bandwidth. These environments provide unique limitations (e.g., cultures where people are unfamiliar with or afraid of technology, environments where power and network connectivity are scarce and expensive).

A recurring narrative in efforts to reform education is the inclusion in the use of ICT underpinned by the expectation that it would fix schools (Vrasidas, 2014). Although there is consensus that ICT can potentially improve educational outcomes, there is also an abundance of literature that confirm that hardware and networks are only the backdrop to realizing this goal (U.S. Department of Education, 2013). The implementation and use of ICT in the teaching and learning interaction remains one of the most significant factors towards this end. As teachers habitually fall back to using ICT's in traditional ways, the challenge remains to change practice (Aldunate & Nussbaum, 2013; Cuban, 2009; NESTA, 2012; Vrasidas, 2014). Voogt and Odenthal (1999) in a large-scale initiative "Emergent Practices Geportretteerd" investigated examples of innovative implementations of ICT in educational practice with the aim of identifying characteristics of emergent practice. These were later tabled to represent characteristics of pedagogical approaches that is relevant for the information society in contrast to an approach for the industrial age (Voogt, 2008).

Table 2-1: Overview of pedagogy in the industrial vs the information society (Voogt, 2008)

Aspect	Less of "traditional pedagogy"	More of "emerging pedagogy for the information age"
Active	Activities prescribed by the teachers Whole-class instruction Little variation in activities Pace determined by program	Activities determined through negotiation Small groups Varied activities Pace determined by learners
Collaboration	Individual Homogeneous Groups Everyone for him/herself	Working in teams Heterogeneous groups Supporting each other
Creative	Reproductive learning Apply known solutions to problems	Productive Learning Find new solutions to problems
Integrative	No link between theory and practice Separate subjects Discipline-based Individual teaching	Integrating theory and practice Relations between subjects Thematic Teams of teachers
Evaluative	Teacher- directed Summative	Student directed Diagnostic

Voogt (2008) argues that the terms "less" and "more" is indicative of a search for a new balance in pedagogical approaches. In addition, the understanding of "integrating technology into teaching and learning" is adopted from the Technology in Schools Taskforce (Schmitt, 2002), as restated by Lawless and Pellegrino (2007).

> *Technology integration is the incorporation of technology resources and technology-based practices into the daily routines, work and management of schools.*

The process of achieving this integration is facilitated through Teacher Professional Development. According to Wells (2007), professional development is the means by which organizations deal with the introduction of innovations into their practice. Professional development for educators consist of activities that enable them to improve their knowledge, skills and strategies (Clarke & Hollingsworth, 2002; Organisation for International Co-operation and Development, 2009). In the context of technology integration in learning (during practical work in this case), a more useful definition is provided by Wells (2007 citing Grant, 1996) as follows:

> *Professional development...goes beyond the term 'training' with its implications of learning skills, and encompasses a definition that includes formal and informal means of helping teachers not only learn new skills, but also develop new insights into pedagogy and their own practice, and explore new or advanced understandings of content and resources. [This] definition of professional development includes support for teachers as they encounter the challenges that come with putting into practice their evolving understandings about the use of technology to support inquiry-based learning (p. 1).*

Having identified what the transformed classroom should ideally act like, and how this process of change will be facilitated, the challenge remained to transform the practice of the participating teachers individually and the culture of the school as a collective.

An appropriate meta-analysis of literature around the use and integration of ICT into the teaching and learning engagement, and the Teacher Professional Development activities that support this was done to identify relevant commonalities regarding obstacles, strategies and best practice. The aim was to harvest experience based best practice to incorporate into the ICT4RED TPD course. The relevant findings are outlined below in the table.

Table 2-2: Relevant elements from literature

Element from Literature	Reference
Physical access to technology is essential for integration	Vrasidas (2014)
Availability of technology does not translate into use	Vrasidas (2014)
The critical elements are pedagogy, learning design and integration of technology into teaching and learning. TPD is the most important factor	Bower (2008); Dobozy (2013); Forrest (2009); Hedberg (2011); Herrington, Herrington, and Mantei (2009); Kervin and Mantei (2009); Olney, Herrington, and Verenikina (2009); Smolin, Lawless, and Burbules (2007); Vrasidas and Glass (2004), Bauer and Kenton (2005); Peralta and Costata (2007); Mueller, Wood, Willoughby, Ross, and Specht (2008); Vannatta and Nancy (2004); Guzman and Nussbaum (2009); Mumtaz (2000)
Mandating change is not necessary successful. Rather prepare teachers to improve their competencies in ways	Yeung, Taylor, Hui, Lam-Chiang, and Low (2012)

Element from Literature	Reference
that they can appreciate the value of technology. Teacher Professional development approaches need to be revisited towards cultivating a positive attitudes towards technology integration.	
Teachers need to have successful experiences in technology integration that can change their perceptions and classroom practices.	Mumtaz (2000); Yeung et al. (2012)
Teachers adopt technology easier if they see value to their teaching. If technology makes a lesson more fun, interesting, easier, more diverse and or more enjoyable.	Cox, Cox, and Preston (2000); Mumtaz (2000); Carney (1998)
Personally teachers are more likely to adopt technology if it is readily available to them. Personal ownership and exclusive use over an extended period.	Cox, Cox, and Preston (2000); Mumtaz (2000); Youngman and Harrison (1998)
Long Term collegial support helps to translate integration of ICT.	Carney (1998)
Initial and immediate success with technology by teachers is advisable.	Youngman and Harrison (1998)
Portability of the equipment is advisable so that it can move between the home and the workplace.	Youngman and Harrison (1998)
Teacher's positive attitude about the adoption and integration of ICT is significant to the successful integration.	Hew and Brush (2007); Keengwe, Onchwari, and Wachira (2008); Buabeng-Andoh (2012)
Student orientated pedagogical approaches have a direct positive influence on the innovative use of ICT.	Drent and Meelissen (2008); Woodrow (1992); Peralta and Costata (2007)
Longer term interventions have a higher incidence of innovative adoption.	Lawless and Pellegrino (2007), Fishman, Best, Marx, and Tal (2001),Wilson and Berne (1999)
Evaluating the TPD engagement is a concern as it is not clear what has been learnt	Lawless and Pellegrino (2007)
Teachers tend to teach the way they have been taught	Guzman and Nussbaum (2009)
More complex technology has a greater chance of leading to	Aldunate and Nussbaum (2013)

Element from Literature	Reference
abandonment	
Presence of early adopters and innovators impact positively on the likelihood of adoption by other teachers.	Aldunate and Nussbaum (2013)
All TPD should help teachers to successfully teach the curriculum to students	Fishman, Marx, Best, and Tal (2003)

The elements outlined above were absorbed into basic design tenants that are given below:

- How teachers teach is generally aligned with how they are taught.
- Access to technology without the professional development on instructional technology and curriculum material that integrate technology use into the lesson content, lead to teachers that are not particularly likely to embed technology based or technology rich activities into their courses.
- While digital technologies have evolved teaching strategies and their effective integration into the teaching and learning engagement have not evolved as rapidly.
- Making sense, coping and using new ICT calls for different teacher knowledge and skills than what is currently operating in the schools.

These relevant insights, outlined in the table and presented as design tenants, provided some additional depth to the operationalization of the Mobile Learning Curriculum Framework (Botha et al., 2012).

In addition to the highlighted elements, it is noted that the quality and efficacy of professional development programs for rural teachers is flagged as an additional concern by Lawless and Pellegrino (2007). Dawes (2001) further states that "[p]roblems arise when teachers are expected to implement changes in what may well be adverse circumstances " (2001, p. 61). As such the rural resource-constrained area needs to be considered and planned for.

2.3.2 Framework for teacher learning

Fishman et al. (2003, p. 645) holds that professional development should fundamentally be about teacher learning. They see that as the changes in the knowledge, beliefs and attitudes of teachers that would lead to the acquisition of new skills, new concepts, and new processes related to the work of teaching. The teacher professional knowledge is considered to consist of knowledge of technology, pedagogy and content (TPACK) (Grossman, 1990; Magnusson, Krajcik, & Borko, 1999; Mishra & Koehler, 2006; Shulman, 1986).

During instruction, knowledge regarding content, pedagogy and technology interact with one another and amongst themselves to produce other types of knowledge needed for the successful use of technology in learning (Abell, 2008; Koehler & Mishra, 2009a). The result is the TPACK knowledge framework depicted in the figure presented.

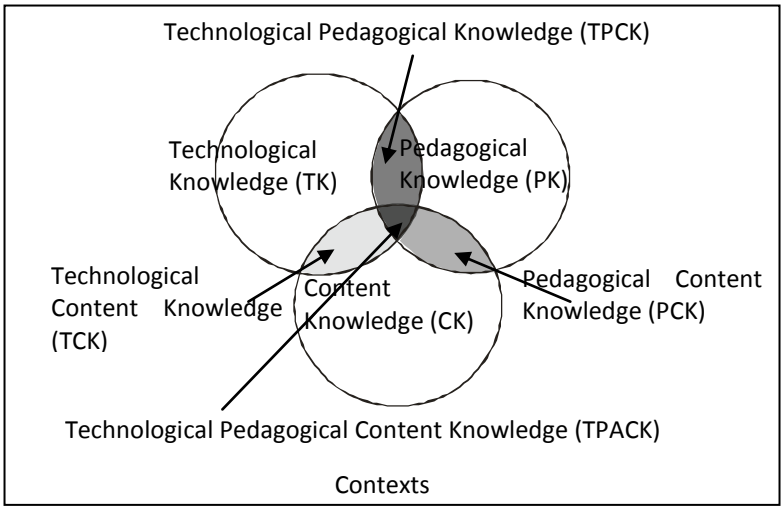


Figure 2-1: The TPACK framework for educator knowledge (Koehler & Mishra, 2009)

The ICT4RED TPD pragmatically applies the TPACK framework as described by Mishra (Koehler & Mishra, 2009a, 2009b; Mishra, 2004; Mishra & Koehler, 2006). Based on the TRACK framework the ICT4RED TPD aims to build a Toolbox as tabled below.

Table 2-3: ICT4RED TPD Toolbox

Toolbox	Operationalised as
Appropriate Technology	Tablet, Tablet Cover, Earphones, SD Card, Tablet Pen, Car Charger. Access tablets for learners, Appropriate digital content on local server.
Technology Knowledge	Technology skills related to the tablet.
Pedagogical Knowledge	Teaching strategies that are appropriate for the use with Tablets towards emergent learner centered practices in the teaching and learning engagement.
Content Knowledge	Content related towards being, participating and teaching and learning in a digital world.

Mindful of the objective of the TPD curriculum, the constraints of the environment and the cost (both monetary and opportunity costs) a number of TDP curriculum design decisions were made. These are outlined and motivated briefly.

- Tablets were chosen as the technology that would support the teachers. As all educators had access to mobile devices it was felt that the barrier to proficiency would be significantly reduced in this way. Android devices was chosen due to the open nature of the operating system and the large quantity of free apps that are available
- The training would take place over a broad spectrum of teachers and as such the TPD could not be subject of phase specific. The teacher, as content and context expert would have to become a co-creator in the process.
- Technology would be provided in use and not in case. This was done through a concept that was called “earn as you learn” It implied that the need for technology hardware would first be created and then met and only when certain well defined goals had been achieved on the side of the teachers and the institutions. These goals were articulated as badges that teachers had to achieve in order to progress and eventually, when they had evidenced that they had the required competencies and skills to use the device meaningful within the learning engagement, the device ownership was transferred to the individual teacher. Depending on the demonstrated competencies and skills of the educators at a

school, the school would receive, or earn, various technology hardware.

- The TPD course was designed in such a way that it did not require any Internet connectivity. Although this was not the most desirable way to structure the course, it was pragmatic. Initially all of the schools were disconnected and there was very limited infrastructure that would support sufficient connectivity. An Internet like experience was catered for through a local Wi-Fi environment and opportunities to connect to the Internet incorporated in various ways through challenges.
- Gamification as a design strategy was implemented in a haphazard way in Phase 1 and a more structured approach in Phase 2 and refined in Phase 3 to facilitate an element of fun and play as it was felt that teachers would be less threatened in such interactions.
- The allocation of badges as clear goals in the teachers' learning path would provide opportunities for regular meaningful feedback and ensures that the TPD sessions actually translated into a change of classroom practice.
- The modules would 'walk the talk'. This implied that no teaching strategy or technology skill would be presented if it was not demonstrated and modelled to the teachers. As such the Jigsaw teaching strategy was introduced and modelled through jigsaw, storytelling through storytelling and so forth. The teaching environment was simulated to the teachers.
- The TPD would build a Toolbox of skills, technology and competencies that would empower teachers to integrate technology meaningfully into their classroom practice in order to portray a more emergent pedagogical engagement. Each module in the curriculum would be about relevant content through a teaching strategy using technology to facilitate the teaching and learning interaction. In addition teachers would be exposed to:
    - best practice in group work
    - different assessment strategies
    - concept of a reflective practitioner
    - concept of online learning and additional resources

2.4 Phase 1

10 Modules were designed and presented at Arthur Mfebe SSS. Initially teachers received 7 inch tablets with some preloaded apps. A local Wi-Fi server was used with some content loaded on it. Each session was facilitated by our current Master Trainer and was presented at the school. The change management was part of the content that was covered. The teaching strategies that were used were identified from practice and from literature. The facilitator arrived after school and presented the module to the teachers. They were then tasked to go and apply the teaching strategy into their classroom practice and to report back on the following session.

The teachers enjoyed the element of fun that was incorporated and the teaching strategies that were employed worked within the environment. The preloaded tablets were not perceived as barriers to the teaching and learning engagement and the teachers were able to start creating content very early on in the intervention.

The teachers, although very enthusiastic about the intervention, did not always take the experience and integrate it into classroom practice. The facilitator was additionally under pressure to complete the module within the time allocated and did not spend enough time following up on the teachers' use of the tablets in their class.

It became evident that a more structured approach was needed to ensure that the experiences and development that the teachers were exposed to, was spilling over into classroom practice. Structured time was needed to have feedback about teachers' experiences and implementation. The change management was deemed important enough to warrant a totally separate focus as it became evident that the introduction of learner devices into the school was very disruptive and teachers and management were unsure of how to manage the resources.

2.5 Phase 2

Phase 1 initiated the ICT4RED TPD. The lessons learnt as outlined above were incorporated in the design for Phase 2.

SchoolNET SA[1] was appointed as the facilitators for the second iteration and they identified and sourced 10 trainers that would go to the schools and expedite the training. SchoolNET SA was identified as one of the largest teacher training organisations in South Africa and would be able to continue implementation after the research initiative ended. Their appointment was then additionally viewed as National Capacity building towards sustainability of the TPD implementation after 2015. The Master Trainer from Phase 1 facilitated *Train the Trainer* sessions for these facilitators. In addition it was felt that they should also go through the course. The trainers were exposed to a 'participation course' where they experienced the course and then did *Train the Trainer* sessions with the Master Trainer. In addition there were virtual sessions hosted for the trainers before implementation of each of the modules.

The participating facilitators were identified local ICT champions that were considered ICT literate and experienced in integrating technology into the teaching and learning interaction. Not all of them however, had extensive experience in integrating tablet technology.

The ICT4RED TPD Curriculum was, after Phase one, formalised and planned as 10 modules that would each be printed as an individual little book that could be given to teachers at the beginning of each module session. A layout and a light hearted theme were decided to be applied in the layout of the whole course.

[1] http://www.SchoolNET SA.org.za/

Figure 2-2: 10 Module ICT4RED TPD course covers[2].

[2] The graphic elements were later kindly donated by AfroFusion (Communication)

There was a purposefully planned progression from personal use to collaboration. Each Module was planned to facilitate a progression towards a reflective practitioner with elements of the TPACK framework as an underpinning.

		Pragmatic Pedagogic Strategies											Mobile Tablet Technology											Content			
		Jigsaw	Role Play	Problem Based learning	Gallery Walk	Social Networking	Story Telling	Flipped Class	Mind mapping	Field Trip	Gaming	Evaluation and reflection	Personalisation	Video (Mp4)	Voice (MP3) Podcast	Images	Document Handling	Spread sheets	Apps	QR Codes	Social Networking	Presentations	EBooks	Creative Commons	Contributed and shared	Reused content	Evaluated Content
Module 1	Personal use	x										x	x	x		x	x		x				x		x		
Module 2									x			x	x		x		x		x				x			x	
Module 3			x	x								x		x			x	x	x						x	x	
Module 4	Professional				x							x		x	x		x		x				x	x	x	x	
Module 5							x					x		x		x	x		x			x			x		
Module 6								x				x		x			x		x				x		x		x
Module 7				x						x		x	x				x		x	x					x		
Module 8						x						x		x			x		x		x		x	x	x	x	
Module 9	Collaborative	x	x	x							x	x				x			x			x		x	x	x	
Module 10		Presentation of portfolios and award ceremony																									

Figure 2-3: Course Matrix for Iteration 2

The initial design of the TPD curriculum incorporated some implied game elements. The success at Arthur Mfebe could not directly be attributed any single factor but was significant enough to motivate a more articulated re-design to incorporate a purposeful gamification of the second iteration. The game elements outlined by Costello and Edmonds (2007) for play, derived from a survey of play theories, were adopted to direct the TPD session (Botha, Herselman, & Ford, 2014).

Table 2-4: Elements towards Gameful Educational User Experience (Botha et al., 2014)

Element from Costello and Edmonds (2007)	Description from Costello and Edmonds (2007)	Application to ICT4RED TPD facilitation
Creation	Creation is the pleasure participants get from having the power to create something while interacting with a work. It is also the pleasure participants get from being able to express themselves creatively.	Time and space was be incorporated for the creation of artefacts on a personal, a professional, a technical or a pedagogical level as objective and as part of co-authoring of the experience. E.g. the creation of a video, taking of photos or creating a

Element from Costello and Edmonds (2007)	Description from Costello and Edmonds (2007)	Application to ICT4RED TPD facilitation
		mind map. Pleasure at manipulating a feature on the tablet device to express a dimension of self.
Exploration	Exploration is the pleasure participants get from exploring.	The participant is confronted with an unfamiliar technology in use. The tablet by its nature presents multiple elements that the participant can explore. Time and space is made for guided and free exploration depending on the perceived level of difficulty.
Discovery	Exploration is the pleasure participants get from exploring a situation.	The participants are confronted with technology and applications that they are able to manipulate in through exploration to discover features and how to manipulate these for themselves. E.g. Setting a photo as a background or using an app to send SMS to parents
Difficulty	Difficulty is the pleasure participants get from having to develop a skill or to exercise a skill in order to do something.	The level of difficulty in mastering initial concepts is pitched to facilitate an initial understanding in the session. An opportunity to exercise the skill through a subsequent challenge is facilitated. E.g. Participants participate in a jigsaw strategy and are then challenged to apply the jigsaw strategy in their class with their own subject content.
Competition	Competition is the pleasure participants get from trying to achieve a defined goal. This could be a goal that is defined by them or it might be one that is defined by the work. Completing the goal could involve working with or against another human participant, a perceived entity within the work, or the system of the work itself.	There are multiple levels of competition built into the curriculum. The participant competes against the system to collect badges, groups compete against each other in the sessions and schools compete against one another.

Element from Costello and Edmonds (2007)	Description from Costello and Edmonds (2007)	Application to ICT4RED TPD facilitation
Danger	Danger is the pleasure of participants feeling scared, in danger, or as if they are taking a risk. This feeling might be as mild as a sense of unease.	The participants are exposed to unfamiliar technology and unfamiliar teaching strategies. This feeling of unease is anticipated and allowed some space and time. E.g. when participants present their work
Captivation	Captivation is the pleasure of participants feeling mesmerized or spellbound by something or of feeling like another entity has control over them.	The participant is captivated by the exposure to using a tablet and initially feels the device has control over them until they get more confident in using it.
Sensation	Sensation is the pleasure participants get from the feeling of any physical action the work evokes, e.g. touch, body movements, hearing, vocalising etc. For example, inter-acting with the work may require participants to wave their arms about in a way that is pleasurable or it may cause them to touch an object that has an enjoyable texture.	The physical activity and movement of participants are planned for. E.g. Moving around, play acting, talking and interacting with the device.
Fantasy	Fantasy is the pleasure of perceiving a fantastical creation of the imagination.	Fantasy are incorporated by role-play, storytelling and scenarios
Sympathy	Sympathy is the pleasure of sharing emotional or physical feelings with something	Understanding for other perspectives is planned for through role play and storytelling. There is a facilitation through which the participant has the opportunity to view situations through as experienced by others such as learners, parents or the headmaster.
Simulation	Simulation is the pleasure of perceiving a copy or representation of something from real life.	The facilitation of each session is a simulation of a class. The facilitator models a teaching strategy by simulating a class and the teachers experience the class as learners.
Camaraderie	Camaraderie is the pleasure of developing a sense of friendship,	There is an emphasis on functional group work as part of the

Element from Costello and Edmonds (2007)	Description from Costello and Edmonds (2007)	Application to ICT4RED TPD facilitation
	fellowship or intimacy with someone.	simulation. In addition the participants are encouraged to support and mentor each other to achieve a common goal. The rise of technology champions has been a side effect of this.
Subversion	Subversion is the pleasure of breaking rules or of seeing others break them. It is also the pleasure of subverting or twisting the meaning of something or of seeing someone else do so. For example, a work might require participants to behave in ways that would be frowned upon in real life and they might get pleasure from being so naughty.	There is a purposeful inclusion of this element through props such as dressing up, assuming roles or tasks that are subversive by nature. E.g. The module on scavenger hunts has tasks such as taking a photo with all participants' feet of the ground.

In addition to these it was a conscious decision to celebrate success and to acknowledge contributors, participants and schools when goals were reached and objectives achieved. This purposeful recognition of success brought a positive air to the ICT4RED initiative and served to motivate and encourage participants to progress.

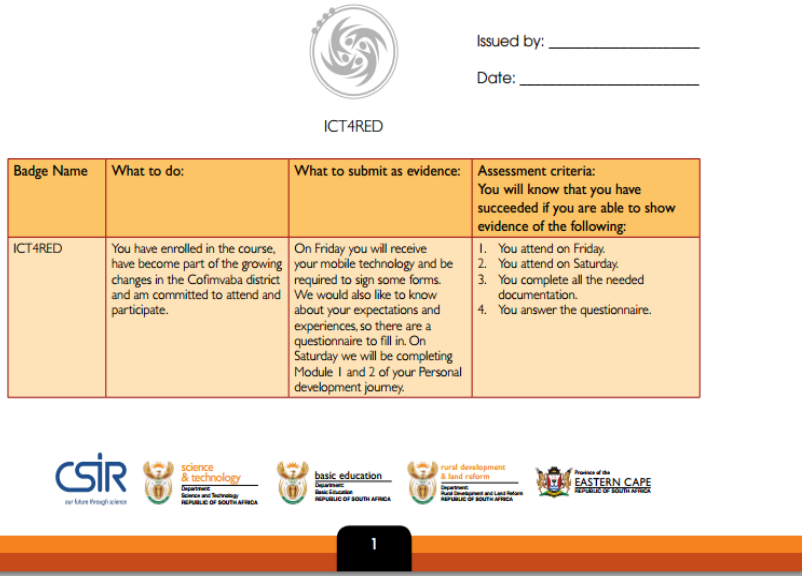
Each module would have clear and easily understood interim goals articulated as badges. Some of these interim goals would be compulsory and the others would be challenges. These were communicated clearly at each TPD session to the participants and were awarded in a transparent and fair manner.

Figure 2-4: Phase 2 badges.

Of the 26 Badges, 13 were compulsory. The "Earn as you learn" was additionally formalised and communicated around this idea and teachers would have to complete all the compulsory badges in order for ownership of the tablet to be transferred to them.

Figure 2-5: Compulsory Badges in Phase 2.

As such it was decided to introduce Mozilla Open Badges to keep track and issue electronic badges. It was however found that the electronic badges had very little meaning to the teachers as their digital personas were, at the beginning of the TPD, virtually non-existent.



Issued by: _____

Date: _____

ICT4RED

Badge Name	What to do:	What to submit as evidence:	Assessment criteria: You will know that you have succeeded if you are able to show evidence of the following:
ICT4RED	You have enrolled in the course, have become part of the growing changes in the Cofimvaba district and am committed to attend and participate.	On Friday you will receive your mobile technology and be required to sign some forms. We would also like to know about your expectations and experiences, so there are a questionnaire to fill in. On Saturday we will be completing Module 1 and 2 of your Personal development journey.	1. You attend on Friday. 2. You attend on Saturday. 3. You complete all the needed documentation. 4. You answer the questionnaire.

Figure 2-6: Paper Based Badge Criteria with place to apply badge

A tangible Badge backpack was printed for each of the participants. These had all the badge names, what to do to achieve the specific badge, the evidence that would need to be submitted to earn the badge and the assessment criteria that the participating teacher would have to produce. There was also, in addition, a place keeper for a sticker that would be issued to the participating teacher on completion of the badge.

The Badge sticker sheet (figure below) was a tracking system whereby facilitators could keep track of what badges and on what date the badge was earned.

Figure 2-7: Badge sticker sheet that was also a tracking system

In addition, it was thought that the badge would be issued electronically as well and additionally a SMS would be sent. This was not very successful as the receiver of the badge would need an email address and very few of the teachers had this at the start of the modules.

Figure 2-8: Paper based badge backpack that was introduced.

The presentation of the module, application and evaluation of the badges, was repeated for all the modules, in much the same way.

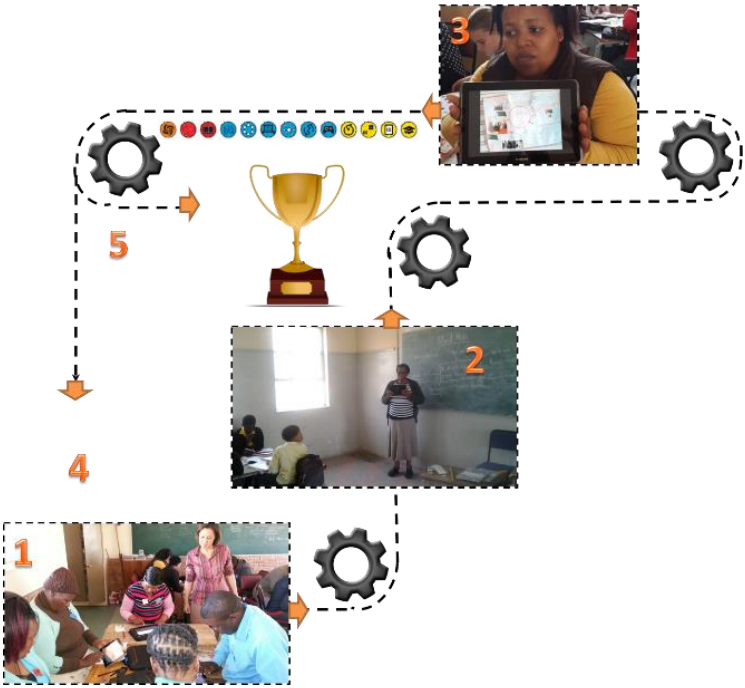


Figure 2-9: ICT4RED TPD course flow

1. The learning strategy, skills and other competencies inherent in each module are simulated during the TPD session. This provides an opportunity to experience the strategy, learn about a topic and gain technology skills. Each school had a dedicated facilitator that acted as a mentor and guide.
2. Subsequent to the TPD session, the participating teachers have about 3 weeks to apply the strategy using technology in their own class. They need to record some evidence as outlined in the badge criteria.
3. In the second iteration, the facilitator initially and then later a badge facilitator, evaluates the evidence provided and either award the badge or gives meaningful input on possible improvements. In the latter case, the teacher can resubmit at any given time.
4. If there are still modules left, another TPD session will be done and the process repeats.
5. If all the modules have been presented the participating teacher has the opportunity to graduate should they have achieved the minimum criteria.

The achievement of badges by individuals, as well as the school, was linked to earning specific equipment as indicated in the table below.

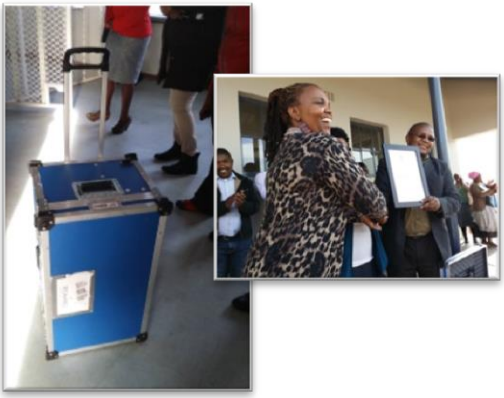
Table 2-5: Individual Earn as you Learn additions associated with the badges

Badges	Tablet Accessory
	Tablet Cover
Module 1-3 	SD Card
Module 4-6 	Earphones

Badges	Tablet Accessory
Module 5  Educational Content Creator	Pen
Module 6  Video Badge	Flash Disk
Module 7-9  Flipped Classroom Gallery Walk Scavenger Hunt	Car Charger

In addition the school would be perceived ready when certain articulated goals, tracked as badges, were achieved. These milestones are articulated below in Table 6 for each time we specified a percentage of the goal. The reason for this was twofold. Firstly we worked on an 80% compliance rate. In other words we assumed that 80% of the teachers would take part and actively pursue the goals we had set. Secondly, we wanted to create an environment in which champions and early adopters in the school can emerge, receive recognition (they made the technology award possible) and not be penalised by some participants not wanting to actively pursue the goals. In this way, the school received technology when they had sufficiently progressed on the road to making use of it. If teachers did more badges, they would achieve the total sooner. If not all teachers are doing the compulsory badges this will be achieved much later in the intervention.

Table 2-6: School Earn as you Learn additions or equipment

Milestone	Technology
80% of 5 badges per participant : Projector For the school to earn a Projector the ideal would be: ▪ Each teacher tried a minimum of 4 new teaching strategies; ▪ Mobiquette is in place; and ▪ School ICT Strategy is in place. This is a total of 5 badges per teacher. We expect the school to have achieved 80 % of this total. So for a school with 10 people on the course, it would imply that they can earn a total of 50 badges. 80% of this is 40 badges.	 The first school to earn their Mobikit. In keeping with celebrating success, a small celebration was held.
80% of 8 badges per participant: Mobikit/s For the school to have Mobikits the ideal would be: ▪ Each teacher tried 5 new strategies; ▪ Mobiquette is in place; and ▪ Teachers have started to create digital content by contributing to the Educational Content Creator Badge. This would imply that they have something to share with the learners. They have become contributors.	 School receiving their Mobikit and a certificate to acknowledge their progress

Milestone	Technology
80% of 11 badges per participant: Tablets to learners or additional Mobikits For the school to have tablets for learners or additional Mobikits, the ideal would be: ▪ Each teacher tried 7 new strategies; ▪ Mobiquette is in place; and ▪ Teachers have are creating digital content and is integrating the technology into the teaching and learning.	 **Additional Mobikits to schools**

The evaluation, feedback and reporting of the badges by the facilitators was much more time consuming as what initially anticipated. A TPD session was rescheduled to facilitate the badge collection and the handing out of the SD cards. After this "Pause" session a dedicated team was instituted to collect the badges.

Although time-consuming, the implementation and evaluation of the badges ensured that the skills imparted during the TPD sessions were integrated into classroom practice at least once per cycle. With the investment in time and opportunity made in the teacher professional development it is imperative that there is evidence of flow through of learning beyond the engagement of the TPD facilitator with the teachers. This evidence of impact feeds into the goals of transforming the teaching and learning engagement and building the teachers personal and professional proficiency.

This flow through to classroom practice and was facilitated by the interim goals as articulated by the badges. The badge goal, attainment, evaluation and the awarding of the badges served a number of functions as outlined below:

- It outlines a clear transparent expectation to the teacher from the initiative initiators.
- It provides an opportunity for the teacher to demonstrate individual proficiency and competence that is acknowledged.

- It allows teachers to individualize and appropriate learning into practice.
- It acts as a scaffolding environment for achieving the teacher development goal.
- It allows the initiative initiators to acknowledge individual growth.
- Acted as an early warning signal of teachers falling behind.
- Allowed for timeous investment in further technology needs.
- Allowed for champions to surface and be acknowledged.

The outcome of the Phase 2 iteration was very positive. There were 137 teachers that completed the 10 Modules. None of the participating teachers failed to obtain the compulsory 13 badges. 17 teachers left the schools in this time and 6 teachers joined; 2 teachers in 2014. Four of these teachers managed to complete the course. 1 Participant withdrew and one participant went on maternity leave. Discounting these two and the teachers leaving the schools, the following outcomes were recorded:

- A completion rate of 100% (one participant withdrew)
- Merit rate (19 badges or more) of 18.98%

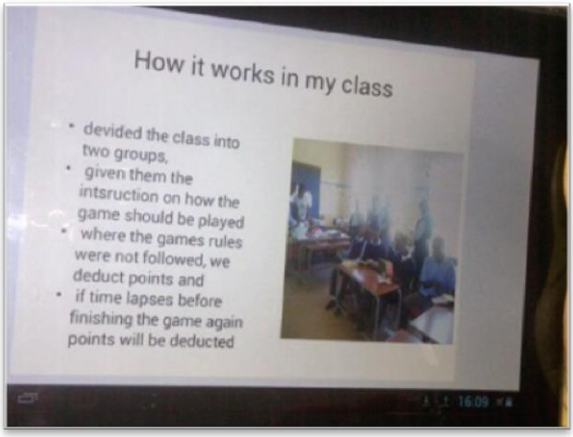


Photo 2-1: Evidence provided for attainment of a badge

Table 2-7: Iteration 2 Schools outcome of the ICT4RED TPD.

School	Total participants	Total Graduating	Merit Graduations	Total Badges	Average	% Merit Badges	Comments
Bangilizwe	17	17	0	302	17.76	-	
Gando,	18	18	6	325	18.06	33%	Second highest achieving teacher is from this school. She completed 21 badges
Gudwana	8	8	0	144	18	-	Whole school achieved 18 badges
Khwaza	16	16	4	289	18.16	25%	
Mgcawezulu	15	15	3	264	17.6	20%	
Mthimbini	3	3	0	51	17	-	
Mvuzo	12	12	0	198	16.5	-	
Ntshingeni	13	13	1	206	15.84	7%	One of the teachers from this school was on Maternity leave and fell in with Iteration 3. Headmaster withdrew.
Siyabalala	7	7	0	107	15.29	-	
St Marks	12	12	0	182	15.17	-	
Zamuxolo	15	15	12	287	19.13	80%	The highest scoring participant is the headmistress of this school and achieved 22 badges.
TOTAL	136	136	26	2355	17.31%	19.11%	

There were 137 teachers that completed the 10 Modules. None of the participating teachers failed to obtain the compulsory 13 badges. 17 teachers left the schools in this time and 6 teachers joined; 2 teachers in 2014. Four of these teachers managed to complete the course. 1 Participant withdrew and one participant went on maternity leave as indicated.

2.6 Phase 3

From Phase 2 the following was revisited and redesigned for implementation in Phase 3.

Due to the remoteness of the area and locality of some of the schools, facilitators were having trouble commuting. It was decided that local facilitators would facilitate Phase 3. ICT Champions from the Phase 2 schools were invited to apply to be facilitators in Phase 3. 6 new facilitators were chosen and one local ICT4RED coordinator was appointed. This was additionally done to increase the department's capacity to continue supporting and doing the training after the completion of the research initiative term.

There were only 3 training venues to bring smaller schools together to enable some of the teaching strategies that required a larger group of participants and to foster a community of practice. These three venues were chosen to make it easier for teachers to commute home after the training had taken place.

The use of the Internet was removed from the compulsory part of the course in the first half of the course. This was done as the setting up of an account to connect through a Wi-Fi router and accessing an email account proved to be very discouraging to participants in the second iteration. These activities were incorporated as challenges till much later on when teachers would be more confident in their use of the technology.

The course was repackaged in a file instead of a number of smaller books. In the previous iteration the teachers had lost some of the earlier module books and were asking for reprints. They also commented on the small space allowed for writing and indicated that they wanted a larger space to make notes. Hence we produced the file on A4 pages. In addition we wanted the option to add content as it become necessary and a file would allow for this.

Some of the modules were reconceptualised. The module on mind mapping was redone and a section was added to each module to illustrate to teachers how they would be able to use the teaching strategy with one device, five devices and when each learner has their own device. In addition, examples of use were incorporated.

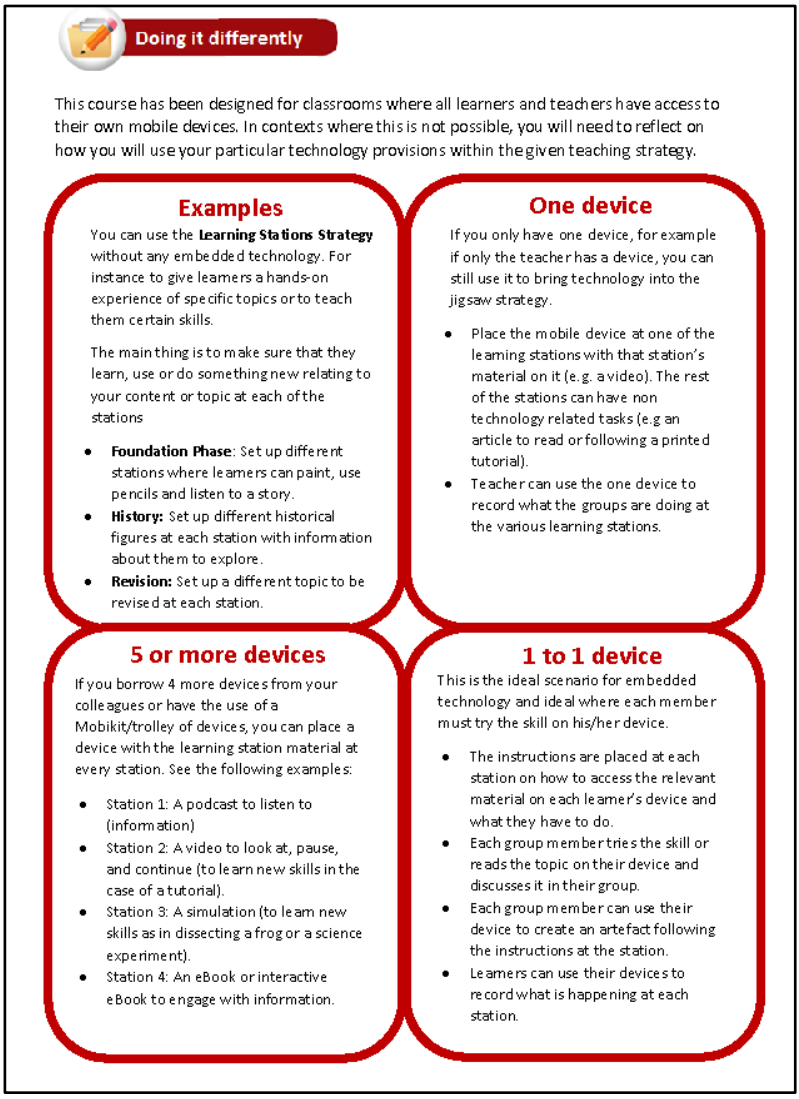


Figure 2-10: Module 4, Learning stations, ideas for application (Botha & Verster, 2014)

The module on flipped classrooms was removed as we had predominantly primary schools and the participating schools had indicated that they would not allow the learners to take the technology home.

A clearer section was incorporated to encourage teachers to reflect on their practice. Where iteration 2 often only implicitly encouraged reflective practice, this was brought more to the foreground in Iteration 3 as a structured process.

Use the *Memoires* app to reflect on the module 3 session:

a. What worked and what did not work? Why?
b. How can I use the Role Play teaching strategy in my classroom?
c. How does the Role Play strategy support 21st century skills (the 4 C's)?

Figure 2-11: Reflective practice was more explicitly facilitated in Iteration 3

How-to-tutorials were written and incorporated into the ICT4RED TPD course modules so that teachers would have a reference for the needed technical skills. An icon was added to indicate the existence of a relevant tutorial

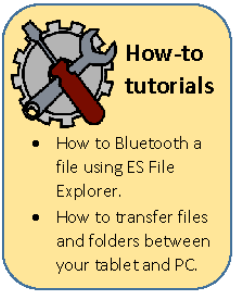


Figure 2-12: How-to tutorials added to aid participants.

Assessment tools were highlighted for teachers through the use of similar icons as illustrated below.

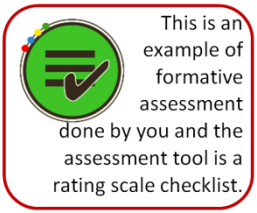


Figure 2-13: Assessment tool indication

It was perceived that there were too many badges and that they were presented very haphazardly (they were alphabetically arranged in Phase 2). A learning pathway, that presented a graphical illustration of the implied course narrative, was introduced to explicitly express the said narrative.

The learning path narrative is explicitly outlined in a graphical manner through the use of colour and the image of a road.

Figure 2-14: Learning path Narrative

It was anticipated that the simplified outline and reduced number of optional badges that are strategically placed to provide challenges throughout the course would be easier to understand and implement.

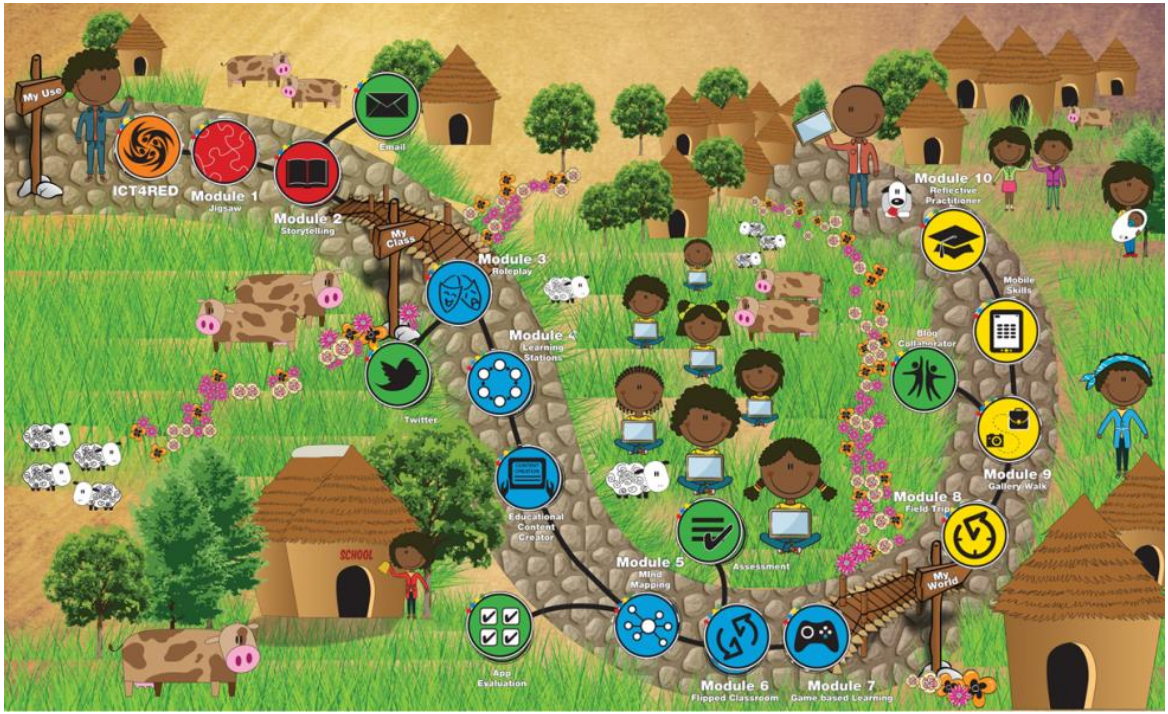


Figure 2-15: Sequential Learning Path represented by a road to be followed and badges to be earned.

The *Earn as you Learn* model was additionally adapted to provide technology earlier in the iteration so that there could be more guidance with the management and integration of the technology into schools. It was also simplified to reduce the labour needed to manage the management of the technology items.

Table 2-8: Updated Earn as you Learn

Badges achieved	Tablet Accessory
	Tablet Cover
	SD Card
	Earphones
	Tablet Pen

In the third iteration the responsibility of handing out of the items was deferred to the local representative. Each item was provided with a name sticker and she was presented with a list of individuals that had achieved the goals.

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The implementation mechanics stayed the same as in Phase 2, however, a group of independent badge assessors have been appointed to collect the badges. This group include some subject advisors from the district office. In addition, materials for the facilitators that are aligned to the curriculum have been produced to standardise the implementation of the training. Investment in the local teachers and district officials to take responsibility for assessing badges was crucial for future sustainability of the ICT4RED initiative. This was specifically the focus in Phase 3. If this is not achieved they will not take ownership of their own assessment and this also allowed for trust between district officials and teachers.

The badge criteria were revisited to remove references to emailing and uploading in the initial parts of the course. In addition the criteria were simplified to be easier to understand.

Every phase allowed for improvement of the modules, which can be referred to as artefacts under the Design Science terminology. These TPD training modules were regarded as valuable mainly because they were hands-on, did not focus on skills training but applied teacher strategies as the basis for integrating technology into teaching and learning.

2.7 Phase 4: Reflections

The creation of a course like this is not an easy undertaking. It is part science and part craft. This is by no means the perfect course, but it has proved to be very successful. There are two images that stand out in my mind as silencing the cynic in me.

Photo 2-2: Emancipation of the rural teacher: Photo Credit M. Ford

This image was taken when we had given out the Mobikits (cf Section 4 under School ICT for a description, it consisted of 15 tablets with charges and extensions in a blue aluminium case) to the schools. The learners took the tablet and the teachers got involved and started showing them what they could do on the tablet. This goes contrary to all the beliefs that the teachers are the ones that are the least likely to be technologically adapt and that the learners will show them up.

The other is a stealth photo that was taken on a visit to a school.

Photo 2-3: A teaching experience that is very different

This teacher is teaching in her class with a tablet. She is not a youngster but she is confidently standing with her technology. The chalk is on the table! There is a mindmap on the blackboard (one of the teaching strategies) and the learners are sitting in groups and not in rows anymore.

These pieces of evidence and a long list of anecdotal bits and pieces have contributed to shape and develop the current curriculum in its present form.

The use of tablets has been a catalyst for to teachers to use another form of technology. In the photo below, collected as evidence for a badge, teachers reflect on the use of the computer labs that have been reported as standing unused

The gamification of the course was no easy task and it has taken two iterations to get it to a point that it is not just badges on leader boards. I use the term gamification rather widely as I am aware of the contention around the term. However, the success is evident in the completion and participation rate. In addition the course was adapted for a “Learning Gains from Play” implementation done by SchoolNET SA. These training modules have been regarded by different external parties as very valuable.

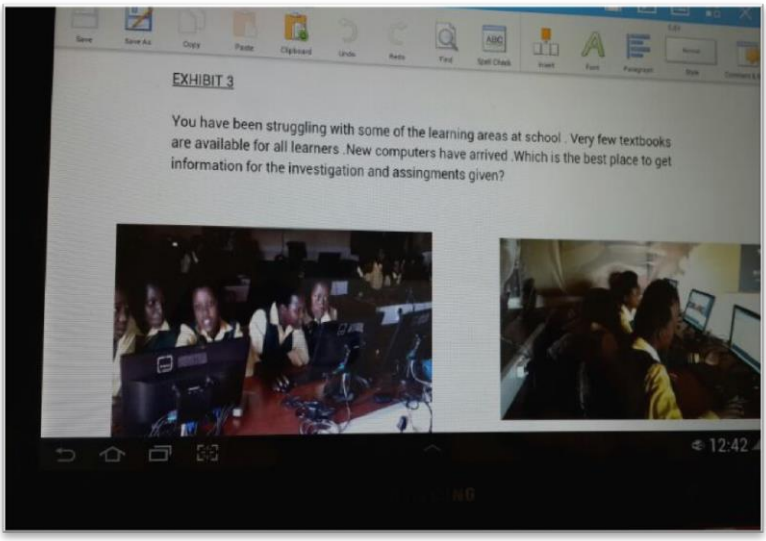

Photo 2-4: Evidence of use of computer labs.

As a result the North West Education Department adopted the ICT4RED TPD course for implementation in 2013 and 2014 in their province, the Eastern Cape Education Department has started to incorporate some of the ideas into their own planning, The Gauteng Department of Education engaged with ICT4RED staff in order to inform their own ICT roll-out, and the Eastern Cape Education Department has also relied on the assistance of the ICT4RED project team to establish Provincial and District level ICT steering committees with the view of better coordinating ICT initiatives in schools. The modules is currently being translated into Arabic and Spanish and some universities have applied the same principles and ideas to develop short courses for training industry colleagues and academics on mobile learning. The impact of the modules is far greater than anticipated in the beginning. A practitioner's guide will also be written in the near future, to assist practitioners to present the modules in any environment.

2.8 Conclusion

The success of the TPD component is testimony to the fact that if you focus on empowering teachers first and expose them to a practical application of integrating technology through teaching strategies to support their teaching and learning where they feel more confident, motivated and competent, you can achieve more success than through a focus on skills training with technology. As was already articulated in Section 1 it is not about the technology, but about the people. Another success factor which was observed during the TPD training was that if the trainer is passionate, competent and knowledgeable it makes a huge difference to the attitude of teachers. Teachers are workshop fatigued and this type of hands-on training is much more valuable where they can provide evidence of successful integration in their classrooms to earn their technology. The teachers were treated with respect and dignity and their achievements were celebrated and shared with the whole community. This provided an element of self-worth and acknowledgement which made them proud of themselves.

In conclusion the course highlights the fact that technology is integrated in a facilitated process. Teachers are launched into teaching careers with limited preparation. Therefore meaningful integration needs to be planned and facilitated and teachers need to be met where they are. If you cannot model it don't do it! The teacher professional development interaction is costly and needs to be seen as an investment in more than just mastering a technology for the sake of it.

The interaction design of a TPD learning interaction must be a positive learning experience for the teacher to translate into a willingness to experiment in their own classroom and simplicity and repetition is key!

Technology endowment for the sake of it does not lead to uptake and use and there needs to be scope for individual and institutional pacing

Financial investment in technology should keep pace with the needs and development of the institution. A type of tsunami endowment does not equate to educational gains but rather overwhelms the institution and individual and can be more harmful then beneficial.

Continual financial investment in technology where there is a clear lack of uptake will not result in educational gains and rather give rise to additional

problems such as equipment that goes missing, misappropriation of equipment and the white elephant syndrome.

Clear measurable criteria and expectations of success is crucial coupled with the acknowledgement of achievement and acknowledgement of interpretation needs and interest in implementing and integrating technology to support teaching and learning. Small manageable steps towards achieving an intervention goal and pathways should be identified and explicitly stated. Transferability of accreditation is needed beyond a project or initiative. End goal needs to be achieved. A random set of badges tends to lose meaning. Micro, meso and macro objectives need to be built into the process and acknowledged.

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Photo 2-5 Teachers at a Badging session

Photo 2-6: Learner engaging with Tablet

SECTION 3: Monitoring and Evaluation

B. Williams

3.1 Introduction

This chapter introduces the monitoring and evaluation framework, reflects on the way in which it was implemented in the context of the ICT4RED initiative, and makes some suggestions on how to use M&E to learn from complex technology initiatives such as ICT4RED.

3.2 The importance of Monitoring and Evaluation of Information and Communication Technology for Education (ICT4E) Initiatives

Monitoring and Evaluation in the South African Public Sector is typically understood as "The systematic collection and objective analysis of evidence on public policies, programmes, initiatives, functions and organisations to assess issues such as relevance, performance (effectiveness and efficiency), value for money, impact and sustainability and recommend ways forward" (Department of Planning, Monitoring and Evaluation (DPME), 2011). Internationally, it is sometimes defined as "a systematic process to determine merit, worth, value or significance" (American Evaluation Association, 2014).

The usual purposes of monitoring and evaluation of public sector initiatives include (Department of Planning, Monitoring and Evaluation (DPME), 2011):

- Improving policy or programme **performance** (continuous improvement) by providing feedback to programme managers;
- Improving **accountability by answering questions such as "**Where is public spending going?" and "Is this spending making a difference?";
- **Improving decision-making** in response to questions such as "Should the intervention be continued?" "Should how it is implemented be changed?" "Should the budget be increased?"; and

- **Generating knowledge and facilitating learning** by increasing knowledge about what works and what does not with regards to a public policy, programmes, functions or organizations.

According to Wagner et al. (2005), Monitoring and Evaluation is crucial in ICT for Education initiatives, not only because it is generally accepted as good practice in development, but because of the peculiarities of ICT in Education initiatives:

> *While there is clearly much promise in the use of ICT for education, there is, at the same time, a widespread ignorance of the specific impact of ICT on education goals and targets… Creating a relevant and actionable knowledge base is a first step in trying to help policy makers make effective decisions. This is essential in the case of ICT4E for which—unlike, say, improved literacy primers—there are high entry costs (such as investments in new infrastructure), significant recurrent costs (maintenance and training), and opportunities for knowledge distortions due to the high profile (and political) aspects of large ICT interventions. (Wagner, et al., Monitoring and Evaluation of ICT in Education Projects: A Handbook for Developing Countries, 2005).*

In the context of the ICT4RED initiative, Monitoring and Evaluation was important to support the work of the implementation team, and also to provide evidence to external stakeholders that could be used to hold the implementation team accountable. The M&E team also had a role in capturing some of the learning that resulted from the implementation.

Ultimately, the M&E was designed to provide some evidence that would allow for the following benefits to accrue (Department of Planning, Monitoring and Evaluation (DPME), 2011)

- Learning and feedback into policy and implementation
- Ensuring policy and management decisions are based on evidence
- Better understanding of which programmes are cost-effective
- Saving money
- Improving understanding and so being better able to overcome institutional bottlenecks to improved impact (adapting policies and programmes)

3.3 How the monitoring and evaluation of ICT4RED was approached

For the ICT4RED initiative, the Meraka Institute supplemented their internal M&E capacity by appointing external consultants for specific tasks. The internal team consisted of 4 junior to mid-level researchers, and a senior researcher whom also acted as the M&E contracts manager. The junior team members conducted some of the fieldwork, telephonic data collection, analysis, and report writing, and the senior team member in addition also negotiated access to stakeholders, provided guidance to the evaluation design and budgeting process, provided quality control of evaluation deliverables and intervened and advised when strategic issues emerged from the evaluation. Much of the strategic work conducted by the senior M&E team member included sensing program energy, supporting common spaces, untying knots iteratively and paying attention to structure – Typical roles take on by Developmental Evaluators (Langlois, Blanchet-Cohen, & Beer, 2013).

The external consultants were brought in to supplement the skills, knowledge and tools of the internal team – For example an ethnographer provided short-term support with detailed ethnographic descriptions, another organization assisted with transcriptions and data capturing. An organization with an already developed School Functionality Instrument was contracted to train the M&E team on the collection of the data and to support the reporting of the data.

A longer term retainer type contract was negotiated with an Educational Evaluation Consultancy which brought a variety of skills and knowledge to the team amongst which were evaluation methodology knowledge, contextual understanding of ICT in education initiatives in general, previous experience working with the Eastern Cape Education Department (ECDoE), data management skills, qualitative and quantitative analysis skills and report writing and editing skills.

Various internal and external members of the M&E team sat into weekly initiative meetings to follow progress with implementation, to immediately assist with requests for monitoring and evaluation instruments and data, and to provide data-supported advice whenever important decisions were made. The M&E team advised other implementation team members of the available data, analysis and reports as appropriate, and made work-in-

progress as well as final outputs available through email, Dropbox, team presentations, and meetings.

The internal M&E team, as well as the external providers were accountable to the ICT4RED Initiative Manager, but also provided inputs such as progress reports, evaluation reports and presentations on strategic issues to the independent Initiative Steering Committee to assist them with their oversight and decision making role.

The approach of combining internal and external capacities had the benefits of ensuring that resources were used optimally, that appropriate skills and knowledge was available to do the M&E, that appropriate skills and knowledge transfer could take place between the internal and external team members whilst maintaining a measure of "independence" in the execution of the evaluation mandate.

3.4 How the Monitoring and Evaluation Framework was Developed

One of the first tasks the M&E team set out to do was to develop an evaluation framework, which detailed the evaluation approach, evaluation questions, and possible evaluation methods. The timing was important – the M&E team started major work on the evaluation framework in March of 2013 – About 7 months after the initiative pilot started at Arthur Mfebe and close to the end of the first pilot phase of the initiative. There were some ethnographic research done prior to this, historic learner results from the school were available and the initiative could also benefit from some of the research that was conducted by another CSIR initiative implemented in the area (Technology for Rural Innovation and Education Development - Tech4RED). Initiative funding constraints prior to 2013, and the experimental nature of the initiative essentially limited the possibility of doing earlier M&E, but to some extent, the delay in implementing the M&E benefitted the evaluation design process - The evaluation design could be built after some experimentation had already taken place, and after the implementation team had a better idea of the kinds of activities it would conduct based on the available funding. The other implication, however, was that some quick evaluative feedback was critically necessary, and that the first evaluation activities had to be conducted while the evaluation framework were still being developed.

3.4.1 Reviewing the background about the initiative

In order to become acquainted with the details of the initiative, the M&E team embarked on a process of document review. The initiative Owner, Merryl Ford, and other early team members were interviewed and asked for any background information and documentation about the initiative. Initiative proposals, initiative budgets, presentations and initial implementation reports were reviewed in this process. The Strategic Plans, Annual Performance Plans, and Annual reports of the Donors – The Department of Science and Technology (DST), the Department of Rural Development and Land Reform (DRDLR) and the Eastern Cape Department of Education (ECDoE) - were reviewed for context about how this initiative fitted with their priorities. The Government partners' commitments in terms of the National Development Plan were reviewed. Based on this review, the M&E team developed a short Case Study on the implementation at Arthur Mfebe. These Case studies was useful in helping the M&E team articulate and check their early understanding of the initiative, and allowed some of the initiative partners to be alerted to the type of early outputs that could be expected from the M&E team and the initiative. A decision was made not to publish the case study because some of the key partners maintained that it was too early to publically share any kind of evaluative Case Study, but it provided a useful opportunity to engage in conversation with the various role players about some of the sensitivities that could be triggered by M&E.

3.4.2 Interviewing potential users to inform the evaluation design

As part of the evaluation framework development process, the M&E team did extensive interviews with the implementation team, donor representatives and beneficiaries of the initiative during the pilot phase 1 of implementation which took place at Arthur Mfebe Senior Secondary. These stakeholders were identified as potential users of the M&E evaluation, and as far as possible, the team wanted to accommodate their needs in the evaluation design – which is in line with the principles of Utilization Focused Evaluation (Patton, 2010) and takes into account the utility principle articulated in the African Evaluation Guideline (African Evaluation Association, 2007) and (Patel, 2013).

The implementation team and various component managers were identified as the primary users of the evaluation information since they

had the potential to act on the evaluation information as it came in. Donors such as the Department of Science and Technology (DST) and the Department of Rural Development and Land Reform (DRDLR), and initiative partners such as the Department of Basic Education (DBE), the Eastern Cape Department of Education (ECDoE) and the Cofimvaba District were identified as the secondary users of the evaluation information – mainly because these partners had to hold the implementation team accountable for the initiative expenditure, and because they were in a position to inform other policy and practice decisions on the lessons learnt in the evaluation and in the research generally.

3.4.3 Interviewing beneficiaries to inform the evaluation design, and test some evaluation ideas

During a visit to Arthur Mfebe (the phase 1 test site) in April of 2013, the M&E team interviewed various teachers, members of the ICT committee, the school principal, members of the traditional leadership, school learners and district officials to establish their concerns and reactions to the initiative. The purpose of this data collection was two-fold – to gather information on potential use from the beneficiaries, and to get a sense of what the beneficiaries thought about the implementation and the likely results of the initiative.

This information was supplemented by facilitating a self-evaluation process with the implementation team during which the team members reflected on the early findings that emerged from the Arthur Mfebe visit. It also gave the implementation team an opportunity to reflect and document some of the challenges and early successes of the initiative. In addition, the implementation team provided inputs that allowed the M&E team to develop an early theory of action and possible theories of change (Funnell & Rogers, 2011).

3.4.4 The first version and various revisions of the evaluation framework

Shortly after the first evaluation report was written and shared with the team and donors, the evaluation framework was consolidated. The evaluation framework was documented, the cost of evaluation activities were determined, budget negotiations ensued, and then the framework was implemented. The framework was shared with the primary and

secondary intended evaluation users, and presented to evaluation peers at the South African Monitoring and Evaluation (SAMEA) conference in September of 2013. After several rounds of evaluation information was collected and the feasibility of the various evaluation activities could be checked, the evaluation framework was again adapted towards the end of 2014.

One of the reasons why it was important to maintain a flexible approach towards the evaluation framework, was that new information needs kept on emerging during the initiative – for example – when the textbook providers and educational content providers came on board in the ICT4RED initiative, they were interviewed to establish their information needs. Although these could not be fully addressed within the scope of the initiative, the existing evaluation processes were adapted to include some of the needs articulated.

3.5 An Overview of the ICT4RED Monitoring and Evaluation Framework

3.5.1 Choosing an M&E Approach to guide the Evaluation

For this evaluation, Developmental evaluation (Patton, 2010) was chosen as the guiding evaluation approach, because it makes provision for the fact that the ICT4RED initiative was complex and constantly evolving, and the approached catered to the needs of the primary intended evaluation users to continually have access to evaluation information when decisions are made.

What the early exploratory work of the M&E team revealed, is that the ICT4RED initiative is different from most other development initiatives aimed at learners and teachers in schools: Besides intending to positively impact the teachers and schools in some way, it was also intended to be a Research and Development initiative, which set out to contribute towards knowledge about how best to roll out tablets and supporting technologies in a rural context.

The role of the monitoring and evaluation team was therefore more than just monitoring and evaluating whether the initiative was well implemented – commonly called “formative evaluation” or to comment on the degree to which benefits accrued to the various beneficiaries affected by the initiative – commonly called “summative evaluation”. In addition,

the M&E team were also required to reflect on- and support higher level learning in the initiative to answer the question "How best can ICT be used to support teaching and learning in rural schools?"

This focus on documenting a "model for success" and learning from the implementation successes and failures as different approaches were tried in the ICT4RED initiative, required that the M&E team also develop a consistent and well supported Theory of Change which identified which aspects of the intervention was necessary to support positive implementation and achieve the intended results. Theory of change is, however, difficult to articulate when there are many interdependent initiative components, which may lead to vastly different results depending on how the initiative interacts with the context and actors in a specific setting. This is commonly referred to as "complexity". Rogers, (2008), drawing on work from Glouberman & Zimmerman (2002), distinguishes complex programme aspects from complicated and simple programme aspects using the following examples to highlight some pertinent characteristics.

Table 3-1: Complex and Simple programme aspects

Simple:	*Complicated:*	*Complex:*
Following a recipe	*Sending a rocket to the moon*	*Raising a child*
The recipe is essential	Formulae are critical and necessary	Formulae have a limited application
Recipes are tested to assure easy replication	Sending one rocket to the moon increases assurance that the next will be OK	Raising one child provides experience but no assurance of success with the next
No particular expertise is required but cooking expertise increases success rate	High levels of expertise in a variety of fields are necessary for success	Expertise can contribute but is neither necessary nor sufficient to assure success
Recipes produce standardized products	Rockets are similar in critical ways	Every child is unique and must be understood as an individual
The best recipes give good results every time	There is a high degree of certainty of outcome	Uncertainty of outcome remains
Optimistic approach to problem-solving	Optimistic approach to problem-solving	Optimistic approach to problem-solving

Developmental evaluation was an appropriate choice for an evaluation approach, because in the ICT4RED initiative there was no pre-designed "recipe" to test, and the implementation team in the initiative was tasked with trying out different approaches and strategies over three initiative phases. Not only were there very many components and initiative variables to investigate, but the path for "success" was impossible to articulate in advance. In fact - the very definition of success was not possible to articulate in full up front.

Developmental evaluation, as defined and described in the Encyclopaedia of Evaluation (Matthison, 2005, p.116).

> *"Has the purpose of helping develop an innovation, intervention, or program. In developmental evaluation the evaluator typically becomes part of the programme or innovation design team, fully participating in decisions and facilitating discussions about how to evaluate whatever happens. All team members together interpret evaluation findings, analyse implications, and apply results to the next stage of development. The evaluator becomes involved in improving the intervention and uses evaluative approaches to facilitate on-going program, initiative, product, staff, and/or organizational development. The evaluator's primary function in the team is to facilitate and elucidate team discussions by infusing evaluative questions, data, and logic, and to support data-based decision making in the developmental process. In this regard, developmental evaluation is analogous to research and development (R&D) units in which the evaluative perspective is internalized in and integrated into the operating unit. In playing the role of developmental evaluator, the evaluator helps make an intervention's development an R&D activity".*

While a more traditional evaluation approach includes the formative and summative evaluation of a relatively stable programme, Developmental evaluation helps a team to improve during the formative evaluation stages and then aims to test or validate a final program model during the summative evaluation stage, developmental evaluation recognises that the model may continually develop and adapt as it is implemented in dynamic environments (Patton, 2010).

Developmental evaluation is particularly well suited to initiatives where complexity is at play:

> *"Developmental evaluation is an evaluation approach that is useful in assisting social innovators develop social change initiatives in complex and uncertain environments. Developmental evaluation supports innovation development to guide adaptation to emergent and dynamic realities in complex environments. Innovations can take the form of new initiatives, programmes, products, organizational changes, policy reforms, and system interventions. A complex system is characterized by a large number of interacting and interdependent elements in which there is no central control. Patterns of change emerge from rapid, real time interactions that generate learning, evolution, and development – if one is paying attention and knows how to observe and capture the important and emergent patterns. Complex environments for social interventions and innovations are those in which what to do to solve problems is uncertain and key stakeholders are in conflict about how to proceed" (BetterEvaluation)*

In practice, this meant that the M&E team became part of the implementation team – taking an active role in close relationship to the team. Langlois, Blanchet-Cohen, & Beer (2013) explain the different role of Developmental evaluators as follow:

> *"Developmental evaluation challenges the convention of traditional evaluation that positions the evaluator as objective and distanced from the program implementers … Gamble (2008) identifies in a primer about Developmental Evaluation skills to consist of building relationship, process facilitation, pattern recognition, listening and communicating, and a tolerance for ambiguity."*

3.6 Choosing Evaluation Focus Areas and Evaluation Questions

Because of the needs articulated by the various evaluation users, it was important for the M&E team to document the programme theory, to check

whether implementation was on track, and to measure results at various levels of the education system. Cost and the sustainability of the initiative was also an important consideration of the donors, and this was also selected as particular areas of concern.

Various frameworks influenced the choice of focus areas and questions: Since the initiative was funded and supported by Government Departments, it was important to take cognisance of the types of evaluation referred to in the National Evaluation Policy Framework (Department of Planning, Monitoring and Evaluation (DPME), 2011), and since ICT initiatives are generally also of interest to donors globally, the OECD DAC Evaluation Criteria (OECD Development Assistance Committee, 2010) were also accommodated to some degree.

In developing Evaluation Questions, the team also referred to other relevant theory – For the documentation of the programme, the M&E team adapted some of the approaches and terminology used by Funell and Rogers (2011), for the measurement of implementation success, the team referred to work of Zvoch, Letourneau and Parker (2007), and to guide the work on costs, the team extensively drew on the GESCI Total Cost of Ownership Method (Twinomugisha & Bassi, 2009). Because Teacher Professional Development was such an important part of the first pilot phase's focus, it was decided to draw on theory about evaluation of training initiatives – Particularly the Kirkpatrick Model (Kirkpatrick & Kirkpatrick, 2006).

The table below indicates the eventual evaluation questions and M&E components that were selected for this initiative, as well as the theoretical base it was built on.

Table 3-2: Evaluation questions and M&E components

Component	Evaluation Questions	Literature base for questions		
		OECD DAC Criteria	DPME Evaluation Type	Other
Documentation of theory of action and theory of change	Which major activities were included in the ICT4RED design? What are the theories of change		Design Evaluation	(Funnell & Rogers, 2011)

Component	Evaluation	Literature base for questions		
	underlying the initiative?			
Cost Study	Programme focus: What was the total cost of implementing the ICT4RED programme and how were costs split between the major activities? Model focus: What would the total cost be to implement such a programme on district-wide level?	Cost Effectiveness Sustainability	Economic Evaluation	GeSCI TCO Tool (Twinomugisha & Bassi, 2009)
Implementation monitoring	Programme focus: Were the programme components, and programme overall, feasible to implement? Model focus: What have we learnt about the implementation of this programme that should be transferred to others? Which factors support, inhibit or prevent implementation?	Effectiveness (Wagner, et al., 2005)	Implementation Evaluation	Treatment fidelity monitoring (Zvoch, Letourneau, & Parker, 2007)
Results Review: Teacher reaction Learner reaction Circuit, district, province	Programme focus: Did the programme deliver the anticipated educational outcomes (learning, behaviour change,	Effectiveness & Impact	Impact Evaluation	Kirkpatrick Model: Level 1: Reaction Level 2: Knowledge & Skill Level 3:

Component	Evaluation	Literature base for questions		
reaction Teacher learning Learner learning District learning Teacher behaviour change Learner behaviour change District behaviour change Organizational change – school Organizational change – households Organizational change – circuit / district / province Organizational – province / country	organizational change) and necessary intermediate outcomes (reaction) at learner, teacher, school, district and province levels? Did the programme deliver the anticipated research outputs and how were these used? What were the unanticipated results? Model focus: What have we learnt about the results of this programme that should be transferred to others? Which factors support, inhibit or prevent the realisation of outcomes?			Behaviour Change Level 4: Organizational Change (Kirkpatrick & Kirkpatrick, 2006)

3.7 Considering the Monitoring and Evaluation Framework in terms of the NEPF & OECD DAC Criteria

When the M&E framework is considered in terms of the National Evaluation Policy Framework (Department of Planning, Monitoring and Evaluation (DPME), 2011) it is clear that the evaluation incorporates elements of design evaluation, implementation evaluation, impact evaluation and economic evaluation. In terms of the OECD DAC criteria, the evaluation framework incorporated a consideration of relevance,

effectiveness, impact, sustainability and although not necessarily cost effectiveness, definitely the cost.

Since the component "**Documentation of theory of action and theory of change**" was primarily concerned with analysing "the theory of change, inner logic and consistency of the programme, either before a programme starts, or during implementation to see whether the theory of change appears to be working" (Department of Planning, Monitoring and Evaluation (DPME), 2011, p. 9), it can be seen as a good example of a design review. This component was strongly influenced by the methods described by Funnell & Rogers (Funnell & Rogers, 2011).

The **Implementation monitoring component** tracked various monitoring data sources to check that the initiative did deliver the activities to the targeted number of people for as long as was needed. It also checked what levels of use – of the devices, of the content, of the other ICT infrastructure - were recorded. This agrees with the DPME definition of the purpose of implementation evaluation which is: "[T]*o evaluate whether an intervention's operational mechanisms support achievement of the objectives or not and understand why. Looks at activities, outputs, and outcomes, use of resources and the causal links. It builds on existing monitoring systems, and is applied during programme operation to improve the efficiency and efficacy of operational processes."* (Department of Planning, Monitoring and Evaluation (DPME), 2011, p. 9). To a degree this is part of the OECD DAC criterion of effectiveness which is concerned with the "*extent to which an aid activity attains its objectives"* (OECD Development Assistance Committee, 2010).

The **Results review component** was concerned with determining whether the anticipated changes at the four levels of the Kirkpatrick model (Kirkpatrick & Kirkpatrick, 2006) occurred – Did target beneficiaries react well to the initiative, learn the necessary skills and knowledge, change their individual behaviour as a result of the intervention, and did the higher level outcomes or impacts of the initiative i.e. development of 21st century skills, improvement in learner results and improving the employability of youth happen? This is exactly as per the DPME definition of impact evaluation, which is: *Impact Evaluation Seeks to measure changes in outcomes (and the well-being of the target population) that are attributable to a specific intervention*. (Department of Planning, Monitoring and Evaluation (DPME), 2011, p. 9). The evaluation questions of this

component also took into account the OECD DAC criterion of Impact, which is defined as: "*The positive and negative changes produced by a development intervention, directly or indirectly, intended or unintended*" (OECD Development Assistance Committee, 2010).

The **Cost component** was concerned with determining the total cost of ownership of the technology used in this initiative, and the cost of roll-out associated with this initiative, in comparison to the existing cost of rolling out learning and teaching support materials (LTSM) such as textbooks. Since there was no intention to do a full cost-benefit or cost-effectiveness analysis, this component was only vaguely similar to the definition of economic evaluation provided by the DPME. "*Economic evaluation considers whether the costs of a policy or programme have been outweighed by the benefits*" (Department of Planning, Monitoring and Evaluation (DPME), 2011, p. 9).

3.8 Choosing appropriate Evaluation Methods for each of the Evaluation Questions

Each of the evaluation questions were operationalized by specifying the evaluation method and data source that would be applied. The table below summarises the evaluation methods in relation to the evaluation questions, and indicates whether the main data source was qualitatively or quantitatively analysed.

Table 3-3: Evaluation methods in relation to evaluation questions

Component	Evaluation Questions	Evaluation Method and Data/ Analysis Type
Documentation of theory of action and theory of change	Which major activities were included in the ICT4RED design? What are the theories of change underlying the initiative?	Participatory Workshop – Qualitative
Cost Study	Programme focus: What was the total cost of implementing the ICT4RED programme and how were costs split between the major activities? Model focus: What would the total cost be to implement such a programme on district-wide level?	GeSCI TCO tool – Quantitative
Implementation monitoring	Programme focus: Were the programme components, and programme overall, feasible to implement? Model focus: What have we learnt about the implementation of this programme that should be transferred to others? Which factors support, inhibit or prevent implementation?	Textual analysis of Twitter feed, and WhatsApp group – Qualitative Post training trainer feedback form – Qualitative and Quantitative Attendance registers - Quantitative Post-training teacher feedback forms - Quantitative Occasional telephonic teacher survey- Quantitative and Qualitative Occasional telephonic school survey - Quantitative and Qualitative Device usage statistics- Quantitative School functionality checklist - Quantitative and Qualitative Learning Briefs – Qualitative

Component	Evaluation Questions	Evaluation Method and Data/ Analysis Type
Results Review: Teacher reaction Learner reaction Circuit, district, province reaction Teacher learning Learner learning District learning Teacher behaviour change Learner behaviour change District behaviour change Organizational change – school Organizational change – households Organizational change – circuit / district / province Organizational – province / country	Programme focus: Did the programme deliver the anticipated educational outcomes (learning, behaviour change, and organizational change) and necessary intermediate outcomes (reaction) at learner, teacher, school, district and province levels? Did the programme deliver the anticipated research outputs and how were these used? What were the unanticipated results? Model focus: What have we learnt about the results of this programme that should be transferred to others? Which factors support, inhibit or prevent the realisation of outcomes?	Post-training teacher feedback forms – Qualitative and Quantitative Ethnographic Observation- Qualitative District interviews- Qualitative Teacher session assessment record (Badge tracker) - Quantitative Teacher baseline questionnaire and follow up- Quantitative and Qualitative Review and tracking of research outputs - Quantitative and Qualitative Small scale experiment to measure Learner 21st century skills with a randomly assigned sample of learners - Quantitative and Qualitative Assessment of learner marks (Matric results, ANAs) in comparison with other matched schools – Quantitative School Functionality checklist - Quantitative and Qualitative Impact Stories - Quantitative and Qualitative Learning Briefs – Qualitative

A variety of quantitative and qualitative data sources were included in the evaluation design, and appropriate analysis of the individual data sources and triangulation across data sources were planned for. In essence, the evaluation design was a Mixed Methods Design (Greene, 2005) where qualitative and quantitative data sources were simultaneously collected, and analysis and triangulation across both kinds of data sources were used to interpret the findings.

The following section provides more information on each of the evaluation methods, as well as the steps followed to design these evaluation methods.

3.9 How the Evaluation Methods were Designed, Tested and Implemented

The design of the evaluation instruments, protocols, rubrics, and analysis templates generally followed the following seven steps in order to meeting the principles of Utility; Precision, Quality and Accuracy; and Feasibility, as outlined in the African Evaluation Guidelines (African Evaluation Association, 2007) and (Patel, 2013).

Step 1: Review Requirements and Examples

The M&E team reflected upon the purpose of the evaluation method in relation to other evaluation methods in the evaluation framework. Examples of other evaluation instruments were sourced and, where available, adapted for the purposes of the ICT4RED evaluation. For example – The Total Cost of Ownership Tool was developed based on a tool developed by GeSCI (Twinomugisha & Bassi, 2009); the teacher baseline and endline survey was based on published work by Papanastasiou & Angeli (2008) and work on e-readiness and e-maturity by SAIDE (2010); and the Learner 21st Century Skills Assessment Rubrics were adapted from the Student Work Rubrics published by Innovative Teaching and Learning (2012). The School Functionality Checklist was sourced from Khulisa Management Services, who developed it for Tshikululu Social Investments, FirstRand Foundation, RMB Fund and the Anglo American Chairman's Fund. The Learning Brief Templates were developed based on work done by the DG Murray Trust (DG Murray Trust, 2014).

Step 2: Draft Evaluation instruments, protocols, rubrics and analysis templates Developed and Checked

Where previous examples of instruments, protocols, rubrics and analysis templates were available, these were adapted for the ICT4RED initiative. Where no other examples were available, the M&E team developed custom tools, analysis protocols and report formats. The tools were circulated amongst implementation team members to inform them of the kinds of data that would be collected and analysed, and to check whether any of the component managers had information needs that could be addressed by the specific evaluation method. In some instances, additional data sources were being collected by the component managers, and this was taken into account in the design of the tool. For example – the Teacher Professional Development Team required facilitators to provide a post-training report, and the information required for this purpose and the information required for the purposes of the M&E team were consolidated so that the trainers only completed one survey after each training session. In some instances, the team also provided input about the credibility of the evidence likely to be generated by the methods – A few consultations were held with internal team members, and a panel of peers, on for example the Learner 21st Century Skills Measurement Protocol.

Step 3: Piloting and Finalisation of Evaluation instruments, protocols, rubrics and analysis templates

Where possible, the evaluation instruments, protocols, rubrics and analysis templates were pre-piloted with a small group of the target respondents – For example the Learner 21st Century Skills Measurement Protocol were tested with a small group of the same learners that would eventually take part in the assessment exercise. Where pre-piloting could not be done due to time and cost constraints, the evaluation method was tested with a few of the typical respondents during early data collection phases. Some data was reviewed, and adaptations were made as necessary. This ensured that the evaluation tools could be designed to be as accurate and precise as possible, whilst minimising time lost. The School Functionality Checklist, for example, was tested in the field with six schools, and small tweaks and adaptations were made to the evaluation instrument by Khulisa Management Services, while the data collectors were trained.

Step 4: Implementation of the Evaluation Methods

After the finalisation of the various evaluation instruments, protocols, rubrics and analysis templates, the responsibility for collecting the data was assigned, and the relevant person was oriented on the purpose of the data collection and the associated procedures. Data were collected either by a member of the M&E team, or by one of the implementers on the initiative, or by one of the students working on their research. The considerations of cost, reliability of the various data collectors, as well as potential bias were central in the decision to allocate data collection responsibility. For example – While the Occasional School Interviews and Occasional Teacher Interviews were administered telephonically by junior members of the internal CSIR Meraka M&E team, the SchoolNet SA trainers were required to collect attendance registers, and a representative from the community was selected to collect the post-training teacher feedback forms during phase 3 implementation.

Step 5: Collation and Quality Control of Data

The various data emerging from the various evaluation methods were collated at the CSIR Meraka Offices and quality controlled. Different approaches were followed depending on who was responsible for collecting the data, and how the data was collected.

For data that were collected on paper in the field (e.g. attendance registers, happy sheets) a batch control sheet was developed that allowed the person who submitted the data, to indicate if there were any problems. The Batch Control Sheet asked the person who collected it to indicate the number and type of questionnaires submitted, the schools from which it were collected, the date of submission, and for comments about the data.

For data that were collected using an online survey platform, the data were immediately shared with the implementation team via a link to the findings, and reminders sent out to the persons via WhatsApp if data were outstanding. These data would be checked occasionally, and clarifications sought via WhatsApp when necessary. Once all the data were collected, the data file would be downloaded, and the data would be submitted to a quality control process.

For data that were collected as audio recordings, a list of the audio recordings would be compiled indicating the file name, the date of collection, the type of data collected, and the person responsible for collecting the data. Snippets of the data would be checked for audibility and clarity prior to further processing. This would assist in arranging for further data capturing.

Generally, the quality control of the data involved checking that the anticipated number of responses was received back, noting any special circumstances that could affect the quality of the data, and checking that the data were as complete as possible.

Each data source was meticulously tracked through the phases of collection, collation, quality control, data capturing, post-capturing quality control, analysis and reporting, using a free online ticketing system available at www.trello.com. For each data source, a ticket was created, and as the data source progressed to analysis, responsibility for certain tasks were allocated, and provision was made for notes to be added to the data source ticket. This ensured that the data analyst would have information about the administration circumstances available at the time of analysis – even if the physical paper data was in archive and collected months before.

Step 6: Data Capturing and Quality Control

The various data were captured internally or by external transcribers using appropriate online and offline data capturing templates. In each case, the data capturing was quality controlled – either by double entry, batch checking or sample checking prior to further data analysis. Electronic data files were kept in an online repository and made accessible to team members via Drop Box. Where possible, each data file also contained meta-data indicating where the data originated from, whether the quality control and cleaning had been conducted, and how far analysis and reporting had progressed.

Step 7: Data Cleaning, Analysis and Reporting

In most instances, both the qualitative and quantitative data had to be cleaned and matched to other data sources before analysis could take place. The teacher attendance data and badge data, for example, had to be matched to a Master Educator list which also contained up to date

information about the status of each of the initiative participants – Whether they were still participating, or whether they dropped out due to illness, retirement or any other reason.

Quantitative analyses were conducted using standard spreadsheet software, as well as open source quantitative analysis software such as PSPP. Qualitative analysis was conducted using Computer Aided Qualitative Analysis Software such as QDA Miner. Topic modelling and sentiment analysis were conducted using appropriate computer tools.

Monitoring and Evaluation Reports were compiled on approximately quarterly to six monthly basis. When data were available and analysed, findings were included in an evaluation report. Each data source was individually analysed and reported, linked back to the relevant evaluation question in the evaluation framework, and triangulated with other data sources. A short summary of the key findings were included in the report, to facilitate evaluation use. This meant that as data became available, the findings were shared with the implementation team, the initiative donors, and the initiative steering committee. As appropriate, meetings were scheduled with various evaluation users to discuss and interrogate the findings and develop or check recommendations.

The table below provides a short description of the various data sources, sample and reporting frequency related to the evaluation framework.

Photo 3-1: Phase 1 Teachers Graduating

Table 3-4: Data sources, sample and reporting frequency related to the evaluation framework

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
Documentation of theory of action and theory of change	Which major activities were included in the ICT4RED design? What are the theories of change underlying the initiative?	Participatory Workshop. (Custom Developed)	During the self-evaluation phase of the initiative, the M&E team called a participatory workshop with implementers, and developed a theory of action (LogFrame) of the implementation activities during phase 1. Towards the end of 2014, the M&E team again updates the theory of action for the initiative and consulted team members on the prominent theories of action	All initiative activities that were completed were reflected in the programme theory, when it was compiled.	Initial Self Evaluation Report – April 2013 End of Initiative report

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
Cost Study	Programme focus: What was the total cost of implementing the ICT4RED programme and how were costs split between the major activities? Model focus: What would the total cost be to implement such a programme on district-wide level?	Total Cost of Ownership Tool, based on the GeSCI TCO tool (Twinomugisha & Bassi, 2009)	The GESCI Total Cost of Ownership tool was adapted and populated with initiative cost data made available by the initiative manager	During July of 2014, the anticipated initiative costs for the full five year initiative (based on historic records of actual expenditure and initiatives expenditure as per initiative proposals) were used to complete a first run of the Cost Modelling. In August of 2014, the initiative team worked with the Eastern Cape Education Department to develop an initiative budget to sustain the most important activities of the ICT4RED initiative, after March of 2015	Various iterations were shared internally from July of 2014 onwards. End of initiative report will contain the final versions
Implementation monitoring	Programme focus: Were the programme components, and programme	Textual analysis of Twitter feed, and WhatsApp group. (Custom Developed)	Qualitative analysis of the twitter feed and the WhatsApp stream was conducted, and submitted to topic modelling. The findings regarding problems were immediately fed back to the	The twitter feed and WhatsApp streams for phase 2 and 3 were monitored in real time by members of the evaluation team.	This was reported in the mid-2014 report

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
	overall, feasible to implement? Model focus: What have we learnt about the implementation of this programme that should be transferred to others? Which factors support, inhibit or prevent implementation?		initiative team during initiative management meetings. The findings were also used to triangulate the findings collected via other data sources.	For Phase 2, a snapshot of the discussions that took place on the ICT4RED facilitators group between May 2013 and November 2013 were analysed. All twitter data for the same period was analysed	
		Post training trainer feedback form. (Custom Developed)	Within a week after each training session took place during phase 2 and phase 3, all facilitators were asked to complete a facilitator feedback from via an online survey hosting service.	7 surveys were conducted for phase 2 training (modules 4 – 10), and 7 surveys were conducted for phase 3 training (modules 1 – 9)	The responses from trainers were immediately made available to the implementation team via the online survey hosting service. Findings were consolidated, analysed and reported on a 6 monthly basis.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
		Attendance registers. (Custom Developed).	The attendance registers were pre-populated with participant names and unique identifiers. The participants had to sign, and facilitators or district officials sent the completed registers to the initiative office where capturing and analysis was conducted.	All teachers who participated in the initiative had to sign an attendance register every time they attended a Teacher Professional Development session during phase 2 and 3. During Phase 3, attendance registers were also collected for Change Leadership sessions	Findings were consolidated, analysed and reported on approximately 6 monthly basis.
		Post-training teacher feedback forms (Happy Sheets). (Custom Developed).	These were short one page surveys anonymously administered. It asked participants to rate the quality of the training. Facilitators collected these, and reviewed them before sending it off the initiative office for capturing and analysis.	All teachers were required to complete one of these post training surveys after every training session.	Findings were consolidated, analysed and reported on approximately annual basis.
		Occasional telephonic teacher survey. (Custom Developed).	This survey was administered telephonically and was intended to get some general impressions about the teachers' reactions and response to the initiative, and to	A sample of 2 teachers from all of the participating schools was phoned during phase 2 and 3.	Findings were consolidated, analysed and reported on approximately 6

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
			monitor technology performance.		monthly basis.
		Occasional telephonic school survey. (Custom Developed).	This survey was administered telephonically and was intended to get some general impressions about the support for the initiative, the performance of the technology, and the impressions of uptake in the school	A sample of 2 ICT committee members from all of the participating schools was phoned during phase 2 and 3.	Findings were consolidated, analysed and reported on approximately 6 monthly basis.
		Device usage statistics. (Sourced from various systems, analysis protocol Custom Developed).	Tracking of server downloads, internet usage, calls logged with the IT support call centre were tracked, once the relevant technologies were rolled out. Logs of the use of Mobikits were kept from end of 2014, when NARYSEC Youth was available to complete the relevant forms.	Due to initiative roll-out delays, this was only implemented from the end of 2014 at all schools where this information was available.	Findings were consolidated, analysed and reported in the last 2 evaluation reports only.
		School Functionality Checklist (Sourced from Khulisa Management Services , who developed it for Tshikululu Social Investments,	A school is visited for a full day and various interviews with the principal, school leadership and teachers are conducted in addition to observation by a trained and skilled educational researcher. Data from Departmental sources such as the Annual School Survey and the Annual National	A sample of 6 of the 26 schools involved in phases 1 – 3 were visited and interviewed for the completion of the School Functionality Checklist. The intention was to initially visit more schools, but this was	Findings were consolidated, analysed and reported in the last 2 evaluation reports only.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
		FirstRand Foundation, RMB Fund and the Anglo American Chairman's Fund)	Assessment results or Grade 12 Senior Certificate Examination results are also used. The School Functionality Checklist is then completed by entering evaluative judgements in relation to the various school functionality indicators into a database. The categories of indicators covers learner outcomes, the contextual environment, school resources, administration, governance, community involvement and staff professional development.	adapted after the feasibility of the data in relation to the value of the output was evaluated	
		Learning Briefs (Template based on work by the DG Murray Trust's Hands-On Learning Briefs (DG Murray Trust, 2014)	Implementation team members were encouraged to think of topics of learning that occurred during the initiative implementation. Participants were asked to reflect on learning that emerged from implementation success, implementation failure, and a reading of relevant literature. A learning brief template was provided as guideline. Team members developed the learning	The first round of learning briefs were developed close to the end of the 2nd phase of implementation in November 2013, and the second round of learning briefs were developed close to the end of the 3rd phase of implementation in December 2014	Reported at the end of 2013, and at the end of 2014. Individual learning briefs were also published on the ICT4RED blog and website.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
			briefs, they were internally vetted by the Initiative Owner, and edited for language. Following the compilation of the learning briefs, a learning workshop was scheduled during which team members shared the learning with each other, and donors.		
Results Review: Teacher reaction Learner reaction Circuit, district, province reaction Teacher learning Learner learning District learning Teacher behaviour	Programme focus: Did the programme deliver the anticipated educational outcomes (learning, behaviour change, organizational change) and necessary intermediate outcomes (reaction) at	Post-training teacher feedback forms (Custom Developed)	(See Description above under Implementation Monitoring Component)		
		Ethnographic Observation (Custom Developed).	An ethnographer with educational and ICT experience and deep understanding of the Cofimvaba context visited the implementation site for a period of 2 weeks. During this period she engaged with the community members, the school staff and became immersed in the implementation context. A detailed ethnographic report, rich with observations, findings, anecdotes and quotes were developed, and shared with the implementation team.	An ethnographer visited the first site of implementation – Arthur Mfebe close to the start of the initiative in 2012, again in the middle of 2013, and finally in the beginning of 2015 to get an in-depth view of the ICT4RED initiative in this context. Data was collected via observation and interviews with various stakeholders. A	Reported in August 2012, August 2013 and again in the final evaluation report of 2015.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
change Learner behaviour change District behaviour change Organizational change – school Organizational change – households Organizational change – circuit / district / province Organizational – province / country	learner, teacher, school, district and province levels? Did the programme deliver the anticipated research outputs and how were these used? What were the unanticipated results? Model focus: What have we learnt about the results of this programme that should be transferred to others? Which factors support, inhibit or prevent the			limited number of other observations of training sessions and schools were also included.	
		District interviews (Custom Developed).	Although it was initially planned the District Officials would be interviewed on a quarterly basis, the involvement of district officials did not justify this approach. Instead, the M&E team conducted a round of semi-structured district interviews close to the end of 2014 in order to ascertain some of the factors that were facilitating and preventing their participation in the initiative, and some of the factors that are likely to affect initiative sustainability.	A snowball sampling strategy was followed until data saturation was reached. More active and less active district officials were asked to nominate peers to give more input on the District Official Interview Schedule.	Findings were consolidated, analysed and reported in the last 2 evaluation reports only
		Teacher session assessment record (Badge tracker supplied by SchoolNet SA, analysis protocol Custom Developed).	The badge tracker was matched with the master educator database and the attendance record of teachers. Appropriate descriptive statistics were reported to determine whether teachers were meeting or exceeding the expectations.	A first round of analysis was carried out after 5 modules of training took place in phase 2, and again after the full 10 modules were completed. Approximately 150 teachers participated	Findings were consolidated, analysed and reported on approximately 6 monthly basis.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
	realisation of outcomes?			during phase 2. For phase 3, the badge tracker was analysed after 7 modules were completed, and again at the end of the initiative. Approximately 105 teachers participated in phase 3.	
		Teacher baseline questionnaire and follow up Based on (Papanastasiou & Angeli, Charoula, 2008) and (SAIDE, 2010)	A teacher baseline questionnaire which asked teachers to reflect on their own attitudes, experience and school context was administered during module 1 and module 10 of both phases 2 and 3. Teachers were asked questions about their biographical information, prior training, uses of technology, technology attitudes, and perceived self-confidence in using ICT in school. It also surveyed the school climate and support. This was mostly a closed ended questionnaire requiring educators to select answers from pre-defined categories or to rate their exposure	All phase 2 and 3 teachers completed the baseline and end-line questionnaire at the start of the training and again at the end of the training. Responses from approximately 260 teachers across 25 schools were collected	Findings for phase 2 was consolidated and analysed in the mid-2013 report, and again in the mid-2014 report. Findings for phase 3 was consolidated and analysed only after the end-line was administered in 2015.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
			and attitudes using Likert scale items. The changes in responses between the baseline and end-line was analysed and reported to provide evidence of changes and shifts in technology behaviours, and attitudes.		
		Review and tracking of research outputs (Custom Developed).	The number and type of publications and presentations were tracked by the ICT4RED information specialist. A custom spreadsheet with the relevant information fields were developed and populated by team members. The number and kinds of users interested in downloading the ICT4RED Teacher Professional Development Course was also tracked using an online form. The number and kinds of research support grants were also tracked by the component manager in charge of research. Occasional analysis was conducted in order to	All presentations, publications, TPD download requests and research grants were tracked.	Findings were consolidated, analysed and reported in the last 3 evaluation reports only, since the lead time for the production of these outputs did not justify earlier reporting.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
			describe the magnitude of the research contribution made by the team.		
		Small scale experiment to measure Learner 21st century skills with a randomly assigned sample of learners based on (Innovative Teaching and Learning, 2012)	A sample of 100 grade 7 learners were selected from participating phase 2 and 3 schools and randomly assigned to 20 groups of five learners each. A sample of 5 initiative teachers and a sample of 5 control group teachers (not trained) were selected to participate in the assessment. During the first assessment, learners were given an initiative based assignment to complete during a time period of 6 hours. Group work outcomes as well as individual work outcomes were evaluated using appropriate evaluation rubrics. In addition a snapshot of the group interaction was video recorded and assessed. During a second assessment – approximately one week later, the same learners were given an	Approximately 100 grade 7 learners, and 10 grade 7 English language teachers participated in the small scale experiment.	Findings were consolidated, analysed and reported in the final evaluation report in 2015.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
			equivalent assignment, but this time had either one of the trained or one of the untrained teachers to facilitate the learning. The group and individual learning outcomes, as well as the group interaction were assessed in relation to the first assessment. The experiment aimed to assess, qualitatively and quantitatively, whether learners facilitated by trained teachers are better able to manifest 21st century learning than those learners who were not facilitated by a trained teacher.		
		Assessment of learner marks (Matric results, ANAs) in comparison with other matched schools based on DBE reports released on the Grade 12	Initially it was intended to analyse departmental learner outcome data like Annual National Assessment records and Grade 12 Senior Certificate results for all of the participating schools and a control group of matched schools from the Cofimvaba district for a period of 3 years prior to implementation, and for at least	All of the phase 1, 2 and 3 schools' learner outcome data for a period of three years were analysed. For schools with grade 12 learners, this included official senior certificate examination results. For schools with learners	Findings were consolidated and reported in the mid-2014 report.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
		examinations and the Annual National Assessments	one year after implementation. An initial exploratory analysis of initiative schools' learner outcomes revealed large fluctuations from year to year – partly due to the fluctuations in the number of learners from year to year, and partly because of the way in which the learner outcome data was obtained from year to year. Based on this analysis, it was decided to discount official learner outcomes data as a potential source of learner impact in the initiative.	between grades 1 and 7, this included ANAs in maths (numeracy) and language (literacy) for grades 1 – 6 and grade 9.	
		School Functionality checklist (By Khulisa Management Services)	(See Description above under Implementation Monitoring Component)		
		Impact Stories based on (Williams & Chilalika, 2013)	Team members, teachers, district officials and initiative partners were asked for stories of positive or negative change that resulted from the ICT4RED initiative. These first telling of the stories were then followed up by a researcher, and impact story template was	Impact stories were collected throughout the phase 2 and phase 3 implementation stages.	Impact Stories were reported in the final evaluation report only.

Component	Evaluation Questions	Evaluation Method	Description	Sample	Reporting Frequency
			completed seeking a detailed description of the change and an attribution to a specific component of the ICT4RED initiative. Contact details of another person that could verify the story was also collected. Prior to analysis, all stories were telephonically verified, and an analysis rubric was used to quantify some of the qualitative descriptions. Data were then qualitatively and quantitatively analysed and reported.		
		Learning Briefs	(See Description above under Implementation Monitoring Component)		

Photo 3-2: Teacher Professional Development

3.10 How ethical clearance and provincial approval for the initiative was obtained

The ICT4RED initiative was a research initiative implemented by the CSIR Meraka Institute, and therefore standard CSIR ethics approval processes had to be followed before the research of the implementation team, various students, and the Monitoring and Evaluation team could continue. This involved completing the relevant ethics application forms as prescribed by the CSIR Research Ethics Approval Committee and submitting examples of draft instruments, examples of consent and ascent forms and the details of the various researchers / investigators. Detailed background about the initiative was also submitted for review. Although the initial ethics approval process took about 5 months to complete, interim approval was provided early in the process, to ensure that no unnecessary delay was encountered. Initial ethical clearance was provided for a period of one year, and after this, the principal investigator submitted a renewal request, together with a report detailing updates to instruments, team member details and other pertinent initiative information. The ethics clearance was subsequently extended to the end of the initiative.

Concurrently, an application for Research Clearance was lodged with the Eastern Cape Provincial Education Department in line with their Research policy. Verbal and written authorization was solicited from the first pilot school, the relevant Education District and the head of the Provincial Education Department, whilst relevant officials in the Department of Basic Education were also kept abreast of developments. The Eastern Cape Education Department Research approval process also required the ICT4RED principal investigator to complete a prescribed research application form. Examples of instruments, consent and ascent forms, as well as initiative background were also submitted. Formal Research approval from the Research Directorate at the Eastern Cape Education Department took approximately 6 months to obtain. Subsequently, the principal investigator was also invited to present to a forum of Education Research Stakeholders at the Eastern Cape Education Department, to share the design and objectives of the research.

After initial authorization and ethical clearance was obtained, all teachers, facilitators and district officials were required to complete an informed

consent form. Two copies were signed when the initiative was initiated in a specific school –One copy was collated and captured at the CSIR office, and the other was given to the participant to refer to. Where learners were involved in the research processes, informed consent were sought with the parents. Learners under the age of 18 were also given the opportunity to be briefed on the research and could provide ascent if they agreed to participate. These forms were also made available in the local language as appropriate, and the informed consent process was facilitated by team members responsible for community engagement, and/or initiative partners such as teachers at the various schools.

Following these procedures assisted the Evaluation Team to meet requirements of Propriety, respect and ethics as set out in the African Evaluation Guidelines (African Evaluation Association, 2007) and (Patel, 2013). At each step of the evaluation and research process, however, the team were required to ensure that all reasonable measures were taken to ensure that participants were not coerced into participation or that they did not suffer any negative consequence by participation. Standard data archiving and maintenance processes were also followed to ensure that data were kept confidential and anonymous as appropriate – Data were and only shared with team members covered by the Ethical Clearance processes. Finally, the effect of exiting from the initiative was also considered and some exit and maintenance arrangements were set in place with the local Education District and Provincial Education Department to prepare for the period after the initiative implementation came to an end.

3.11 Implementing the Monitoring and Evaluation Framework – Some Lessons

- ***Being flexible in the M&E approach***

When a complex and innovative initiative is being implemented, the intervention design and the anticipated outcomes are likely to continually change and adapt as more is learnt about possibilities and interaction with other resources in the implementation context. Iterative design in the ICT4RED initiative meant that the objectives, definition of success and initiative terminology were continually evolving. These changes, together with the emergence of new evaluation needs, meant that the evaluation

team needed to be nimble and flexible in their approach. The initially designed evaluation framework was tested and updated as needed, and it is unlikely that the evaluation team would have been able to keep up with the implementation changes and initiative requirements if they were not involved in the weekly initiative management meetings. This, however, meant that the evaluation team spent a significant portion of their time engaging in meetings. Although the usual evaluation tasks such as collection, collation analysis and reporting still needed to be conducted, the use of the information and findings that emerged from these findings could only really take place in engagements between the evaluation team and the other evaluation users.

- ***Relationships between the M&E team and the evaluation users***

This also had implications for the way in which the M&E team had to approach their relationships with other team members and evaluation users. It was important for the evaluation team to remain critical of all claims made by the initiative partners, but in such a way that it provided an opportunity for the interrogation of evidence in support of better decision making and choices. Strong working relationships and trust developed between the M&E team members and implementation team members, based on an understanding of the shared values in the initiative. This did not mean that the M&E team were less impartial about the ICT4RED initiative – the shared values were used to evaluate the evidence and ascribe relative value to the various findings.

- ***Differing sets of values of different evaluation users***

The primary evaluation users were identified as the implementation team, and it was relatively easy to develop an understanding of the values of the team that could be used for evaluative purposes. The secondary users – such as initiative donors and initiative beneficiaries, however, were further removed and it was not always possible to provide evidence that was valued according to their definitions of "value". To this end, it was recognised that the evaluation team should be explicit about the values used to judge the merit and worth of the intervention and evidence, and where possible, engage with the other evaluation users to check interpretations against expectations.

- ***Timing of the Evaluation Activities***

Due to funding constraints, the main monitoring and evaluation activities only got underway approximately six months after the initiative pilot had started at Arthur Mfebe. This benefited the process of evaluation design since the implementation team already had a clearer idea about the way in which activities would be rolled out.

Towards the end of the initiative period, however, it also became apparent that it would be ideal for some of the evaluation activities to continue after the formal initiative closure. The initiative donors were encouraged to consider extending funding for the evaluation after initiative closure, or to at least consider extending the timeline for the submission of the final evaluation report.

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SECTION 4: Managing ICT Deployment in Schools

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This section will focus on how programme management, operations management and School ICT were managed in the ICT4RED initiative. The essence of what each had to deliver will be highlighted. Although each of these components have already been discussed under the framework in Section 1 it is important to indicate what each provided to support the Teacher Professional Development component. Without proper programme management, operations management and the School ICT provision the ICT4RED could not have addressed its aims and objectives.

4.1 Programme Management

As was already indicated under Section 1, where the framework was discussed, programme management supported the whole initiative and was the component which was essential to drive all the other components.

The main role of the Programme Management component was to take strategic leadership of the initiative, re-conceptualisation, planning and delivery. The Programme Manager had overall responsibility to ensure that the overall strategic objectives are met.

This also involved constant open communication with funders and primary stakeholders (government departments, general public, participating schools and communities, partners like Eastern Cape Department of Education) and potential partners and funders. An externally facing website was necessary to share content with the outside world and an internal initiative-focused communication and sharing platform was also developed as a resource repository for initiative participants.

The programme manager had to ensure that the Blogs are constantly updated, social media accounts and records are kept and branding is done. Therefore a communications strategy was developed with guidelines on branding and ways of communication on the initiative. It was important to capture how communications will be managed throughout the life cycle of an initiative of this calibre. **The Communication strategy** provides a Plan

which describes the planned and periodic communications occurring between all the ICT4RED Initiative stakeholders. This plan also covered scheduled written and oral communications, responses to unsolicited requests for information, the frequency of the scheduled communications, and the responsible person(s) for providing the information. The Communication Plan is an integral part of the overall Programme Management and will be used to provide guidance to the ICT4RED initiative. Based on this strategy the programme manager had to present the initiative at various forums, do conference presentations and collaborate or support publications on the initiative. Important weekly meetings were scheduled with the rest of the team to keep track of developments within every other component and to manage risks and challenges.

This is why the knowledge management function also resided within this component. The programme manager had to negotiate budgets with the funders if underestimations or additional costs arise. The applications for ethics approval at various organizations or at national departments were also controlled and managed from this component. Any other high level approvals and final decisions on deployment, implementation and involvement of other parties had to be done within this component.

The programme manager provided advice, reports and inputs to stakeholders, which can affect policy changes in the long term, especially regarding deployment of technologies in schools. The programme manager also had to provide evidence of how this initiative has affected a change in behaviour of the whole community (which includes representatives from the provincial Department of Education, district officials, principals, teachers, learners, parents and local suppliers). There had to be close collaboration between this activity and all other activities, so that learning and knowledge can be shared in transparent and easy-to-digest ways.

Evidence-based policy needs of government and stakeholders had to be managed and supported. This includes engagement with universities and experts in the research fields of Education and ICT4D were important to share lessons learnt and best practices. Recruitment of postgraduate students was important to show impact and human capital development, if they can base their studies on the initiative in the fields of Education, Information systems, IT/Computer Science. The postgraduate students were supported with a once off payment (via their university student

accounts) and their studies and publications were a support mechanism to market the ICT4RED initiative through their publications and presentations. For this purpose **Memorandum of Understandings (MoU)** and **Memorandum of Agreements (MoA)** had to be signed with the respective universities. A process of engagement with universities and the process of selection of students are artefacts of this part of the programme management component.

To get postgraduate students involved, special attention was paid to get university students from universities which are in the same province than the ICT4RED initiative. The following process was applied:

- Universities and specific departments/Faculties are approached to present the ICT4RED initiative to them to determine if any of their students, staff or other researchers associated with their university will be interested to be part of the initiative at postgraduate level. They did the selection themselves and the ICT4RED team were requested to provide an overview of the initiative and also some ideas on what are the possibilities for postgraduate studies.
- Prospective students had to provide a summarised overview of their possible title, scope, and a one pager which addressed the what, where, when, how and why as a starting point within 2 weeks for further discussions.
- Individual in-depth discussions were held with interested students and their supervisors at the universities.
- Students had 6-9 months (depending on the university) to complete a proposal which had to be accepted by their respective research committees.
- Students had to get their own ethical approval at their universities. Any other ethical approval which was gained before the ICT4RED initiative was implemented was provided to them. The Department of Basic Education: Eastern Cape Province provided a letter of approval to conduct the ICT4RED initiative and do research based on the initiative.
- A MoA was signed with each university and its respective Faculties and departments with timelines and specific deliverables.
- Each accepted proposal from the universities was supplied to ICT4RED team as proof.

- Quarterly progress reports were provided to track student progress.
- All students with their supervisors were funded to visit the Nciba school district to meet the respective teachers, principals and other stakeholders involved before commencing with their field work or empirical research;
- Fieldwork trips were arranged to coincide with other activities or training dates at the schools and was done after school hours;
- Scholarship payments were done by the initiative manager. Payments were only affected after signature of the MoAs, Proof of registration of students was received and student's proposals were accepted and approved by their respective Faculties.

This process proved to be successful as some students who failed to submit their proposal were not funded.

The programme management component supports all other components and uses their inputs to improve or advise on new directions.

The following were developed from the Programme Management component:

- How to deploy tablets in schools (a step-by-step guide) – known as The Blueprint
- Communications strategy (already mentioned)
- Research framework report (which outlines the Research Methodology, approach and strategy to develop the final framework)

4.2 Operations Management

The objective of this area of focus was to establish an Operational Management environment linked to the strategy known as "Central Control, Decentralised Services". The setup of this environment was linked to industry best practises like ITIL (formerly known as the Information Technology Infrastructure Library which is a set of practices for IT service management or ITSM that focuses on aligning IT services with the needs of the business). The four main areas of focus for this deliverable were:

- **People:** A multi-tiered approach was followed.
- **Process:** Each of the deliverables was documented in a process.

- **Policies:** All the policies that have governed the initiative was documented and signed-off by all the stakeholders.
- **Tools:** The tools will monitor all the ICT components to enable pro-active management as far as possible. The tools will also allow us to record all events and manage them in a structured way. (Software tools like Service-now for incident reporting, tracking and resolving issues with tablets and for Asset Management)

Here the project manager took day-to-day responsibility for planning and implementation. This includes responsibility for all administration processes, financial reporting, procurement and logistics relating to the ICT4RED initiative.

The Operations Management defined common processes and procedures, policies, roles, responsibilities, terminology, best practices and standards for managing IT before and after deployment and implementation. This also included the procurement, device management and support and maintenance of technology.

The three core objectives were:

- Achieving stability: it is in the nature of Operations to try to maintain the status quo, and minimize changes as the main source of service disruptions.
- Continual improvement: to improve the IT infrastructure and services it provides. It implies changes, and it conflicts with the previous one.
- Diagnosis and resolution of occurred operational failures. Here Operations has to cooperate tightly with Service Desk and Incident Management.

The challenge was that these objectives were sometimes conflicting. This challenge was overcome through strong leadership, adherence to policies and processes, good management and excellent communications.

4.2.1 IT Operations

The IT Operations function is divided into two sub functions namely (a) IT Operations Control and (b) Facilities Management. Each of the sub-functions in turn has a number of activity or service categories.

Figure 4-1: IT operations for ICT4RED initiative

4.2.1.1 IT Operations Control (ITOC)

ITOC is a sub-function that centrally monitored and controlled operations tasks. These tasks included but were not limited to:

- Remote and onsite maintenance and support activities: Performing maintenance activities requested by Application Management and Technical management functions. Operations can be organized to work in shifts, in order to perform assigned after-hours tasks.
- Console management: Monitoring IT infrastructure through various IT control tools and/or real-time reporting engines.
- Job scheduling: Automated and manual execution various scripts and batch jobs.
- Backup and restore: Management of centralized and distributed backups for all environments. This includes backing up of configurations (server, desktops, switches etc.)

4.2.1.2 Facilities Management (FM)

FM managed facilities that house physical IT infrastructure such as server rooms, data centres and disaster recovery sites. It takes care of all the accompanying functions including but not limited to:

- Cooling
- Power
- Security (e.g. Physical & logical access control) and Safety (e.g. fire control)
- Monitoring and alerting

FM is also responsible for large transitions such as:

- IT infrastructure consolidation
- Construction / upgrade initiatives concerning facilities, cabling, power, monitoring & alerting etc.
- Deployment of large scale hardware and / or software upgrades

The ICT service providers in the ICT4RED initiative formed part of a three-tier support service to schools in the area. Tier 1 comprised of the service desk, tier 2 provided on-site ICT administration and included a field service team, and tier 3 comprised a centrally located specialist technical support service, to deal with problem escalation and management (see Figure 4-1). Service providers assigned through the NARYSEC programme primarily formed part of the Tier 2 ICT administrator team, located at the 26 schools. The NARYSEC programme stand for The National Rural Youth Service Corps (NARYSEC) and it was established in September 2010. NARYSEC's main goal is to recruit and develop rural youth; and to perform community service in their own communities (DRDLR, 2014).

Their roles and responsibilities are provided below:

Table 4-1 Roles and responsibilities of NARYSEC Youth in support of ICT4RED at schools

Key Result Area	Responsibilities / Objectives
ICT fault reporting and response administration	Use IT Services Management Software to generate weekly reports on calls handled and performance w.r.t. call resolution Customise reports in line with stakeholder requirements
Technical support (end-users)	Log and manage all hardware or software faults or general enquiries related to end-user devices (tablets, laptops, etc.) Respond to calls (service orders) issued by Tier1 and Tier3 support
End-user training	Training with respect to use of hardware and software (tablets, laptops, printers, audio-visual equipment, content servers, Wi-Fi, Internet access)
ICT user training	On the job training of ICT users at the school who are part of Tier 2 support
Special projects	Manage and assist with ad hoc special projects (e.g. data collection and analysis: user needs survey)

These young people were trained to act as support and maintenance champions at each school. They assisted the teachers and ICT committees (which will be discussed under the School ICT component) at schools with the booking and charging of tablets, and overall ICT school architecture.

From the following figure it is evident that if they cannot resolve an incident it then escalates to the CSIR staff to provide support.

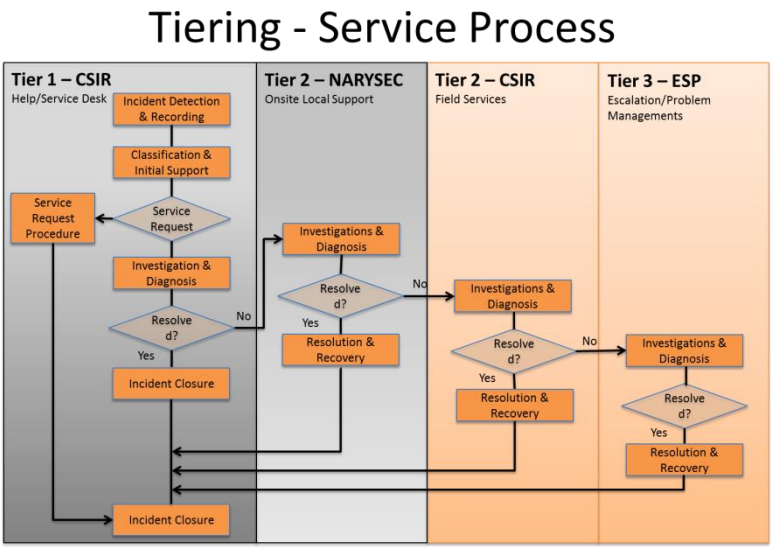

Figure 4-2: Service process for each Tier in the ICT4RED initiative

The more detailed deliverables are:

- Tier 1: This will be the first point of contact level for all users. Different channels were established to make it as easy as possible for the users to report problems or issues or requests.
- Tier 2: Once the user has made contact with the previous Tier and the reported incident could not be resolved then this Tier will take-over. This Tier is onsite within the area where the technology gets deployed (through the NARYSEC youth). The plan was to develop local youngsters in the area to be deployed at each school.
- Tier 3: This is the last level of escalation and is a combination of core skills within CSIR and External Service Partners.

The following is an example of how individual incidents were handled to resolve technological problems or issues with tablets:

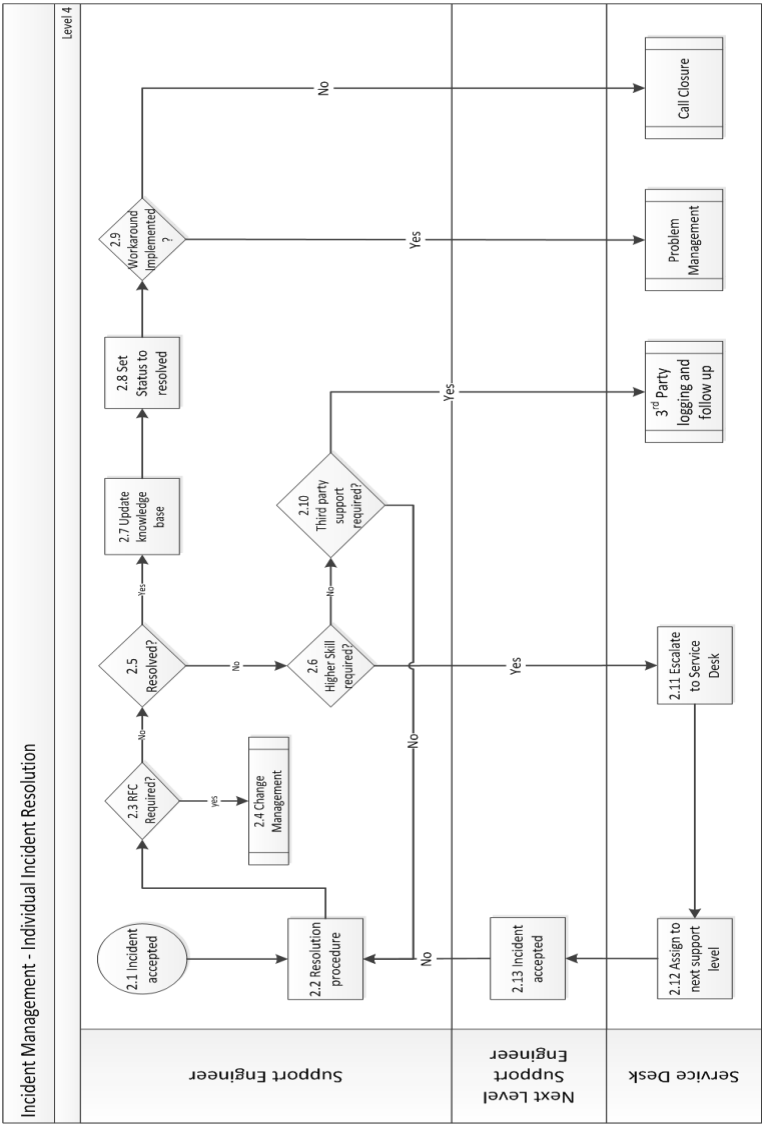

Figure 4-3: Incident management of individual incident resolutions

The following table explains the process, description and responsibility for each level and process:

Table 4-2: Process descriptions and responsibility for individual incident resolutions

Process	Description	Responsibility
2.1	The technical person assigned will accept the incident into an "In Progress" status when they are ready to start working on it.	Technical Staff Member
2.2	If they are unable to identify what is wrong and find a solution within the defined SLA timeframe, the incident must be assigned it to the next level of support - hierarchical escalation (initial support, Advanced Support and to 3rd level – assign to a vendor, Advanced Support logs the call and updates the record with the reference. Advanced Support monitors the resolution from the 3rd Party. Escalate to management if 3rd party miss deadline).	Technical Staff Member
2.3	Investigate the cause and identify if it can be resolved without a change required to be logged.	Technical Staff Member
2.4	If necessary, a request for change should be logged and the change management process should be followed.	Technical Staff Member
2.5	Resolve the incident; either with a fix or work-around confirming with the user (if there is one involved) that the service is working again.	Technical Staff Member.
2.6	If the incident is not resolved a decision should be made to either hand over the incident to higher skilled resource or requesting the relevant third party to resolve the incident.	Technical Staff Member.
2.7	Update the incident record and knowledge base as described in the relevant procedures.	Technical Staff Member
2.8	Set the status to Resolved when sure that service is working again.	Technical Staff Member
2.9	If resolved follow call closure process.	SD
	END	

The figure below provides an overview of how the different users will respond to different incidents based on the tier level where it resides:

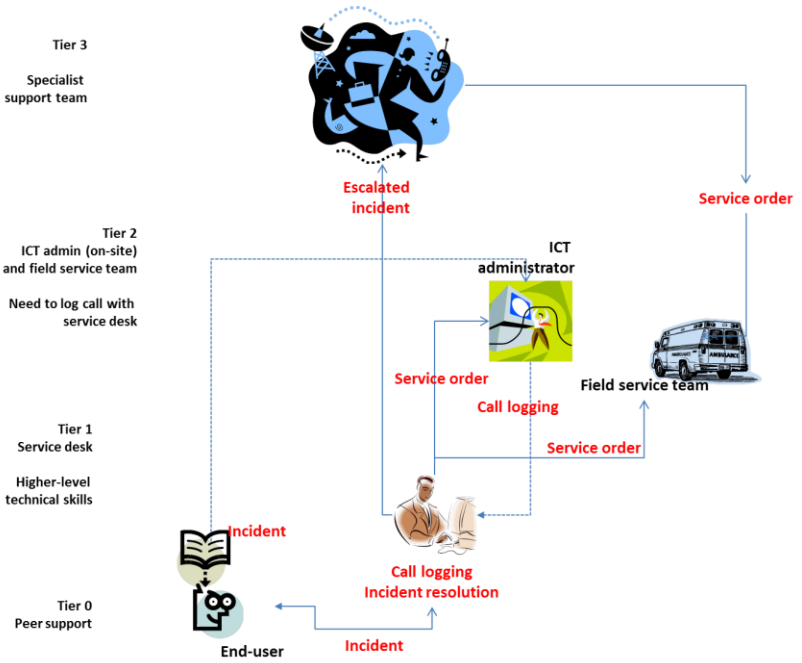

Figure 4-4: User incident logging

The following signs were posted at all schools to indicate what teachers can do if their devices had problems:

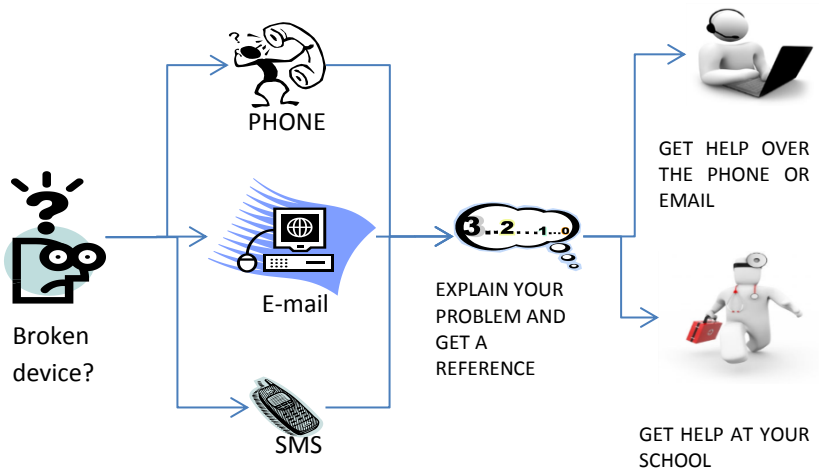

Figure 4-5: Posters made to assist teachers to report on problems with their devices

This poster was then linked to a specific held desk procedure which teachers could follow to report their individual incidents about their devices. The following held desk procedure was communicated to all teachers and ICT committees at schools:

Helpdesk Procedure

Consider any computer problems that you may have, such as:

- The tablets of any of the kids in your class are broken: the screen is cracked, the battery does not charge, or anything similar
- Any of the computer equipment at the school was stolen
- You cannot connect to the Internet
- Someone took a tablet home, and it was lost or stolen
- You need software to be installed on your computer

You can solve this by contacting the help desk. This can be done as follows:

- Phone the helpdesk at ******
- Send an email to ***
- Send an sms to ****

You will be asked to provide the following information:

- Describe the problem
- Give the serial number(s) of the equipment that is affected
- Give the address of the school where the equipment can be found
- Give two or more contact names and numbers of people that know about the problem

You will receive a reference number

The problem will then be solved immediately (over the phone or via email), or someone will be sent to your school to assist you.

4.2.2 Device Management

The following were seen as important for device management and for support and maintenance of the technologies which were deployed to schools and the district:

- ***Asset Management***: All the assets which were deployed were recorded and a full Asset Lifecycle management tool exists for this purpose.
- ***ITSM (IT Service Management***): This was the central system as far as Incident -, Change -, Problem -, Workforce – and Asset Management was concerned.
- ***Monitoring:*** ICT components which were deployed were remotely managed from an availability and capacity point of view.
- ***Continuous Improvement***: Maturity levels were monitored to measure what can be implemented to bring the initiative in line with peers and industry best practises.
- ***Service Level Management***: All SLA (Service Level Agreements) were managed and governed by this area of expertise and tools.

In this component the ICT4RED initiative was managed via the following phases:

- Research and Development
- Plan
- Site Survey
- Detailed Site Plan (DSP)
- Work Commence Order (WCO) – Create
- Work Commence Order (WCO) - Accept
- Provisioning

- Site Prep
- Implementation/Installation
- Site Sign-off
- Quality Assurance (QA)
- Fix Issue List
- Transition to Operations
- Operational Management

The above phases were managed via the ITSM system (Service-Now) and each phase is a stage gate i.e. workflow will prevent you to skip or move on to a next phase unless the previous phases have been signed-off.

It was important to ensure that pre-agreed deliverables were signed with the successful bidder and it provided them a clear Detailed Site Plan (DSP) and Work Commence Order (WCO) before work commenced. Any changes to the WCO had to follow a proper Change Management process before work commenced.

4.2.3 Service-Now

Service now (http://www.servicenow.com/solutions.html), is a cloud-based service which supports operations. This means that all information, incidents and processes are available anywhere where there is access to the Internet. Service Now creates a single system of record.

The power of it lies in the fact that if it is used correctly, it manages business processes from start to finish with integrated solutions for:

- Asset and Configuration: identify and monitor IT service assets and their relationships.
- Planning and Policy: define IT strategies and manage projects.
- IT Services: deliver IT services and support to business users.
- IT Operations Management: track and manage IT resources and systems.
- Non-IT Services: automate business processes outside of IT.

It has the following applications and operations:

Figure 4-6: Components for Service-now as an ITSM software tool

Service-now Components that have been used for ICT4RED initiative were:

- Configuration Item Management which assists with where an item is, what its status (in stock/in use/in maintenance) is, who is the owner of the item, supplier of the item, warranty etc. It also allows one to add the user data (name, surname, contact detail and location) as well as location data which include the site name, latitude, longitude and to which project it is linked (ICT4RED).
- Incident Management where Service Level Agreements and business rules are actively used in the system. This indicates for example the time it takes to resolve an incident and can calls can be logged from OMA which is an automated process. The call logging from users in the field is a manual process.
- Service Desk where calls are logged. This is then divided into tiers (as indicated in Figures 2-4).
- It captures the Field Service Management (Support and Maintenance) for service orders for Field Services.
- Knowledge Base where all the Policies, Processes, maps, how to etc. are stored.

- Reports can be automated with regards to all data in the system e.g. Users, Locations, Incidents, etc. These can be visible inside Service-now or emailed to users
- Supplier Management module which ensures the reliability and cost-effectiveness of outside suppliers. The supplier management team negotiates contracts with external suppliers, and regularly reviews these contracts to ensure that they are being met. The Service-Now platform provides tools for defining and monitoring these contracts.

This was found to be an excellent tool to support ITSM. From the main components illustrated in Figure 4-7 above ICT4RED mainly used the Design and Operate components (light blue and green blocks).

Device management was also done at the CSIR before devices were sent to the district office, which then send it to the individual schools. The serial numbers were linked to the school and individual teacher tablets were also linked to the school for asset management purposes.

4.2.4 Tablet preparations before deployment

The mobile tablets had to be prepared before teachers and schools can receive these. Different content were loaded for teacher tablets than for learner tablets.

For teachers

Before deploying the tablets to the teachers it was important to load specific supporting material and Teaching Applications on the devices. This included the following:

- All the TPD training modules and Applications which support the training for each of the 10 training modules;
- Curriculum Assessment Policy Statements or CAPS (curriculum documents based on the South African education system). CAPS form part of the National Curriculum Statement Grades R-12, which represents a policy statement for learning and teaching in South African schools and comprises the following (Department of Basic Education, 2014): Curriculum and Assessment Policy Statements (CAPS) for all approved subjects

- National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R – 12; and
- National Protocol for Assessment Grades R – 12
- Old examination papers for all the grades (depending on available content providers) and papers, which could be found from teachers in all grades, and for all subjects, were placed on tablets of the teachers.

For schools

Tablets that are deployed to schools in the Mobikits were also pre-loaded with certain specific content and applications. All tablets had to contain the same content, applications and additional materials in order for all teachers to have an equal access to the same material and content. This was done at the CSIR.

Once the tablets arrived from the suppliers, a master device had to be made, which contained all the applications loaded either from the Play store or from an Android application package (**APK**) which is the package file format used to distribute and install application software and middleware onto Google's Android operating systems. This was manually installed. Books and videos were also copied to the devices. A backup was made from the Master device using **CMD** (term commonly used to mean "command") in order to make an image of that master device.

The next step was to enable USB debugging on each tablet, to restore the backup file (which was created earlier). This allowed for a complete tablet that was similar to the master tablet.

The master tablet assisted in ensuring that no other installations had to be done of any Applications or content. The only challenge was that it was very time consuming and sometimes took an hour to complete one tablet.

Email accounts (per school) had to be created through the administration console of each tablet. Once this was done, it had to be manually loaded onto each tablet. Tablets were then packed into the Mobikits with cables. Each Mobikit consisted of 15 tablets and serial numbers for all these tablets were scanned and placed onto the asset management tool (service-now) with a user ID and site ID.

Photo 4-1: Example of the Mobikits where black sponge was used to line the cases where 10 tablets could be placed. Underneath the tablets were place for the chargers and extension plugs. This was the first version of the Mobikits the later Mobikits consisted of 15 place holders for tablets and was blue in colour.

4.2.5 Network

The objective of this area was to design, implement and manage a network between the schools and to the Internet.

The main deliverables for this area were:

- Backhaul Connectivity: Establish a network to connect the ICT4RED initiative to the outside world.
- Access Network: Create connectivity between the schools and to the backhaul network.
- Internet: Give all the schools Internet access and monitor that access.
- Central Processing and Storage: This will be the central data store and content management environment.

The figure below provides an overview of the Wi-Fi coverage and how it was grouped to do the implementation between the different schools.

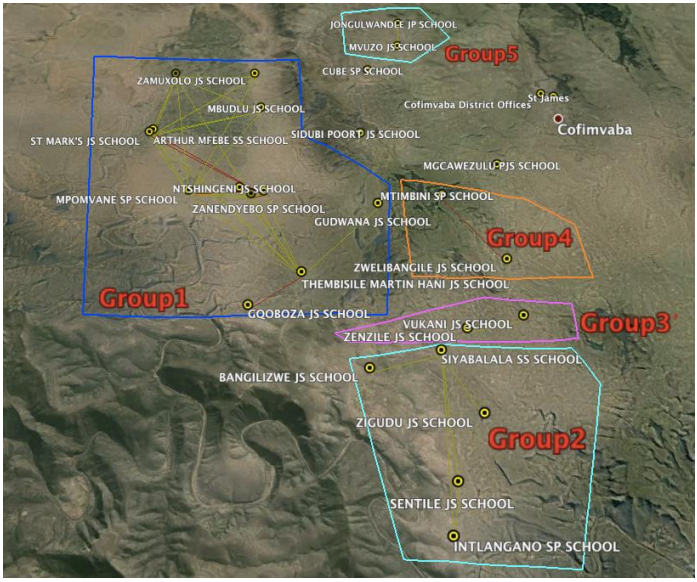

Figure 4-7: Wi-Fi between schools

Each school was connected to the Internet through a VSAT link at the school. The In-School Wi-Fi Zone was supporting the equipment that

provides the Internet connectivity at the school. A secure room was provided for the network cabinet, content server and related equipment.

All access to the wireless network and wired network in the school were authenticated.

The Wi-Fi network allowed registered users to access the network when the WAN link (VSAT) is down (there is no Internet connectivity). Wi-Fi access was provided on 2.4GHz and 5GHz channels to allow devices (tablets and notebooks) to select the best channel for the optimal throughput. This approach also reduced the risk of interference within the network between APs.

The required coverage standards were ≥ -75dBm for both 2.4GHz & 5GHz across the school buildings and the capacity (AP) had to be able to support 60 concurrent sessions.

Lightning is prevalent in the area and hence protection had to be designed into the way buildings were interconnected in order to reduce damage to network equipment. It was essential that good practice had to be designed into the solution in order to achieve the most reliable network for the schools.

The Network consists of different types (standard and access) of sites based on its main function in the Network. The site types and numbers are indicated below:

- Standard Sites were 21 in total;
- Access Sites (Group Entry Point) were 5 in total.

The Standard Sites connected amongst each other via HPNs as a wireless mesh. The Standard Sites also connected to the Access Sites via HPNs as part of the wireless mesh. Each group of sites (Standard sites with Access Site) constituted an independent mesh network.

Standard equipment for the Standard sites was:

- A 9U Data cabinet (Swing Frame) and inside the cabinet are:
    - Microtik 5 Port 100Mbps managed Router/Switch with a 12V Power Supply Unit;

- POE Adapter 24V for the HPN, which was installed on the outside of the Building either on a wall mount bracket or on a mast.

There was also a Din Rail 12V Transformer, 16Amp Circuit breaker with connectors to accommodate the Power Supply Units. Two RJ45 Data Modules were installed on the side the Cabinet connected to the Router Switch. These Modules provided user data access as well as VOIP and/or Wi-Fi access.

Equipment for the **Access site** was included:

A 12U Data cabinet with a swing frame which was fitted with a front mount shelf, a 3U Circuit Breaker housing with a Din Rail, a Wall Box, Side Mounted Single Fan and a 50mm x 50mm cut out for the UTP DATA Modules.

The Equipment that was installed in the 12U Cabinet were:

- Microtik 5 Port Gigabit managed Router/Switch with a 12V Power Supply Unit;
- POE Adapter 24V for the HPN, which was installed on the outside of the building either on a wall mount bracket or on a mast.

There was also a 48V POE Adapter for the Microwave link which was installed on mast outside, a Din Rail 12V Transformer, 16Amp Circuit breaker with connectors to accommodate the Power Supply Units. A YAB (Yet Another Box) was supplied by CSIR and a satellite Modem in the Cabinet was linked to the Dish outside of the building to provide backup connectivity. At these sites there was also a Meissner double conversion on-line UPS with automatic by-pass and power factor correction with SNMP and HTML, Modbus/JBus and relay outputs. Two RJ45 Data Modules were installed on the side the Cabinet connected to the Router Switch. These Modules provided user data access as well as future VOIP and/or Wi-Fi access.

Satellite access equipment was also deployed at the Access sites to provide connectivity to the Internet for each group. The Satellite Internet connections had been used for the monitoring of the Network.

The satellite dishes, which were provided to each of the 26 schools, had to connect to the South African Research and Education Network (SANREN).

Each had a 1024kbps Downlink and 256kbps Uplink, at a contention ratio of not more than 10:1 and supported dynamic bandwidth management within a pool of bandwidth for all sites. There uncapped data usage solutions with a proper QOS (Quality Of Service) scheme with the ability to handle a mix of "realtime" traffic such as voice or video at the same time as non-real-time traffic. Real-time monitoring of the Satellite Link was essential to monitor and report alarms into our ITSM system (service-Now). The NMS, (Network Management System) provided a graphical display of bandwidth usage at each site in real time. Occupational Health and Safety issues required that VSAT antennas should be installed at least 2.4 m above ground level. 220 Volt 50 Hz AC was the electrical current of the schools.

4.2.6 Content Management and curation

The Content component in the ICT4RED initiative consisted of the following:

- Digital forms of existing paper-based South African Learning and Teaching Support Material (LTSM), such as workbooks, textbooks, lesson plans, teacher notes, CAPS documents, focusing on numeracy, literacy, mathematics, science and English as a first additional language;
- New digital/multimedia content, consisting of educational apps, quizzes, tests, games, audio books, video material, interactive workbooks, interactive stories, music, animations, that were appropriate for the South African curriculum;
- Open Educational Resources (OERs).

The aim of this component was:

Content Sourcing, Mapping and Management

- Identification of organisations and individuals willing to collaborate by sharing, developing and/or digitising a wide variety of appropriate content, that is curriculum-aligned
- Sourcing, mapping, alignment, digitisation and quality assurance of appropriate Open Source and Proprietary Content
- Source or commission additional content to fill any 'gaps' in the content repository

- Develop a content strategy and identify appropriate content to be pre-loaded onto tablets for the different phases and/or form part of the content repository.

Photo 4-2: The silver box is where the server was placed in a secure, folding container which had to be placed in a secure and ventilated area in the school.

Teacher Support

- Design and collation of 'digital teaching packs' to support teachers in understanding the technology environment, integrating technology into their teaching, and creating a successful blended learning environment.

Photo 4-3: Photos of teachers showing evidence of using their tablets after receiving training in their own classrooms

Documentation Design and Revision

- Design and develop digital Content standards for widespread use in Basic Education
- Contribute to the design of a larger technology rollout model to inform national and provincial policy and implementation.

One of the first priorities of the initial pilot is the provision of digital content (CAPS-aligned and Open Source/Content, where possible) with a focus on:

- Literacy and Numeracy in the Foundation Phase
- Mathematics and Science from Grades 4 to 12
- English (FAL) across all grades

In this ICT4RED initiative we were fortunate to have had free access to all McMillan and Pearson electronic books. Teachers and learners could access these to supplement their own textbooks or to get more examples of specific content.

Over 4000 additional items for subjects other than Maths and Science (including Life Sciences, Languages, Business related subjects, Life Orientation, NSC and ANA exams, etc.) are available on the school servers. The following is a list of the content which is available on all the servers of all 26 schools:

Table 4-3: Content available on all content servers for teachers and learners to download via the Wi-Fi at schools

Grade	Content on servers
R	Workbooks for Afrikaans, English, isiNdebele, isiXhosa, Sesotho, isiZulu, Sepedi, Setswana, SiSwati, Tshivenda, Xitsonga
1	Workbooks for all First Additional Language (FAL) and Home Language (HL) for Afrikaans, English, isiNdebele, isiXhosa, isiZulu and Life skills (all languages in column above). Examination papers for Afrikaans, English, isiNdebele, isiZulu and isiXhosa, Mathematics, numbers, relationships and operations and 2014 ANA guidelines. Interactive books for English FAL.
2	Workbooks for all First Additional Language (FAL) and Home Language (HL) for Afrikaans, English, isiNdebele, isiXhosa, isiZulu and Life skills (all languages in column above). Examination papers for Afrikaans, English, isiNdebele, isiZulu and isiXhosa, Mathematics, numbers, relationships and operations and Numeracy with 2014 ANA guidelines with some 2013 Memos and tests.
3	Workbooks for all First Additional Language (FAL) and Home Language (HL) for Afrikaans, English, isiNdebele, isiXhosa, isiZulu and Life skills (all languages in column above). Examination papers for Afrikaans, English, isiNdebele, isiZulu and isiXhosa, Mathematics, numbers, relationships and operations and Numeracy with 2014 ANA guidelines with some 2013 Memos and tests.
4	Workbooks for Afrikaans and English (FAL & HL), language construction and conventions as well as listening and speaking with 2013 examination papers with memos and 2014 ANA guidelines. The same for all other African languages. Mathematics, natural sciences and technology, social sciences (history) and life skills workbooks and examination papers.
5	Workbooks for Afrikaans and English (FAL & HL), language construction and conventions as well as listening and speaking with 2013 examination papers with memos and 2014 ANA guidelines. The same for all other African languages.

Grade	Content on servers
	Workbooks for mathematics, natural sciences and technology, social sciences (history and geography) and life skills and 2013 examination papers, memorandums and ANA 2014 guidelines.
6	Workbooks for Afrikaans and English (FAL & HL), language construction and conventions as well as listening and speaking with 2013 examination papers with memos and 2014 ANA guidelines. The same for all other African languages. Workbooks for mathematics, natural sciences and technology, social sciences (history and geography) and life orientation and examination papers with memorandums.
7	Workbooks for Afrikaans and English (FAL & HL), language construction and conventions as well as listening and speaking with 2013 examination papers with memos and 2014 ANA guidelines. The same for all other African languages. Workbooks for mathematics, natural sciences, technology, social sciences (history and geography), economic and management sciences and life orientation and examination papers with memorandums.
8	Workbooks for Afrikaans and English (FAL & HL), language construction and conventions as well as listening and speaking with 2013 examination papers with memos and 2014 ANA guidelines. The same for all other African languages. Workbooks for mathematics, natural sciences, technology, social sciences (history and geography), economic and management sciences and life orientation and examination papers with memorandums.
9	Workbooks for Afrikaans and English (FAL & HL), language construction and conventions as well as listening and speaking with 2013 examination papers with memos and 2014 ANA guidelines. The same for all other African languages. Workbooks for mathematics, natural sciences, technology, social sciences (history and geography), economic and management sciences and life orientation and examination papers with memorandums.
10	Additional material and books for Business studies, civil technology, English FAL, geography, life orientation, life sciences, mathematic literacy and mathematics, mechanical technology, physical sciences.
11	Additional material and books for Business studies, civil technology, English FAL, geography, life orientation, mathematic literacy and mathematics, mechanical technology, physical sciences.
12	Examination papers for Afrikaans (FAL & HL), Accounting, Agricultural management practices, agricultural sciences, agricultural technology, business studies, civil technology, computer applications technology, consumer studies, dance studies, design, dramatic arts, economics, electrical technology, engineering graphics and design, English (FAL & HL), geography, history, hospitality studies, information technology, isiNdebele, isiXhosa, isiZulu (FAL & HL), Life sciences, mathematical literacy and mathematics, mechanical technology, music, physical sciences, religion studies, Sepedi, Sesotho, Setswana, SiSwati, tourism, Tshivenda, visual arts, Xitsonga,

The following figure is an example of how the navigation worked on the content servers:

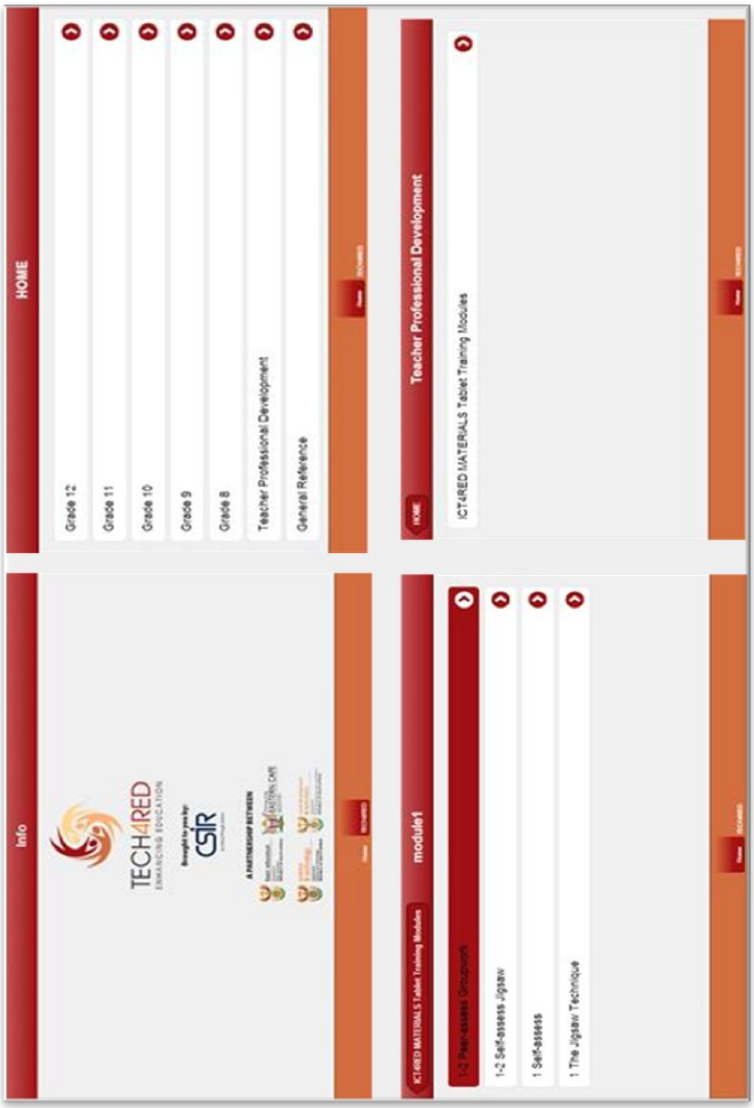

Figure 4-8: Navigation on the content server

In this ICT4RED initiative we were fortunate to have had free access to all McMillan and Pearson electronic books. Teachers and learners could access these to supplement their own textbooks or to get more examples of specific content. The content covers grade 4-12 and there is also a set of reading books from FundZA available for secondary schools.

The eLearning kiosk was a donation from CoZa Cares. It now mirrors the content on the school server and is accessible to learners, teachers and visitors via Wi-Fi and screen navigation. Content can be downloaded onto DVD, Flashdrive, tablets, smartphones and laptops. It works both online and offline. Here are some photos of it:

Photo 4-4: Photos of the e-learning toolbox at Arthur Mfebe school

Under the content management component a group of researchers from the University of Pretoria under the management of Dr Ronel Callaghan (Faculty of Education) were tasked to investigate which Android Application will be best suited to support the CAPS documents. In order to select these applications for all subject and for all grades, this group

developed an Application evaluation software tool to address the specific requirements. Their research can be used to support many other teachers who are searching for Application with the same purpose. It can even lead to the creation of a South African Education supporting App store.

4.2.7 School ICT

The objective of this component was to establish an "Eco System" in each school that was aligned to the objectives of the initiative and also offer the necessary scalability and flexibility that is expected from a 21st Century solution.

This component consisted of the design, implementation and management of the following:

- Mobile devices (tablets),
- School infrastructure that will be needed to support the mobile devices, such as local Wi-Fi networks, storage solutions, provision for charging and power, security and content servers.
- Software solutions and services

The main deliverables for this area were:

- Electrical Supply: Work with the different stakeholders to investigate and agree alternative energy solutions in collaboration with another initiative known as TECH4RED Energy working group. This TECH4RED was the bigger initiative under which ICT4RED was one component. For Data and Electrical Reticulation it was important to ensure that the electrical and data cabling needed plus all infrastructure to support it i.e. trunking, conduit, etc. is available at each school.

The following is a photo of the data and electrical reticulating and for charging the tablets:

Photo 4-5: Data and electrical reticulating and for charging the tablets

- Physical Security: Making sure that all the equipment was stored securely when not in use. All the equipment had to be stored in secure enclosures and in the case of the tablets it had to be charged while stored.

The following is a photo of how each school was provided with a cage where equipment could be securely stored:

Photo 4-6: School security

The following charging station was a prototype of the ones that were provided to schools:

Photo 4-7: Charging Station

- Tablets: Establish a minimum specification for tablets to be supplied to the learners and teachers. Teachers got 10 inch and learners 7 inch Android tablets. Mobikits with 15 tablets in each were provided to each school if they show evidence of use and only after their teachers have completed the 1st four badges.

The following is a photo of the learner with their tablets:

Photo 4-8: Learners with their tablets

The following is a photo of the teachers using their tablets:

Photo 4-9: Teachers with their Tablets during a TPD session

The following is a photo of the Mobikits:

Photo 4-10: Mobikits

Photos of the Mobikits which were handed over to schools after their teachers have earned their tablets and have received training in using their tablets in their classrooms

- ***Wi-Fi Zone*:** Each of the schools has received a dual band (2.4Ghz and 5.8Ghz) Wi-Fi network that covered all the classrooms in the school and also supported the high density of end-user equipment linked to an initiative of this nature (as was discussed in Section 4.2 above)

The following photo shows the Wi-Fi equipment on the roof of one school:

Photo 4-11: Wi-Fi equipment

- ***Email and Calendaring***: Enable every user (Teachers and Learners) to have each their own email address. The email and calendaring must be available outside the school infrastructure.

To make decisions on all the above each school established their own ICT Committee and the decision of who should be elected to serve on this committee resided with each individual school.

Purpose of ICT committee at the schools was to make decisions about the following:

- Drawing up of the schools ICT policy;
- Identify learner champion to serve on committee;
- Monitor the use, safety and security of tablets;
- Check if tablets are functioning well and batteries are fully charged;
- Check tablet content is relevant;
- Organise training workshops with staff members and coordinators;
- Help those that are behind in training;
- Complete tasks given by facilitator;
- Make sure tablets are moved from store room to the classrooms;
- Check equipment safety and that tablets are stored correctly;
- A record of all faults with tablets or initiatives is kept;
- Community awareness campaign-parents should know about this initiative so they are not surprised when they will be bringing tablets home in future and help safe guard them;
- Make sure all tablets are allocated to teachers using an IMEI to track usage.

The ICT committees performed a variety of important tasks that was important for integrating the technology sustainably into the participating schools. It was important to continue to monitor the functionality of the School ICT committees, as the planned change management processes implemented as part of the initiative comes to an end.

It was also realised that each school will have to have an ICT champion to assist teachers with tablets bookings and charging as well as overall ICT maintenance and support (as was already indicated above under Operations management). This where the NARYSEC youth group were used to support teachers with the ICT maintenance and support functions.

The aim is to develop a process for sharing information between stakeholders inside the initiative. This includes an ICT4RED website and a social media strategy. Social media accounts and branding for the initiative were also undertaken. Section 7 provides an overview of how the Twitter and WhatApp social media platforms were used to support the management of the ICT4RED initiative.

4.3 Summary

This section provided the overview of the detail and depth which was covered under the components of programme management, operational management as well as School ICT. It underlines the importance of coordination, support and maintenance and the role of the principals, ICT committee and district to provide the devices, maintain it and support the teachers in their training (TPD).

Careful planning and execution of various processes are necessary to make the deployment of tablets to schools a reality. Even after these were deployed they have to be monitored, loaded. Stored and decisions have to be made about when to use the tablets for which subjects and for which grades on a daily basis. The role of the ICT champion at each school cannot be under estimated as well as the role of the ICT Committee. All of these decisions can also not be realised if the principal is not 100% committed to support and manage the integration of technology into his/her school. For this purpose it was necessary to also focus on change management in this school district and also to involve the district officials.

4.4 References

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Department of Basic Education. (2013). National Report 2012: The State of Literacy Teaching and Learning in the Foundation Phase. http://www.education.gov.za/LinkClick.aspx?fileticket=rnEmFMiZKU8%3d&tabid=860. Assessed: 21/11/2014.

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Photo 4-12: First group of teachers to complete a TPD during Phase 1.

SECTION 5: Change management

M Herselman & SchoolNET SA[3]

In Section 1 the Evidence-based ICT4RED framework articulated the importance of engaging with the community and to involve stakeholders even before the initiative was implemented. If this was not handled correctly the initiative would have failed even before it started.

5.1 Changing a community

The whole community in the Nciba school district was invited to stakeholder meetings as well as Mobikit deliveries. The following photos indicate the involvement of both the parents and grandparents and how they were intrigued by the new technology:

Photo 5-1: Community involvement

Although this is a rollout of mobile devices to learners, it is important not to underestimate the effect of this on the school system of the Nciba school district. The schools and district officials need to be prepared for

[3] http://www.schoolnet.org.za/

what is the beginning of a fundamental change in the way teaching and learning happens.

In order to ensure adoption and ownership of the initiative and thus its effectiveness, school management teams (SMTs), district personnel and teachers require workshops that outline the potential impact of technologies on learning as well as on school administration. In many cases, there is a need to first work with the school at a holistic level, looking at "softer" skills within a school and district (for example, focusing on leadership and management skills; empowerment; psycho-social and emotional health; a sense of safety and security; compassion; a resilience to change etc.). The premise under which change management was be undertaken includes:

- Sustainable change requires systemic design and implementation.
- Ad hoc interventions have limited or unsustainable impact and could leave harmful systemic effects.
- Systemic dynamics must be dealt with explicitly, to create readiness to embrace change, even positive change.
- Stuck systems are often identified by systemic symptoms such as:
    - Apathy/de-motivation
    - Incongruent behaviour
    - An inability to implement new skills
    - An inability to embrace change; even if it is positive change
- Re-aligning the system at crucial points of impact (catalytic points) has ripple effects throughout the system itself
- Project diagnosis of catalytic points makes coaching more targeted and meaningful and this can result in behaviour change.

The aim was to work with the schools in the Circuit and focus firstly on the "softer" skills as outlined above. Thereafter the focus was specific to preparing each school for the technology implementation.

Schools participating in this project had to develop a new vision for learning in the 21st Century (as part of their ICT committee tasks). Teachers, who were part of a connected community, drew support and inspiration from the sharing of good practice and effective resources. The intention was that learners will eventually develop a sense of responsibility for their own learning.

Technology is an effective resource for supporting school-directed change. In order to allow the school community to develop their vision for transforming learning through technology integration, a change management process was undertaken that specifically included activities that:

- Develop a common vision of key e-education concepts such as e-learning, ICT integration, ICT literacy.
- Align technology integration in the school with the provincial and national educational ICT policies
- Visualise learning with ICT
- Recognise key responsibilities of the school and the district in implementing technology integration
- Recognise the ICT integration competencies expected of teachers
- Understand the role of a school manager in formulating a school technology policy
- Evaluate their school technology learning programme
- Identify critical success factors relating to integration of technology in the classroom
- Assess school readiness for technology integration
- Assess the effectiveness of the use of technology in the school

Creating ownership and buy-in from the whole community was essential for the success of such an initiative. It strengthens accountability to take care of technology especially because it has to be earned. Hansen (2008) states that ownership is one of the critical success factors that need to be considered as it plays a significant role in ensuring local buy-in and the sustainability of projects. Ownership was created when tablets were handed over. As was observed by Nkula and Krauss (2014) during the hand-over the ICT4RED team emphasized that the students should hold their teachers accountable and ask them where the tablets were if they were not using them. The project team encouraged the parents to ask their children if they were using the tablets to learn.

According to change management.com (2014) change management is crucial where impact is on how people do their jobs. Effective project management is not the only key to success. The other more important key is to manage the human side in meeting a project's objectives.

Schaefer (2008) indicates that change management is not an easy task as reactive and proactive responses to these changes are possible. The change process can be thought of as a process, which stops the current process, makes the necessary changes to the current process and then run the new process. Therefore managing the changes requires a broad set of skills like political skills, analytical skills, people skills, system skills, and business skills.

The following are some benefits which individuals can get from change management (Change management-coach.com, 2014):

- Effective change management supports a smooth transition from the old to the new while maintaining morale, productivity, and even company image
- Provides management and staff support for concerns regarding changes
- An efficient change management process creates the correct perception of the change for staff and public
- Helps to plan efficient communication strategies
- One of the benefits of change management is that it minimizes resistance to change
- Improves morale, productivity and quality of work
- Improves cooperation, collaboration and communication
- A carefully planned approach to change reduces stress and anxiety and encourages people to stay loyal to the organization
- Increased employee acceptance of the change
- Personal loss/gain to individuals is acknowledged and addressed
- Change management reduces disruptive aspects and emphasises positive opportunities in the change process

Change management can thus increase project success. Motivation and skills of those who will be affected by the change is more important than a good strategy. Change management is of strategic importance and the ability to change and adapt quickly brings enormous advantages. Thus it was important in the ICT4RED initiative to also focus on change management as bringing in a new technology like tablets into a specific context can disrupt current ways of doing things. Tablets can be seen as disruptive technologies in the Nciba school district. According to Utterback & Acee (2008) disruptive technologies affects performance and allows for lower cost, more efficiency and improve the time it takes to perform a

task. It is a powerful means for enlarging and broadening markets and providing new functionality.

At the top of this environment where the disruptive technology affect a community and more specifically schools are the principals.

5.2 Changing the principals

The principals play an important role in ensuring the acceptance and use of any technology mainly because they create environments for use and give teachers more free time to explore and apply their knowledge in using technology despite the facilities and availability of resources (Flanagan and Jacobsen, 2003; Hew and Brush, 2007 Eteokleous, 2008).The attitude and drive of the principal is important in ensuring integration (Nkula & Krauss, 2014).

Thus, to support the principal and the other managerial bodies in the schools, the ICT4RED initiative decided to include a change management strategy, because it was recognised that adequate change management is the single most important factor affecting the success of ICT in Education interventions in schools. SchoolNET SA South Africa was assigned to implement change management training.

Specific issues which were identified related to implementation issues. For example, it was felt that principals needed practical ideas on how they could manage charging of devices, monitoring how the Mobikit gets checked in or out, and handling and care of the device. It was also felt that principals lacked the ability to encourage the use of tablets in the classroom after the teachers had received training. This was because principals who had not attended training were not aware of the teaching strategies that form part of the professional development programme.

The principals were provided with a printed guideline on how to ensure the successful achievement of the ICT4RED's goals and objectives. However, given that the initiative had brought about significant changes to the way in which teaching and learning can take place in the classroom, and requires significant commitment from the teachers involved, it has become apparent that these issues concerning the lack of capacity in the principals could be a result of a ***lack of change leadership*** rather than solely a lack of expertise.

SchoolNET SA therefore proposed to focus on supporting principals, SMTs and district officials in a process of change leadership. A change leadership course was developed by SchoolNET SA to teach the principals that ICT leadership should be a shared domain and it encourages them to establish a culture of learning in the workplace and between schools in the district. If they could understand their roles and responsibilities (and those of others) in making this initiative vibrant and sustainable, and implement the principles of change leadership, they would understand their role in leading change. They also learned that a vision for ICT use in their school is an evolving process, that ownership develops over time with all stakeholders involved, and that challenges can be collaboratively solved if the vision is collaboratively developed.

This Change Leadership training was provided to principals, SMTs and district officials over a period of 7 months and covered 7 modules.

The outline of the Change Leadership course below was meant to provide the basic framework for achieving this understanding. In its implementation the course activities would:

- model the pedagogical skills.
- address the practical issues in the form of case studies which model collaborative problem solving activities
- model peer coaching
- provide the principals with tools to reflect on, monitor, evaluate and communicate about what is happening in their schools.

It was also possible that a lack of an effective communication strategy within the school has led to this situation and this course will seek to help the principals to find a solution to how they can better communicate and support each other.

This outline has been influenced by literature on the key elements of change management and the debate about change leadership which is underpinned by Fullan's work (2006) on *Learning to Lead Change*; the idea that change needs energy, ideas, commitment and ownership rather than a controlling management. The following is a summary of the Change Leadership training modules which were presented in the ICT4RED initiative and which underpins the book of Fullan (2006):

Table 5-1: Change Leadership Modules overview

Module Name	Purpose	Key questions which were addressed
1. Facing problems	The purpose of this module is to give an overview of the ICT4RED teacher professional development course a general introduction. Perhaps more important the purpose is to launch this change leadership process by asking one of the toughest questions about change: "Why?". Understanding the moral purpose is a fundamental cornerstone of change. It is not just a statement on paper that justifies change as a commitment to learners who are disadvantaged in some way; it is a call to action that will take place in the school. It will help to justify the effort and commitment that is required to make new initiatives a lasting success in schools.	What is the problem? Focus on moral purpose, seeing change and create a shared vision.
2 Understanding the change process	The purpose of this module is to develop an understanding for what change leadership is and requires of the principals. The essential elements of this are that change leadership is an ongoing process of building collective ownership of and commitment to the school's vision for learning with technology. This is not a process of coercion or trying to sell a point of view. It is a process of developing a collective understanding through the input of all the stakeholders. We include an activity in which the participants will analyse what goes wrong and what goes right and try to understand the cause of the issue. This should help them understand the important role of their leadership in building ownership and commitment.	Understanding the change process Focus on managing versus managing change and leading change, commitment and ownership.
3 Capacity Building	The purpose of this module is for participants to understand and plan implementation of the key elements of capacity building. It is a collective process and it involves all stakeholders developing new skills, understandings and competencies. These are defined according to specific roles and responsibilities. One of the key roles of the change leadership is to identify the stakeholders and to delegate responsibilities to them. They then support each other during their	Capacity building What new skills and understandings are required? What new roles and responsibilities are emerging? New competencies? New resources?

Module Name	Purpose	Key questions which were addressed
	capacity building and in this way leadership skills are developed across a broad base of stakeholders. If one stakeholder leaves the school there will be many others to step into the breach and the growth of the school vision will be able to be sustained.	
4 Facing challenges	The purpose of this module is to help change leaders understand that some problems (technical problems) can be solved by simple consultation or an expert or a manual. Other problems (adaptive challenges) are more complex and need to be analysed and considered more deeply, but can be solved collectively by the stakeholders involved. It is the responsibility of the change leaders to lead or delegate this process of tackling adaptive challenges.	How do I handle technical and adaptive challenges?
5 Let us communicate change	The purpose of this module is to develop a communication strategy for the change leadership. Communication is not just about announcements, notices, persuasion and newsletters. A communication strategy requires careful thought and planning, it is about using the right people, the right messages and the right methods. Most importantly, it is about dialogue (two-way). In this activity the participants would identify what the best strategies are for them to communicate with the various stakeholders.	How to develop an IT strategy? How to communicate effectively? How do I embrace resistance?
6 A culture of workplace learning	The purpose of this module is to raise awareness and start the process of developing a culture of collaborative peer-to-peer support in the school. This is a very important part of capacity building. Peers can collaboratively solve problems and come up with ideas much more effectively than individuals can. It introduces principles of ongoing peer to peer support within the school and beyond its boundaries.	How can peer coaching assist me? What are professional learning communities?
7 A culture of evaluation	The purpose of this module is to promote the use of assessment and evaluation as learning strategies - because we learn something from them and change the way we do things as a result. Evaluation is a cyclic appraisal of a	What gets measured and improved? How to create wins? How do I respond to data?

Module Name	Purpose	Key questions which were addressed
	process. Assessment tends to more often be once off and directed at the self or other individuals (as we know the purpose can be summative or formative). It also reinforces the notion that change is not an instant fix, but an ongoing, evolving process that benefits from reflection and responses.	

A summarised analysis of the change in approach:

Table 5-2: Change in approach

Instead of this:	We advocate:
Accountability	Capacity Building
Leadership quality	Collegiality
Technology	Pedagogy
Initiatives and strategies	Systemic change

This change leadership addressed some critical elements, which included:

Table 5-3: Critical Elements of Change Leadership

Technical components	What are technical components that can be solved with technical solutions?	Can find technology support resources, and identify experts within the school to support others
People	Who are the people and how must people change for this problem to be solved?	Expert teachers – must become more collaborative and supportive, must take ownership of the vision Complaining teachers (non-users) – must negotiate and commit to an achievable goal to start on the path with technology, must understand the moral purpose, later understand and support the vision
	If there is conflict, where does it emerge?	Teachers who do not want to commit resist, but no real conflict

Technical components	What are technical components that can be solved with technical solutions?	Can find technology support resources, and identify experts within the school to support others
Conflict	Do all agree with the vision?	No
	Do all agree with the objectives of the strategy?	No
	Do all agree with the implementation of the strategy?	No

These elements assisted the principals to then ask these five important questions:

1. Vision – are teachers committed?
   - How has the vision been built collectively?
   - Is there a sufficient ownership?
   - Has there been a communication strategy in place?
2. How do we deal with the resistance
   - Should it be challenged?
   - Should they be ignored?
   - How to make a connection with them?
3. Can we use champions?
   - How can they use them?
     - Try to avoid whole staff training, make it more needs-based and context sensitive support
     - Promote the idea of peer-to-peer discussions
     - How do you make time available?
4. How to show the way?
   - Celebrate wins, examples of exciting lessons and student work
5. Teacher Professional Development strategy
   - How to follow up and support what happens in the ICT4RED training
   - Avoid pressure of badges for technology gifts – it is a negative outcome and not a sustainable source of motivation

- Come back to moral purpose and vision as the driving forces.
- What is their action plan?

The change leadership training assisted principals to address the changes which were the result of tablet technology integration into their schools. It assisted them to develop an IT strategy and to understand their context better. Feedback from the principals was very positive about the training and they felt it was assisting them to deal with resistance, conflict and teachers. They also understood the training that the teachers had and how it can be used to develop an IT strategy and communicate with stakeholders outside of their schools.

Change management, community engagement and stakeholder management are thus important components which cannot be under estimated. Within many communities one gets the socio-political issues and if you now add socio-technical issues you can end up with a disaster!

5.3 Summary

The ICT4RED initiative is a good example of how a specific context were changed based on a soft skills focus and support before technology was provided. It also provides a good example of how ICTs, if used appropriately, have the potential to contribute to the social and political development of communities (World Bank 2009).

Torero and Von Braun (2005) argue that the so-called digital divide is not just a case of not having access to ICTs but part of a much bigger development divide. Effective access to ICTs is dependent on, amongst others, education, appropriate language skills, income, wealth and social position, and not just the availability of technology (Torero and Von Braun 2005).

> *The one resource that liberates people from poverty and empowers them is knowledge. Possessing knowledge is empowering, while lack of knowledge is debilitating (Nath 2001:318).*

Unwin (2009, p. 360) also remarks that ICT4D is not only about economic growth, but also about participation and empowerment (i.e. more on

human development), and proposes that "ICTs can have a key role to play in delivering both of these contrasting views of development". In this initiative we focussed on participation and empowerment of teachers, learners, district officials and parents (the whole community) and hopefully this will have a positive effect on their economic development as well.

> *The new information and communications technologies are among the driving forces of globalisation. They are bringing people together, and bringing decision makers unprecedented new tools for development. At the same time, however, the gap between information 'haves' and 'have-nots' is widening, and there is a real danger that the world's poor will be excluded from the emerging knowledge-based global economy - Anon.*
>
> *The most effective route to achieving substantial benefit with ICTs in development programmes is to concentrate on re-thinking development activities by analysing current problems and associated contextual conditions, and considering ICT as just one ingredient of the solution - Roger Harris*

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Photo 5-2: Fun Day 2014

SECTION 6: Sustainability and Value through Improved Decision-making

I. A. Meyer & M. A. Marais

6.1 Introduction

In a resource-constrained environment, it is essential that development initiatives deliver *value*, for the funders of the initiative as well as for the beneficiaries. Furthermore, initiatives need to deliver *sustained benefit* to the communities within which they are deployed.

Sustainability in development initiatives is often reduced to the question:

> *"will the benefits of the initiative continue after the funding has been withdrawn?" (OECD, n.d.)*

While this question is relevant and appropriate, it does not provide the initiative team with insight in terms of how to work towards sustainability at a practical level. The question is mostly asked in the context of evaluating initiative outcomes. However, an after-the-fact view on sustainability is not proactive. Initiative teams require a means of embedding sustainability in their initiative design, execution, exit and maintenance. Sustainability of the change brought about by the intervention in the beneficiary system is ultimately what needs to realised. A sustainability focus by the initiative team forms the basis from which to enable this.

The nature and complexity of each initiative differs, and sustainability (at a practical level) means different things in different contexts. The ICT4RED initiative provided the opportunity to engage with questions of sustainability from multiple perspectives in an Information and Communications Technology for Development (ICT4D) context. The 12-component design of the initiative emphasized the fact that the focus of the initiative was on creating a different teaching and learning environment, rather than just delivering technology. This design provided a framework against which sustainability could be interrogated.

A *decision-making* view on sustainability was adopted. Sustainability is influenced by the multiple and often conflicting decisions that role players

in the initiative make. This chapter outlines a framework that was developed to focus initiative managers on sustainability during initiative execution. The framework comprises a number of models, and the applicability thereof is demonstrated through the use of some of these models to support decisions such as the following:

- How should technology (tablets) be selected for use in the initiative?
- What should the investment strategy look like, across initiative components, to be sustainable and affordable?

These concepts are demonstrated by means of the technology selection model and total cost of ownership (TCO).

This chapter discusses the concept of sustainability. It outlines the rationale behind a decision-making focus on sustainability, and describes the portfolio of models that was defined through a decision analysis process. The technology selection and total cost of ownership models, as applied to this initiative, are described in more detail. Finally, learning from this approach to enabling sustainability is summarized.

6.2 Sustainability and value in ICT4D initiatives

6.2.1 From sustainability to sustained benefit

Definitions of sustainability are often ambitious, or vague, or ill defined, with little practical use at initiative level. Consider for example the following broad definition of sustainability as a general concept (Willard, 2014):

> *Enough… For all…. Forever*

- What is enough?
- Who are all?
- How long is forever?

Similarly, the well-known definition of the 1987 Brundtland-report that "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, 43) does not provide practical, initiative-level guidelines for enabling sustainability.

The OECD definition of sustainability, as outlined in the previous section, deals with the continuation of the benefits of the initiative after the funding has been withdrawn (OECD, n.d.). This poses a number of implicit questions, such as:

- What are the benefits that the initiative aims to deliver?
- For how long should these benefits continue?
- Why would we want them to continue?
- What is the source of the benefits: are they created by the initiative, or are some of them secondary to what the community gains from the initiative?
- What should the initiative do to ensure that they continue?

Finally, is the concept of sustainability even relevant to this initiative?

The challenge in ICT4D initiatives is to engage with the beneficiary system in such a way that the benefits demonstrated by the initiative is adopted by the beneficiary system, and is sustained and delivers value, while dealing with numerous initiative-level operational complexities.

Some authors have emphasized that elements other than technology contribute to sustainability in ICT4D initiatives. They have defined sustainability as having environmental, economic, social and institutional components (Marais 2014). Other authors omitted environmental sustainability, but added political and technological dimensions (Pade Khene, Mallinson and Sewry 2011).

Pade Khene (2011) used these definitions to map critical success factors of ICT4D initiatives to the various components of sustainability. This approach provides a means of ensuring that initiative elements are addressing components that are critical to sustainability.

In operationalizing the concept of sustainability, the notion of sustained benefit could be more useful.

In the context of the ICT4RED initiative, we can make the concept of sustained benefit real by asking the following questions at some point in future:

- Has teaching and learning improved?
- Are learners eligible for better employment opportunities?
- Are learners accepted for tertiary education?

Delivering sustained benefit would require that self-correcting continuous improvement processes are in place. For example:

- Is there ongoing development of the teachers' teaching skills?
- Is ICT use integrated in the teaching processes?
- Are there adequate technical support, maintenance and upgrading of ICT equipment?
- Does the educational system make decisions that support sustained benefit?

Sustained benefit can be defined as the benefits that this initiative will initiate in the education system over various time scales (short, medium and long term) and at different levels of influence (strategic, tactical and operational) for beneficiaries as well as for funders. Changes to operational models need to be supported by strategy that drives tactics. Long term change needs rethinking at strategic, tactical and operational levels. This perspective provides the opportunity to operationalize the concept of sustainability. Furthermore, it places the focus on the level at which the initiative is making a contribution by informing decisions for long term sustained benefit.

For the Cofimvaba initiative, these definitions could be as follows:

Table 6-1: Mechanisms of enabling sustained benefit

Sustainability focus	Definition	This initiative (for example)
Strategic	Initiative initiates mechanisms that ensure adaptability and continuous alignment with goals	Mechanisms are in place to facilitate communication between stakeholders Joint planning takes place Monitoring and Evaluation results inform strategic decision-making
Tactical	Initiative initiates mechanisms that will perpetuate desired outcomes	Processes and systems are in place to secure continuous funding Participants identify opportunities to use outputs for different outcomes? Monitoring systems feedback into a continuous improvement process
Operational	Initiative initiates mechanisms that ensure that outputs are sustained during initiative and hands over to the educational system	Operational support procedures are in place to ensure that tablets are functioning Ongoing training processes are in place that ensure that teachers are trained

6.2.2 Value

Value is another important concept that needs to be considered when executing development initiatives. In resource-constrained environments, it is important that the maximum Value for Money (VFM) is delivered to funders, as well as to the beneficiaries of the intervention. Value for money has been defined as having elements of *economy, efficiency and effectiveness* [Jackson, 2012]. These definitions have been mapped onto an outcomes chain, as is depicted in Figure 1 below (Emmi *et al*, 2011).

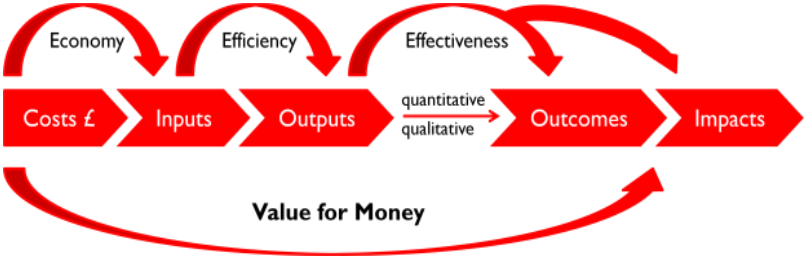

Figure 6-1: Value for Money

This definition is useful from the perspective that it provides initiative owners with a means of applying and operationalizing the concept of value. For each step along the chain, initiative owners can explore means of improving economy, efficiency and effectiveness of the initiative, which will in turn increase the value that is delivered for shareholders. This would support a better use of costs for delivery of outcomes, which should in turn ensure more benefit to the community for the work that is delivered (provided that outcomes sufficiently support impacts).

6.3 A decision-making view on sustainability

A framework is required within which to operationalize the above concepts of value and sustainability. In this initiative, the view was adopted that 'the value that an organization creates is ultimately no more or no less than the sum of the decisions that it makes and executes" (Blenko, 2010). In any ICT4D initiative, a number of decision-makers participate in delivering the initiative and in engaging with the beneficiary system. Each of these organisations makes decisions that can either enable or disable sustainability for both the initiative and the beneficiary system.

A focus on decision-making would enable an understanding of:

- The context (beneficiary system) within which the initiative is rolled out, and inefficiencies and lost opportunities within this context;
- Key decisions that could be used to enable sustainability and/ or unlock value; and
- Models that could be used to support decision-making.

The decision-making context of the initiative was analysed from two perspectives:

- An organizational view on decision-making; and
- A initiative-level perspective on decision-making

The analyses, done from these perspectives, are outlined below.

6.3.1 Organisational view on decision-making

For the ICT4RED initiative, role players that can influence decision-making include government departments (as funders, interested or influencing bodies, or eventual owners of the intervention), the implementation agency (CSIR), the community, the learners and the teachers. Decision mapping is an approach that is aimed at outlining the scope for introduction of decision tools and methodologies, by analysing the organizational processes that leads to the making of key decisions. It is aimed at providing information to the research team for this purpose, while at the same time serving as a mechanism for educating key decision makers (Bouchart, Blackwood and Jowitt 2002). A preliminary decision map of the ICT4D initiative is outlined below. Role players (excluding the implementing agency) and their roles relative to the initiative are depicted, and conflicts or inconsistencies are identified.

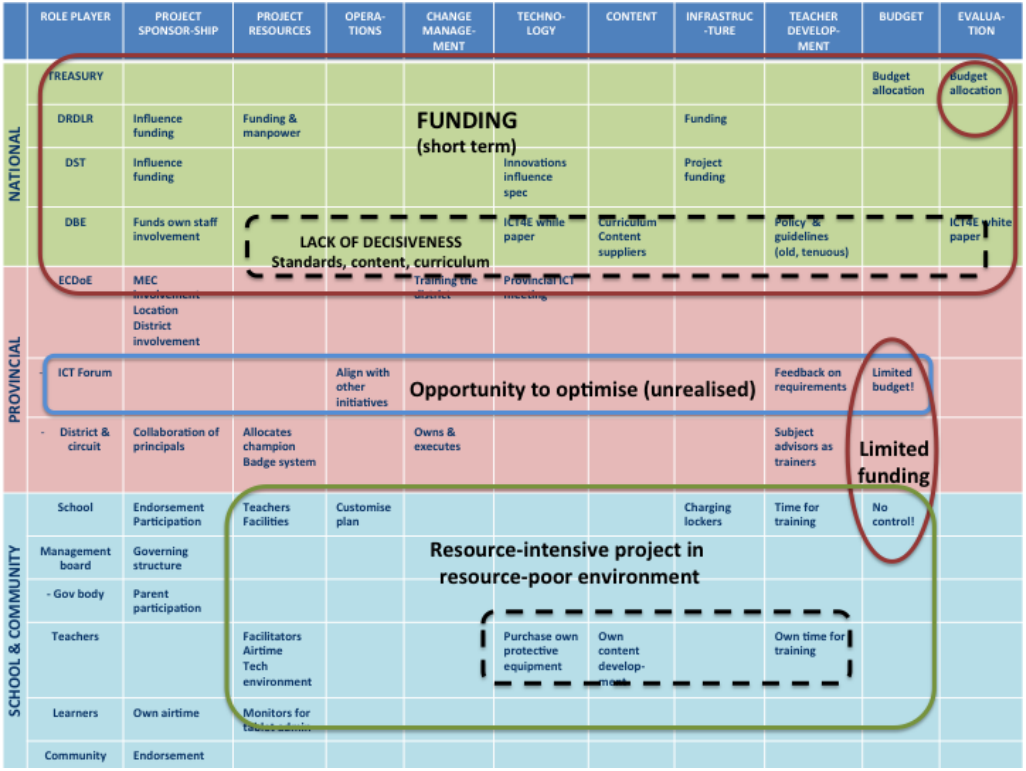

Figure 6-2: Organisational-level decision map

This map serves to demonstrate some of the inefficiencies that are created among multiple role players associated with this initiative. Examples of these are outlined below, with an indication of the sustainability implication associated with each inefficiency (Meyer and Marais 2014):

Inflexible and unsustainable initiative funding

Sustainability implication: financial, operational

Initiative funding is allocated at a national level, from a strategic perspective. It has a short-term (three year) focus on implementation rather than on long-term sustainability. The initiative requires commitment of resources at district and school level, but there is a disjunct in school- and initiative funding. Funding of the educational system is controlled within pre-defined budgets, with limited flexibility for re-allocation. The result is that the resource-poor school-, teacher- and learner environments need to commit their own resources in order for the initiative to be successful.

Requirement to participate without decision-making power

Sustainability implication: operational, social

The above situation is exacerbated by the fact that end-users and solution owners have limited decision-making power, in terms of initiative participation and in providing inputs with respect to user requirements. While schools, teachers and learners are expected to participate, they are resource-poor and therefore cannot customise the solution for their specific environment.

Dependencies and risk factors

Sustainability implication: operational, institutional

Initiative success is dependent on (and at risk in terms of) resources that are contributed at district and school level, especially in terms of reallocation of resources and personal time that teachers commit. The risk of non-participation is increased by the limited involvement of the district / school level in initiative design and budgeting.

Immature supporting environment

Sustainability implication: institutional, operational, technical

The initiative is executed in an environment where limited guidelines exist in terms of content creation, technology standards, etc. The initiative is executed within short time frames, while the supporting environment (beneficiary system) evolves at a slower rate. Short-term sustainability is dependent on the school and district implementation environment, while long-term sustainability is critically dependent on involvement of the province for the development of a supporting environment. While this provides the initiative with the opportunity to influence the long-term environment pro-actively (e.g. via technology selection models), it also leaves the environment vulnerable to initiative-driven agendas, and may result in unsustainable and costly technology ecosystems.

Ad-hoc drivers of decision-making

Sustainability implication: institutional

Decision-making at initiative and beneficiary level is driven by the agendas and objectives of individual organisations, and of individuals within organisations. A single view of sustainability, and a joint set of objectives for decision-making, does not drive behaviour.

Node for integration and optimisation not functioning optimally

Sustainability implication: institutional, operational, and financial

The provincial ICT forum is positioned as a potential node from which to optimise initiative activities across the province. It has the role to coordinate activities, and to provide feedback in terms of technology and learning requirements of teachers. However, this forum is under-resourced, and hence cannot function effectively to execute this critical role.

6.3.2 Initiative-level view on decision-making

The next level of analysis considered the various initiative areas for which decisions needed to be made and outlined the decisions, possible decision models and (subjective) assessment of the implication on sustainability. The resulting initiative-level decision map is outlined in the table below (Meyer and Marais 2014):

Table 6-2: Initiative-level decision-making

PROJECT DECISION AREA	WHAT IS DECIDED	POSSIBLE DECISION MODEL	ELEMENT and DURATION OF SUSTAINABILITY			IMPACT
			SHORT TERM	MEDIUM TERM	LONG TERM	
INFRASTRUCTURE	Internet vs. internet-like experience	Total cost of ownership	Operations	Financial	Social (use)	High
TECHNOLOGY	Which tablets to use?	Technology selection (multiple criteria) Total cost of ownership	Financial	Operations (supplier ecology)	Social Institutional	Medium
TEACHER PROFESSIONAL DEVELOPMENT	What training is done at district, school and provincial level respectively?	Cost-benefit Scenario development		Financial	Institutional	High
CONTENT	Internet-like experience? (local content server)	Cost-benefit	Financial	Operations	Social	Medium
	Which content provider to use?	Supplier selection (multiple criteria)	Financial Operations	Operations (supplier ecology)	Supplier ecology	
	Open vs. proprietary content	Cost-benefit Total cost of ownership	Financial Technological	Financial Operations (supplier ecology)	Financial	Medium
OPERATIONAL MODEL	What should the technology support model look like?	Evaluate alternative strategies against total cost of ownership	Financial Operations	Institutional	Institutional	High
	Service Level Agreement – performance parameters	Cost-benefit of different service levels	Financial Operations	Financial Operations Social (use, uptake)	Financial Operations Social (use, uptake)	Medium
RESOURCE ALLOCATION	Number of tablets per school	Resource allocation for optimal impact	Financial Operations	Financial Operations	Institutional Social (use, uptake)	High

The above table outlines some of the decisions that the project team needed to make during project implementation. The associated decision models serve to demonstrate examples of models that could be developed to enhance decision-making throughout the process.

In retrospect, these decisions had varying impacts on the overall sustainability of the intervention. For example, the choice of the technology support model influenced the affordability of the solution to the Provincial Department of Education. This is critical to sustainability. The TCO decision model was successfully used to demonstrate this impact.

6.3.3 Decisions that support Value for Money

The final perspective of the decision analysis was to gain an understanding of the role of decisions on influencing the Value for Money (VFM) of the initiative. For each of the concepts of *economy, effectiveness* and *efficiency,* questions that are appropriate to this initiative were overlaid on the VFM outcomes chain. Decision models were then defined to answer these questions. The intention was to identify, along the chain,

opportunities where improved decision-making could improve the Value for Money of the initiative.

A *sustainability framework* was defined as a means of aligning the environments within which decision-making takes place. This framework provides the opportunity to reduce risk of failure, by identifying aspects that need to be addressed during implementation.

This analysis is outlined below (adapted from Meyer and Marais 2014):

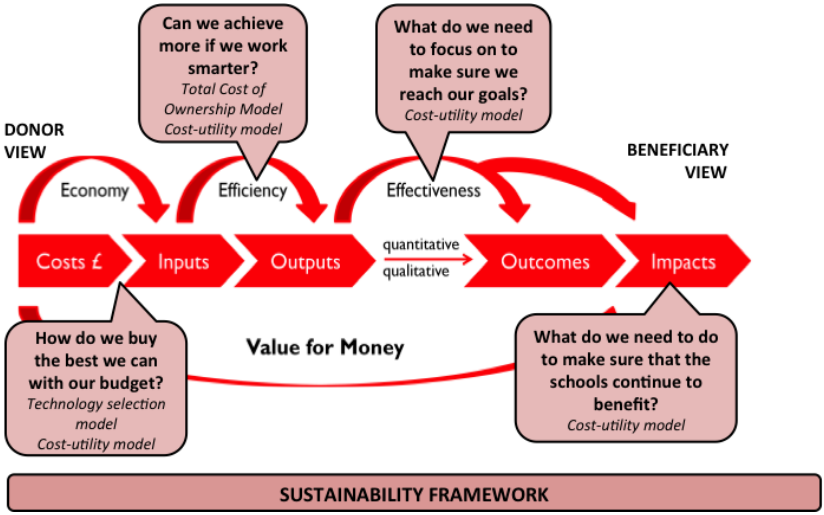

Figure 6-3: Questions and decision models to enhance Value for Money

This view provides a useful means of highlighting decisions that could affect the ability of the initiative to increase the Value for Money that it delivers. Better execution of decisions along this chain can result in outcomes that deliver better value. For example, if technology decisions are made with the objective to purchase tablets that is affordable, but at the same time durable and appropriate for the specific rural environment (high glare, high dust, low electricity), the tablets are more likely to be used over a longer period of time, be usable for its purpose and cost less over the duration of its lifetime. Similarly, if money is spent to have the best utility (i.e. to reach the most students with technology given the

budget, and reach the largest number of schools in the circuit), the overall impact of the initiative could be larger.

Based on the above analysis, the following four models were developed:

Technology selection model

This model assists with the selection of technology from perspectives other than cost only. The model is supported by a web-based decision tool, which can be used to rate the relative importance of elements and score different tablets. An appropriate recommendation is made, based on these importance and ratios (Section 4).

Total cost of ownership model

The total cost of ownership of the initiative (invested cost, and initiative cost to maintain the solution over the next five years) is analysed. The analysis is used to determine the appropriateness of the investment strategy across components, and to assess affordability of the implementation (Section 4).

Cost-utility model

The purpose of the cost-utility analysis is to provide an indication of the *utility* that is derived from investment, i.e. how much has been gained in terms of usable activities / infrastructure / learning etc. through the investment that was made. This provides a means of evaluating different investment strategies, and choosing an appropriate one. In addition, it provides one of many possible means of justifying to funders the value that was created (DPME, 2014).

For the ICT4RED initiative, cost-utility parameters have been calculated along the outcomes chain, thus highlighting parameters that indicate *economy, efficiency*, and *effectiveness* respectively. Example parameters are outlined below:

Table 6-3: Cost-utility model

	ASPECT	PARAMETER	UNIT OF MEASURE
ECONOMY ➔ **Economical procurement**	Technology acquisition	Connectivity cost per school Equipment-related cost Content-related cost	Rand per Mbps Rand per tablet procured Rand per content server procured Rand per e-book license procured
EFFICIENCY ➔ **Efficient delivery of outputs**	Technology deployment	Cost to deploy technology at one school (infrastructure, connectivity and tablets) Cost to deploy infrastructure and connectivity at one school (excluding tablets) Cost to deploy tablets at one school	Rand per school (setup cost)
	Content availability	Cost to deliver subject content per learner per year	Rand per learner per year
	Technology availability	Cost to operate ICT deployment per school Rand invested per hour of tablet use Rand invested per hour of teacher tablet use Rand invested per hour of learner tablet use	Rand per school per year (excl. setup) Rand per hour of tablet used, including setup cost, and initiative over 5 years
	Training and awareness	Cost per teacher trained Cost per learner trained Cost per technical support person trained Cost of creating community awareness Cost of leadership change management	Rand per person year, including training setup cost, over 5 years Rand per school per year, including setup if any, over 5 years Rand per district per year, including setup, if any
EFFECTIVENESS ➔	Reach	Rand invested per learner reached with ICT-enabled teaching methods	Rand per learner for 5 year period, including

	ASPECT	PARAMETER	UNIT OF MEASURE
Achieve intended outcomes			setup and operations cost

The intention of the cost-utility model is twofold:

- To illustrate the value which is created at various points along the chain, and the investment that has been made to deliver the value (retrospective view, aimed at justification of spend); and
- To provide a means of comparing alternative strategies, by evaluating the cost of a specific strategy to deliver a specific type of value (prospective view, aimed at improved planning and design)

The *economy* parameters provide a means of assigning a cost to the way in which procurement was done. The value addition or *utility* is associated with the action of procurement. Improved procurement strategies would reduce the cost per item procured. For example, a procurement strategy that considers local service providers may (or may not) result in reduced cost of connectivity per school.

The *efficiency* parameters provide a means of assigning cost to the way in which outputs are delivered. The *utility* is associated with the action of taking inputs and delivering outputs. Improved means of making this translation would reduce the cost per item delivered. For example, different technical support models would result in different costs for delivering the utility of tablets that are available and functioning. Cumulative costs of delivering the output are considered throughout.

The *effectiveness* parameters provide a means of assigning cost to the way in which outcomes are reached. The *utility*, for the purposes of this intervention, is associated with the *action* of turning inputs to outcomes (i.e. cumulative cost along the chain). For example, different choices of technology and content, or different community engagement strategies, would affect the total cost of reaching learners with technology.

Since it is not possible to include all perspectives on utility, the focus of the model is on capturing aspects that are likely to inform decision-making. Economy parameters are aimed at informing better procurement

decisions. Efficiency parameters provide a means of comparing different strategies of delivering outputs, and effectiveness parameters provide a means of reflecting on the overall cost of delivering a desired outcome. As such, the cost of different strategies along the outcomes chain can be compared.

A principle has been adopted to regard the infrastructure as a *pipeline* that connects the school to ICT, with the devices as a means of accessing ICT. It also highlights the fact that, once the investment in the pipeline has been made, this investment can be utilized in numerous manners to realize various types of utility. For example, other initiatives could connect to the pipeline by deploying electronic whiteboards. Similarly, different types of content (e.g. exam papers) can be accessed virtually free of charge once the infrastructure has been established. The cost associated with these opportunities is not reflected by the cost-utility model. In order to compensate for this aspect, technology deployment cost-utility parameters have been developed that determines the cost-utility of the deployment of technology infrastructure and connectivity (i.e. the pipeline) separately from the deployment of tablets (devices).

Sustainability framework

A key characteristic of the deployment of ICT in rural environments is the mismatch between the relative maturities of the different environments, and the lack of readiness of environments relative to each other. For example, in this initiative the handover of initiative management responsibilities from CSIR to the District Office failed due to initiative management capacity that is under strain. Similarly the initiative deploys technology (e.g. tablets) that requires a level of technical support that exceeds the availability thereof within the environment in which it is deployed. In general, the ICT4RED initiative needs to be accommodated by the Eastern Cape Department of Education (ECDoE), of which the capacity (personnel, business processes, initiative management capacity and budget) to support the initiative is under strain.

An assessment of the *readiness* for environments relative to each other would provide useful information that could potentially reduce the risk associated with deployments. Readiness assessments would provide information pertaining to critical success factors that need to be aligned before and/or during initiative execution. Similarly, checklists of critical

success factors, based on initiative experience and/or experience stated in literature, could be used for assessment prior to implementation:

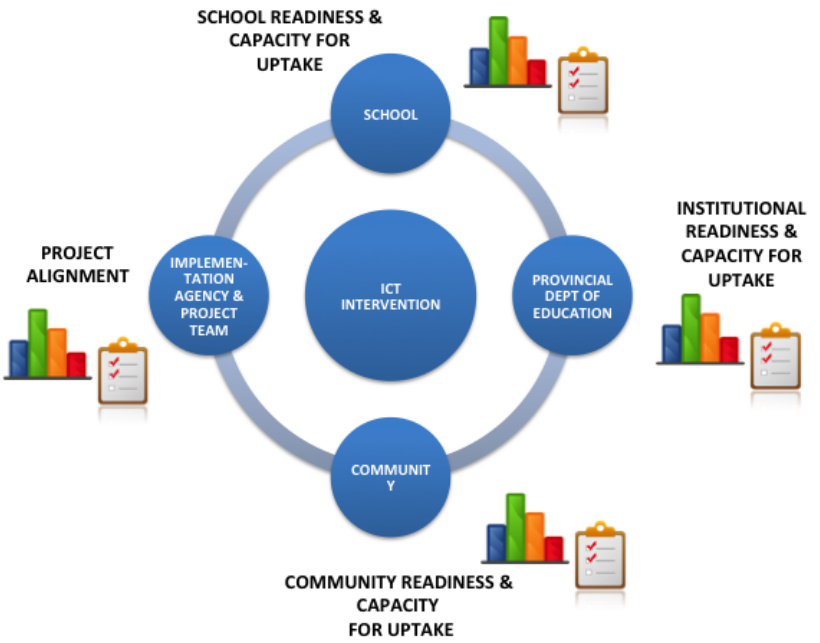

Figure 6-4: Sustainability framework

In this initiative, the need for matching the maturity of the intervention to maturity of the environment became apparent during implementation. This prompted the conceptualization of a sustainability framework. Future work would focus on the design of a framework to include readiness assessments that are customised to deployment in a particular type of environment (e.g. rural).

Such assessments could include the following in order to improve the long term success of implementation:

Table 6-4: Potential assessment models

Role player	Assessment	Purpose
Implementation agency	Readiness at initiative level to adapt to the implementation environment	Initiative alignment: selection of appropriate approaches, selection of pilot sites
Department of Education	Change readiness at organizational capacity level	Alignment with existing initiatives. Ensuring adequate capacity for uptake (e.g. personnel and initiative management skills). Informing strategy development.
School	Change readiness at personal and organizational level. ICT readiness	Ensuring adequate capacity for uptake (e.g. availability of personnel, professional teaching skills and ICT skills).
Community	Community readiness for adoption of development initiatives	Mobilising local leadership structures and different levels of support for the initiative.

Some of these models were developed to support decision-making during initiative planning and execution, while other concepts were developed retrospectively. Ideally, the portfolio of models should be planned for from the outset of the initiative, and model results should be used to guide initiative planning and execution.

6.4 Understanding costs: Total Cost of Ownership model

6.4.1 Why costs?

A sustainable ICT4D deployment requires that initiative components include more than the mere delivery of technology. Non-technology components include, amongst others, people-focused elements such as community engagement, change management, etc. In a sustainable implementation, all components would be included, and would be sufficiently addressed during initiative execution. This requires adequate funding. It is assumed that “adequate funding” would be reflected in an appropriate investment profile for a specific initiative. An understanding of the allocation of funding across the various components would enable a discussion around the appropriateness of the investment.

Unwin (2009, p. 365) states that sustainability is primarily a problem with "externally situated ICT4D programmes, and in part reflect a desire by those who create them to guarantee their continued success after the initial period of investment is over". In his opinion too little attention is paid on how initiatives can become self-supporting, and he recommends that all ICT4D programmes that are introduced by external players have a framework for ensuring "continued viability beyond the initial period of funding" in order to not leave the beneficiaries with the burden (ibid). He also recommends the use total-cost-of-implementation models.

The learning from the ICT4RED initiative indicated that initiative costs need to be understood from the following perspectives:

- To secure sufficient budget, as soon as possible – this enables the ability to plan for sustained benefit;
- To ensure an appropriate allocation of costs across initiative components; and
- To ensure that the solution that is developed is affordable to the agency to which it is transferred.

The latter point is especially relevant in evolving initiatives, where solutions are adapted and developed as more is learnt about the initiative environment. Such adaptations need to be done with the view of affordability at handover.

6.4.2 Initial approach: Initiative-based costing

Development initiatives can in some cases be characterized by funding that comes from more than one source, and by funding that comes available over time (and during execution of the initiative). This impairs the ability to develop a comprehensive investment plan from the outset. Uncertainties associated with the initiative (at design as well as implementation level) further complicate the budgeting process.

In the ICT4RED initiative, costing was broadly done as follows:

- A top-down budget was developed, based on the expected requirements of the 12-component model.
- The budget was based on the estimated effort to execute the 12-component model.

- The actual costs were determined by the responses from contractors to Requests for Proposal for each component, based on stated initiative requirements (bottom-up process).

This budgeting and costing process resulted in a specific investment profile, which may or may not have been a good match with the strategic intent of the initiative. Furthermore, the technology solution that was developed may or may not be affordable within the implementation environment.

6.4.3 Revised approach: Costing based on Total cost of Ownership

A view on the Total Cost of Ownership (TCO) of a technology solution provides the opportunity to develop a solution that is affordable to develop as well as to maintain over time. A combination of a TCO view and a view on the investment over 12 initiative components provides the opportunity to interrogate both the affordability of the solution and the appropriateness of the investment profile.

A Total Cost of Ownership model was developed. The model was an adaptation of the GeSCI TCO model for large-scale deployments (GeSCI 2008), and consists of the following elements:

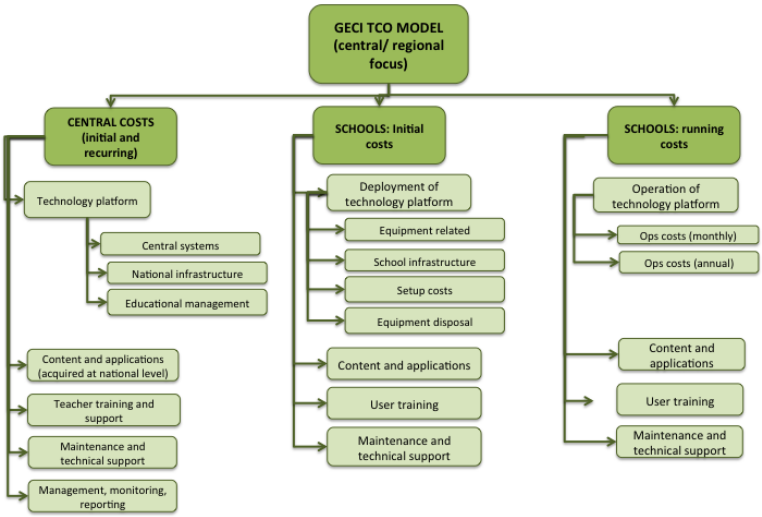

Figure 6-5: Elements of GeSCI TCO model

The TCO model, as outlined above, differentiates between the following:

- Investment at regional or national level (central costs);
- Investment at school level; and
- Capital vs. operational investments.

The model calculates the Total Cost of Ownership over a five-year timeframe. The original GeSCI model was extended to reflect all elements of the 12-component model. The model was used to reflect the following:

- Total cost of setting up and maintaining the initiative, over a five year period
- The investment across components; and
- The investment over time (i.e. the costs required to maintain the initiative over time, for each component).

The high-level elements all remained relevant in the adapted model, but elements were added to the management, monitoring and reporting dimension of the central costs to reflect all elements of the 12-component model. These included change management, stakeholder management, research, communications and marketing, and community engagement. Some elements were renamed to facilitate alignment with the initiative. In addition to this, all elements were mapped to the 12-component model, and graphs were developed to reflect this mapping.

6.4.4 In future: using cost information to inform decision-making for sustainability

The TCO model can be used to inform a number of management decisions, all of which would support sustainability. The model produced results that could be used to improve the following aspects:

- Investment profile: is the investment in the initiative in support of long-term sustainability?
- Affordability: is a solution developed that is affordable to the agency that needs to support it over time?

Investment profile

The investment profile for this initiative, showing the percentage of budget that was spent on different initiative components, is outlined below:

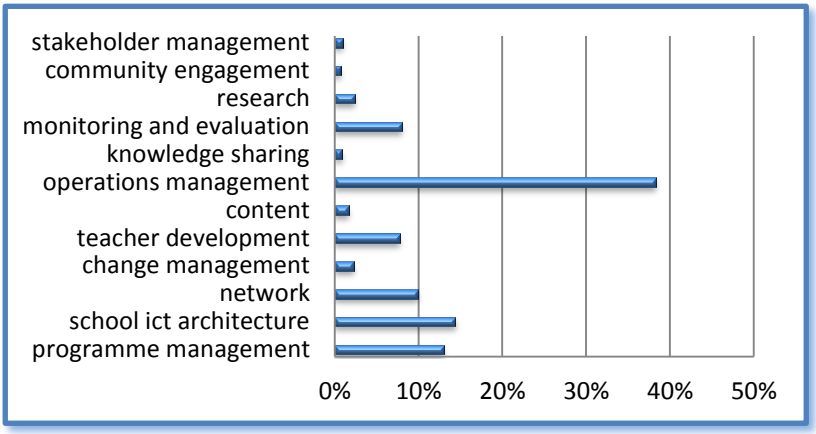

Figure 6-6: TCO model results: investment profile – setup cost and 5-year operational cost

The intent of the ICT4RED initiative was to create a 21st Century teaching and learning environment, in addition to the deployment of technology. The investment profile indicates that the deployment and maintenance of the ICT solution required the bulk of the funding. The combined investment in operations management and school ICT architecture comprised just over 50% of the budget. Even in this initiative, with its focus on teacher professional development, relatively modest investment was allocated to teacher development in comparison to the high cost of the technical and operations components. The large monitoring and evaluation component reflects the research nature of the initiative. Stakeholder engagement, community engagement, knowledge sharing and change management each attracted less than 2.5% of the investment.

An appropriate investment profile is not known. However, the above profile does generate questions pertaining to the investment that is required in aspects other than technology, in order to generate a sustainable solution.

In practice this could mean that a regular assessment should be made of the achievement of outcomes that are sensitive to changes in the investment profile. Ideally, the outcomes that are expected for a given investment profile should be compared with the actual outcomes achieved. Investment in critical components should be adjusted to ensure that outcomes that are critical to sustainability are reached.

Affordability

An analysis of the investment that was required to maintain the ICT4RED implementation over the next 5 years indicated that the ECDoE is unlikely to have sufficient resources to absorb the cost that is required to maintain the intervention. This precludes sustainability.

This first cost analysis focused on the initial design of the implementation. A number of aspects inflated the costs associated with the intervention. For example, the intervention is designed and implemented by a research organisation, and this affects the Total Cost of Ownership through the utilization of research resources in operational roles. Furthermore, the development process is experimental, which leads in some instances to a trial-and-error approach to implementation, and hence inflated costs.

These aspects inflated the initiative five-year affordability of the initiative, and the TCO model served as a means of illustrating this.

A revised operations management scenario was defined, and the associated cost (which would be more affordable to the ECDoE) was calculated. The revised cost constituted approximately 25% of the original (research environment) operations cost.

While more affordable, the initiative cost to maintain the implementation was still significant.

Learning

The above analysis highlighted two aspects that are critical for sustainability:

- The investment profile in the technology initiative indicates that there is a potential imbalance in the spend on elements that the initiative considered as key elements of a complete implementation; and
- Affordability of the implementation needs to be considered in the design phase of the initiative.

The cost model provided a tool for assessing the cost of alternative operations management scenarios, and alternative scopes of implementation.

For this initiative, the cost model was developed towards the end of the initiative, and the investment was analysed after it had already been allocated across components. Also, affordability was not the prime concern of solution design. Planning and sustainability can be improved if the cost analysis is done at the outset of the initiative.

6.5 Selecting technology for sustainability: multi-criteria technology selection model

6.5.1 Why a focus on technology selection?

The choice of appropriate technology affects sustainability from financial, technical as well as organizational perspectives. Technology choices influence the sustainability of the initiative in terms of affordability, as well as in terms of usability and durability of the technology.

The tablets that were chosen for deployment in a rural environment needs to be affordable in terms of initial investment, as well as in terms of ongoing maintenance and support. In addition, the technology needs to be appropriate for the specific circumstances (e.g. high glare, dust, low electricity environments), and needs to be easy to support. It should not place an undue load on the ability of the implementing agency to integrate it with existing support services.

Technology selection is typically the result of a vendor-push approach, which could lead to selections that are not in line with initiative needs, and that are perceived to favour specific vendors. A scientifically-founded technology selection process is therefore not only important in terms of ensuring financial sustainability and technology fit, but also in terms of facilitating transparency of procurement decisions.

6.5.2 Initial approach: vendor push

Initial technology selection decisions in the ICT4RED initiative had a minimum-cost focus. Technology choices were based on a trade-off between performance and cost. Suppliers inundated the implementing agency with sample tablets, which placed a high demand on the initiative team for tablet testing and evaluation. Selection criteria were based on a minimum technical acceptability of tablets and cost concerns without a clear process of tablet and supplier selection.

6.5.3 Revised approach: multi-criteria decision-making

The selection of technology can be considered against the following question:

Will the technology that you choose today still be a good choice over the next few years?

The technology selection model provided a basis from which to consider the definition of "good choice" from multiple perspectives. Perspectives were defined by the relevant initiative team members, during a series of facilitated workshops. Participants considered the following categories were to be important for tablet selection: technical specifications, quality, supply chain reliability, finances and tablet ecology.

The purpose of the model would be to select tablets that represent Value for Money, as is evaluated against more dimensions than finances only. These dimensions are broadly defined as follows:

Table 6-5: Dimensions of the Technology Selection Model

Aspect	Interpretation
Technical specifications	The technical specifications are relevant to the environment within which the tablets are deployed (e.g. high dust and glare, low availability of electricity). Some specifications are disqualifiers.
Quality	The quality of the tablets will enable them to be functional over their expected lifespan.
Supply chain reliability	The supply chain is reliable to deliver in remote rural areas.
Finances	The solution is affordable, and the cost of maintaining the tablets over their expected life span is affordable. The value of the tablet justifies its cost.
Tablet ecology	The tablet fits with the rest of the technology that is already supported by the relevant provincial Department of Education. Integration of these tablets into the school system will not place an undue load on the existing support structures.

For each of the above categories, a number of criteria were developed. Criteria were weighed to reflect their relative importance to the final selection. Categories and sub-categories of criteria are mapped below.

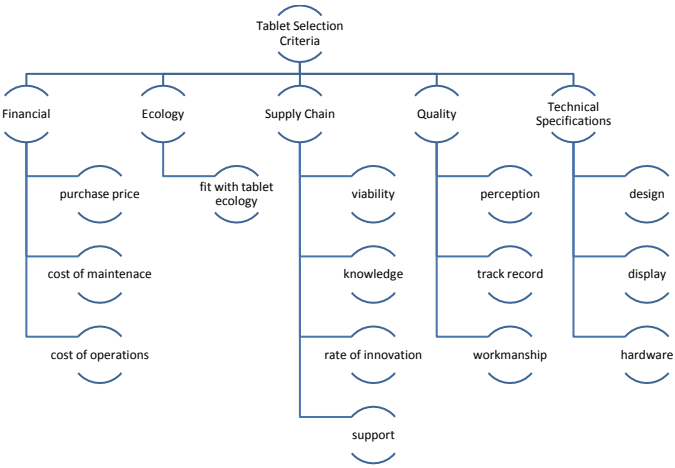

Figure 6-7: Categories of Tablet Selection Criteria

Each sub-category contains varying numbers of criteria. Categories were weighted at the highest level, and weights were escalated down, and normalized across categories to account for the varying numbers of criteria within each sub-category.

A web-based model was developed, that allows the user to rate a set of tablets against the predefined criteria. Users have the opportunity to set their own weights, or set the default weights that were developed by the initiative team based on their experience with the initiative.

Figure 6-8: Web-based Tablet Selection Tool

In addition to the weights, users are required to rate the performance of each tablet against the multiple criteria.

The model provides a comparison of tablets against the multiple criteria, and indicates tablets that do not comply with minimum requirements with a negative score.

Based on the above results, the decision maker can come to an objective and transparent conclusion with respect to tablet selection.

6.5.4 In future: use of technology selection models in support of sustainability

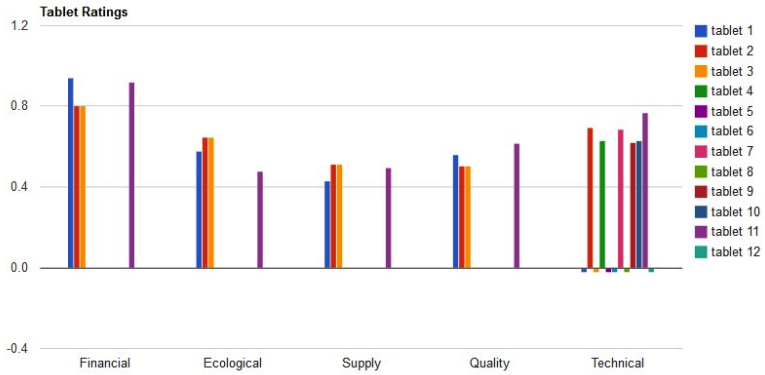

Figure 6-9: Technology Selection Model Output: tablet comparison

practice of tablet selection in education initiatives. It has the advantage of providing a defendable and transparent process upon which procurement decisions can be based. Furthermore, it speeds up the selection process by rapidly rejecting unsuitable tenders based on essential criteria. It also made the initiative team sensitive to determinants of suitability other than cost only.

The tablet selection model could enable a number of benefits, such as:

- Buy tablets that give better value for the money invested.
- Reduce costs by selecting tablets from a total cost of ownership perspective rather than a purchase price perspective only.

- Improve availability by including maintenance and supply chain considerations in the purchase decision.
- Buy devices that are fit for purpose.

The model is intended for use by decision makers at national and provincial government level, as well as for use by school principals, teachers, parents and learners. It can support the following levels of decision-making:

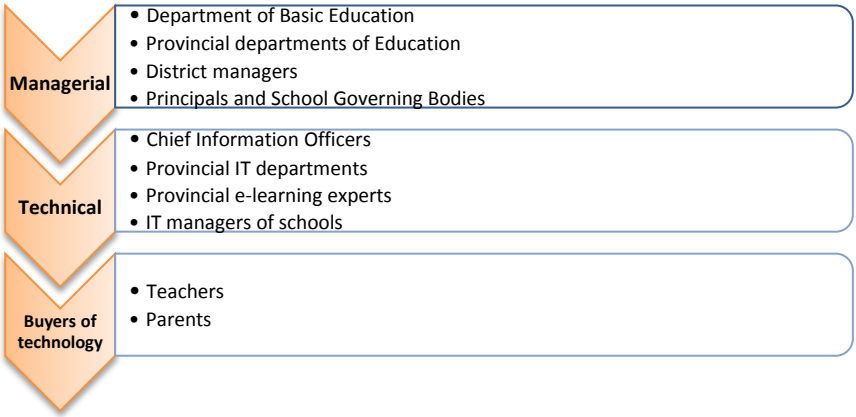

Figure 6-10: Users of Tablet Selection Model

A tablet testing service is envisaged, that uses the web-based tool as a basis of developing a repository of user knowledge and experience. Expert opinion and learning by the initiative team is captured in the weightings of the various categories.

6.6 Enabling Sustainability through Improved Decision Making

Multiple lenses can be used to assess the sustainability of an intervention. For this intervention a decision making view was taken on sustainability, with the purpose of improving and enabling sustainability throughout the process of initiative planning, design and implementation.

A more nuanced version of evaluation questions to be considered when thinking about sustainability is as follows (Miller, 2012):

- Will the benefits generated by the initiative continue once external support ceases?
- In the long run, will the benefits continue to be higher than the costs?
- Is the initiative supported by local institutions and well integrated into local social and cultural structures?
- Do the initiative partners have the financial capacity and are they committed to maintain the benefits of the initiative in the long run?
- Is the technology used appropriate to local conditions?

This question consider the classical OECD question of continuation of benefits, but also calls for thinking about the *enabling environment* (or beneficiary system) that needs to be in place to support the intervention.

The decision making view on sustainability, as considered in this initiative, defined tools that are a starting point for addressing the questions outlined above:

- The Total Cost of Ownership and cost-utility models address some of the aspects pertaining to benefits and costs (questions 1 and 2)
- The technology selection model addresses appropriateness of technology (question 5)
- The conceptually defined sustainability framework addresses issues around alignment with, and integration into, the beneficiary environment (questions 3 and 4).

The portfolio of models proved to be useful to highlight new perspectives on the concept of sustainability, at an initiative implementation level.

The application of the above models introduced new perspectives into the initiative. The various models contributed as follows:

Table 6-6: Perspectives contributed by decision models

Model	Perspective
Tablet selection	Non-technical view on performance The tablet is part of an technology ecology Supplier sustainability
Total Cost of Ownership (TCO)	Appropriateness of investment profile Affordability
Cost-utility	Comparison of utility of different strategies, rather than focus on either cost or long-term impact

Sustainability framework	Long-term drivers of sustainability Risk reduction

Approaches such as decision mapping served to connect initiative and organizational levels of sustainability.

The learning that was gained through the process of defining and developing the portfolio of decision models can be summarized in the following general approach to enabling sustainability:

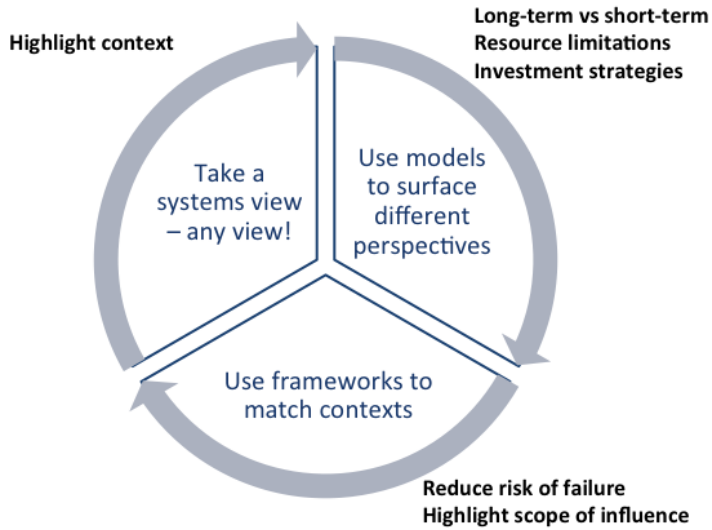

Figure 6-11: Approach to the use of models to enable sustainability

A systems view is on the initiative is essential for enabling sustainability. Viewing key elements in isolation prompts a skewed focus, and can lead to a focus on aspects that are not critical to sustainability. Methods that enable sustainability needs to be linked to a framework that makes the role of the method clear relative to the overall intervention. In this work, the combination of decision mapping and the Value for Money framework served as a systemic view on the intervention.

Models are useful in terms of surfacing different perspectives and stimulating debate. For example, the Total Cost of Ownership model could

serve to stimulate debate around investment strategies, and to prompt the question of adequate financial planning at the outset of the initiative.

A sustainability framework was conceptualized, and some concepts were defined. This framework aims to prompt the matching of contexts before implementation, and as such reduce the risk of implementation failure. For example, an understanding of the organizational capacity of the school to interact with the initiative could lead to adjustment of the implementation strategy, or strengthening of local resources, in order to reduce risk and enhance success and sustainability of the implementation.

6.7 Summary

Sustainability in development initiatives is difficult to attain, and there are numerous cases of initiatives that failed at implementation, failed when operations are transferred or failed to reach their intended objectives. The failure of ICT4D implementations has been attributed to numerous kinds of factors. Heeks (2002) ascribed the high rates of failure of information systems (IS) initiatives in developing countries to a design-actuality gap where there is a mismatch between the desired systems state of the IS designers and the local actuality of the users. Toyama (2011) found a multitude of reasons for the failure of ICT4D in his literature survey. These include failures to: design context-appropriate technology, partner with local organizations, adhere to socio-cultural norms, account for poor infrastructure, build relationships with local governments, invite the participation of the community, provide services that meet local needs, think through a viable financial model, and provide incentives for all stakeholders. Toyama (p. 75) makes the point that “poorly designed technology or technology by itself, rarely has impact” and that other things are needed.

In this intervention, we had the opportunity to think about sustainability and ways in which to reduce the risk of failure.

We took multiple perspectives on sustainability, and defined success as the sum of decisions that are made by all role players involved in the design, implementation and transfer of the intervention. Value was defined as along an outcomes chain, that captures the concepts of economy, effectiveness and efficiency. The combination of these two perspectives provided a framework within which to design a set of decision tools that

could add value to the intervention, with the goal of enabling sustainability.

A portfolio of models was conceptualized, some of which was developed and implemented. This process generated new perspectives on sustainability, and lead to the definition of new approaches to improving sustainability at an initiative level. For example, the TCO model allowed us to clarify the difference between an initiative-based total cost of ownership and a more realistic operational scenario. This illustrates the key learning that an initiative is typically over-resourced relative to the beneficiary system that has to adopt the intervention. Similarly, the decision mapping process illustrated the implicit and explicit demand that is placed by the intervention on the beneficiary system.

Development initiatives are characterized by diverse and challenging implementation environments, and by frequent failures. The challenge is to generate learning that is transferrable between contexts. Too often the wheel is reinvented and Kleine and Unwin (2009, p. 1060) find that in the ICT4D field there is "a failure to learn from previous initiatives, and the tendency for development practice is to be top-down and supply led".

The approach to sustainability that was adopted here is to take sustainability as a departure point when planning development initiatives. This approach led to the definition of tools that could serve to transfer learning between environments. Future work would include definition of appropriate readiness assessments in order to be able to match critical initiative components with the key characteristics of the environment.

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SECTION 7: The use of social media in the management of an ICT for Education initiative

- ***Van der Vyver; B. Williams & M.M. Marais***

7.1 Introduction

The advent of the Internet and all its supplementary applications generated huge expectations regarding the economic empowerment of the poor and the disadvantaged. Kleine (2010:674) defined the following paradox: "ICTs and particularly the Internet are widely regarded as ground breaking inventions that have changed the way millions of people live their lives, and yet researchers and practitioners in the field of ICT and development often struggle to prove specific impacts of the technology to funders." According to Heeks (2010:629) "information and communication technology has experienced a particular diffusion cycle within development; a cycle that can be characterised as heavy over-promising followed by noticeable under-delivery."

An analysis of initiative failures rendered an array of reasons why ICT initiatives fail. Poor communication seems to feature on most of the lists. Krigsman (2012) found that "communication failures occur when communications are infrequent or honest discussion of initiative problems and issues are avoided."

The South African designers of an educational ICT4D initiative had these warnings at the back of their minds when they commenced with the initiative in the Nciba school district. With all the stakeholders involved it is clear that co-ordination and communication at managerial as well as grass roots level pose major challenges.

The focus of this section is on the use of social media in support of the management aspects of the initiative. The research was done by the monitoring and evaluation team (authors two and three) and a researcher external to the initiative (the first author). The principles of canonical action research that were described by Davison, Martinsons and Kock (2004) were followed. The section is structured as follows: initiative

background, literature review, methodology, data analysis, findings and conclusions and recommendations.

7.2 Literature Review

7.2.1 Why do ICT for Development initiatives fail?

ICTs have the potential to make development initiatives more efficient, lower costs and improve the communication of initiatives. Since the commercialization of the Internet in 1995 and the establishment of the social media a decade later, the development community and national governments have enthusiastically embarked on ever more ICT initiatives in health, agriculture, e-governance, education and many more fields. A number of highly successful initiatives have been documented however there has been no shortage of failed initiatives. Unfortunately, only very few stakeholders share their experiences of a failed ICT initiative publicly.

Gurstein (2006) pointed out that "(t)he major failures in the use of ICTs for development have not been failures in technology, nor in software nor even in funding; rather the failures have been in the implementations." Krigsman, in his analysis of initiative failures, found that "poor communication and mismatched expectations lie at the root of many failures.

Parkinson (2005, p. 13) identified internal management and leadership as a key factor for sustainability of a development initiative and lists the following variables: "vision/champion, capacity, cohesion versus complexity in decision making, level of internal conflict, ability to partner, network, technical know-how, marketing skills, flexibility and quick response". All the key variables referred to were taken into account in the design of the ICT4RED initiative in order to avoid the numerous pitfalls that are well-documented in the literature. In one such article 18 reasons why e-learning initiatives fail are discussed. The author concluded that "In the context of e-learning the bureaucratic and administrative mechanisms behind the scenes of development initiatives heavily condition and constrain the possibilities for an effective introduction of technology in the school ecosystem" (Anon, n.d.). The social media and its potential role in serving as managerial tool are discussed in the following section.

7.2.2 The role of the social media

The establishment and growth of virtual social networks such as LinkedIn, Facebook, Twitter and YouTube, and, in general, all kinds of virtual communities, has been the most significant development in ICT in the first decade of the new century. Their impact "is increasingly pervasive, with activities ranging from economic and marketing to the social and educational" (Chiu et al., 2006, p. 1872). They are embedded in enterprise networks, professional communities, e-business platforms, research networks, education networks, networks with clients, suppliers, friends, etc. (Garrigos-Simon, Alcamí and Ribera, 2012). "Online social networks are platforms that support content sharing and co-creation in online environments" (Li, Lee and Lien, p.120).

The micro-blogging tool, Twitter, was launched in 2006. By 2009 it had registered 58, 5 million users (Schönfeld, 2009). Jansen et al. (2009) described Twitter as a form of electronic word-of-mouth (WOM). "The specificity of Twitter lies in its messages – tweets – that can have maximum 140 characters, with the default setting public, which means that the essence of events can be transmitted on a large scale across the network, instantaneously (Jansen et al., 2009). Early research on other social media applications, such as blogs and social networking sites, rarely demonstrate a strong commitment to relationship building and dialogue from the practitioners running the organizational accounts (Waters et al., 2009). While it is easy to think of Twitter as being a source for news from far-flung places, it also allows professionals to learn quickly about topics that are important to their clients and business partners (Schlinke and Crain, 2013, 88).

There seems to be a difference of opinion regarding the managerial value of the social media. Consultants and practitioners have praised social media for its assistance in cultivating relationships with stakeholders (e.g. Li and Bernoff, 2008). A leading practitioner had the following to say: "Respondents in the MIT Sloan Management Review study indicated that they have seen operational benefits to using social business software, such as breaking down silos (34 per cent), faster time to innovation (31 per cent) and improving employee morale and motivation (31 per cent)." He added that it creates opportunities for retaining knowledge before people retire and allows them to collaborate and share knowledge with one another at all locations (Emelo, 2013). Twitter has been singled out for its

ability to facilitate public conversations through its reply function, which is available for all to see. However, early research on other social media applications, such as blogs and social networking sites, rarely demonstrate a strong commitment to relationship building and dialogue from the practitioners running the organizational accounts (Waters et al., 2009). To date, little research has examined how public affairs practitioners are using Twitter in relation to dialogue and relationship building efforts (Waters and Williams, 2011).

Another new force to be reckoned with is WhatsApp, a cross-platform mobile messaging application that is available to all the relevant mobile operating systems (Asian Tribune, 2013). WhatsApp "has more than 350 million monthly active users globally. That makes it the biggest messaging app in the world by users, with even more active users than social media darling Twitter, which counts 218 million" (Olson, 2013). It has further strengthened its market position by launching a voice messaging service in August 2013 (Ladage, 2013).

7.2.3 Evaluation in support of management

Evaluation is an increasingly important support to management and initiative management and, as the saying goes: "Feedback is the food of champions". Major trends in the dynamics between evaluation and management include Results Based Management and Developmental Evaluation.

Before the introduction of Results Based Management, it was common for initiatives to merely report on their outputs, instead of assessing the degree to which initiatives achieved outcomes and real benefits. Proponents of Results Based Management introduced Logical Frameworks into international evaluation in 1969s, with view of providing initiative managers with a tool to understand what results are being achieved. It was expected that managers would then use the information generated through such evaluation activities to make appropriate management decisions. This effectively helped to institutionalize evaluation as a legitimate management role in development initiatives (Anderson, 2010).

Although Results Based Management quickly diffused through international development thinking, it turned out to be less of a panacea than originally thought. It was common that managers treated the collection of Results Based Management information as a mere compliance

issue, rather than information to manage by (Anderson, 2010; Mayne, 2007). Logical frameworks were also frequently found to be poor approximations of the outcomes to be achieved in complex programmes implemented in changing and complex environments (Rogers, 2008).

Developmental Evaluation (Patton, 2010), is an evaluation approach that emerged as one potential answer to the challenges experienced with Results Based Management. Developmental Evaluation, as defined and described in the Encyclopaedia of Evaluation (Matthison, 2005, p.116):

> *"Has the purpose of helping develop an innovation, intervention, or program. In developmental evaluation the evaluator typically becomes part of the programme or innovation design team, fully participating in decisions and facilitating discussions about how to evaluate whatever happens… The evaluator's primary function in the team is to facilitate and elucidate team discussions by infusing evaluative questions, data, and logic, and to support data-based decision making in the developmental process".*

Developmental Evaluation supports quick feedback loops for management action. The use of social media in an initiative is particularly useful to the implementation of Developmental Evaluation since it provides a real-time communication flow that can be analysed and used more quickly than formal interviews or surveys.

7.3 Methodology

The researchers followed a canonical action research (CAR) approach in their analysis of the initiative. According to Davison et al. (2004, p.66) "(t)he term 'canonical' is used to formalize the association with the iterative, rigorous and collaborative process-oriented model developed by Susman and Evered (1978) that has been widely adopted in the social sciences and hence which has gained 'canonical' status. The five steps are diagnosing; action planning; action taking; evaluating; and specifying learning (Susman and Evered, 1978).

Canonical action research is only one form of action research. Baskerville and Wood-Harper (1998) clearly identify and describe the unique characteristics of 10 forms of which information systems prototyping, and

participant observation feature regularly in the extant literature. So does canonical action research.

Pirenen (2009, p. 126-127) described action research as follows:

> *"Action research aims to solve current practical problems while expanding scientific knowledge. Unlike other research methods, where the researcher seeks to study organizational phenomena but not to change them, the action researcher is concerned with bringing organizational change in front while studying the process. It is strongly oriented towards collaboration and change, involving both researchers and subjects. In this case it is iterative in scope and a continuous research process that capitalizes on learning by both a researcher (as a member of the expertise community) and other participants (e.g. students, colleges, collaborators and management)."*

In action research the researcher gets actively involved in the initiative that is being investigated. This involvement may commence any time during the execution of the initiative, i.e. as early as in the planning phase or even when the initiative is already in an advantaged stage. Miller and Pine (1990, p.6) make out a case for sustained action research in order to integrate research and professional development. They argue that both these objectives support improved students' learning.

It is pointed out on an influential scientific educational website that "in schools, action research refers to a wide variety of evaluative, investigative, and analytical research methods designed to diagnose problems or weaknesses—whether organizational, academic, or instructional—and help educators develop practical solutions to address them quickly and efficiently (The glossary of education reform, 2014).

7.3.1 Canonical action research

Davison *et al.* (2004:69) suggested the following five principles of canonical action research. They are:

- the Principle of the Researcher–Client Agreement (RCA);
- the Principle of the Cyclical Process Model (CPM);
- the Principle of Theory;
- the Principle of Change through Action; and

- the Principle of Learning through Reflection.

This template fits the ICT4RED initiative. Each of these principles and their implementation will now be explained.

7.3.1.1 The Principle of the Researcher–Client Agreement (RCA)

The political landscape in which the ICT4RED initiative is executed, underscores the importance of the principle of the researcher-client agreement. With four government departments representing two spheres of government, a government research agency (Meraka) and two independent researchers (the first two authors of the chapter) involved, a formal multi-party contract might have been too idealistic. The ICT4RED initiative is guided by two formal contracts and a collection of correspondence between the stakeholders.

The ICT4RED initiative is funded by way of two contracts between CSIR (in this case represented by its Meraka Institute) and two South African government departments. The Department of Rural Development and Land Reforms (DRDLR) funds the infrastructure required, namely computer tablets, Wi-Fi network in the schools, satellite connectivity and Wireless Mesh Networks to connect schools. The Department of Science and Technology (DST) funds the balance of the initiative such as program management, teacher training, change management, research, monitoring and evaluation and content. DRLDR has also provided two participants of the National Rural Youth Service Corps (NARYSEC) program per school in order to provide onsite technical assistance. The two formal contracts between the CSIR and the two government departments respectively regulate the funding as well as the services provided by each party.

A memorandum of understanding also exists between the DST and the national Department of Basic Education (DBE) and the DBE has been invited to participate in the governance as well as events held in the Eastern Cape. There are no formal agreements with the Eastern Cape Department of Education but the endorsement of the Member of the Executive Council (MEC) for education and the head of the education department has been demonstrated via participation at the initiative launch event and other events.

7.3.1.2 The Principle of the Cyclical Process Model (CPM)

Davison et al. (2004, p. 72) recommended that the researcher follow a cyclical process model. They buy the 5 stage-model that Susman and Evered (1978) proposed namely diagnosis, planning, intervention, evaluation and reflection as well as the suggestion of Kemmis and McTaggart (1988) that the model should take the form of a spiral, not a cycle (Davison et al., 2004, p. 72). In line with their version of progressive coherence they also embed elements of the model of Mc Kay and Marshall (2001) into their own interpretation.

The McKay-Marshall model presents AR as two separate but interconnected and interacting cycles: one cycle representing and focused on the problem solving interest in AR, and the other cycle representing and focused upon the research interest in AR. Not only does this help dispel the criticism of AR that it is just like consultancy, but it arguably facilitates researchers in being much more explicit about the reflection and learning process that seems to be part of the essence of AR (Mc Kay and Marshall, 2001, p.57).

In the case of ICT4RED the involvement of a wide array of stakeholders, two formal contracts as well as a number of memoranda of agreement caused the researchers to make provision for two social media platforms to facilitate communication. This diagnosis of complexity, and the subsequent creation of two social platforms to supplement the conventional communication channels, formed the first two stages of the 5-stage model from Susman and Evered (1978). Although the researchers initially embedded there platforms in the initiative design to serve as informal communication channels between the initiative managers in Pretoria and the facilitators in the Eastern Cape, they were soon redefined as formal communication channels. The fact that complete narratives of the discussions could be printed served as justification for this intervention by the researchers. The results of the first analysis of the content of these narratives validated this decision.

This decision constituted a classical third stage intervention in terms of the model of Susman and Evered (1978). The fourth stage evaluation now took the form of the formal questionnaires that the facilitators completed after each milestone as well as the continued analysis of the narratives of the social media.

In the last stage that deals with reflection, the researchers compared the analytical information that they gathered. In accordance with McKay and Marshall (2001) two cycles could be identified. The first cycle was an iterative evaluation of the narratives generated from the discussions on the social platforms. The one independent researcher, the first author, conducted the first iteration. This was followed by two more iterations, one from the other independent researcher and a final one by the third author who is representing Meraka, CSIR. These analyses led to the formulation of grounded theory.

7.3.1.3 The Principle of Theory

Since the challenges that were faced by the ICT4RED team were mostly of a very practical nature, they did not engage in too much theorising at the start of the initiative. This approach favoured the subsequent challenge to generate grounded theory from the empirical data that was collected. "The investigator needs to set aside, as much as possible, theoretical ideas or notions so that the analytic, substantive theory can emerge" (Creswell, 1998, p.59). On the other hand McKay and Marshall (2001) insisted that AR without theory is 'not research'. It was therefore imperative for the researchers to embark at an early stage on a quest for theory.

7.3.1.4 The Principle of Change through Action

The fourth principle reflects this essence and the indivisibility of action and change, with intervention seeking to produce change (Davison et al., 2004). Eden and Huxham (1996) added that "(t)he essence of CAR is to take actions in order to change the current situation and its unsatisfactory conditions."

The researchers effected change at two levels. On macro-level their intervention of giving text books to learners on digital devices addressed a longstanding problem of outdated text books and non-delivery of text books. On micro-level they dealt with the perceived problem of the imminent risk of inefficient communication between the initiative managers in Pretoria and the implementers in the Eastern Cape. The two communication platforms that the researchers included in the planning model of the initiative facilitated daily managerial adjustments as well as fast-tracked solutions for unexpected problems.

7.3.1.5 The Principle of Learning through Reflection

This principle also applies to two levels: the practical and the theoretical. Davison et al. (2004:76 explains that "(t)he rationale for our Principle of Learning through Reflection stems from the multiple responsibilities of the action researcher: to clients and to the research community."

This principle has been implemented in three stages, i.e. a planning stage which made provision for the design of the ICT4RED initiative. Issues regarding implementation, monitoring and evaluation were taken into account. The actual implementation that consisted of the deployment and training of facilitators as well as cyclical evaluation by way of a questionnaire followed. In the last step the printing and analysis of the narratives from the two social platforms were introduced. The first author conducted the first and second analysis in accordance with the principles of grounded theory. Thereafter, the other two authors each conducted one iteration before the team engaged in triangulation activities.

7.3.2 Analyzing the social media

Social network sites (SNSs) has over the past decade become the dominating force in cyberspace. This development led to massive amounts of casual as well as formal data flooding into cyberspace. It also did not take long before SNSs were featuring prominently on a wide array of research agendas. Guille, Hacid, Favre and Zighed (2013, p. 17) commented that "(g)iven the impact of online social networks on society, the recent focus is on extracting valuable information from this huge amount of data. Events, issues, interests, etc. happen and evolve very quickly in social networks and their capture, understanding, visualization, and prediction are becoming critical expectations from both end users and researchers."

Information diffusion has become a recurring theme in many of these research endeavours. As computer scientists and information systems researchers, we focus here on the particular case of information diffusion in online social networks that raises the following questions: (i) which pieces of information or topics are popular and diffuse the most, (ii) how, why and through which paths information is diffusing, and will be diffused in the future, (iii) which members of the network play important roles in the spreading process? (Guille et al., 2013, p.17).

The first researcher made use of discourse analysis to examine the data. Terre Blanche, Durrheim and Kelly (2006, p.328) pointed out that the term discourse can be used in many different contexts. They added that "although this can be confusing, the openness of the term is also useful in signalling the fluid quality of what is being analysed." Johnstone (2002, p.9) explained how discourse is shaped by its context and pointed the following six aspects out in which the text is shaped:

- Discourse is shaped by the world, and discourse shapes the world.
- Discourse is shaped by language, and discourse shapes language.
- Discourse is shaped by participants, and discourse shapes participants.
- Discourse is shaped by prior discourse, and discourse shapes the possibilities for future discourse.
- Discourse is shaped by its medium, and discourse shapes the possibilities of its medium
- Discourse is shaped by purpose, and discourse shapes possible purposes.

Johnstone sees these six aspects as a heuristic for examining discourse. She explained that "a heuristic is not a theory. It is a step in analysis which may help you to see what sorts of theory you need in order to connect the observations about discourse you make as you see the heuristic with general statements about language, human life, and society" (Johnstone, p.9).

It is important to Johnstone (2002, p.16) that "(d)iscourse is shaped by the limitations and possibilities of its media, and the possibilities and communications media are shaped by their uses in discourse." In this study the researchers did not harbour great expectations regarding the managerial potential of the two social media platforms that were introduced. The short history of Twitter and WhatsApp pointed to their usage in an environment that is more suited for light-hearted, informal communication. The possibility that they may fulfil a triangularly role in the evaluation of managerial communication was viewed as an unlikely option but since they formed part of the planning model of the initiative the researchers nevertheless decided to explore their value. Each of the postings on WhatsApp as well as the Twitter feeds (tweets) that were included in the sample were subsequently analysed and categorized. The primary categories were based on managerial contribution.

Data from the three data sources were analysed qualitatively and subjected to content analysis. Coding categories were created based on a grounded theory approach informed by management communication theory and a specific focus on problems encountered during the implementation of the initiative for evaluation purposes.

Triangulation was also used in the data analysis. In general, triangulation refers to the application and combination of several research methodologies in the study of the same phenomenon (Bogdan and Biklen, 2006). In this case we are referring to the overarching phenomenon of management communication in the initiative. The communication researched was conducted via two channels with different degrees of formality and scope: a formal channel consisting of a questionnaire asking facilitators to provide feedback on their teacher training session and informal conversations between facilitators and initiative team members via social media about the initiative's progress. The mode of communication, scope, tenor and audience of the social media channels differ. WhatsApp was used by a closed group to communicate internally about the initiative, while the Twitter feed was mostly a broadcast to an external audience of information about the initiative with few responses.

A more restricted definition of triangulation is that it a way of cross-checking data from many sources in order to search for regularities in the data (O'Donoghue and Punch, 2003). In fact many types of triangulation are possible in this research. Denzin (2006) identified data, investigator, theoretical and methodological types of triangulation, all of which were used applied in this research.

7.3.3 Data collection

7.3.3.1 Data Scope

The subset of data analysed in this article includes data from phase 2, the expansion to eleven schools. It includes 1) a text stream collected from a WhatsApp group set up between the facilitators and the initiative management and course designers, 2) the responses of facilitators to a structured post training feedback survey administered via an online platform after the training of four modules were completed, and 3) a sample of messages posted on twitter by the @ICT4RED twitter handle or

which referenced the #ICT4RED twitter hashtag. Although these different data sources included responses from different participants, the collection time period overlapped and all data sources referenced the ICT4RED initiative.

7.3.3.2 WhatsApp

The WhatsApp text stream originated from conversations between the course developers, initiative management and individual facilitators that started after Module 1 and 2 of the Teacher Professional Development (TPD) training. Messages posted to the WhatsApp group for the period July 2013 to October 2013 was downloaded and analysed. Although photos were also frequently shared in the WhatsApp group, this was listed but not analysed for the purpose of this study. The WhatsApp discussion group was set up by the managers of the TPD component (Section 2 of this book) in order to facilitate communication between management, the course designers, the facilitators, the government partners and other ICT4RED team members. No ground rules were set prior to the group's inception, but the group had some opportunity for getting to know each other prior to the start of the data collection. WhatsApp provided the platform through which the facilitators could be supported on a day-to-day basis during execution of the initiative. WhatsApp was not the only form of contact between the Gauteng based management and course developers and the Eastern Cape based facilitators. They also had occasional online webinars and face to face meetings with the TPD component managers to discuss progress with the training.

7.3.3.3 Post-Training Facilitators Feedback Survey

The post-training facilitator's feedback survey was administered after modules 3 to 6 of teacher professional development training were delivered. This was administered using survey monkey, an online survey tool between July of 2013 and October of 2013. The post-training facilitator's feedback survey was developed as one of the monitoring instruments used by the initiative's Monitoring and Evaluation team. The purpose of the post-training facilitator's feedback survey was to provide feedback on the training that would allow the identification of areas for improvement and to ensure that the training was on track. The survey consisted of a mixture of open-ended and closed-ended questions to which

the facilitators had to provide answers, based on their experience of facilitating modules 3 to 5 and the additional catch-up session.

7.3.3.4 Twitter

The Twitter data comprised the first 50 Tweets that were posted since the start of the tweets by the user @ICT4RED (the ICT4RED contract manager) and tweets that mentioned the hashtag #ICT4RED. These were collected from 5 to 7 June 2013 and provide an introduction to the initiative for the Twitter audience (partly via retweets from the contract manager's personal tweets of May 2013) and cover the final days of Phase 1, the pilot of the ten module training course and technology roll out in one school.

Ethical consent was given by all participants in the WhatsApp group, and by respondents to the post training facilitators' feedback form which enabled the team to collect and analyse the data. Twitter data was sourced from the public domain.

7.4 Data Analysis

In this section the WhatsApp social media is analysed and compared with the structured evaluation data, the Twitter analysis is discussed and then triangulation possibilities are explored.

7.4.1 WhatsApp and teacher survey

The analysis of the WhatsApp stream revealed that personal communication was common, but that the app also allowed for very strong two way management communication between the implementers and team management.

A frequency count of communication types in a sample of WhatsApp coded exchanges is provided in Table 1 below.

Table 7-1: Communication types in a sample of coded WhatsApp exchanges

Type of Communication	Code	Number of Messages	% of Messages	Wordcount	% of Wordcount
Management Communication	Motivational	37	10.0%	476	6.9%
	Explanatory	29	7.8%	537	7.7%
	Inquiry	24	6.5%	337	4.9%
	Coordination	20	5.4%	401	5.8%
	Reference to other interaction	19	5.1%	404	5.8%
	Informational	16	4.3%	293	4.2%
	Managerial	16	4.3%	482	6.9%
	Live Feedback	15	4.0%	1464	21.1%
	Directional	12	3.2%	235	3.4%
	Arrangement	10	2.7%	278	4.0%
	Instruction	10	2.7%	235	3.4%
	Problem Solving	10	2.7%	340	4.9%
	Request	8	2.2%	169	2.4%
	Technology Reference	6	1.6%	95	1.4%
	Declarative	4	1.1%	58	0.8%
	Reservation	1	0.3%	15	0.2%
Management Sub Total		237	63.9%	5819	83.8%
Personal Communication	Expressive	50	13.5%	367	5.3%
	Confirming	37	10.0%	308	4.4%
	Emoticon	17	4.6%	49	0.7%
	Personal	15	4.0%	242	3.5%
	Welcome	10	2.7%	105	1.5%
	Humorous	5	1.3%	57	0.8%

Type of Communication	Code	Number of Messages	% of Messages	Wordcount	% of Wordcount
Personal Communication Sub total		134	36.1%	1128	16.2%
Grand Total		371	100.0%	6947	100.0%

Approximately 64% of the messages could be categorised as Management Communication, whilst approximately 36% of the messages were personal in nature. Personal exchanges were generally shorter than the management communication exchanges. By word count, Personal communication made up only approximately 16.2% of the sampled communication whilst Management communication made up 83.3% of the communication. This shows that in the ICT4RED context, the WhatsApp group that was intended to support the facilitators was mostly used to support the management of the initiative. Since other opportunities for interacting were limited to occasional face- to- face train the trainer sessions, webinars and more traditional electronic communication like phone calls and email, the continuity and immediacy of the WhatsApp communication was a significant benefit.

The range of management and personal communication was also quite wide. The kinds of management communication that were recognised are expanded in Table 2 and illustrated with verbatim quotes.

Table 7-2: Communication Types Codes

Communication Code	Code Description	Example
Arrangement	An arrangement between individuals (not pertaining to the whole group)	"I will b driving through to QT on mon morning. Can I meet up with u monday night?"
Coordination	Co-ordinating participation	Can all the facilitators who r training tomorrow and travelling from QTN come and fetch their packs from me at The Gallery. 9 wainwright
Directional	Directing to an electronic and or physical venue	The link to tonights webinar room is http://meet00000.adobeconnect.com/ict4red/ see u at 7
Informational	Informational	@facilitators just received an updated Professional Teacher Development Schedule

Communication Code	Code Description	Example
		- module 4 will happen at the school on the week of 26-29 Aug.
Instruction	Instruction to do something or not do something	@xxx - pls don't bring the broken tablet back. We need it to be logged properly and test the help desk system, etc. It will be fixed.
Managerial	Managerial: planning, staffing, organizing, leading, controlling	@xxx - what do you think? Main problem is we don't have replacement devices. If we can get a feel for the extent of the problem across all devices (facts & figures), that will help with decision-making...
Live Feedback	Feedback on how well the course is going, what the immediate problems are, while the course is ongoing / directly after acourse	Thanks to xxx fr joining me. I saw a lot of improvement. They have completed all tasks, majority managed to send emails to me. They were very excited this time.
Declarative	Declaring an intention/fact - "can't attend"	I've already downloaded the app from Play Store.
Explanatory	Explaining an arrangement or previous comment	Oi..sorry everyone. ..I had tested this with xxx yesterday and hence the wrong date...
Reservation	Expressing a reservation??	We just started a whatsup group for School M, still one teacher though?
Refer	[Refer] Reference to other communication (face to face, telephone, email)	Ok I'm sorted, XXX's meeting me thanks
Tech	Giving technical instructions and/or an explanation	Remember people the video to show is the ict4red video. When u c me u can get that from me. I will also show u how to install and share apks. will write a how to today
Inquiry	General or detailed	Is the FT course materials on dropbox or box and can we send link to everyone?
Request	Posing a request	Facilitators need softcopy of printed manuals. XXX can you email??
Motivational	Motivating individual or group to participate in one or more activities, Expressing support	Have a gorgeous gorgeous day...have fun and do great things with the teachers. It will all be wonderful. Fantastic!!!!! You get the star badge!!!
ProbSolve	Suggestion to	@xxx & @xxx - think we need a tech

Communication Code	Code Description	Example
	problem solve a situation	"problem" form to capture issues with the tablets - we need to make sure we respond - there is a 2-yr warranty on all tabs
Confirming	Confirming an arrangement/comment	Thanks for the info
Emoticon	Emoticon intended to express emotion	☺ ☹
Expressive	Expressing gratitude and/or other emotion	Hmm I love it too
Humorous	Humorous	Scared of the mice?
Personal	Personal comment	Also try get XXX's wife to give I some of her rice cakes....its to die for....another spoilt person!!!
Welcome	Welcome wishes, personal greetings	Hi XXX good to see you. We are neighbours and don't see you around but technology is bringing us together.

About 22.6% of the exchanges (or 28% in terms of word count) included communication coded as arrangements, directional communication, instructions, coordination, informational exchanges, and other managerial communication which all aimed to support the planning, staffing, organizing, leading and controlling function of management. This communication was mostly initiated by the managers.

Another significant portion of the communication can be categorised as live feedback – in other words descriptions of the experiences during the actual training sessions or just after the training sessions. Although it only made up about 15% of the exchanges, it accounted for almost 21% of the total word count. These were posted mostly by trainers themselves, or individuals that observed or supported the facilitators during their training sessions.

Inquiries, requests and explanatory remarks made up 16% of the exchanges and 15% of the word count, whilst the interactions categorised as declarative, reservations, technology references, or references to other interactions made up 8% of the exchanges and word count. These interactions were frequently initiated by the trainers.

Motivational messages in recognition of efforts by the team members were frequently posted by management and other trainers and served the important management function of supporting team members. This made up about 10% of the exchanges and 6.9% of the word count.

An interesting category of exchanges are those that aimed to solve problems – these were frequently started by management. Although small in number (only about 2.7% of the exchanges) these exchanges also tended to be somewhat longer, yielding about 4% of the total word count.

Personal communication was overwhelmingly supportive and encouraging with a high emotional content. It included welcome and greetings, expressive exchanges, confirming exchanges, comments of a personal nature as well as humorous exchanges. These were used by both facilitators and managers as appropriate.

For the evaluation it was important to quickly identify problems. This was addressed by implementing the facilitator feedback form, but the WhatsApp data proved to be a valuable additional data source in this regard. Table 3 lists the categories of problems that were encountered in the WhatsApp data, together with some examples.

Table 7-3: Problem Codes

Problem Code	Problem Description	Example
Bluetooth	Challenges with using Bluetooth during training	We tried to make the bluetooth visible to all devices and that didn't work too. So the bluetoothing is a blanket challenge as I received only 4 bluetooth messages out of 16 teachers.
Catering	Catering was not arranged	They asked if we didnt have bunz and drinks for them. They are used to eating during trainings. They thought XXX had somethng for them in her bag and after she left they asked for their food
Directions	Need directions, can't find directions, problem with directions to physical places / web places	Do anyone know where the satellite coordinates are of the schools? I cant remember how to get to

Problem Code	Problem Description	Example
		School N Hi xxx, just go via School A ,when you are there, they will show you the route to School N, is about 2km from them
Electricity Down Part Session	Electricity at the venue was down	we had a power cut less than 30 mins into the presentation but we managed. you can do without a initiator.
Forgot password	Participants forgot passwords to email or other service	Common problem forgetting password
Internet challenge	Problem with Internet connectivity / Internet down, Internet signal too weak, devices can't connect to Internet	Biggest challenge Internet connection
Need e-resource	Can't find an electronic resource, electronic resource not available, electronic resource not working	Me and XXX don't have tht video at es file Me too I don't have this video at es file I don't have the FT course
Need tablet	An additional tablet is needed because a teacher did not get a tablet, a new teacher did not yet receive a tablet	the new principal does not have one
Software	Software problems on the tablet	Got 1 problem with a xxx tablet. It shows sms received but does not open them. Same with emails, it doesnt open them. The contacts do not open as well as the WhatsApp. The Playstore does not allow to search for adverts which are not automatically displayed when u open it. Half the number of Apps are refusing to open
Tablet freezes	Tablet stuck on a specific screen or unable to switch on	Help, one of my teachers tablet has been frozen since she took it out of the battery in the morning. She has tried switching it on, but it doesn't switch on. Any idea what to do?

Problem Code	Problem Description	Example
Tablet Charge	Problems with the charging of the tablets	Lots of the tablets dud not charge
Teacher left school with tablet	Teacher left school with the tablet	Hey one educator at School S has sent a msg to the principal saying she has resign, gone forever and she has left with the tablet her cell is on voicemail since then. I asked principal to make follow up but also he is new in the school, he came a week ago so he doesn't have tablet. This is a problem?
Teacher Not Coping	a teacher or teachers are not keeping up, not coping with the Training content or the technology	XXX gogo is not coping at all, but is part of collaboration
Teachers Absent	Teacher absent for part or full session	XXX is bereaved, so he is not going to attend on the 2nd Nov
Time to evaluate Badges	Time too short to effectively evaluate badges, badge allocation took longer than the planned session, badges could not be awarded because time was too short	We had the normal badge run where they insisted on having their badges marked. Poor XXX stayed on even after we left at 6h40.....
Training plan changed	Training dates changed from what was originally planned; training dates change on short notice, conversation with school, indicates originally planned dates won't work.	School M was also thinking of changing time, but I said I will need to hear from School N first, but I can't get hole of the Principal
Travel Trouble		Just had my 1st blowout!? U ok? I'm between cathcart n stutt Yes I am

Problems ranged from technological challenges to logistical challenges, and some mention was made of problems relating to the individuals involved in the ICT4RED initiative.

When the problems that were mentioned on WhatsApp were compared to the problems that were uncovered using a more traditional post-training

feedback survey, it was evident that WhatsApp was a useful additional data source.

Table 7-4: Problems uncovered: WhatsApp compared to the Post-Training Feedback Survey

	School 1	School 2	School 3
Problems mentioned in both data Sets	There was a problem with attendance and continuity of participants during modules 3 – 5 of the training. The training overrun the planned time in some modules.	Module 3 one teacher was absent. Technical issues with some of the tablets - network coverage, sharing via Bluetooth, Wi-Fi hotspot connection errors, one tablet did not switch on. The training material might need more space for allowing participants to write.	The trainer was unable to make one training session, but arranged for a stand-in (via WhatsApp) Technology issues: difficulty with Bluetooth, some tablets had freezing screens, there were problems with charging some of the devices Struggled to send email due to connectivity issues
Uniquely mentioned in WhatsApp	Administering the assessment takes longer than planned. One teacher had a freezing tablet. One teacher left the school with a tablet.	The teacher that was absent during module 3 was on leave. Module 3 Training was rescheduled. Needed initiator for the school for module 5.	None.
Uniquely mentioned in Feedback Form	The technology help desk is not providing the right level of support. During module 3 there was a power interruption at the training venue. Although most teachers have a positive attitude, there were some participants who were somewhat disruptive.	The venue for the first training session was not conducive to group work, because of the mounted desks. The module 3 training session overran in time During module 3 some of the teachers had not done their homework because they did not understand what was necessary. The training might	Time lost due to loading of PowerPoint slides onto tablets during the pause module. Sessions consistently ran longer than planned.

	School 1	School 2	School 3
		need more time, especially since the administration of the assessment takes long. Assistance with the administration of badges might be necessary.	

Some of the problems that were mentioned in the WhatsApp stream would not have been known if the management team had only relied on the feedback form. The trainer for school 2 could indicate that he anticipated a problem, since his school did not yet have an 'initiator', and it was possible to make arrangements for this on WhatsApp.

Some of the problems that were mentioned in the feedback form were also mentioned in the WhatsApp stream – which allowed for triangulation of data. The WhatsApp stream provided also some other benefits:

- In some cases, it allowed for more explanation. In school 2 for example, the feedback form indicated that there was a teacher absent, the WhatsApp stream indicated that it was because the teacher was on leave.
- The fact that the information could be shared via WhatsApp meant that management was made aware of the issues quicker than they would have, if they had to wait for the feedback from the post-training survey. It also allowed for quick action to be taken. Facilitators at school 1 and school 2 indicated that their training overran the allocated time. During a webinar, it was possible for the management to address time management issues, and to brainstorm solutions regarding the time it took to do the assessment of homework.

7.4.2 Twitter analysis

The first researcher did content analysis on the first 50 Twitter feeds (Tweets) that were posted since the start of the initiative by the user @ICT4RED (the ICT4RED contract manager) and tweets that mentioned the hashtag #ICT4RED. The data was found to be rich in managerial

content. The breakdown of the appeals embedded in the tweets looks as follows:

Table 7-5: Appeal types represented in Twitter communication

Appeal	Number	Percentage
Informational	15	30%
Declarational	12	24%
Motivational	10	22%
Emotional	4	8%
Philosophical	2	4%
Explanatory	2	4%
Evaluative	1	4%
Political	2	4%
Humorous	1	2%

The top three categories are of a managerial nature. They represent 76% of the tweets. By adding the explanatory and evaluative categories it can be concluded that 84% of the tweets are related to managerial communication.

An analysis of the type of content renders the following table:

Table 7-6: Content types in Twitter communication

Type of content	Number of tweets	Percentage
Announcement	8	16%
Milestone	3	6%
Objective	3	6%
Policy	3	6%
Evaluation	2	4%
Explanation	2	4%
Gratification	2	4%
Philosophy	2	4%

The same trend that was detected in the previous table manifests again. The top six categories relate to managerial communication while the next two depicts communication of a more personal nature. The fact that announcements form a major part of the communication is to be expected, since the Twitter feeds that were analysed took place during the start-up phase of the initiative. One person was responsible for 82% of the tweets: the contract manager posted under the official user name (@ICT4RED) and in a personal capacity. Initiative team members contributed the balance of the tweets.

Eighty percent of the tweets carried text while photographs were embedded in 20% of them.

7.5 Findings

Since 82% of the tweets carried content of a managerial nature and 83.8% of the content of the postings on WhatsApp (64% of the messages) dealt with managerial communication there can be no doubt that the social media added immense value to the management of the ICT4RED initiative.

The social media also had a variety of evaluation benefits. Not only did the two social platforms offer great triangulation potential but the information they generated could also be compared with the information obtained from the questionnaires. In that respect the second researcher examined the overlap between problems reported in the questionnaires and problems that surfaced in the WhatsApp transcripts. Since WhatsApp offers real-time interactivity, solutions could be introduced much faster than in the case of problems detected in the formal questionnaire feedback. Despite this time lag, the two data sets lend itself to valuable triangulation.

The major benefits that the researchers detected in this triangular model are:

- High frequency of communication with 50 tweets in the first three days (5-7 June 2013)
- Real time intervention and/or problem solving in the case of the social media
- Dynamic agenda setting for all three evaluation platforms
- Dealing with unintended consequences
- Real time triangulation
- Enriched triangulation. Making sense of the questionnaire data by providing a communicative context.
- Referential value – the WhatsApp data analysis provides leads for evaluation team to follow up on.

The following negative aspects may come into play:

- Participants may engage in side shows (very limited according to the data analysis)

- Cutting through the clutter (may apply to Whatsapp; tweets limited to 140 characters)
- Validation of statements by participants may be required
- Conflict Resolution (inevitable but essential – to keep initiative on track)
- Power play. Some participants may try to dominate discussions while others may lose interest.

7.6 Conclusions and recommendations

Extant literature pointed out that poor communication was one of the main reasons why ICT4D initiatives fail. The initiative combines a strong practical contribution with an essential research component in the form of evaluation. This dualism makes the initiative a perfect fit for the template of canonical action research of Davison et al. (2004). The inclusion of two popular social media platforms, WhatsApp and Twitter, offered the researchers the opportunity to evaluate the value added by these platforms.

The research results exceeded all expectations. Not only did discourse analysis of the transcripts of the communication that took place via these social media platforms expose discussions that were rich with managerial content, it also showed that it contributed a high level of interactive managerial efficiency. Management communication dominated the discourse recorded on both media platforms. Sensible explanations of issues that came up in the structured survey were recorded. Opportunities were also created to interactively deal with unintended consequences. Against all odds, the researchers detected a minimal amount of trivial communications.

The study demonstrates that the additional data that was made available via social media had evaluative value that far outweighed the effort required to collect the information. This has implications for evaluation as management tool:

- At the most basic level, the analysis of social media data can help to strengthen the evidence base for evaluation findings, since more data is available and more triangulation opportunities are likely without much effort expended to collect additional data.

- Although the study demonstrates evaluative value from data that was collected without any deliberate probing from the M&E team, it is likely that with active probing the M&E team may be able to collect data via social media platforms that directly address evaluation concerns.
- The most exciting evaluation possibility links to the fact that data is immediately available via social media. If an evaluator could develop some simple analysis rubrics, they may be able to participate in social media platforms with the intention to identify issues for management attention as they come up, thus shortening the loop between data collection, data analysis and feedback to managers. Real time data collection, analysis and feedback provide an opportunity for the evaluation team to execute the developmental evaluation mandate in a manner that has not been possible before.

The initiative has undoubtedly proved that immense managerial value can be added by making social media part of the managerial communication structures of ICT4D initiatives. An upfront analysis of the management and evaluation requirements of an initiative that can be met via the use of social media will deliver value. It is recommended that the use and analysis of social media to support rapid feedback cycles to inform different aspects of initiative management such as governance and risk management be investigated.

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SECTION 8: Synthesis of the ICT4RED initiative

M Herselman

8.1 Introduction

This section will provide a synthesis of the ICT4RED initiative and highlight certain important elements of success. It will re-address the aims and objectives which were provided in Section 1 and also address some significant changes which became evident while and after the implementation occurred.

The Sections above provided evidence of how the ICT4RED initiative was managed and developed over a period of three years through the application of design science research in three different iterations (one school ,then 11 schools and finally 14 schools) in four phases (cf Table 3 in Section 1). After every phase the feedback from all the stakeholders, teachers, district officials and community were noted and these were used to improve the components for the next phase.

8.2 Addressing the aim and objectives

In Section 1 it was explained that this initiative had clear aims and objectives with models which had to be tested through research and implementation in order to develop a framework which could inform policy changes and to make recommendations for future implementations of a similar nature.

The main aim of the ICT4RED initiative was to investigate the application and deployment of tablets, supported by other technologies (which include school infrastructure, network connectivity, e-textbooks and other electronic resources) to the identified 26 schools in the Nciba school district in the Eastern Cape of South Africa, in order to improve rural education via technology-led innovation in a specific school district in one province of South Africa.

The result was that this aim was reached. Through the investigation more than 6500 learners, 350 teachers and 16 district officials were affected in the Nciba school district over a period of three years. The whole community was involved and this also had an effect on their own lives. The

improvement of rural education is not just evident from the infrastructure that was provided (Wi-Fi, Satellite dishes, content server, charging stations, security cages, etc), but also from how the schools were changed. The tablets allowed for better planning, the establishment of an ICT committee for each school to make decisions on the use of the tablets to support teaching and learning and allowed for teachers to be exposed to new ways of teaching with technology. Each school has an ICT champion to support them in the use of the technologies. Teachers became co-creators of new content and classroom settings changed from sitting in rows to working in groups and finding new ways to make teaching fun and exciting for learners. Teachers for the first time in that area felt empowered with new knowledge to use technology with confidence. Some teachers have excelled more than others have, but all of the teachers earned their technology with evidence of successful applications of teaching strategies. It is not often than you get a 100% pass rate for earning technology through the badge system.

The following ***objectives*** were envisaged:

- Design systemic and sustainable approaches to providing access to digital content by learners at resource constrained rural schools in South Africa;
- Design models for teacher professional development that focus on "how to teach with a tablet", rather than "how to use a tablet";
- Design, develop, test and improve new and evolving educational technologies, devices, platforms and processes that support the access to digital content for rural school environments;
- Measure the effect of this initiative on the 21st century skills of learners; and
- Use the evidence from the research within this context to inform policy in an integrated and coherent manner.

These objectives had to test the following models:

- Infrastructure & Connectivity
- Integration of technology into the school
- Operations, Logistics, Support & Maintenance
- Costs (Total Cost of Ownership) & Sustainability
- Content selection and organising content on servers
- Tablets (selection and upgrades)

- Change Management
- Teacher training and professional development

The table below indicate how each objective was addressed and what the results was to support each:

Table 8-1: Addressing the objectives with evidence of how

Objective	Evidence of achievement	Section where it was discussed in this book
Design systemic and sustainable approaches to providing access to digital content by learners at resource constrained rural schools in South Africa	Developed monitored the 12 essential components which resulted in the Evidence-based ICT4RED Implementation Framework. Arranged access to digital content on the content servers at each school which teachers and learners can download via Wi-Fi to their tablets. Access to McMillan and Pearson e-books.	Section 1 Section 4 (School ICT)
Design models for teacher professional development that focus on "how to teach with a tablet", rather than "how to use a tablet"	Developed the 10 module Teacher Professional Development training material with a badge system and licenced under Creative Commons.	Section 2
Design, develop, test and improve new and evolving educational technologies, devices, platforms and processes that support the access to digital content for rural school environments	Access to digital content via the content servers as well as on the tablets which are pre-loaded Developed processes for procurement of infrastructure equipment, tablet loading, support and maintenance. Developed Decision-support tools (cost utility model, Total cost of ownership model, Tablet selection model)	Section 4 (all sub-sections) Section 6 (sustainability and tools)
Measure the effect of this initiative on the 21st century skills of learners	Developed a 21st century evaluation checklist or guideline based on literature and applied it on teachers and a small group of learners	Section 3 (M&E framework and how the 21st century skills test was applied)
Use the evidence from the research within this context	Developed guidelines, models and frameworks, standards,	Section 1 (Evolvement of Evidence-based

Objective	Evidence of achievement	Section where it was discussed in this book
to inform policy in an integrated and coherent manner	recommendations, policy briefs to national and provincial governments. Developed practitioner outputs (planning and implementation guidelines, tools, templates, checklists) to various practitioners (schools, NGOs, provincial implementing agencies, etc.)	ICT4RED implementation framework) Section 4 (Programme Management)

All the objectives were addressed and various outputs were indicated above. The learning from this initiative was designed to feed into the system in a multi-dimensional way, to a variety of stakeholders in the rural educational eco-system.

8.3 What were the biggest success factors?

What made the ICT4RED initiative a success was that it was an implementation initiative with a sound research basis and the monitoring and evaluation component provided lessons learnt which could be applied to improve the implementation of each phase.

The Design Science Research methodology proved to be the best suited for this type of initiative as can be seen in Section 1. The phased approach with applicability of the lessons learnt after each phase allowed for improvement and more successful outputs. If the whole initiative was implemented at all 26 schools at the same time, I think, we might have had less success. The fact that the initiative was well researched and planned in the beginning and was organised around essential components with champions allocated to each component who were all experts in their own domains is one of the most important success factors.

The Department of Education (2014) indicated that South Africa has 12.3-million learners, some 386 600 teachers and 26 292 schools, including 1 098 registered independent or private schools. Of all schools, roughly 6 000 are high schools (grade 7 to grade 12) and the rest primary (grade 0 to grade 6). In the Eastern Cape Province the Department of Education (2014) indicated there are 7407 schools. This initiative only target 26 schools in a very remote and resource-constraint environment. Although this is a small

number compared to the total number of schools in the province, it still made an impact in the lives of the teachers, learners, district and community. Teachers who did not necessarily know who was teaching the same subject in the same area as them got to know each other and started sharing ideas and lessons with the intent to support learners to become more skilled in 21st century skills. We target an 80% pass rate for teachers who will eventually earn their tablets in the training and in the end we had a 100% pass rate, which is a huge achievement. Teachers are more motivated and keen to learn more and have already requested additional training on specific topics which were not covered in the TPD training modules (like Internet use).

Spence and Smith (2010) define five main stories in their review of the literature of ICT, development and poverty reduction, namely: universal access, economic and social services, openness, human development, and innovation. These five can all be found in the ICT4RED initiative as openness and transparency were some of the values that were communicated from the start. Economic and social services were not measured, however it was observed that on a social level the initiative did provide support and on an economic level the district and principals were trained in the Change leadership courses to develop a vision and planning their budgets. Human development of all involved are evident in all the sections above and innovation were seen as playing an important role in that the teachers became co-creators of new knowledge and created new innovative lessons based on the training and application of the training in their own classrooms.

Heeks and Molla (2009) and Heeks & Molla (2010:635) indicate that good practice of ICT4D project managers are measured around three issues:

- Design: ensuring that designs are sufficiently aligned to local realities.
- Governance: drawing on the strengths of multiple actors.
- Sustainability: ensuring this from an economic and socio-political perspective.

The ICT4RED initiative complied with all three issues above as it was well design and used its phases and a sound research methodology to track changes and progress. Governance was well managed and multiple actors or component champions provided progress on the developments in their

components over a period of three years. Sustainability was addressed although one can never claim that economic sustainability can be guaranteed. There are just too many factors that can influence this (Provincial commitment to maintain and deploy tablets, cutting budgets and expenditure on upgrading technology, the context of poverty where parents do not always have the means to buy new tablets for their children, etc.). The ICT4RED initiative has supported sustainability from a socio-political perspective as all political leaders in the community (chiefs, tribal leaders etc.) were involved in community engagement meetings and workshops from the beginning until the end. They felt that they were part of the initiative and their roles in the community were valued. Sustainability of ICT4D interventions has shifted the focus away from the technology aspects to the human aspects. The role of technology has become clearer as being "only a magnifier of human intent and capacity" (Toyama, 2010).

As Marais, Steyn and Villeneuva profoundly indicates (2011) the role of technology is limited in sustainable ICT4D interventions, the human dimension is paramount. In each of these overviews of sustainability issues, the focus is wider than the individual project and includes the greater context within which the project is conceptualised and executed, and within which it ultimately has to become sustainable.

Having a sustainability plan, as a district, does not guarantee sustainability. The same can be said about having a Mobikit with 15 loaded and ready to use tablets at each school. If it is not executed and used, it cannot work and if it is not supported by national and provincial government departments, it will also not suffice. These are the contentious issues that can play a role in the future of this initiative.

> *"You cannot teach a man anything, you can only help him find it in himself." – Galileo Galilei*

8.4 Other significant results

The following are some other important results from the ICT4RED initiative:

- A greater variety of Learning and Teaching Support Material (LTSM) is available to more learners and teachers.

- 21st century skills of teachers and learners have been influenced.
- Innovative and practical focussed Teacher Professional Development training modules were developed, which can be adapted and used by anyone and is available online under a Creative Commons Attribution-Non-commercial-Share Alike 3.0 licence. This allowed for teachers who were empowered with knowledge on how to use technology in their classrooms and to apply new teaching strategies;
- The principals can now communicate via e-mail and not just over the phone or in meetings and have received Change leadership training.
- The province and circuit manager have developed a sustainability plan to support teachers and learners after the initiative.
- Schools are better equipped with electricity, security, storage and charging of mobile devices and with satellites and Wi-Fi for Internet access and for downloading content from servers.
- Schools all have an ICT committee which takes decisions about the use of the technology in their school.
- All schools have an ICT support person to assist with bookings and maintenance and support of the technology at their schools.
- Other provinces are duplicating the TPD training material for their teachers.
- Universities are developing the training material to offer short courses to industry and other academia.
- Overseas universities are translating the training content into Arabic to use in Morocco.
- Advice is provided to other schools and lessons are shared at conferences, workshops and at forums.
- The overall changes are mostly positive and initiative is well received both nationally and internationally.
- The uptake and use of the technology have affected every person who was part of the initiative. There is ownership and use which can affect impact.
- New decision-support tools were developed (Total Cost of ownership model, Cost utility model, Tablet selection model, Application evaluation tools to ensure the apps support CAPS)
- A sustainability model was developed for this type of initiative in this type of environment

- Guidelines were developed to deploy tablets in schools.
- The schools seemed to have support from parents, but safety and security issues
- Teachers are also using the tablets for administrative purposes which was not covered in any of the TPD training modules
- Schools also report a change in way the district interacts with them after the project started in their school. Especially the officials involved in e-learning and institutional development are visiting schools more frequently and assisting with tasks such as co-ordination of training, assisting in incorporating tablets into teaching, providing moral support and boosting teachers' confidence, suggesting strategies on how to keep tablets safe.\
- The ICT4RED project is contributing towards the Department of Science and Technology's Human Capital Development goals: The ICT4RED project is actively supporting 6 Master's degree students and 2 PhD students with funding for their studies, and a further 3 Honour's Students, 3 PhD students, 2 Post-Doctoral students and a team from SAP research are also using the ICT4RED project in their research.
- The ICT4RED project is contributing to the body of knowledge in fields such as ICT for Education, Rural Development and Evaluation. By July 2014, the ICT4RED project had delivered 7 published papers in local and international conference proceedings, with other research outputs in process.
- The initiative did not focus on improving results of learners if this was the case the whole scope and objectives would have been different. There are too many variables that can play a role in saying that this initiative has had a positive influence on results of learners.

These are the most important results thus far.

8.5 Challenges

- State of buildings, which has to be attended to safely secure the tablets.
- Rationalisation/Reallocation - Grade 8, 9 classes from Junior Secondary schools that are close to Senior Secondary schools have

been merged into new "Secondary Schools" in 2014. This has caused severe disruptions in schools.

- Financial sustainability – ECDoE have requested ICT4RED to help with their budget so that the operational costs can be integrated into the departmental budget. This is a major step forward in terms of long-term financial sustainability of the project.
- Crime is always an issue to contest with in this type of implementation initiatives, especially in rural areas.
- Electricity is a real challenge, both in terms of quality of electricity, cost of electricity as some schools use prepaid and budget R100 a month. This issue is critical as the equipment is dependent on electricity. The aim should be to use renewable energy as a possibility.

8.6 Recommendations for further implementations

Integrating technology is a facilitated process and as such meaningful integration needs to be planned and facilitated. This is not a process that happens overnight and can be experienced as disruptive and stressful to the school system as well as the individual teachers. As such change management forms an important mitigating activity.

Teachers need to be met where they are and their current competencies and skills matched to expectations and activities. As this is often not possible when doing TPD with a number larger number of teachers, it is advisable to aim at the lowest common denominator and to scaffold from there.

If you cannot model it don't do it. Actions speak louder than words and there is very little that can replace the actual experience of a strategy. It is often easier to lecture but as teachers often teach like they are taught it is imperative that strategies and skills be modelled.

The **teacher professional development interaction** is costly and needs to be seen as an investment in more than just mastering a technology for the sake of it. Careful consideration needs to be given to content, strategy as well as technology use.

The interaction design of a TPD learning interaction must be a positive learning experience for the teacher to translate into a willingness to

experiment in their own classroom. In conclusion simplicity and repetition is essential for success.

The **badging system has to become a digital badging system**. The linkage of badges as measurement of achievement was very successful. It also had the added benefit of ensuring very close monitoring of the teachers and enabled the team to intervene very quickly when problems were picked up. Digital badges are evolving into a key credentialing and assessment tool for the 21st century and are particularly effective in promoting lifelong learning and can accredit accomplishments or skills attained outside formal learning environments.

The developing of **an intelligent, distributed, cloud-on-demand rural content service** that takes the concept of a content repository to a new level. The proposed Content Server will act as a localised content repository that will intelligently harvest, download, tag and present relevant content from either a cloud repository or the web via Wi-Fi, Bluetooth or tethered download. It will implement collaborative filtering techniques to anticipate download requests from schools that are similar in nature. The content server will facilitate the packaging of learning activities and the creation, sequencing and pacing of learning pathways to facilitate the completion of complex tasks as a series of smaller tasks or activities

There is a need to continue **work with the district and province in terms of integrating tablets** into all the processes at both levels. This is part of the research that needs to be done in order to identify what needs to be done to embed technologies sustainably into the system. This includes a lot of work at a national level, in terms of using the research evidence from the project to support policy and implementation.

A particular need would be to **continue monitoring and evaluation activities over the next 2 years**, in order to measure the true impact of the initiative, once the larger ICT4RED project team has withdrawn. Because of the "Earn as you Learn" and phased implementation approaches, rollouts of the various technologies have only occurred once schools have demonstrated they are ready.

Other important considerations are to consider the load on each school pertaining to **Wi-Fi downloads for each classroom**. This can inform broadband policies especially if content will be hosted in the cloud.

Further research on **specific content and Application uses** are recommended in order to develop a **South African Educational Application store** in the future. This provides opportunities for local content creators and entrepreneurs in terms of e-textbooks, videos, applications.

The concept of a **"Digital Library"** for rural communities consists of a central library management server and distributed "digital libraries" hosted at any facility which has access to the Internet and which provides Wi-Fi hotspot access to communities.

8.7 Summary

The impact of the ICT4RED initiative will only be seen years after this publication as many postgraduate students are still in progress to complete their studies. The uptake and use of the technology is now evident but the real impact of that on the development of the 21st century skills of both the teachers and learners will only be realised in future. One thing is for sure if the teachers stay as dedicated and motivated as they are now to apply the technology in their classroom it can only have positive results for the future of this school district.

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Photo 8-1> Teacher Professional Development session

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Photo 8-2: Bangilizwe Junior Secondary School