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ICT4RED 12 - Component Implementation Framework: A Conceptual Framework for Integrating Mobile Technology into Resource-constrained Rural Schools

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Abstract: ICT for Rural Education Development (ICT4RED) is a large-scale pilot that is testing the use of tablets in 26 deep rural schools in the Eastern Cape Province of South Africa. The aim is to develop a replicable framework that will enable evidence-based learning and replication on a national basis. This purpose of this paper is to provide an overview of the evolution of an initial high-level ICT4RED 6-Component implementation model that was used to guide planning, into the current iteration of an ICT4RED 12-Component Implementation Framework. This framework attempts 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. This is a unique framework which has not been implemented before in this specific manner and the evolution of this framework through the application of design science methodology has never been done before.

Keywords: tablets, mobile learning, ICT for Development, rural, schools, implementation, mobile technology

1. Introduction

School education in South Africa, despite an investment of 19% of total government spending [1], 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 maths and science teaching is ranked even lower at 138 [2]. The National Planning Commission's Diagnostic Report [3] states that efforts to raise the quality of education for poor children have largely failed. Research evidence [3,4,5] 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 [6]. 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 [7].

ICT is seen as having a transformational effect on the education system [10]. However, many ICT for Education initiatives in South Africa and the rest of the developing world have resulted in failure [10,14,15]. 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

[10,15]. 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 [15]. 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 [10].

The emergence of smartphones and tablets and their potential to provide digital content (e.g. in the form of etextbooks) using one-to-one models have become popular in both the developed and developing worlds. Educational tablet initiatives have been announced around the world [16].

The Technology for Rural Education Development (TECH4RED) research programme aims to contribute to the improvement of rural education via technology-led innovation. It was initiated in the deep rural educational district of Cofimvaba in the Eastern Cape Province of South Africa by the Department of Science and Technology (DST) in collaboration with the Department of Basic Education (DBE), the Eastern Cape Department of Education (ECDoE) and the Department of Rural Development and Land Reform (DRDLR). TECH4RED is applying a range of technology-intensive interventions, including initiatives in ICT, nutrition, health, water, sanitation and energy to determine the extent to which the programme will enable positive contributions at all levels and spheres of influence in the school system [7]. The learning from this programme will enable evidence-based policy development within government.

ICT for Rural Education Development (ICT4RED) forms the ICT focus of the TECH4RED programme and is investigating the implications of providing tablets to 26 rural schools in the Nciba Circuit of the Cofimvaba school district. 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. There are 3 senior secondary schools (Grades 10 – 12) and 23 junior and primary secondary schools (Grades R to 9) [8]. 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 project 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. Thus to address all these challenges in rural ICT in Education initiatives the ICT4RED part of the TECH4RED programme developed a conceptual implementation framework for integrating mobile technology in resource-constraint rural schools.

2. Objectives

The ICT4RED engagement with the schools will be undertaken over 3 years, with an initial pilot study at 1 school which was completed in 2012. In 2013 the engagement was scaled to an additional 11 schools and in 2014 it is being expanded to the remaining 14 schools. This engagement will involve more than 6 500 learners, 350 teachers and 40 district officials.

ICT4RED aims 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 schools in the Nciba Circuit of Cofimvaba district of the Eastern Cape Province. The intention is to use the learning to develop a framework and a set of processes and tools, which can be replicated and scaled to other provinces and across the rural education system. The problem is that none such specific implementation framework exist which can be used in resource-constraint environments. In developing this framework, it will 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. In order to address the aim the following objectives are 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 project 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.

3. Methodology

In designing the conceptual framework design science research was applied. Design Science research focuses on creation and the purpose of design is "to change existing situations into preferred ones" [13]. Design science addresses 'wicked problems' in Information Systems [13] and is fundamentally a problem-solving paradigm. Wicked problems as explained by Hevner & Chatterjee [13] 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, grounded in the philosophy of pragmatism will apply the deductive reasoning approach.

The operational methodology to implement this framework with it components consists of the following process:

- **Apply, learn and develop "best practice"**
  In-depth desktop research was undertaken to gather information and learning from similar projects, particularly the One-Laptop-Per-Child (OLPC) initiatives in Peru and Venezuela. Experience from similar large scale ICT for Development projects undertaken by the project team was gathered.
- **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 project. 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 project. A technology scan was undertaken in order to decide whether the project should employ tablets or dedicated ereaders and the pros and cons of each technology were taken to the Department of Basic Education. They made the decision to deploy tablets.
- **Education-focused vs 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 school. 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.
- **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.

- **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**.**
- **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 project and to be prepared to work to develop the necessary skills. We therefore developed an "Earn as You Learn" model, where progress was measured by using a badging system as a form of assessment and micro-accreditation.

The project was designed to go through very specific stages, as indicated in *Table 1*.

Table 1:ICT4RED Project Phases

&	**DESIGN**	**PHASE 0 (2011/12)**
This phase consists of desktop research, in order to learn from projects around the world, taking into account the particular context of the schools. This feeds into the design of the project.		
?	**EXPLORE**	**PHASE 1 (2012/13) – 1 SCHOOL**
This phase tests the design and enables the project to try various things out, so that the learning and research can be used to enhance the next iteration.		
#	**DESCRIBE**	**PHASE 2 (2013/14) – 1 + 11 SCHOOLS**
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 project 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.		
!	**ADVISE**	**PHASE 3 (2014/15) – 1 + 11 + 15 SCHOOLS**
This phase does a final redesign, based on the learning from PHASE 2 and enables the project to improve the learning around both process and scaling. It is here where the project can make final recommendations, based on data and evidence as input to implementers and policymakers.		

A conceptual model was developed in order to identify various components that would need to form part of an overall project plan over the 3 project phases. An initial version of the model is provided in Figure 1.

A champion was selected for each of these components, who was given the responsibility (with support from the Programme and Project Managers) to conceptualise, design, plan, manage and implement their component.

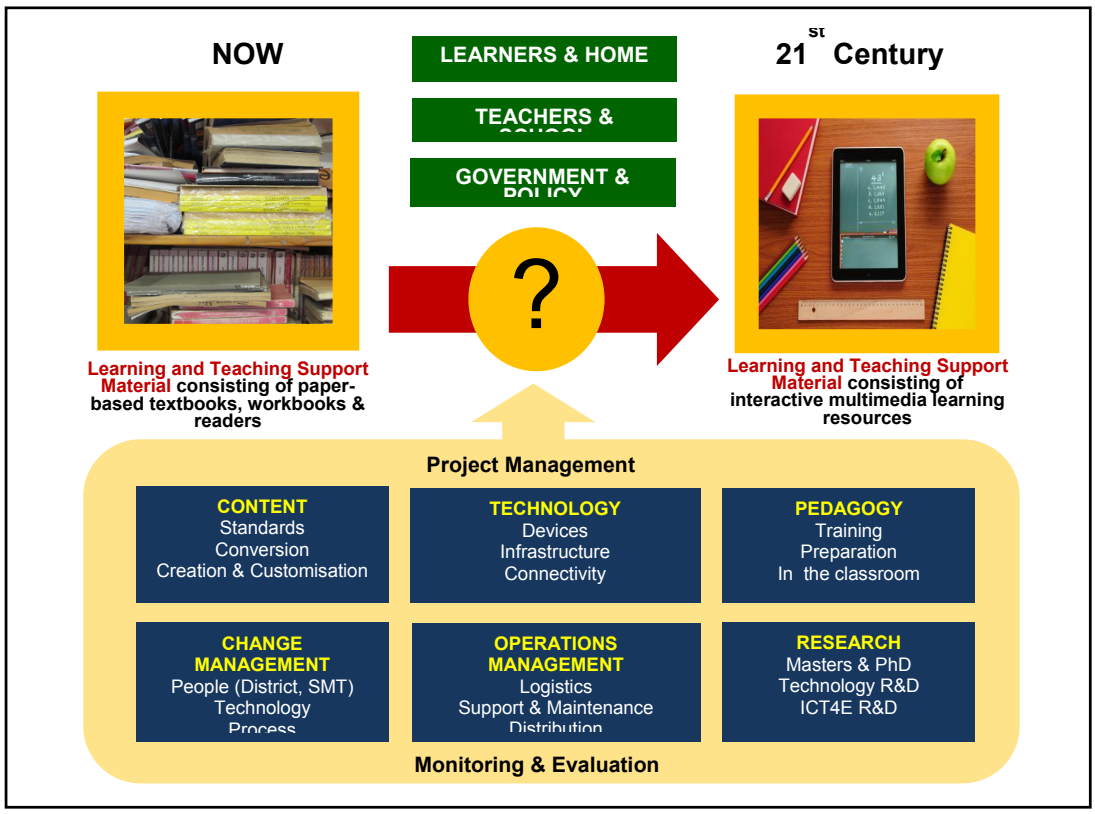

Figure 1:ICT4RED 6-Component Model

This model will inform the final framework and its evolution throughout the project has formed the basis for all work within the project. The context of the Cofimvaba schools and the complex and unique problems that have to be solved, lend themselves well to this approach.

4. Developments

Evidence was gathered after Phase 1 and on an ongoing basis throughout the project, analysed and informed the conceptual design going forward:

1. An ethnographic study one year after 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;
2. A self-evaluation report was developed by the Monitoring & Evaluation team for Phase 1 of the project, 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.

This resulted in the model undergoing two additional iterations, to make provision for identified needs and gaps in the model. In the first iteration, at the beginning of Phase 2, 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 project 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 9-component model is illustrated in *Figure 2*.

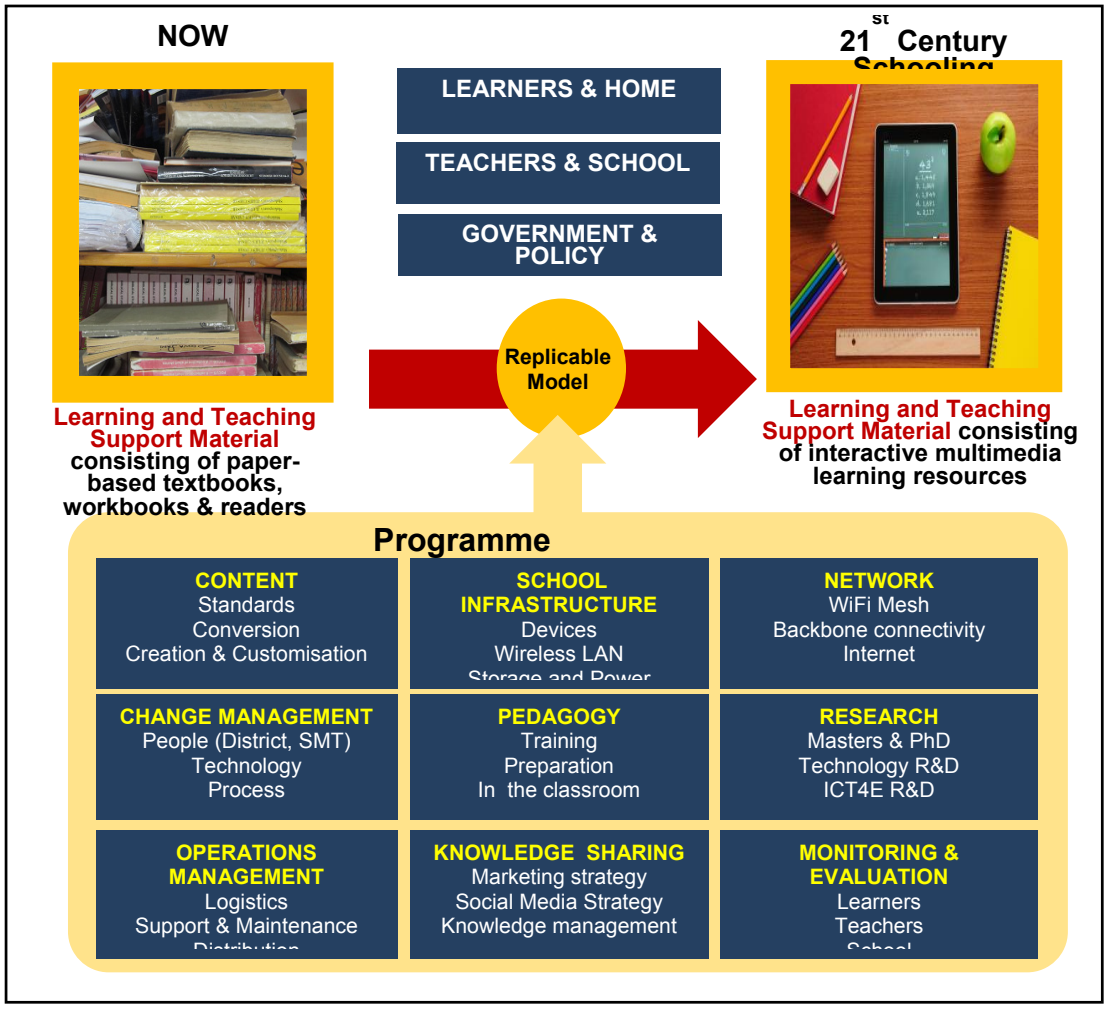

Figure 2: ICT4RED 9-Component Model

The model did not cater adequately for the transformation of the schools into "21st Century school environments", so the improvement of teaching practise was added as understanding of what it would take to transform these schools became clearer. The concept of "PEDAGOGY" was thought to be too vague and this eventually became "TEACHER PROFESSIONAL DEVELOPMENT", one of the primary drivers in the project. 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, which was rectified during Phase 2 of the project, as it became increasingly important to share the learning of the project and to get the correct message out to the media and other interested parties. The model currently consists of 12 components, as identified in *Figure 3* below.

This conceptual model is in the process of being improved and expanded to show the relationships between the various components and is becoming a framework to guide implementation (see *Figure 4* below).

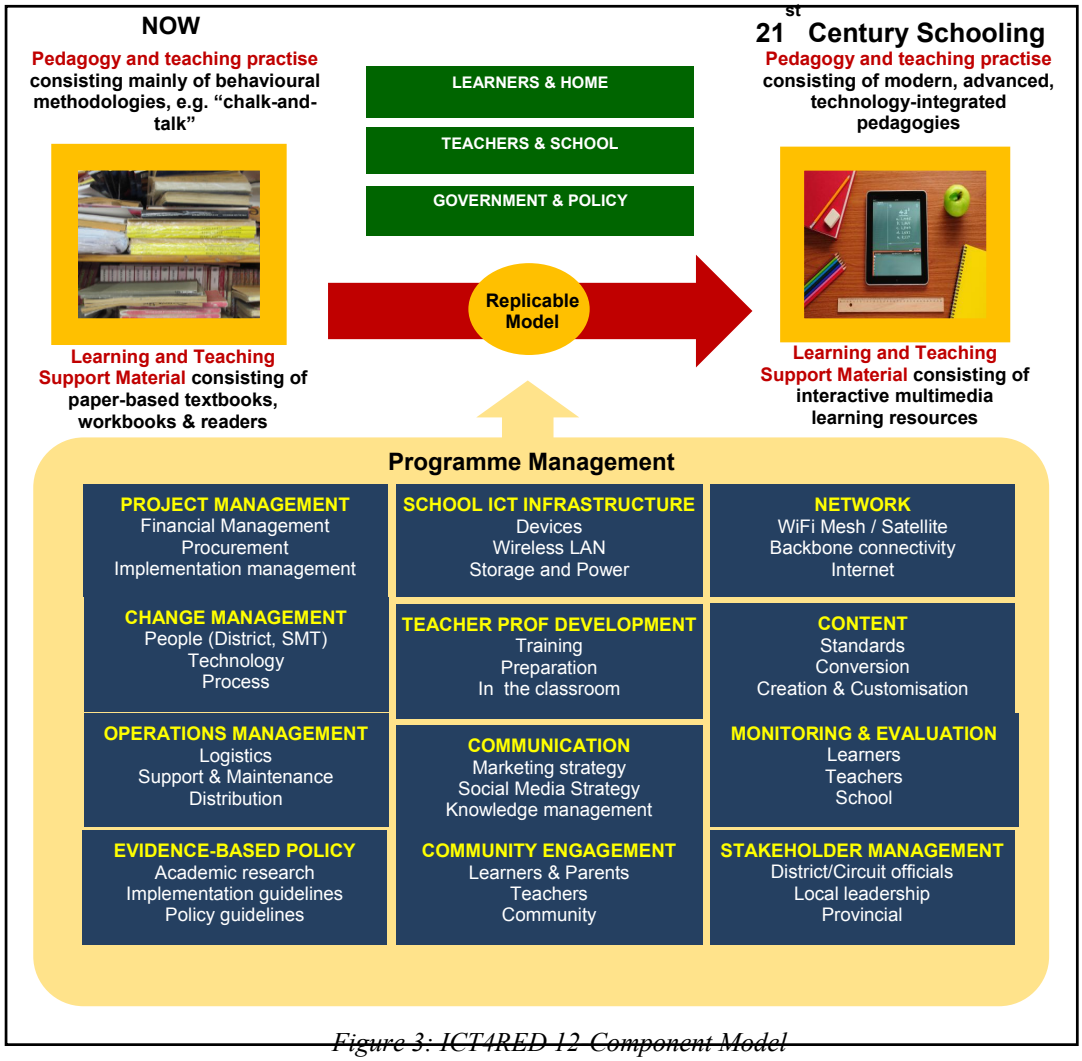

Figure 3: ICT4RED 12 Component Model

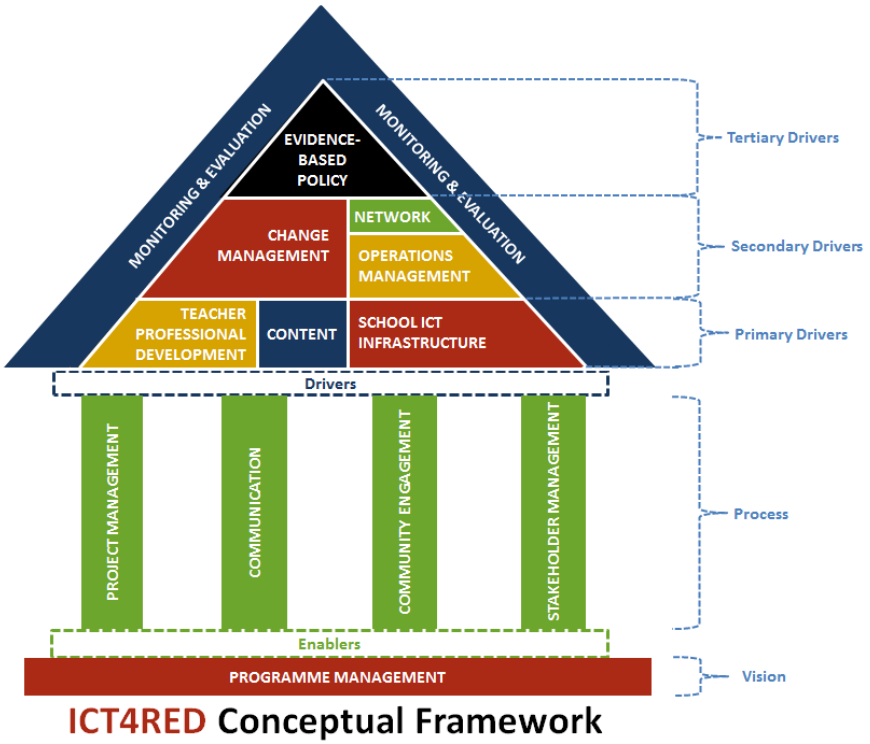

Figure 4: ICT4RED Conceptual Framework v1.0

5. Results

The following insights are organised according to the various components in the 12-component conceptual framework:

VISION AND LEADERSHIP:

Programme Management:

Although this is not strictly one of the 12 components, it is critical that someone takes overall responsibility for the project, 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.

ENABLERS

These are process-driven activities that are needed to support the project.

1. Project Management

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

2. Communication

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

3. 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.

4. Stakeholder Management

Identify your most important stakeholders. For the purposes of our project, 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 project to project. 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 project).

DRIVERS
PRIMARY DRIVERS

5. Teacher Professional Development

A decision was made that teacher professional development would be the "golden thread" that runs through the project. 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.

6. 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.

7. 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

8. 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.

9. 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.

10. 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 wifi-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 project in the UK, the minimum bandwidth suggested for schools with about 500 – 900 learners with tablets is 100MB/s [14].

TERTIARY DRIVERS

11. 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

12. Monitoring and Evaluation

Every project 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 is also important to share your learning with others, so that the same mistakes are not repeated.

6. Conclusions

Very often the magnitude and complexity of deciding to introduce technology such as tablets into schools is underestimated. The focus is on the the technology challenges that are experienced, particularly in an infrastructure-poor environment. Our experience in this project has been that these shortcomings are relatively obvious to identify, quantify and plan for. The real challenge is the fact that the introduction of technology into a school system to support teaching and learning has a fundamental effect on the way schooling will happen in that environment. Although the perception may be that you are merely substituting paper textbooks with digital textbooks, in fact what you are doing is introducing a paradigm shift in the way education will happen in the future. In the case of tablets, these are powerful multimedia devices that can be used in a myriad of ways to improve the learning environment. It is imperative that this is recognised and that the appropriate actions are taken to take full advantage of the investment in the technology.

The ICT4RED 12-Component Framework attempts 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.

The fact that there has already been successful implementation of Phase 1 of the project and that expansion of Phase 2 of the project is on track after 9 months, points to evidence that the ICT4RED 12-component framework has successfully identified the different activities that need to be undertaken in a complex ICT for Education project [17].

Further work needs to be done to test the 12-component conceptual framework as a guide for implementation strategies and project plans in other contexts and for other ICT for Education technologies – ranging from large-scale national ICT rollouts to smaller school-based ICT for Education implementations. However, the framework already provides good support for schools and education departments who intend to start introducing tablets into their schools.

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