An Examination of the Impact of Mobile Technology on Quality of Education in a Large Public School in Mozambique

By

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Declaration

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Mary Linda O'Sullivan

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Abstract

This study was carried out in parallel with a wider study on the impact of the introduction of a mobile technology project, IADT's School in a Box, on the quality of education in a large public school in Mozambique. The study is grounded in Sustainable Development Goal 4: ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (United Nations, 2015). In particular, this thesis focuses on the role of teachers in the achievement of the goal, examining how mobile technology can be a catalyst for changing teaching practice toward a more collaborative and creative approach, and how teachers can support each other's improving practice through a community of practice.

The study used a developmental research approach over thirteen months, mediated by the Irish Embassy in Mozambique. During this time the researcher visited Mozambique four times carrying out field research, deploying the technology and developing and co-ordinating eleven days of teacher workshops over this period. Ten teachers from the school, all teaching third grade, took part in the teacher workshops, five of those taught using the technology, and five did not use the technology in their classes over this time period.

The use of the technology by teachers was examined using a Cultural Historical Activity Theory (Vygotsky, 1978; Engeström, 1987) framework, implementing changes in practice in step-by-step approach, within the socio-cultural context of the school. The outcome of teachers' changing competence was examined within the TPACK Framework (Koehler & Mishra, 2009). Findings showed that even within very complex and challenging contexts, that a holistic step-by-step approach to change in teaching practice, did lead to teachers' growing competence in collaborative and creative teaching practices using mobile technology in a whole class teaching approach.

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It has been a long and hard journey, both rewarding and exhausting, and I would never have done it without the support of a lot of people.

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Dr Nuno Miguel Seabra was the heart and soul of School in a Box. His passion, dedication, commitment and pure joy for his work inspired the continuation of this study after his death.

Dr Joao Couvaneiro provided invaluable experience, knowledge and insight into the development of teacher workshops and design of the research.

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List of Abbreviations

CHAT	Cultural Historical Activity Theory
CoP	Community of Practice
DBR	Design Based Research
DBRC	Design Based Research Collective
EGRA	Early Grade Reading Assessment
EPDC	Education Policy and Data Centre
GEM	Global Education Monitoring Report
GESCI	The Global eSchools and Communities Initiative
IADT	Institute of Art, Design and Technology, Dun Laoghaire
IFP	Instituto Formação de Professores (Teacher Training Institute)
IWB	Interactive Whiteboard
JC	Dr João Couvaneiro
NEW	Novel Effective Whole (rubric for creative artifacts)
NMS	Dr N. Miguel Seabra
ODL	Online Distance Learning
OER	Open Education resources
SAQMEC	The Southern and Eastern Africa Consortium for Monitoring Educational Quality
SDG	Sustainable Development Goals
SSA	Sub-Saharan Africa
TPACK	Technological Pedagogical and Content Knowledge
WEF	World Education Forum
ZPD	Zone of Proximal Development

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1.0 Introduction

1.1 Rationale

The aim of the study was to examine how mobile technology could impact on the achievement of Sustainable Development Goal 4; Quality Education for All (United Nations, 2015) in the context of a typical public school in Sub-Saharan Africa. The use of the term Sub-Saharan Africa in this thesis is consistent with its use by UNESCO, as a geographic location consisting of 49 African countries (United Nations 2013) and is used in order to provide relevant critique of and input to policy that is aimed at countries encompassed under this term. Using a design-based research approach, suitable for the complexity of the environment, the study examines the value of a cultural-historical activity framework for implementing and examining the impact of the introduction of mobile technology as a tool for teachers.

1.2 Research Aims and Questions

The research questions are developed from the literature relevant to the context of public education in Sub-Saharan Africa and are concerned with the specific ways in which mobile technology can enhance quality education within the context of teaching and professional development for teachers.

In the context of a large public school in Mozambique;

(i)   how can mobile technology support teachers' use of collaborative teaching practices, particularly in the use of interactive exercises, group work and open questions, if at all?

(ii)   how can mobile technology support creative teaching and learning practices, specifically using technology to create new artifacts and integrate local examples into digital lessons, if at all?

(iii)   how can mobile technology support school-based teacher-to-teacher continued professional development by sharing and re-using digital content, and through formal or informal teacher events where practice or experience is shared, if at all?

1.3 Researcher Context

Over the duration of this study, the researcher worked for IADT (Institute of Art Design and Technology, Dun Laoghaire) as the manager of a number of educational outreach projects related to technology and creativity in education. Most of these projects and collaborations were in Ireland with Irish teachers, but one project called IADT's School in a Box was based around a technology solution designed for remote learning environments in developing countries, in locations with lack of access to electricity. The School in a Box project had already been piloted in Nepal, having run successfully in a remote school high in the Himalayas for over three years. Additionally, two pilot studies had been run in Mozambique, one in remote adult literacy centres in collaboration with UNESCO, and the other in remote field farm schools in collaboration with the Aga Khan Foundation.

This project was in collaboration with Irish Aid and the wider research aim was to measure the impact of the technology on literacy. Through the researcher's work with Irish teachers, she was particularly interested in how to best enable teachers to use the technology as a tool to enhance their own practice. On previous trips to Mozambique for the UNESCO project, the researcher was aware of some of the contextual and cultural challenges. Her attention was on solving issues on previous projects where focus has been on the technology and visually impressive, but educationally questionable applications or simply in some situations, the technology becoming an expensive exact substitute for the blackboard. The researcher's previous

professional background had been in animation and educational technology, and she was aware that a strong educational context was needed in her own professional knowledge as well as for the project's long-term sustainability and relevance in educational contexts.

The parameters of the broader study and this doctoral study were mapped out side by side. Irish Aid's priority was to explore if the technology could have an impact on learning outcomes in the context of an average setting of a public school in Mozambique. Separately, for this doctoral study, the researcher examined additional data to examine how the technology could, if at all, impact teachers' practice in the classroom and teachers' peer to peer learning to improve practice.

As the project manager and lead researcher for the entire study, the researcher was involved in building relationships, organizing the specification, purchase and deployment of the technology, set-up on site, organizing the teacher workshops and principal investigator on the research study. She was largely guided by Irish Aid on the political partnerships necessary for integration of the project into the formal educational in Mozambique, as well as working closely with them on designing the workshops so that they were relevant to local needs, curriculum, culture, and teachers' professional development requirements.

There were a number of professional and personal challenges on this project over the course of the study. Geographic distance and language barrier made communication with the project on site challenging between teacher workshops. Much of the communication had to be mediated by the Irish Embassy in Maputo, which depended on their availability between many other projects and priorities. Teacher workshops required a Portuguese speaking tutor highly skilled in best practice for integration of iPad technology in the context of a teacher using the device as a teaching aid. Apple were able to provide guidance in identifying experts on this topic through

their Apple Distinguished Educators programme. The first two workshops were tutored by Dr N. Miguel Seabra (NMS), who had previously traveled to Mozambique a number of times on the School in a Box project for other implementations with UNESCO and the Aga Khan Foundation. Over the course of those trips, Miguel's energy, enthusiasm for the project and natural ability to break down cultural barriers with humour were hugely important in building relationships with teachers and partners, and creating an energy and enthusiasm for the project in the school. Tragically, Miguel passed away at the end of 2015, halfway through this project. Dr Joao Couvaneiro (JC), who had been a friend and colleague of Miguel in Portugal and was familiar with Miguel's work on this project, agreed at very short notice to step in for the next scheduled workshop. Joao brought many years of experience working with teachers in Portugal on the integration of technology into education and deep knowledge of a range of methodologies in the use of iPads as a teaching aid.

At the beginning of the research study, the scale of the project seemed quite overwhelming, and the researcher struggled at times to see how a few iPads could have a meaningful impact on quality of education in such a challenging setting. However, over the course of the study, it became clear that very small changes in practice could have a significant impact, and that over time, an incremental approach of building on small changes with other small changes of practice, led to significant change in teacher attitudes and beliefs about the nature of teaching and learning, as teachers witnessed the impact of the changes in their practice on the classroom. This led to a transformation in the teachers, in how they spoke about their practice and represented themselves and their work. As a researcher, this was a threshold moment of realization of the possibility of meaningful change in even circumstances that are local, complex, diverse, dynamic, uncontrollable and unpredictable (Chambers, 2010).

Attending a lecture by Robert Chambers at the Irish Development Education Association annual conference, at the beginning of this journey was pivotal. Having worked in complex development environments all over the world, in a range of research topics, Chambers has devised a range of participatory research approaches that enable researchers to share and co-generate knowledge with the communities within which they work (Chambers, 2012; Chambers, 2010). While, ultimately Chambers' methodologies were not deemed to be a suitable fit for this project, his work in similar complex environments was very influential in providing a foundation for examining an approach to the research and crucially, the guiding principle of co-generation of knowledge with the researched community.

1.4 Outline of the Study

The technology contained an iPad pre-loaded with relevant software, a small powerful projector, a solar battery and a solar panel. This study was conducted in conjunction with a wider pilot study, funded by Irish Aid, commencing in August 2015, in a large public primary school, in the outskirts of Maputo, the capital city of Mozambique. The overall study specifically examined the impact of the intervention on literacy levels in Portuguese language for Grade 3 students. Over the course of the thirteen-month period of this study, three workshops were held for teachers, with one additional visit to the school. While the focus of the Irish Aid study was on the impact of introducing the technology on teaching Portuguese literacy, the teachers were also free to use the technology to teach other subjects, and a number of teachers reported that they frequently used the technology for the teaching of Natural Sciences also. The approach of the workshops was to use the technology as an enabling tool for teachers with a particular emphasis on using the photographic capacity of the iPad to contextualise learning in local examples, recognisable as part of children's lived

experiences, and to create interactive and problem posing lessons. The end goal of each intervention was for the project to be owned and led by the local partners, facilitated by the researcher, according to their needs.

While the broader research project was focused on the impact of the intervention on learning outcomes in Portuguese literacy of the participating students, this doctoral research is concerned with the impact of the introduction of the technology and the teacher workshops on teaching practice, in a cultural-historical activity context.

1.5 Structure

Chapter two provides the literature review, examining literature through the lens of the Sustainable Development Goal 4; Quality Education for All (United Nations, 2015). Literature relating to definitions of and measurements of quality education are examined as it relates to teaching in the classroom and improving quality teaching through professional development. The debate on quality education is heavily weighed on largely quantitative measures that are easily definable measurable and comparable globally, such as school completion rates, pupil teacher ratios and standardized testing scores. Qualitative examinations of what teachers do in the classroom to impact quality education are sparse in international comparison reports or policy documents. The literature review also examines international policies and reporting mechanisms on quality education, especially those set by UNESCO. The importance of a contextual understanding of educational change is examined in different developing country contexts with particular attention to the challenges of implementing a dialogic, social constructivist, or learner-centred pedagogy in typical Sub-Sahara African contexts, with large class sizes being a particular challenge. The review then extends to an examination of the role in policy and the literature of the use of technology in the

achievement of the quality in education goal, concluding with an examination of comparable studies using mobile technology in public school settings in Sub-Saharan Africa.

Chapter three seeks a theoretical framework suitable for the examination of teacher practices with technology within the complex context of a large public school in Sub-Saharan Africa. The chapter provides a socio-cultural perspective of the teacher's interactions with students in the classroom and within the wider school community with other teachers, with particular focus on Vygotsky's(1978) activity theory and Engestrom's (1987) socio-cultural activity theory (1978) and Freire's (2000) dialogical pedagogy. A creativity perspective is then brought to examine the teacher's activities with technology in the classroom. And finally, the framework encompasses a technological perspective by examining teacher's competencies with technology within the socio-cultural activity framework of the classroom and the community of teachers, through the TPACK Framework (Koehler & Mishra, 2009).

Chapter four sets out the research methodology. A comprehensive overview of the intervention is outlined in section 4.1 including elements of project management and partnership, technology and community engagement approach. The context of the study, details of the school setting, phases of research and project partners is provided in section 4.2. Potentially appropriate research approaches and methods are examined and discussed in section 4.3, identifying a design-based research approach as the most appropriate for the context and the nature of the study. Characteristics and issues specific to this approach are outlined. Sample selection and data collection are discussed in sections 4.4 and 4.5 and a research methods framework is developed cross referencing data collection methods with the research questions. Data analysis is

discussed in section 4.6, with particular attention to issues such as translation of video and the application and cross-correlation of data from multiple sources. A short discussion is provided on how the researcher attempted to ensure researcher's objectivity is provided in section 4.7, while specific issues in relation to sampling in data analysis are examined also. Issues of power and empowerment are discussed in the reflexivity section 4.8. An overview of ethics processes on the project is provided in section 4.9.

Chapter five introduces to the findings in relation to collaborative practices in teaching with technology in section 5.1, and collaborative learning practices in a development context are examined in section 5.2. The implementation of collaborative teaching practices are outlined in detail in section 5.3. Section 5.4 outlines the findings and discussion in relation to teachers' use of interactive exercises. Section 5.5 provides findings and discussion on the use of group work in classes, with a segment on mixed ability groups. Section 5.6 examines and discusses findings in relation to the use of open questions by teachers. Teachers' reporting of participation and their changing attitudes to a participative classroom is outlined over the course of the study and discussed in section 5.7. Obstacles to participation in the classroom are outlined in section 5.8. Finally, the role of technology in supporting a collaborative classroom is examined in section 5.9, outlining dialogic teaching supported by technology, and the stages of integration of technology for interactive teaching. The implications of the research are discussed in section 5.10.

Chapter six discusses findings in relation to creativity in teaching with technology. An introduction to findings is provided in section 6.1. with a short

overview of instigating creative teaching with technology in section 6.2. Teachers'

creation of new digital artifacts is discussed in section 6.3, including an examination of

how long it took participating teachers to learn to create new artifacts and an

examination of the quality of the artifacts produced using Mishra and Henrikson's

(2013) NEW model. Findings on how teachers integrated local examples into lessons

with technology are outlined with a discussion on specific issues related to the

availability of locally relevant content in developing countries. Creativity and

relevance are discussed separately in section 6.5. Barriers to creative teaching are

examined and discussed in section 6.6, including time required to create digital

artifacts. The impact of creative teaching on the motivation of students is discussed in

section 6.7 and the implications of the findings are discussed in section 6.8.

Chapter seven sets out findings and discussion in relation to teachers'

community of practice Lave & Wenger, 1998). An introduction to findings is provided

in section 7.1 with the characteristics of a community of practice examined as it relates

to this study in section 7.2. Section 7.3 outlines findings in relation to sharing and re-

use of digital content by teachers. Community of practice events are outlined in

section 7.4 including formal events such as teachers meetings, and informal events.

Section 7.5 outlines findings in relation to obstacles to developing a community of

practice. Factors facilitating a community of practice are discussed in section 7.6,

including strong interpersonal relationships, teacher personal attributes, role of

leadership. Factors constraining a community of practice are discussed in section 7.7,

including time pressures, staff or leadership turnover, individuals in peripheral roles in

the community. The limitations of the study including the time scale of the pilot project

and challenges of context are discussed in section 7.8.

Chapter eight provides a general discussion and returns to the broader context of the Sustainable Development Goal of Quality Education for All in the context of public schools in Sub-Saharan Africa, with an examination of cross-cutting themes and issues. In section 8.1 the discussion focuses on the role of teachers in achieving the goal, with a focus on the professional development of teachers and teachers change in practice over time. Section 8.2 examines how mobile technology can advance the goal and discussions of different approaches; one device per child, whole class approach (akin to Interactive Whiteboard), technology for access to content and for teacher professional development. There is further discussion on the advantages including cost, electricity and internet access, and the challenges of mobile technology including technophobia. 8.4 looks at the combined role of teachers and technology and 8.5 addresses the element of quality education for ALL, in the context of school dropout, disengagement and student motivation. Section 8.6 discusses the study's contribution to theory in relation to a socio-cultural model of education, a socio-cultural model of creativity, and a socio-cultural model of teacher professional development. The discussion expands into an examination of how practice in a CHAT framework (Engestrom, 1999) developed teacher competency in a Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2009) framework, over time creating a transformation in teachers practice that becomes a cultural change. Section 8.7 discusses success factors for educational change.

Chapter nine provides a discussion on reflexivity in the study, especially in relation to power balances and empowerment, as in this study, the researcher was in a position of considerable power in relation to the research participants. The limitations of the study are outlined in terms of methodological and implementation limitations. Gatekeepers in the complex political environment are discussed in particular and the

potential limitation of the Hawthorne effect, given that research participants understood their contributions may have impact on further continuation or growth of the project and the associated benefits to themselves and their school of this. Recommendations for practice in relation to implementation of mobile technology in similar contexts are provided. Recommendations for policy pay particular attention to the role of the teacher in achieving the Sustainable Development Goal of Quality Education for All, and in a practical, cost-effective, sustainable and culturally appropriate approach for the use of mobile technology by teachers in the attainment of the goal. Areas for further research are outlined, followed by concluding remarks.

2.0 Literature and Policy Review

Looking at Sustainable Development Goal 4; Quality Education for All (United Nations, 2015), the literature review will examine literature relating to definitions of and measurements of quality education as it relates to teaching in the classroom and improving quality teaching through professional development. International policy and reporting on quality education is also examined, extending to use of ICT by teachers. Comparable studies using mobile technology in public school settings in Sub-Saharan Africa are researched and examined, and lessons developed from these.

2.1 Quality Education

The fourth Sustainable Development Goal sets out to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (United Nations, 2015). The previous generation of development goals, the Millennium Development Goals covered the period 2000 to 2015 and aimed to achieve universal primary education (United Nations, 2015). The resultant increase in enrolment rates and improved access to education at primary level globally led to a crisis of overcrowding, teacher shortages, under qualified teachers, low learning outcomes and high dropout rates (Fox, Santibañez, Nguyen & André, 2012; EPDC, 2014). Following on from this, the Sustainable Development Goal related to education evolved to include the term quality. However, a definition of quality education is broadly absent in the policy documents related to this goal in a development context. The discussion around quality of education instead focuses on the perceived factors leading to quality education. In the face of large-scale global challenges, these factors are predominantly easily quantifiable measures that are easily definable, measurable and comparable globally, such as school completion rates, pupil teacher ratios, standardized testing scores (Alexander, 2015).

Teachers view.

In a World Bank (Beutel, 2011) report focusing on the voice of teachers in Mozambique in 2011, Mozambican teacher were asked what they regarded as the factors necessary for achieving good teaching. The factors identified by teachers were; well qualified and trained teachers, teachers' professional commitment, good pay and conditions, good working conditions and learning environment for pupils, appropriate curriculum and involvement of parents and commitment (Beutel, 2011). Many of these factors were pointed out by teachers in the negative, that is, that quality education could be achieved if these factors were present (Beutel, 2011). Other teachers defined quality education in terms of pupil achievement, one teacher defining it as "what a child demonstrates after completing a cycle… If the pupil is not able to meet the objectives of the cycle, then quality is not achieved" (Beutel, 2011, p.16). Neither the teachers, international comparison reports nor policy documents address in any significant way practices used by teachers to achieve quality education.

Human rights approach.

UNESCO (Craissati *et al*., 2007), in its framework for the realisation of children's rights to education and rights within education, defines quality of education firstly from the perspective of cognitive development and secondly in supporting creative and emotional development, supporting citizenship, equality, security and respect for and nurturing of global and local cultural values (p.32). These perspectives have been integrated into the educational aims of the United Nations Convention on the Rights of the Child (2010), recognising each child as a unique individual with unique abilities, needs, characteristics and interests, and providing a framework of obligations to promote children's optimum development. Article 29 addresses the aims of education as the holistic development of the child, recognising their potential, and with respect for each child's innate dignity and human rights, sense of identity, interaction

with society and the environment. Inherent to this is respectful and flexible learning environments and teaching that recognise children as active agents in their own learning, and a move away from traditional forms of schooling that expect children to be silent passive recipients. Specifically, the framework suggests "a variety of interactive methodologies" be used by teachers to enhance and strengthen learning opportunities through participatory learning (p.34).

Education for All.

In advance of the Sustainable Development Goals negotiation in September 2015, the Incheon Declaration was signed by over 130 Education Ministers at the World Education Forum in 2014. This most recent Education For All framework takes the view of education as a fundamental human right and an enabling right, aiming at "the full development of the human personality and promoting mutual understanding, tolerance, friendship and peace" (World Education Forum, 2015, p. 6). It defines quality education as fostering not only the foundational skills of literacy and numeracy, but also "creativity and knowledge and…analytical, problem-solving and other high-level cognitive, interpersonal and social skills", supported by teaching methods and pedagogical approaches appropriate to the needs of learners and supported by appropriate use of ICT (World Education Forum, 2015).

Two further UNESCO papers lay out the context for the Quality Education for All goal; Position Paper on Education Post-2015 (UNESCO 2014a) and the Muscat Global Education Monitoring (GEM) Agreement (UNESCO 2014b). Target 7 of the position paper outlines one target out of ten that mentions teachers "close the teachers' gap by recruiting adequate numbers of teachers who are well-trained, meet national standards and can effectively deliver relevant content, emphasis on gender balance". Target 6 of the Muscat GEM Agreement "by 2030, all governments ensure that all learners are taught by qualified, professionally-trained, motivated and well-supported

teachers. The position paper further elaborates this into a number of key aspects (a) recruiting well trained, motivated teachers who use participatory approaches to ensure effective and inclusive learning (b) to provide relevant content to learners in their lived contexts (c) establishing safe and inclusive learning environments, (d) ensuring learners meet national standards for learning (e) supporting learners ability to be creative and adapt to change and (f) engendering responsible citizenship and sustainable development (Anderson *et al*., 2001; UNESCO, 2014a).

Separately, UNESCO examines the usefulness of level descriptors such as Bloom's Taxonomy coming from a behaviourist tradition and focusing on six levels of cognitive development from knowledge of facts at the lowest level, moving through comprehension, application, analysis, synthesis and evaluation at the highest level (Bloom, 1956) and also the SOLO taxonomy coming from a more constructivist tradition and describing increasing levels of complexity of students' understanding from pre-structural, through uni-structural, multi-structural, relational and extended abstract (Biggs and Collis, 1982). The report concludes that a blend of both traditions leading to a revised Bloom's Taxonomy where both taxonomies are cross-correlated (UNESCO, 2015b) could provide a more useful framework for international level descriptors. However, these taxonomies and level descriptors do not follow through into the GEM reports as tools for measuring quality education.

The Muscat GEM Agreement (UNESCO 2014b) and the Incheon Declaration (World Education Forum, 2015) are consistent in the inclusion of participatory approaches, use of locally relevant content and engendering learner creativity as teaching approaches consistent with achieving the goal of quality education for all.

2.2 Measurement of Quality Education

Measuring education according to the holistic aspirational definitions provided in the Education for All framework is a more complex issue. Aspects such as recruitment of trained teachers, measurable aspects of inclusive learning environments such as adequate toilet facilities, sustainable development inclusion in school curricula and meeting national standards for learning have translated into indicators (World Education Forum, 2015). However, other aspects such as participatory teaching approaches, relevant content, supporting learners' ability to be creative and adapt to change have not translated into measurable indicators.

The Global Education Monitoring (GEM) 2017/18 report, which focuses on accountability in education acknowledges that learning outcome indicators can be ineffective, and worse, counter-productive as an indicator of quality education (UNESCO, 2017). The risk of education systems, schools and teachers over-focusing on learning outcomes, and leading to focus on stronger students to the detriment of students who are struggling has been recognized.

However, GEM Report 2017/18 and previous GEM Reports (UNESCO, 2015; UNESCO, 2016; UNESCO, 2017) continue to address quality education through proxy-measures; national assessments in reading and mathematics, gross intake to last grade, completion rate, out-of-school rate, percentage of children over-age for grade and number of years of (a) free and (b) compulsory primary and secondary education guaranteed in national legal frameworks.

Instruction quality is mentioned, but in passing. In GEM 2015 (UNESCO 2015) out of a 516 page report on education, just two pages are given to teaching processes in the classroom, which stress the importance of moving towards a learner-centred pedagogy to close the gap of access to quality education. In 2017, in one small table (p.72), addresses criteria on which classroom inspections should be based was defined

as "subject matter knowledge, teaching methods, student assessment and students' academic achievement (UNESCO, 2017).

Critique of Education for All quality education indicators.

While the increased emphasis on the importance of teacher in quality education provision has been broadly welcomed, some have warned about of the risk of a "managerialist and regulatory" approach to a narrow school effectiveness debate, which would "reduce the agency of teachers to an audit trail" (Sayed & Ahmed, 2015), and an over-simplification of the relationship between teaching and learning outcomes, removed from often vastly challenging contexts (Naylor & Sayed, 2014). The policy has also been criticised for its focus on inputs that can easily be measured, rather than on evidence-based factors (Sayed & Ahmed, 2015; Barrett, 2013; Alexander, 2015). There is a need for "dynamic process-oriented models of teaching and learning" (Sayed & Ahmed, 2015, p.337) as well as engagement with context (Naylor & Sayed, 2014; Sayed & Ahmed, 2015, Alexander 2015, Barrett, 2013).

Quality of education in international policy documents is often defined in terms of those easily measured inputs, such as class size, time on task, instruction time, incentives, rather than in terms consistent with the wider educational literature such as classroom processes and outcomes that are transformative for children (UNESCO, 2014a; UNESCO, 2014b; Alexander, 2015; Sayed & Ahmed, 2015). Alexander (2015) suggests that the very act of isolating these measurables gave them value in the eyes of governments, donors and administrators who have the budgets and power to place policy focus on these. He recommends firstly that clear goals need to start with the educational process and its purposes and finding the indicators that resonate clearly with the goals stressing that a more creative approach needs to be found to keep important indicators in the frame, even when they are difficult to measure. He proposes that learning needs a process as well as an outcome indicator, suggesting

reciprocity in teacher-student interaction as a potentially suitable process indicator. However, Alexander is careful to warn against a single globalised measure of quality that can easily create a new tyranny in the search for quality education (Alexander, 2015).

2.3 Context: Education in Mozambique

Mozambique is situated on the coast of South-Eastern Africa and has a population of close to 30 million people and a GDP of 12.6 Billion US dollars, $417 per capita (World Bank, 2017b). Mozambique ranks 180 out of 189 countries in the Human Development Index (United Nations, 2018), with an average life expectancy of 58.9 years, 9.7 years of expected schooling, 76.8% of the population defined at working poor (earning less than $3.10 per day) and 17.5% of the population with access to internet. An ex-colony of Portugal, Mozambique obtained independence in 1975, but retains Portuguese as its official language and particularly in its capital city Maputo, retains cultural and architectural references to its colonial past. Portuguese is mostly spoken as a second language with other languages varying across the long geographic spread of Mozambique and including Bantu, Tsonga, and Shona groups of languages. Mozambique is largely Christian, with minority Muslim and other religions.

Primary education in Mozambique runs across two cycles; EP1 (Ensino Primário do 1 Ciclo), grades 1 - 5 (ages 6 - 10) and EP2 (Ensino Primário do 2 Ciclo), grades 6 - 7 (ages 11 - 12). Secondary education runs in another two cycles from grades 8 - 10 (ages 13 - 15) and grades 11 - 12 (ages 16 - 17). Teacher education requires grade 7 education plus a 3 year programme, or grade 10 education with a 1 year programme (Fox *et al.*, 2012, p.4).

In 2004, the Mozambican government operated a set of reforms to increase enrolment. These included the abolition of fees for primary schools and free provision

of textbooks, increased direct funding to schools for non-salary expenses, and semiautomatic promotion within each grade block. Additional resources put into school construction and teacher training. Most significantly for this study, the new curriculum emphasizes respect and scope for socio-cultural factors, allowing up to 20% of the curriculum to be developed at district or province level and providing for teaching in first language for grades 1 and 2.

In reality, because teaching hours per shift are just three hours per day (in many schools, and in the school of this case study, the school day is divided into three shifts of three hours, to cope with increased enrollment rates; each child is assigned to attend only one of three school shifts; early morning, late morning or afternoon) and teachers often work multiple teaching shifts, with limited time to prepare, these provisions have not yet translated into common practice. Additionally, in the context of the school in which the study takes place, because of the multiplicity of languages from around Mozambique in the school, as an outskirt of the capital city, teaching in a first language is not frequent practice.

Enrolment and completion rates.

The latest available data from the Global Education Monitoring (GEM) Report 2017/18 shows a primary school completion rate of 42% in Mozambique (UNESCO, 2017), a reduction from a 52% primary completion rate quotes by Education Policy Data Centre's (EPDC) country report for Mozambique in 2014 (EPDC, 2014). The reason for this reduction is unclear, and there was no available data on secondary school completion rates in the GEM 2017/18. The latest data to be found on secondary completion rates in a World Bank report from 2013, cited less than 5% of all pupils completing secondary level of education (Fox *et al.*, 2012, p.56). This varies widely according to the demographic group; in 2008 completion rates of upper secondary were at 50% for urban males, as compared to 5% for rural females (Fox *et al.*, 2012, p.11).

The official age for starting 1st grade is six years old, but the observed average age is nine, and the official time to complete five years of primary education is five years, but the average observed time is six years. These average ages are for children who complete five years of primary education, these are higher for those who drop out (Fox *et al*., 2012). In 2006, between 1.2 and 1.6 million Mozambican children were orphaned (UNICEF, 2006). Attendance rates for poor orphaned children (75%) are significantly lower than for non-poor orphans (96%) and poor non-orphans (95%) (Fox *et al*., 2012). Attendance rates are differentiated by gender, urban or rural divide. Initiation rites, which are community led and initiate children into full adulthood around the age of twelve often create a natural end to schooling, particularly for girls, a factor which is stronger in rural areas (Fox *et al*., 2012).

There are 193 school days per year, a USAID funded study in 2010 found that instruction time was reduced to 30 days per year on average due to high teacher absenteeism and limited instructional time (USAID, 2013).

The official language of instruction is Portuguese, with allowances for instruction in first language for grades 1 and 2. There are twenty languages spoken in Mozambique, in addition to the official language of Portuguese. Teachers report that many children do not speak Portuguese outside school, particularly those children being raised by grandparents. In Maputo and its outskirts as the capital city of Mozambique, many families have migrated from different regions of the country and as a result, children may have different first languages, not just the language local to the region.

Learning outcomes.

In the USAID study 22% of primary school children performed below the lowest performance benchmark in reading, and 33% scored below the lowest benchmark in Maths, putting the country in the 15th percentile worldwide for learning.

The learning measures used were internationally benchmarked across low to middle income countries, using a number of different research instruments, such as SAQMEC and EGMA (EPDC, 2014). In a USAID study from 2013, out of 49 schools studied, 59% of third grade students could read less than one word per minute, the better performers could read on average five words per minute, with 2% deemed to be fluent readers (USAID, 2015)

Pedagogy.

As is common across Mozambique and other developing countries, pedagogical practice widely relies on repetition, rote learning and chalk and talk (Fox *et al*., 2012; Hardman, Abd-Kadir & Smith, 2008). While the new curriculum emphasises more learner-centred pedagogy, this hasn't yet filtered down into practice. A study examining pre-service teachers at one of the main teacher education colleges in Mozambique in 2010 observed that while lecturers were eloquent on explaining learner-centred methodologies as emphasised in the new curriculum, "talk-and-chalk, expository and lecturing and question and answer methods dominated" in their own teaching methods, and students were expected to memorise and regurgitate content as defined by the lecturer (Guro & Weber, 2010, pps 253-258).

Mozambique's Education Sector Plan 2012-2016.

The government of Mozambique is very aware of the challenges faced by its education sector and in Mozambique's Education Sector Plan 2012 – 2016 sets out its aim to continue to prioritise the provision of seven-year primary education for all children with the goal that all children acquire basic skills in reading, writing, mathematics, natural and social sciences, as well as cultural and physical education (Republic of Mozambique, Ministry of Education, 2012). The focus is on improving the teaching-learning processes and conditions, with a particular emphasis on inclusion of more vulnerable children. Teaching-learning processes and aspects of these as they

relate to including the needs of more vulnerable children are of particular interest and focus for this study, specifically in an examination of how mobile technology may have a role in supporting these goals.

2.4 Quality Education Factors in a Development Context

While factors that influence quality education are universal, special attention needs to be given to literature that examines educational change within the context of the specific challenges of Sub Saharan Africa (Vavrus, 2009; Sriprakash, 2010; Abd-Kadir & Hardman, 2007; Mtika & Gates, 2010; Chisholm & Leyendecker, 2008). Cultural and historical factors are as influential as environmental and sociological factors.

Classroom resource and textbook factors.

Median availability for textbooks across 22 Sub Saharan African countries was 1.4 pupils per textbook for both reading and mathematics (World Bank, 2012). A World Bank field survey in Uganda found actual pupil textbook ratios to be as low as 1:30 as different to official estimates of 1:7. The reason for the disparity is due to the short life expectancy of books due to poor storage, humid, dusty environments and other factors (World Bank, 2015a; Drajea & O'Sullivan, 2014). Book to pupil ratios often vary within countries from urban to rural to remote regions, with remote regions generally faring the worst (World Bank, 2015a). Common classroom practice was the teacher having a copy and transcribing text onto the blackboard, losing a large portion of valuable classroom time (Hardman *et al*., 2012).

In the context of this study, three textbooks were used in the school in third grade; one for reading in Portuguese, one for mathematics, and one for natural sciences. Each child had fulltime ownership of one of these books and shared with other children, so that each child had access to text at home and could share for the

other books during class time. This was reported by the director of pedagogy as an improvement from previous rates of access to books.

School dropout factors.

There are many factors associated with high rates of school dropout in Sub-Saharan Africa; distance from school and fears for safety of child traveling to school (Verspoor and Bregman, 2008; World Bank, 2015b), education levels of parents (Oreopoulos, Page & Stevens, 2006; World Bank, 2015b) household income (World Bank, 2015b; Huebler, 2011), perceived opportunity to continue to secondary school (World Bank, 2015b), gender (UNESCO 2017; World Bank, 2015a), early marriage, pregnancy (World Bank, 2015b), children needed for household chores (Moyi, 2011; World Bank, 2015b), influence of peers (Thomas, Weber and Walton, 2002), among others (World Bank, 2015b). As students get older, poor school quality increases as the reason provided for dropping out of school (World Bank, 2015b). This has a bigger impact for students who are not progressing at school, where poor progress at school or exam failure becomes a push factor for school dropout (World Bank, 2015b).

Large class size factors.

Large class sizes are a particular challenge, particularly when combined with scarcity of material resources (Alexander, 2015; Barrett, 2013; O'Sullivan, 2006). Average pupil/teacher ratio in Mozambique was 55 in 2015 and pupil/qualified teacher ratio was 1:59 (UNESCO, 2017). Large class sizes, particularly combined with limited space, are a particular challenge in changing from traditional pedagogies relying on repetition, choral response and rote learning (Chisholm & Leyendecker, 2008, Mtika & Gates, 2010; Abd-Kadir and Hardman, 2007; O'Sullivan, 2006). Approaches where dialogue is dominated by teachers and students are passive, are commonly used to avoid disruption in a tightly packed space (Mtika & Gates, 2010).

Integrating a more dialogic pedagogy in a whole class teaching approach, alongside more traditional approaches to teaching, can help to bridge the gap between local practice and international best practice (Hardman, Abd-Kadir & Tibuhinda, 2012; Westbrook *et al*., 2013; O'Sullivan, 2006). Westbrook *et al*. (2013) identified a number of specific strategies that have been found to be effective within the contextual realities of large class sizes, multiple languages and scarce resources : (i) Planning lessons provides a useful support for teachers to provide varied and stimulating classes, particularly as new teaching practices become embedded (Westbrook *et al*., 2013; O'Sullivan, 2006) (ii) use of open questions encouraging student participation (Westbrook *et al*., 2013; O'Sullivan, 2006; Schweisfurth, 2015) (iii) use of group work even in a limited way in the context of a large class can have a positive impact on student motivation, particularly for the children who are most disadvantaged or in the lower quartile for learning outcomes (Layne *et al*., 2008; O'Sullivan, 2006; Rohrbeck *et al*., 2003) (iv) providing locally relevant content or examples beyond the use of the textbook (Westbrook *et al*., 2013; O'Sullivan, 2006) (v) use of visual examples (Westbrook *et al*., 2013) and (vi) use of local languages (Westbrook *et al*., 2013; UNESCO, 2014a; UNESCO 2014b).

Cultural and Historical Factors

Similarly, to other countries in the region, pedagogy relies heavily on completion of teacher's phrases, repetition and choral class responses, a legacy of colonialism with a strong emphasis on hierarchy and obedience (Hardman *et al*., 2011; Abd-Kadir & Hardman, 2007; Hardman *et al*., 2008). A strong culture of respect for authority can make moves towards a more learner-centred or collaborative approach to teaching difficult to implement (Mtika & Gates, 2010; Abd-Kadir & Hardman, 2007). For this reason, Vavrus (*Op*. *Cit*., 2009) argues for a pedagogy that can adapt to the "material conditions of teaching, the local traditions of teaching and the cultural

politics of teaching in Africa and beyond" (p.310).

Teacher Professional Development Factors.

According to the Global Education Monitoring Report (2017) 93% of primary teachers in Mozambique are qualified. This includes older teachers who qualified with a one-year post-secondary certificate, and more recent teachers who have completed a three-year education degree post-secondary (Beutel, 2011). There are very limited opportunities for continued professional development courses for teachers, while multiple reforms have placed many increased demands on teacher performance (Fox *et al*., 2012; Beutel, 2011).

Two additional factors were recognised as being of importance to reform: change needs to be driven by teachers themselves, rather than being imposed from outside the school community and change needs to be supported by school-based professional development and teachers collaborating and providing peer learning for each other (Westbrook *et al*., 2013; OECD, 2011; UNESCO 2014a; UNESCO 2014b; Hardman *et al*., 2015).

In Finland, South Korea, Cuba and Canada, teachers themselves are leading reform on the use of school-based Professional Development for *teachers*, taking responsibility as professionals rather than a top-down approach being imposed (OECD, 2011). The most effective programmes work over sustained periods of time, supporting peer coaching and collaborative research to guide classroom practice, curriculum development, assessment and professional learning decisions (OECD, 2011). Similar approaches can also work in Sub-Saharan Africa. In a study in Kenya (Hardman *et al*., 2015) teachers worked with peers investigating what can be observed in the act of teaching i.e. task, activity, classroom interaction, assessment, as key indicators of quality (Alexander 2008). Working on their own ongoing professional development with more experienced colleagues, observing, coaching and providing

feedback over a sustained period of time was critical to the success of the project (Hardman *et al*., 2015). Hardman, Abd-Kadir & Tibuhinda (2012) suggest that in-service teacher education, focused on classroom practice and emphasising the importance of reflection in practice may be more useful to build competence in a range of pedagogical practices than current pre-service teacher education provision. Linking professional development to a competency framework and promotion structure was also seen as key to the success of the programme (Hardman, Abd-Kadir & Tibuhinda, 2012; Hardman *et al*., 2012).

2.5 Role of Technology in Quality Education

The role of technology in achieving quality education is promoted widely across policy documents. Goal 9 of the Dakar Frameworks sets out that new information and communication technologies must be harnessed to achieve EFA goals. The proposed use of these technologies extends across management and data collection, teacher professional development, and reducing inequalities in relation to the digital divide and improving access to education in remote and marginalised communities (WEF, 2000). However, the use of technology by teachers in the classroom is not widely mentioned, except in UNESCO's ICT Competency Framework for Teachers.

2.5.1 ICT competency framework for teachers.

UNESCO's (2011) ICT competency framework for teachers addresses three approaches that connect education policy with economic development; (i) technology literacy incorporating technology skills into the school curriculum, (ii) technology deepening which is focused the use of ICT to solve complex, real-world problems and

(iii) knowledge creation, which enables learners to innovate and create new knowledge (p.7). This framework is then applied into different aspects of teachers work.

In the classroom, teacher competences work on three levels; (i) technology literacy – ability to integrate technologies, tools and digital content into didactic instruction (ii) knowledge deepening – the teacher guides complex problem-solving processes through collaborative project work related to complex real-world situations (iii) knowledge creating –the teacher models the learning processes and creates a community of learning in the classroom whereby the learner develops self-management through processes in which they are creating and building on their own and each other's knowledge and skills (UNESCO, 2011).

In teacher professional learning, the teacher competencies work on three similar levels (i) technology literacy – the use of digital literacy in their professional development, (ii) knowledge deepening – teachers are expected to create, manage and guide complex projects related to their professional development, and (iii) knowledge-creation – the teacher becomes the model learner and knowledge producers for their students (UNESCO, 2011).

The framework is built around a process model of teachers' developing skills with ICT as a pedagogical tool and a tool for professional development. As the teachers' skills deepen with the technology, they move from a quite superficial use of the technology, digital literacy, through to deeper use of the technology to create complex projects and deepen knowledge. Finally, when using technology to its full potential, teachers are creating new knowledge collaboratively in the classroom, becoming model learners for students through the use of the technology. According to the Global e-Schools and Communities Initiative (GESCI), the UNESCO competency framework standards may be too high, and it recommends the development of national standards referencing the UNESCO standards (GESCI, 2014).

As a process model and framework it is a useful structure for implementing and progressing teachers' use of ICT in the classroom and for professional development. Neither this framework nor any alternative relating to teacher competencies in using ICT for effective teaching has been mentioned at all in the last version of the GEM report (UNESCO, 2017). This signals a lack of continuity of policy at international level on where priorities are emphasized, in relation to teacher competencies with ICT as a means of enhancing quality education.

2.5.2 Mobile technology in education in developing countries.

UNESCO, UNICEF and others recognize the potential of mobile technology in addressing educational inequality. At the opening of the 2016 UNESCO Mobile Learning Week policy forum in relation to the role of mobile technology in innovating for quality, Irina Bokova, Director General of UNESCO, stated that Mobile technology was the turning point for global education (personal communication). The opportunities afforded by mobile learning are personalised and contextually relevant learning that is student centred, creating modalities for peer learning, as well as access to vast reservoirs of information (UNESCO, 2011).

Many NGOs, technology start-ups and government agencies in different countries have used different approaches to harness the power and flexibility of mobile technology to provide stimulating high quality digital learning content in remote environments where textbooks and other resources are few.

One device per child model.

A few projects using game-based learning have operated on a one device per child model, that does not require any input or involvement from a teacher, other than to co-ordinate the distribution of the devices. The One Billion maths application (One Billion, 2018) has been piloted in Malawi and is now expanding into Kenya and

Ethiopia with a one-to-one tablet to child intervention. iPads or other tablet devices with headphones are provided to the school, pre-loaded with a game-based learning maths application. Children are scheduled for one hour on the devices per day. Impressive gains in learning outcomes were achieved over an eight-week period, particularly for children who were classed as 'low achievers' (Pitchford, 2015). In another project called Mwabu (Mwabu, 2018) in Zambia, millions of dollars have been spent on putting the Zambian curriculum on a game-based learning software programme. Again, children spend time in rotation on the tablet devices on a one to one basis, combined with group work and a teacher professional development programme. Significant gains in literacy and numeracy were measured over a one-year period, in comparison to normal delivery (Mwabu, 2018). These projects require very significant financial investment for the entire curriculum to be adapted for a game-based learning software. It is unknown what the development teams are planning in terms of scope of integration of curriculum or ambitions around this.

A number of African developed technology solutions have emerged in recent years. Kio Kit (Brck, 2018) is an African designed and developed hardware and software project using offline mobile devices pre-loaded with educational content linked to the Kenyan curriculum. Another African developed project is Fundza Cellphone Stories (Fundza, 2018) in South Africa, which shares content via text messages and online social networks, a strategy designed to work in book poor but mobile phone rich environments. Some of the key findings of the Fundza Cellphone Stories project outline the importance of nurturing communities of practice and spaces for leisure reading outside of school, as well as the importance of the recognition of new literacies associated with dialogue driven genres and textual forms associated with digital communication that youth already operate in (Walton, 2009). Eneza Education (Eneza, 2018) develops educational content in collaboration with Kenyan teachers for

delivery via SMS, web or mobile web suitable for devices already available to teachers, using a pay-per-use model with mobile credit. Many of these locally developed technology solutions have developed from very simple models using either commonly available pre-existing technology or specifically developing technology suitable for the African environment and are experiencing rapid growth to meet demand for the opportunties that digital technology can provide.

Mobile technology for professional development.

Mobile technology also has important professional development opportunities for teachers. UNESCO specifically examined the possible roles of mobile technologies in learning for teachers in Africa and the Middle East in a specially commissioned report in 2012. It found that teachers' attitudes in the adoption of ICT in education is key any potential professional development opportunities afforded by mobile technologies. UNESCO (2012a, 2012b) illustrated a number of examples in the use of mobile phones in reducing technophobia, extending teacher professional development into remote areas, supporting teachers in classroom practice and enabling peer support between teachers. Many of these examples involve use texting, online chat rooms and discussion boards as well as use of Online Distance Learning (ODL) and Open Educational Resources (OER) via mobile phones. The report criticises the lack of leadership in capturing the potential of mobile technologies to enhance learning, and the pre-occupation with more traditional forms of ICT instead. This is partly due to negative attitudes towards mobile technology, and a perception of mobile phones in particular as being used by students for negative purposes such as pornography or bullying (UNESCO, 2012b, p.26). Agbatogun (2010) found that computer anxiety had a significant correlation with teachers perceived attitudes towards ICT.

Mobile technology in the classroom.

Haßler, Major and Hennessy (2015) carried out a critical review of 23 studies from 2009 to 2015, examining of the use of tablets in primary and secondary education with a particular emphasis on learning outcomes, of which 16 showed positive learning outcomes. They identified the factors contributing to successful use of tablets as; high usability and integration of multiple features in one device, easy customisation which supports inclusion, pictorial representations of learning, and immersive learning experiences, arguably similar to those found in museums or historical sites (p.13). For successful implementation they emphasised the importance of fostering collegiality and teacher empowerment at the level of school culture. Additionally, they found that the technology was most effective when it "acted as a catalyst for more creative pursuits and exploration of new pedagogical approaches" (p.16). Importantly they found the many-to-one use of the devices was more effective in terms of learning outcomes than one-to-one use of tablet devices.

In the context of low-income countries, they found a real need for more research of high quality on this topic. Much of the research stressed that new technology takes time to embed and gains might not be immediate (Carr, 2012), and that effective professional development for teachers determined eventual benefits to students (Hennessy *et al.*, 2010). Haßler *et al.* (2015) additionally called for further studies that examine the role of solar energy as part of the overall solution. UNESCO highlighted the paucity of research focused on teacher's use of mobile technology to enhance their practice (UNESCO, 2012, p.27). The available research has not increased much since that report, and UNESCO seems to have ignored ICT as a tool to enhance teaching in its latest iteration of the GEM Report (2017) with no mention in relation to a potential role for mobile technology in improving quality of education delivery, or ICT used by teachers in the classroom in any capacity.

There are very few studies robustly examining the impact of mobile technology in the primary classroom in the context of developing countries and unique challenges such as large class sizes and remote locations without access to electricity or broadband. There are even fewer studies to date examining the potential of mobile technology when used by teachers in a whole class teaching context in these environments.

2.6 Summary of Literature and Research Gaps

The Incheon Declaration provides a definition of quality education that is both holistic and useful; fostering literacy and numeracy, as well as creativity, critical thinking, interpersonal and social skills using teaching practices that are appropriate to learners' needs and supported by relevant use of ICT (WEF, 2015). This is supported by Target 6 of the Muscat GEM Agreement (UNESCO 2014b) ensuring that positioning teachers at the heart of educational quality, using participatory approaches, content relevant to learners' lives and engendering learner creativity.

Repeated throughout the literature is a call (Sayed & Ahmed, 2015; Alexander, 2015; Naylor & Sayed, 2014; Barrett, 2013) to include process indicators as a measure of quality of education, incorporating reciprocity in teacher-student interaction. A step-by-step approach to educational change is called for, with an awareness of the context of the specific challenges of Sub Saharan Africa (Vavrus, 2009; Sriprakash, 2010; Abd-Kadir & Hardman, 2007; Mtika & Gates, 2010; Chisholm & Leyendecker, 2008).

The need for teachers to lead reform at school level has also been emphasised and efforts to support teachers in forming a school-based professional development support structure through peer-to-peer learning to ensure the embedding and growth of meaningful change over the medium to long term (Westbrook *et al*., 2013; OECD,

2011; UNESCO , 2017; UNESCO, 2014a; UNESCO, 2014b; OECD, 2011; Hardman *et al*., 2015).

While teacher competencies in relation to ICT are addressed in the UNESCO's ICT Competency Framework for Teachers, there are few if any studies addressing teachers use of ICT in the classroom to enhance quality education in a whole class context, or in the context of Sub-Saharan Africa or other development contexts. Furthermore, there is scant research on the role of ICT in school-based teacher peer-to-peer learning or continued professional development.

However, there is a nascent body of promising research on the potential of mobile devices to become a valuable resource for teachers and learners in Sub-Saharan Africa. There are many examples of simple content on mobile devices substituting for expensive books and enhancing scant resources in the classroom. Promising results have also been found for mobile technology providing a valuable resource for teacher professional development. It is this research gap related to the role of technology in enhancing teacher practice in the classroom and teacher peer to peer learning which this study and thesis aim to address.

3.0 Theoretical Framework

The previous chapter took the factors related to the Sustainable Development Goal of quality education from international policy and the literature in relation to technology and context. This chapter will seek a theoretical framework for examining of teacher practices with technology within the context of a large public school in Sub-Saharan Africa. The context of the study will require a theoretical perspective providing a useful framework for analysis within a complex setting. Secondly, the

framework needs to be useful for examining activity and change in outcomes as a result of that activity, within the complex setting. Thirdly, the framework must be useful for examining the impact of technology as a tool within the complex activity setting.

This chapter firstly sets out a socio-cultural perspective of teachers' interactions in the classroom with students and within the wider school community with other teachers, with particular focus on Vygotsky's activity theory and Freire's dialogical pedagogy. Secondly, teacher's activities with technology in the classroom are examined from a creativity perspective. Thirdly, the theoretical framework is examined from a technological perspective, examining teachers' competencies with technology within the socio-cultural activity framework of the classroom and the community of teachers.

The theoretical framework analysis combined with the literature review build towards the development of the research questions.

In the context of a large public school in Mozambique;

(iv)   how can mobile technology support teachers use of collaborative teaching practices, particularly in the use of interactive exercises, group work and open questions, if at all?

(v)   how can mobile technology support creative teaching and learning practices, specifically using technology to create new artifacts and integrate local examples into digital lessons, if at all?

(vi)   how can mobile technology support school-based teacher-to-teacher continued professional development by sharing and re-using digital content, and through formal or informal teacher events where practice or experience is shared, if at all?

3.1 A Socio-Cultural Perspective

A socio-cultural perspective is useful for this study on a number of levels. The specific research questions for this study are all related to the context of the study; a large public primary school in Mozambique. Firstly, using a socio-cultural theoretical lens through which to examine the context, provides a framework through which a complex context with multiple players and factors can be examined in their relationship with each other (Vygotsky, 1978; Cole & Engeström, 1993; Engeström, 1999). Secondly, a socio-cultural perspective provides a framework for an activity, with objects and outcomes, allowing analysis of an intervention within a complex environment (Engeström, 1999; Vygotsky 1978). And thirdly, socio-cultural activity theories focus on use of tools, such as language or technology, to mediate activity (Cole & Engeström, 1993; Vygotsky, 1978).

3.1.1 First generation activity theory.

In the early history of the cognitive sciences, thinking was regarded as internal in relation to the external, and removed from the cultural, social and historical context of the individual; cognitive science was a project of explaining the mind "from the inside out" (Lecusay, Rossen and Cole, 2008, p.92). Vygotsky developed a theory based on the principle that it is through participation in mediated social activity that individuals first develop, only later internalising those process to influence their own behaviour, in a process of appropriation/internalisation (Lecusay *et al*., 2008; Wertsch, 1985).

Vygotsky developed a model for mediated activity, which focuses on tool mediation. The simple triangle describes natural "unmediated" functions along the base of the triangle between the subject, who is the individual, and the object, which is the goal of the activity. The apex of the triangle represents activity which is intermediated by artifacts. Tools and symbols are seen as two aspects of artifacts; mediation by tools

is a more outward focused activity, and mediation by symbols (or language) is a more inward focused activity. (Cole & Engeström, 1993; Vygotsky, 1978).
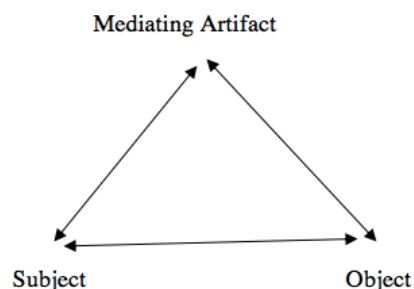
Figure 1: Vygotsky's basic mediated action triangle (adapted from Cole & Engeström, 1993)

The base of the triangle represents a direct relationship between the individual and the environment, and the path via the apex, represents mediation via artifacts. Both occur simultaneously, creating what Vygotsky's refers to as "the cultural habit of behaviour" (Lecusay *et al*., 2008, p.94). The focus of the model is on human activity, which is always motivated to achieve a particular outcome (Lecusay *et al*., 2008).

3.1.2 Second generation activity theory; Cultural Historical Activity Theory (CHAT).

Leont'ev extended Vygotsky's thinking to include relations within the larger social structures and Engeström subsequently visualised this in creating an expanded version of Vygosky's simple triangle model to represent the unit of collective activity, by including mediating social structures (Engeström, 1999; Lecusay *et al*., 2008). The resultant Cultural Historical Activity Theory (CHAT) model attempts to provide a structure for analysis for human behaviour which includes communities, their collected mediating artifacts and the rules that govern the behaviour of these groups or communities, with activity as the basic unit of analysis (Engeström, 1999; Cole and

Engeström,1993). CHAT provides a framework for examining the role of social processes in human development and for mapping individual change within its social and cultural context (Lecusay *et al.*, 2008). In this framework, individual cognition and culture are co-constituted in culturally, socially and historically conditioned forms of activity (Lecusay *et al.*, 2008).

In the U.S. literature sociocultural theory is the term more commonly used to describe Cultural Historical Activity Theory. The terms are regarded as inter-changeable, and for the purposes of this study, the term Cultural Historical Activity Theory (CHAT) will be used to in relation to the theoretical framework. However, the socio-cultural context and socio-cultural approaches are referred to where the cultural context is of particular interest.

Engestrom's triangle.

Engeström's (1999) model of CHAT incorporates structures of community, rules and division of labour. Rules and division of labour mediate relations between subject and object, and between subject and community, and between the community and the object, in the process of object being transformed into the outcome. Rules can be both implicit and explicit norms of the community that constrain and shape social interactions within the activity system (Lecusay *et al.*, 2008).
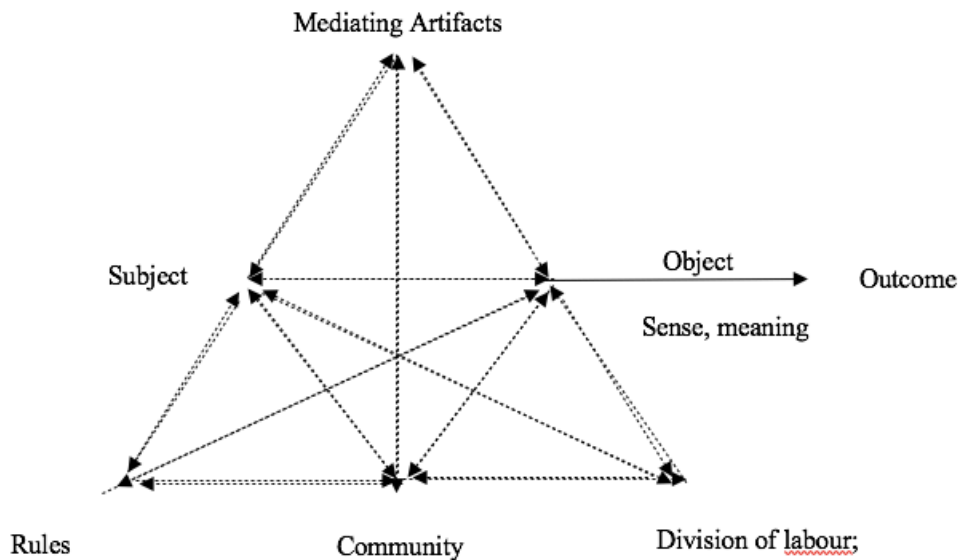
Figure 2: The structure of human activity system (adapted from Engeström, 1999)

This framework provides a basis upon which to examine the whole, rather than each connection separately (Engeström, 1999). The model represents multi-directional inter-connectedness which means that the activity is rooted in an interpretation of the individual as constantly changing through shared activity (Lecusay et al., 2008). Artifacts that function as tools are invented and re-invented during the activity process and new artifacts are developed. The rules, which are created by the community, and division of labour components are additional to Vygotsky's triangle and bring the new socio-historical elements of mediated action. The interactions among the components of the CHAT triangle can cause tensions, which can cause the action to collapse or lead to innovative change (Yamagata-Lynch, 2010; Engestrom, 1993), expanding the process of education to the context of the wider school community.
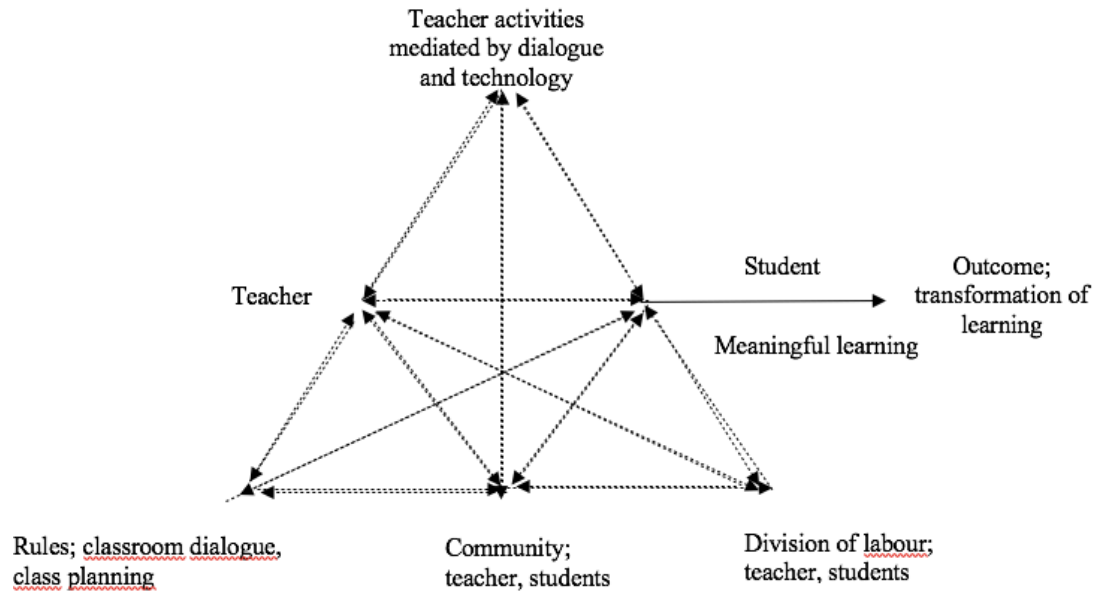
Figure 3: Application of Engeström's (1987) CHAT model to teacher practices in the classroom

Applying the model to this study in the context of teachers' use of the iPads in the classroom, the subject is the teacher. The teachers' activities in the classroom are mediated by dialogue and use of the technology and supported by the wider context of the rules of the classroom, the community of teacher and students in the classroom working together to co-create knowledge and transform learning in the classroom. The community and rules of the community in this context remain within the context of the classroom. Rules include teachers' use of class planning to provide a varied lesson and how the teacher uses interactive dialogue with the students. The community is the teacher interacting with the students, and the students providing support for each other through group work and participation in the classroom dialogue and activities. The division of labour is between teacher and students, with both working together to co-create learning.

Teachers bring to this context their own socio-historical experiences of learning and of being taught (Triggs & John, 2004) and local classroom culture as well as the national and international factors such as curriculum and standards (Davies *et al*.,

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2004). Students bring out-of-school factors and attitudes to schooling and education, as well as to technology (Facer *et al*., 2003; Kent & Facer, 2004).

The research questions therefore reflect the complexity of the full cultural-historical context of the school community, by examining the interactions between teachers and students through the tools of dialogue and the iPads, as well as interactions between students in group work and between teachers in communities of learning, and additionally by connecting learning continually back to the local environment.

Criticism of CHAT.

Dafermos (2015) pointed out the contradiction in the popularity of Vygotsky's theories in international psychology and contemporary pedagogical literature, with the roots of those theories remaining poorly developed or understood in their full socio-cultural context, mainly because of a keenness to remove them from their original link with Marxism. However for this study the full usefulness of the model is its very applicability to a complex socio-cultural context. Others have pointed out an over-emphasis on the individual's transformation (Engeström 1999; Leont'ev, 1987), while neglecting the individual's impact on the social environment (Matusov, 1998). For this study, co-creation of knowledge and learning between teachers and students and between teachers in the wider-school community through use of dialogue and technology is emphasized, in a collaborative and multi-directional model of learning and transformation.

3.1.3 Community of practice.

A community of practice is a useful theoretical framework for teacher peer learning within a small socio-cultural context such as a school. In a community of practice learning is regarded as a process of social interaction in authentic contexts

(Lave & Wenger, 1998; Chalmers & Keown, 2006). In the context of teachers sharing experiences, knowledge and learning with fellow teachers as relevant to their specific context, a community of practice model is particularly useful. Wenger defines a community of practice as a "group(s) of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2011, p.1). Communities of practice are communities of practitioners working within a shared domain of competence or practice, who help each other through discussion and joint activities, sharing experience, information and resources (Wenger, 2011). A visual interpretation of the community of practice framework within the CHAT framework in the context of this study is represented as follows:
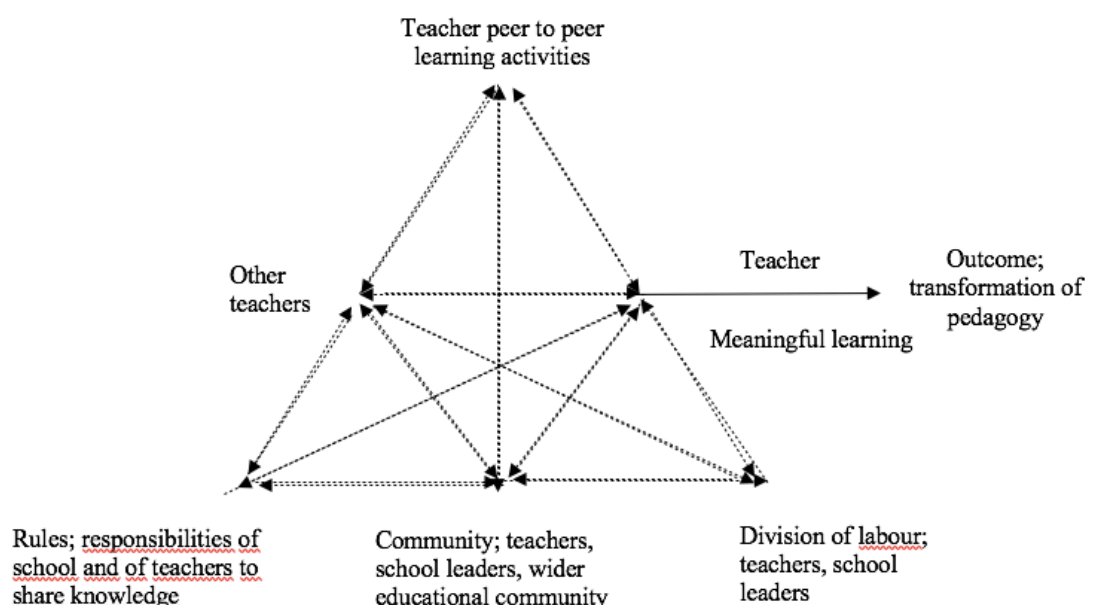
Figure 4: Application of Engeström's (1987) CHAT model to teacher community of practice

Applying the model in the context of teachers' continued professional development at school level, the subject is again the teacher. The teachers' activities in this case are again mediated by dialogue and use of the technology in their collaborations with colleague teachers, supported by the wider context of the community of teachers in the school. Rules are agreed between teachers on how they collaborate with each other in the sharing of knowledge, experience, class plans and

digital artifacts created for use in the classroom. The community is the wider community of teachers within the school, with the support and leadership of the school director and director of pedagogy. The labour is divided between teachers, supported and enhanced by the school directors. Other factors such as school culture, relationships between teachers, school leadership and wider factors including teacher pay and conditions influence the socio-historical context of the relationships within this model (Fox *et al.*, 2012; Westbrook *et al.*, 2013; Beutel, 2011).

Communities of practice can be naturally occurring or set up for a specific purpose (Hoadley, 2012; Andriessen, 2005). While projects can be initiated by outside agents, long term agents of change need to come from within the community in which the change needs to happen which can then lead to further innovation and growth from within the community (Laksov, Mann & Dahlgren, 2008).

3.2 A Transformative Perspective

The outcomes of learning in the above CHAT models are a transformation of learning and of teaching. This transformation happens on a socio-cultural plan through exchange of dialogue and collaborative use of technology. The transformative perspective of education is explored further through a number of key theories; Vygotsky's (1978) zone of proximal development (ZPD), Stetsenko and Arievitch's (2004) activist transformative stance and Freire's (2000) dialogic pedagogy.

3.2.1   Zone of proximal development.

The essence of Vygotsky's (1978) zone of proximal development (ZPD) theory is that learning leads development in the child rather than the inverse, which had previously formed the basis for theories of learning. Learning occurs firstly (on the interpersonal plane) through social interaction and later (on the intrapersonal plane)

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becomes internalised in the individual. The zone of proximal development is essentially a model of collaborative development; key to the concept is the difference in what the learner is capable of alone, versus what the child is capable of with the help of another through social interaction, and the importance of mediational tools such as language in this exchange.

Murphy, Scantlebury and Milne (2015) summarise Vygotsky's ZPD as being focused on learning as development from interaction between real and ideal forms, focusing on "buds of development", while addressing the importance of emotion in learning, use of Vygotskian imitation, and allowing scope for recursion and struggle as a natural part of the process (p.287). Vygotskian imitation involves emulation by the learner of activities of the expert-other to the next higher level, rather than mere copying. Murphy *et al*. (2015) additionally highlight the importance of emotion in learning, both positive and negative, in creating the conditions where learning is more likely to be reflected on and internalised, leading to increased self-awareness and ability to change behaviour. Learning progress may not always be smooth, and will often involve stages of recursion and re-learning.

The internalisation phase of the ZPD is when the child learns to do something unaided the he/she could only previously do with help. Thus, the teachers role involves creating zones of learning and mediating meaning and so that children can consciously apply what they are learning to new situations, and take ownership of their own learning (Moll, 1990). Rogoff (2008) takes internalisation a step further to the concept of appropriation. Appropriation is distinguished from internalisation in that it involves the transformation of the person rather than internalisation of knowledge or skills. Rogoff exemplifies this with an example of girl scouts who through simply participating in the process of cookie selling become transformed into planners, organisers and leaders in how they approach the activity. It is a process of becoming

rather than a process of acquiring, as learners handle new events based on their experience of previous events (Rogoff, 2008). Moll (1990) warns however, against reductionist views in the interpretation of what the ZPD is in relation to the transfer of knowledge between teacher and learner, that could describe almost any instructional practice (Moll, 1990). Teaching practices needs to be holistic and involve language and other social mediation to create higher order thinking skills.

While creating opportunities for meaningful group type work and activities in the context of very large class sizes and just one device can be a challenging task, it is possible for group learning tasks to be assigned and the results of these imported into a digital lesson. In this situation children become leaders, organisers and knowledge creators, mirroring Rogoff's appropriation. Throughout this study, appropriation was a process witnessed frequently in the case of teachers' use of technology in ways that were specific to their own teaching contexts and would not have been foreseen. As the project progressed, participating teachers were becoming technology leaders in their own specific contexts.

3.2.2 Stetsenko and activist tranformative stance.

Stetsenko and Arievitch reposition Vygotsky's view as an endeavour to create psychological processes that set individuals free, rather than observe existing processes. In this positioning, Vygotsky's work is grounded in teaching-and-learning as a social transformative practice, with "practice as the linchpin of theory" (Stetsenko and Arievitch, 2014, p.77). In these social processes, people not only transform their environments, they also transform their lives, through gaining knowledge about the world and themselves. Human activity is viewed as the basic essence of human life; social, material and practical, aimed at transforming the world and people themselves, including the production of knowledge (Stetsenko and Arievitch, 2014). Stetsenko

articulates that participation in the world is not enough, and that contribution to the world needs to occur for transformation to happen (2014).

In the context of this study, students become co-creators of knowledge, by providing examples from their lives than can contribute to lessons, these lessons in turn are integrated into new digital artifacts that are re-used and re-created by other students and teachers collaborating in other classrooms in the school. In this process a resource of locally relevant digital artifacts are created for the school, transforming teaching and learning across the whole school.

3.2.3 Friere's dialogic pedagogy.

Freire posits dialogical pedagogy in opposition to education as mere transference of knowledge in his banking model of pedagogy. In the banking model of education, the teacher merely transfers knowledge, owned by the teacher, to the students for memorization, a practice that is very common in the context of Sub-Saharan Africa (Fox *et al*., 2012; Hardman, Abd-Kadir & Smith, 2008). However, in dialogical pedagogy the teacher brings a starting point to a discussion with students, which allows teacher and students to enter into a dialogue where both parties move together towards a more critical understanding of the subject. In a model of critical education, teachers and students work together to create and re-create knowledge (Shor & Freire, 1987). The learning is always situated in the reality of the students lived experiences, either starting from there, or relating an academic theme or subject to the students' lives and culture. Key to this process also is self-reflection and learners becoming self-aware learners and "thinking subjects" (Shor & Freire, 1987, p89). These approaches show similar aims to the CHAT model in situating learning in the real-life context of learners, using semiotic mediation, and bridging the gap between knowledge of facts and the development of higher order thinking skills.

According to Freire (2000) banking education seeks to conceal facts, repress imagination and creativity, avoids dialogue and regards students as recipients of assistance. Problem posing education on the other hand seeks to de-mythologize, encourage creativity, engage in dialogue and regards students as critical thinkers. Problem posing education sees humans as being in the process of *becoming,* who "transcend themselves" (Shor & Freire, p.84). Education is an ongoing activity, and which is constantly re-made in the practice through dialogue which is based on students understanding of their daily lives, and relating learning back to the reality of those daily life experiences (Shor & Freire, 1987).

Freire's view above can be drawn in parallel with interpretations of the ZPD (Moll, 1990) and appropriation as *processes of becoming* (Rogoff, 2008), Engeström's (1999) view that the CHAT framework always aims to understand the *systematic whole*, and Stetsenko's (2009) activist transformative stance. Freire warns against facile and reductionist uses of dialogic educational practices, and that transformation needs to be led by the learners, not the instructors. For Freire (2000) dialogue is not polemic, it is not depositing information, it is co-creation of knowledge. There are similarities in this position with Murphy *et al*.'s (2015) work with co-teaching using ZPD in a CHAT framework, allowing all participants equal voice in the learning process, regardless of position within institutions.

These positions of relevance to student's lives, dialogue between teachers and learners, learner led knowledge questions, and student participation in co-creating knowledge, are all consistent with the findings in the literature in relation to effective changes in teaching practices in the context of challenging classroom environments in Sub-Saharan Africa and other similar contexts (Hardman, Abd-Kadir & Tibuhinda, 2012; Westbrook *et al*., 2013; O'Sullivan, 2006).

3.3 A Creativity Perspective

Target 6 of the GEM Muscat agreement (UNESCO, 2014b) sets out quality education as supporting learners' ability to be creative and adapt to change, and to learn in the context of relevant content to the lived realities of learners. Craft (2005) described creativity as "an important element of the zeitgeist in the early twenty-first century" (p.ix) and the ability to creatively problem-solve is widely regarded as an essential twenty-first century skill (Robinson & Aronica, 2016; Trilling & Fadel, 2012; Dede, 2010). Memorisation and rote learning as a standard approach are no longer relevant in the context of a modern technological society. Technological leapfrogging is advocated as the key to Africa's future development, and already this is being witnessed in many ways; solar rural electrification, development of 4G networks having skipped previous generations, first generation educational publishing going straight to digital, such as some of the African digital projects mentioned previously. Any use of technology within education, must support the developing capacities of young learners for creativity, problem-solving and innovation to adapt to the needs of this rapidly changing world.

3.3.1 What is creativity?

Vygotsky defined creativity as "any human act that gives rise to something new is referred to as a creative act, regardless of whether what is created is a physical object or some mental or emotional construct that lives within the person who created it and is known only to him" (Vygotsky, 2004, p.7). Glăveanu provided a definition of creativity within a sociocultural context as "concerned with the action of an actor or group of actors, in its constant interaction with multiple audiences and the affordances of the material world, leading to the generation of new and useful artifacts" (Glăveanu, 2013, p.76). Both definitions require action and interaction with others as the source of creativity.

Woods (1990) pioneered the concept of creativity in teaching. He describes four main properties of creative teaching; innovation (new skill insight gained, new knowledge), ownership (of knowledge and of learning resulting in a difference to self), control (of learning process by student, student is intrinsically motivated) and relevance.

Innovation out of reality.

Vygotsky (2004) saw creativity as "an essential condition for existence" (p.11) and credited creativity with all human activity that involves innovation. By Vygotsky's understanding creativity is already present in childhood, as evident in children's creative play, which is not mere imitation, but a re-working of experience to fit a child's own needs (Vygotsky, 2004). For Vygotsky creativity can only build on experience of reality and the richer that experience of reality is, the richer will be the range of material accessed. Woods (1990) identifies innovation and relevance as key components of creative teaching. Innovation in terms of new skills, knowledge or insight gained, occurs when learning is relevant to children's interests and lives. Relevance to children's everyday lives is necessary in order for learners to control their own learning processes, and in turn become emotionally connected to the learning and therefore motivated to learn more (Woods, 1990).

Vygotsky identified four ways in which creativity is associated with reality. Firstly, everything created by the imagination is based on elements found in reality, even if they are re-connected in new ways. Secondly, imagination can be based on second hand experiences or creations, for example historical accounts of the French Revolution. The third is the connection between creativity and emotion, in both the sense that emotional experiences link themselves to visual images, and conversely imagination equally influences emotion. The fourth is the translation of imagination or creativity into reality with the production of something new. The cycle is completed

when the new products of creativity are returned to reality but with the capacity to influence and change that reality. The emotional and intellectual elements are both equally necessary for the completion of the cycle of creativity (Vygotsky, 2004).

As students co-create lessons and digital artifacts with teachers, relating topics to their lived realities, they engage in a cycle of creativity that engages them both emotionally and intellectually to their learning.

Student ownership & control.

Student ownership and control of learning is identified by Woods (1990) as the other key components of creative teaching. Ownership of knowledge and of learning results in a difference to self and control of learning process by student leads to the student becoming intrinsically motivated. "If relevance, control and ownership apply, the greater the chance of creative learning resulting—something new is created, there is significant change or 'transformation' in the pupil—i.e. innovation" (Woods, 2002, p. 70).

Jeffrey and Craft (2004) highlight the importance of the inclusion of the learner in making decisions about what to investigate, how to investigate and how the learning process is to be evaluated, in a learner inclusive approach. Collard and Looney (2014) describe the creative classroom as student-centred, requiring strong domain and pedagogical knowledge on the part of the teacher, as well as an "openness to the unexpected" which requires a profound change in the dynamics between teachers and students (Collard & Looney, 2014, p.351). Jeffrey (2006) in a broad ranging ethnographic study across nine European countries (CLASP Creative Learning and Student Perspectives 2003 – 2005) identified common teaching and learning practices which they recognised as creative; involving innovation, ownership, control and relevance. Participants brought their own experience and imagination to learning situations, both teachers and learners engaged in teaching and learning through

intellectual enquiry, altering the teacher learner relationship and experience in the process. An additional component of this approach was that learning became meaningful to participants through self-affirmation and development of social relations and identities (Jeffrey, 2006). These teaching practices moving towards a model of co-creation of knowledge between teacher and student are consistent with teaching practices regarded as being effective in whole class teaching in development contexts. This approach is also consistent with a human rights perspective on education (UN Convention on the Rights of the Child, 2010) emphasising teaching that recognises children as active agents in their own learning.

The challenges of implementing this approach in the context of large class sizes, limited space and resources have been outlined in detail in Chapter 2. However, there is scope in the context of this study for a step by step approach to involving children in the co-creation of lessons through inviting them to participate in the creation of digital lessons by bringing in local examples, by writing or drawing text into a lesson, or contributing local knowledge to a lesson. This is turn creates the emotional connection with the learning (Vygtosky, 1978) leading to transformation in the learner (Woods, 1990; Freire, 2000; Stetsenko & Arievitch, 2014).

3.3.2. Creativity in its socio-cultural context.

Glăveanu (2013) developed a model to examine creativity within a sociocultural context. In Glăveanu's model, actors, actions, artifacts, audiences and affordances, which he terms the Five As are inextricably connected with creativity and culture. The first A is the actor, which is "a person embedded in the field of social relations specific for any human community and society", people who are "shaped by a sociocultural context and act from within it, in coordination with others, to change and mold this context in suitable ways". The actor is being an agent, but also learning

simultaneously. The model provides the theoretical advantages that it allows for a sociocultural context and different levels of creativity, serving as a contextual organizer, applicable across a range of different domains (Glăveanu, 2013). Artifacts are considered in the context of meaning-making processes occurring between actors and audiences in different sociocultural settings (Glăveanu, 2013).
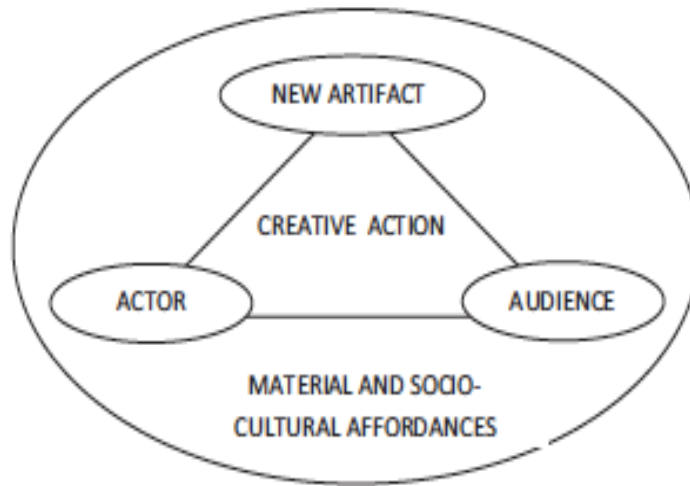
Figure 5: Socio-cultural model of Creativity. (Glăveanu, 2013, p.71)

Applying the model to this study, the teacher is shaped by her socio-cultural context and acting within it. She is the agent who is also learning simultaneously in collaboration with the audience, the students. The teacher and students are engaged in collaborative lesson building with the teacher to create new digital artifacts. The material and socio-cultural affordances become the iPads and classroom community working with the technology within the context of the local environment, for example, taking photos from the local environment to illustrate examples of lessons, and integrating these into digital lessons. The new digital artifacts become part of the material and socio-cultural affordances of the environment in turn, becoming used and enhanced by other teachers in other classrooms in the school.

3.3.3 Barriers to creativity in education.

Curriculum.

Lack of clear definition of creativity within educational policy or guidelines on how to develop creativity (Cachia *et al*., 2010, Craft 2003) create confusion and lack of clarity on what creativity is in relation to teaching. Jeffrey (2006) points to conflicts in policy and practice and the paradox between the tightening of control of curriculum and pedagogy and the stated support for more creative teaching and learning, as well as unclear distinctions between priorities for creativity in the curriculum (Jeffrey, 2006). These conflicts are common across different national curricula and even within international teaching standards and reports (UNESCO, 2017). Mozambique introduced a new curriculum in 2004, with the stated objectives of moving from subject-based to interdisciplinary teaching, moving from teacher-centred to pupil-centred teaching, emphasising context specific and culturally relevant approaches. However, these changes have been brought in at the same time as changes in enrolment numbers, and concern has been widely expressed that resources have not been available to address increased quantity of students in school at the same time as curriculum changes requiring a more creative approach to teaching (Beutel, 2011).

Lack of time.

Overloaded curricula and necessity of teaching to the test (Cachia *et al*., 2010) were identified as key barriers to creativity in teaching and learning across Europe. This challenge is multiplied in the context of a public school in Mozambique with three school shifts per day, given the much shorter teaching hours (Beutel, 2011; Fox *et al*., 2012). Researchers who have examined the specific constraints of short teaching hours and large class sizes have emphasized the importance of lesson planning for teachers attempting to change their practice (Westbrook *et al*., 2013; O'Sullivan, 2006).

Teacher professional development.

Cachia *et al.* (2010) emphasise the importance of teacher professional development and support for teachers to take creative risks within the constraints of traditional structures. Cultural contexts are often difficult to change as students, parents and teachers expect didactic forms of teaching and professional development programmes, with an awareness of this context and a step-by step approach are an essential support for teachers attempting to change their practices within this context (Schweisfurth, 2015; Hardman *et al.*, 2011; Vavrus, 2009; Pontefract & Hardman, 2005).

Educational culture and leadership.

Change needs to be supported by school leaders and policy makers (Cachia *et al.*, 2010). Vavrus (2009) examined the impact of cultural context in Sub-Saharan Africa at national and school levels in moving towards a socio-cultural pedagogy, finding that local traditions and context have a large impact on an individual teacher's ability to impact change.

Teacher fluency in use of technology.

Competence with ICT and digital media is a factor in ability to teach creatively using technology and digital content (Cachia *et al.*, 2010) and in the case of this study also creating digital content. Mishra (2012) points to a common mis-perception that technology should lead to creativity and instead emphasises the importance that teachers need to be creative in repurposing technology tools so that they serve the purposes of pedagogical and inter-disciplinary learning goals. The emphasis on this study is for teachers to become fluent enough in the use of the technology so that it becomes a tool to enhance creative teaching, rather than the technology becoming the lead factor in the teacher's practice.

3.4 A Technological Perspective

Finally, any theoretical framework for the examination of teaching with technology must come to a technological perspective. The perspective however must focus on the actions of the teacher working with the students, in the classroom and within the wider school community, with technology as the tool.

3.4.1 TPACK model.

Koehler and Mishra's (2009) Technological Pedagogical Content Knowledge (TPACK) is a framework designed to examine the complexity of teachers using ICT in their classroom practice.
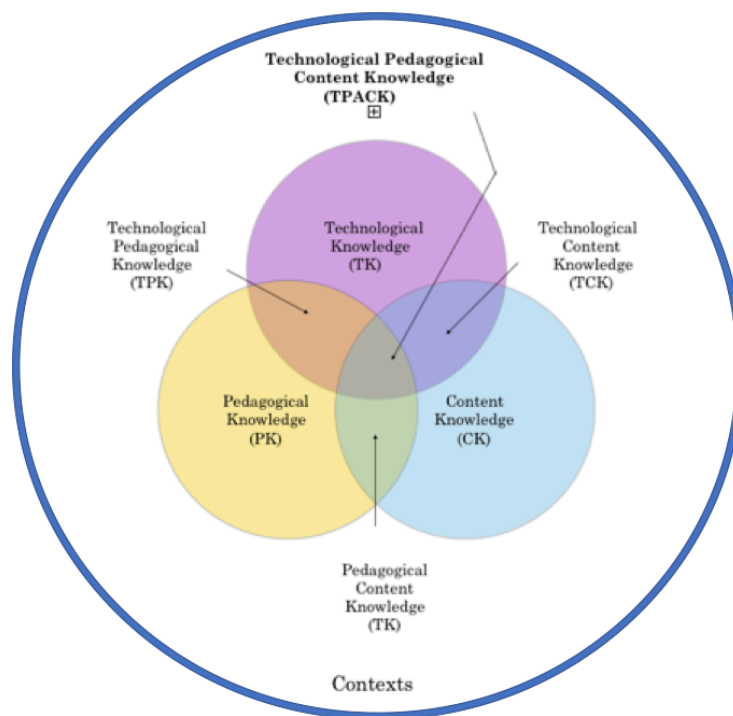
Figure 6: Koehler and Mishra's (2009) Technological Pedagogical Content Knowledge

The framework integrates three core components of teaching with technology: content, pedagogy and technology and their interaction across various contexts. Content knowledge relates to teachers knowledge of the subject matter they are teaching. Pedagogical knowledge relates to teachers' knowledge about the processes

and methods of teaching and learning including; lesson planning, classroom management, assessment, and how students learn. Technological knowledge is constantly in flux, however, this relates to ways of thinking about and using technology that can be applied across different technology types (Koehler & Mishra, 2009). The framework aims to provide a basis for describing how technological knowledge can be implemented in practice by the teacher in the classroom. Use of technology in this framework requires "deep, flexible, pragmatic, and nuanced understanding of teaching with technology" and "forward-looking, creative, and open-minded seeking of technology use, not for its own sake but for the sake of advancing student learning and understanding" (Koehler & Mishra, 2009, p.66). Crucially the model is set within the contexts of the teaching environment, thus incorporating the socio-cultural context as previously examined.

Mishra & the Deep-Play Research Group (2012) caution against myths giving the impression that technology tools should drive teaching and learning and a tendency to focus on the newest and coolest tools' determining how we teach. Mishra points out that to design teaching around current technology would have more no more sense than designing education around the invention of the crayon in 1903. "To be used productively, teachers must understand the different ways that technology can represent content and recognize how this synchs (or doesn't synch) with possible teaching approaches" (p.14). He argues that technology has been conceived of too narrowly, instead the technology is more useful when focused on what students need to learn and how that learning can happen. Mishra proposes that the TPACK framework emphasises the importance of creativity of the teacher in using technology tools to achieve pedagogical and learning goals.

The Deep Play Research group (Michigan University) led by Mishra, have further developed the model to emphasise the importance of trans-disciplinary thinking

with teaching and technology, calling it the the three T's; technology, trans-disciplinary thinking and teaching. Mishra describes this as an "(in)disciplined framework" (Mishra, 2012) which acknowledges that (a) creative work always occurs within a discipline and (b) is interdisciplinary in using divergent thinking and creativity. Mishra explains trans-disciplinary thinking as seeing with fresh eyes, particularly by using photography and video of familiar objects to examine them in new ways. Mishra describes this as "TPACK in action – bringing together Technology, Pedagogy and Content in an original and innovative manner" (Mishra, 2012, p.16). Trans-disciplinary thinking requires skills such as "perceiving, patterning, abstracting, embodied thinking, modeling, play, and synthesis" which allow transformation to be transferred creatively from one domain to another, thus facilitating insights as everyday phenomenon and things are viewed from different perspectives (Henriksen, Mishra & Fisser, 2016; Mishra, Koehler, & Henriksen, 2011; Mishra & Henriksen, 2018; Mishra, Yadav & Deep-Play Research Group, 2013). Using time lapse, slow motion or microscopic lenses are further examples of ways in which to view objects differently, or what Csikzentmihalyi (1998) calls the perception-recognition distinction.

The approach of TPACK as a framework for the professional knowledge of teachers for using ICT in education has many parallels with UNESCO's ICT Competency Framework for Teachers (2011). UNESCO's framework sets a trajectory through layers of competence from ICT literacy, to knowledge deepening to knowledge creation, with the knowledge creation approach reflecting the highest level of competency, using technology to innovate and create new knowledge

3.4.2 Technology as a catalyst for creative education (in its socio-cultural context)

While the TPACK model is focused on the teacher's individual competencies, it is set within the wider socio-cultural context and focuses on the teacher's actions with the technology in the context of teaching and peer learning between teachers. Extending Mishra and the Deep-Play Research Group's thinking on creativity in the context of teaching to include the learner and the socio-cultural context in which the learning takes place, a framework for the examination of technology's impact on creativity in teaching and learning in its socio-cultural context can be developed. The individual teacher's competencies are in turn influenced by his/her actions with students and with other teachers within the context. The outputs of the creative actions of the teacher in the form of digital artifacts further influence the developing competencies of the teacher within the context. Through creative use of technology, the teacher moves towards deep knowledge building and transformative learning in a virtuous cycle of creative actions producing outputs that feed back into more creative actions and expanded outputs, transforming teachers (and students) in the process.

3.5 Theoretical Framework Summary

The literature and policy review and examination of theoretical frameworks related to the context and activities of this research study have focused on a collaborative model of learning within an authentic and complex socio-cultural context of a large public school in Mozambique. The CHAT model (Cole & Engeström, 1993) establishes how technology is used as a tool in the complex socio-cultural context to instigate changes in practice leading to teachers' increased competency in Technological, Pedagogical and Content knowledge (TPACK Framework) within a Community of Practice (Lave & Wenger, 1998) of teachers in the school. The following diagram illustrates the interrelationships between the CHAT and TPACK models within the context of a Community of Practice.
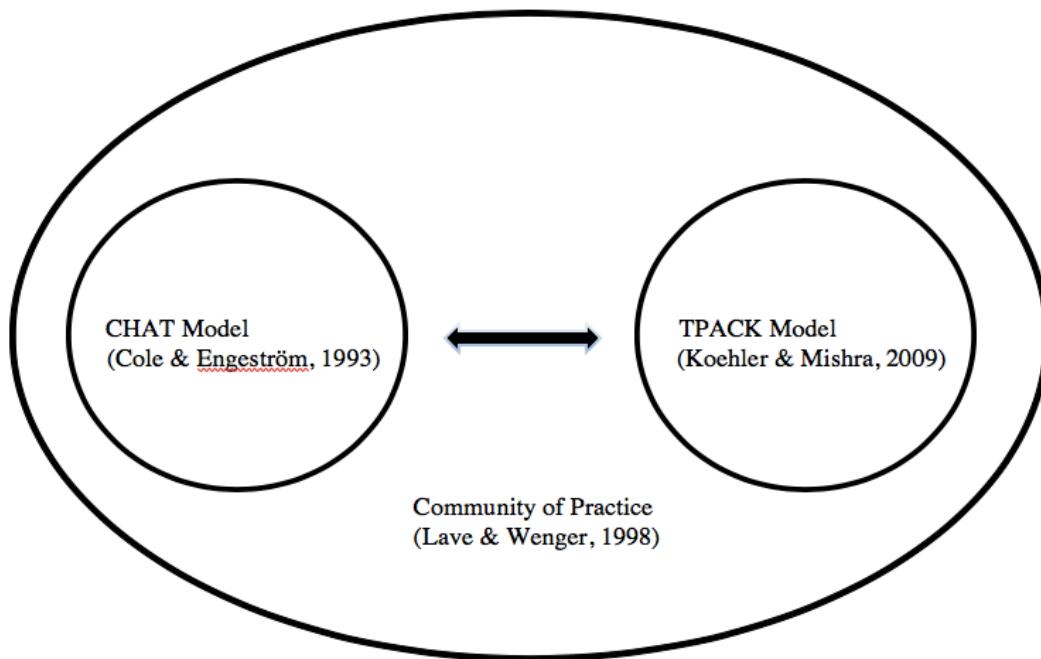
Figure 7: Theoretical Framework Summary

Examination of the literature and theory has brought focus to three main aspects of teaching; collaborative teaching, creative teaching and a community of practice whereby teachers can support each other's professional development for sustainability and growth of the project into the long term. The boundaries of the approach are set as a whole class teaching approach, with the teacher using an iPad connected to a projector as a tool providing a catalyst for change in a step-by-step approach. The three main aspects for examination are further distilled down to specific teaching practices practicable within the authentic socio-cultural context of the study and form the basis of the theoretical framework and research questions for the study as follows.

Aspects of Teaching Emerging from Theoretical Framework
1. Collaborative practices in the classroom, specifically: (i) use of interactive exercises (ii)use of group work, (iii)use of open questions
2. Creative teaching and learning practices specifically: (i)creating new artifacts with technology (ii) integrating local examples into lessons with technology
3. Community of Practice events, specifically: (i)sharing and re-use of digital content (ii) events where knowledge or experience is shared between teachers, whether formal or informal.

Table 1: Aspects of Teaching Emerging from Theoretical Framework

3.6 Research Questions

The research questions are therefore formulated within the context of the theoretical framework and previously identified research gaps.

In the context of a large public school in Mozambique;

(i)   how can mobile technology support teachers' use of collaborative teaching practices, particularly in the use of interactive exercises, group work and open questions, if at all?

(ii)   how can mobile technology support creative teaching and learning practices, specifically using technology to create new artifacts and integrate local examples into digital lessons, if at all?

(iii)   how can mobile technology support school-based teacher-to-teacher continued professional development by sharing and re-using digital content, and through formal or informal teacher events where practice or experience is shared, if at all?

4.0 Research Methodology

The research proposal is instigated by the Sustainable Development Goal of quality education for all, and an examination of the impact of mobile technology in the achievement of this goal. Emerging from the literature are three teacher key practices which provide a basis to inform the research design for the study; collaborative practices, creative teaching to relate learning to children's lived experiences, and teachers working in a community of practice. These practices are mapped against teachers' use of technology in the classroom, in a design-based research study. The research design used mixed methods and fitting practices in a process of design and re-design to develop an intervention that worked in the real-life context of a large public school in Sub Saharan Africa.

4.1 Definition of Intervention

Over the duration of this study, the researcher was a manager of a number of educational outreach projects related to technology and creativity in education, one of which was called IADT's (Institute of Art Design and Technology, Dun Laoghaire) School in a Box. School in a Box (IADT, 2016) was a technology solution designed for remote learning environments, in locations with lack of access to electricity, containing an iPad pre-loaded with relevant software, a small powerful projector, a solar battery and a solar panel. The School in a Box project had already been piloted in Nepal, having run successfully in a remote school high in the Himalayas for over three years. Additionally, two pilot studies had been run in Mozambique, one in remote adult literacy centres in collaboration with UNESCO, and the other in remote field farm schools in collaboration with the Aga Khan Foundation.

This study relates to a pilot project funded by Irish Aid commencing in August 2015, in a large public primary school, in the outskirts of Maputo, the capital city of

Mozambique (Appendix 1). The wider study specifically examined the impact of the intervention on literacy levels in Portuguese language for Grade 3 students. Over the course of the thirteen-month period of this study, three workshops were held for teachers, with one additional visit to the school.

While the broader research project was focused on the impact of the intervention on learning outcomes in Portuguese literacy of the participating students, this doctoral research examined additional data relating to the impact of the introduction of the technology and the teacher workshops on teaching practice in the classroom and on teacher peer learning, within the socio-cultural activity context of the classroom and school community.

Project Management and Partnership.

The workshops were conducted by two different Portuguese tutors, both of whom were Apple Certified Professional Development (APD) tutors. To receive this certification from Apple requires proof of creative teaching with apple technology and attendance at annual workshops on innovative teaching with apple products. The first tutor contracted by IADT to run the teacher workshops was NMS, a lecturer in University of Lisbon in architecture and design thinking. He tragically passed away in December 2015. Subsequently, a second tutor was found; JC, who was contracted to run the second and third workshops. His background was as director of a teacher education institute in Portugal, currently seconded to the Minister for Education in Portugal as an advisor.

Across both studies, the partners on the project were IADT (this researcher), Irish Aid, the two tutors NMS and JC, the school and its leaders, the local teacher continued professional development organization; Instituto Formacao de Professores (IFP) and the Provinha team for the Portuguese literacy measurement.

Technology.

The technology pack contained an iPad, a small projector powerful enough for use outside under a tree for example, a solar batter and a solar panel, all contained in a pelicase or over the shoulder bag, depending on the environment. The final technology components were designed for each project following a needs analysis phase and depending on the environment of the particular project. Applications were pre-loaded to the device in advance of deployment, usually containing a number of basic easy to use, content creation apps, such as Book Creator (interactive book creation app), Keynote (presentation app similar to Powerpoint), Explain Everything (whiteboard app), iMovie (video editing app) with options for additional applications, depending on requirements. This combination of technology was chosen for its robustness, intuitiveness and ease of use, and lack of need for technical support. The White Paper on School in a Box outlines the use of the technology in more detail across a variety of contexts (Appendix 2).

Over the course of this study the technology was not used outside, and therefore the solar components of the project were not used over the course of this study.

Community engagement approach.

Using a community engagement ethos, the researcher worked with on-the-ground educational and community partners to assess needs and co-design technology deployment, teacher professional development and content requirements suitable for the environment, everyday constraints and most immediate needs of teachers. The end goal of each intervention was for the project to be owned and led by the local partners, and facilitated, according to their needs, by the researcher. The aim was to build local capacity and expertise in the application of the technology in the local context, in a community partnership model. In return, it was explained at the outset to community partners that their learning experiences on the project would inform further

development of the project and its application in other contexts.

4.1.4 Teacher professional development.

Figure 8: Teachers preparing and presenting digital lessons during professional development workshop

The teacher professional development programme aimed to support and scaffold teacher skills in a very practical and simple way to allow the tool to be useful and relevant to the classroom and community environments teachers are working in. The workshops focused on the use of the technology to enable a more participative approach to teaching, through very small and practical changes to practice. These included the planning of classes that included interactive exercises, open questions and group work. New digital resources were made linked to class plans, incorporating local examples and photographs. The technology itself was very easy to use and incorporate into a classroom context using very easy to learn apps that facilitated high quality interactive content creation and use on the iPad. The photographic and video making capacity of the iPad allowed easy integration of examples from the immediate environment.

The approach of the workshops was to use the technology as an enabling tool for teachers to introduce (i) collaborative teaching practices in the form of digital lessons incorporating interactive exercise, group work and open questions (ii) creative teaching practices leading to the creation of new digital artifacts and integrating local examples through the photographic capacity of the iPad and (iii) encouraging community of practice supports between teachers to share and re-use digital content and meet, share and practice and experience regularly beyond the scope of the professional development workshops.

4.2 Context of Study

This doctoral research study was run in parallel to the wider study. The researcher was also the principal investigator on the wider study and primarily responsible for its design in collaboration with project partners.

4.2.1 Overview of study.

The study took place over a thirteen-month period from August 2015 to August 2016. A three-month period of preparation preceded this period, with a number of emails, and phone calls in order to establish the environment of the study, requirements of the funder (Irish Aid) and the needs of the school. Three phases of the research proper took place:

Phase 1	Teacher Workshop August 2015 and School Visit October 2015
Phase 2	Teacher Workshop February 2016 and follow up until June 2015
Phase 3	Final Teacher Workshop August 2016 to final literacy assessment October 2016

Table 2: Research Phases

The focus of the wider study was on the impact of introducing the technology on teaching Portuguese literacy, however the teachers were also free to use the

technology to teach other subjects, and a number of teachers reported that they frequently used the technology for the teaching of Natural Sciences also.

4.2.2 Pilot primary school.

The study was a pilot action research project working with Grade 3 teachers in a public primary school, chosen by Irish Aid because of its easy access from Maputo for the purposes of monitoring and evaluation at pilot stage, and because of its typicality in size, pupil teacher ratio and performance as a large urban public school in Mozambique. There were approximately 5000 students in the school and 72 teachers. Approximately half of the classrooms were exterior under the shade of some trees, and the rest were interior. Interior classrooms for the most part did not have desks, chairs, windows or doors. Electricity as available in interior classrooms but could be intermittent. Teachers for the most part were qualified, which requires completion of secondary school plus one year of teacher education.

There were three school shifts per day and each child attends just one of those shifts; early morning, late morning or afternoon. Some, but not all of the participating teachers, taught more than one shift per day. Before each shift there were often many children waiting around the school grounds for their shift to begin. The school buildings were joined and or clustered in a horseshoe shape, with a water tap in the centre of the courtyard space in the middle, where children could drink from. Around one side of this cluster were the latrines, and around the other side are a number of mature trees, under which children sat on the sandy ground for their classes, facing towards the teacher who had a blackboard on a stand. Seven classes were contained under the trees.

Figure 9: School grounds and outdoor classrooms in school

4.2.3 Project partners.

School team.

The school was the head school in a cluster of seven schools and some of the teachers involved in the study taught across a number of those schools. The director of pedagogy (Saul) of the school and co-ordinator for training in the school cluster was the leader of the School in a Box project on the ground in the school. His role was to co-ordinate the scheduling of use of the technology, arrange the environment for teaching with the technology, ensure the technology was working properly, reporting any issues or problems back to the researcher, and to co-ordinate community of practice activities with the teachers. He acted as facilitator between the teachers and the researcher, as well as the project leader in the school. Towards the end of the study period, the director of pedagogy resigned from this role and returned to his teaching

role, but continued to act as project leader at school level.

Irish Aid team.

Irish Aid funded the pilot project through the Irish Embassy in Maputo. Irish Aid's primary objective is that all projects they engage in ultimately aim to reduce poverty. Mozambique is one of nine key priority countries for Irish Aid. Their education advisor in Mozambique, and project lead from the Irish Aid team is Mozambican with a Masters in Education, who has worked in the Irish Embassy in Maputo for over twelve years, specialising in education and participating in many working groups and committees in the Ministry for Education. Her role was to keep lines of communication open with the Ministry for Education and the local institute responsible for continued professional development for teachers, in order to allow teachers to participate in the workshops, and on the project. She worked with an Irish intern, and together they were the main liaison between the researcher and the school for monitoring and evaluation activities, as well as project management and trouble-shooting for any issues that arose.

Instituto Formação de Professores (IFP).

IFP is the local teacher professional development body for teachers for the district in which ABC School is located. A teacher instructor from this institute attended all of the professional development workshops. Two different specialists in curriculum attended the workshop in February 2016. Their role was to provide ongoing support to the school leaders and teachers in the School.

Provinha team.

As part of the evaluation process on the Irish Aid research collaboration, an assessment tool developed by the Ministry for Education in Mozambique to measure Portuguese language literacy called *Provinha* was used. Teachers in the school participated in a workshop as part of the teacher workshop in February 2016 in how to

administer the measure. The two main developers of this tool attended the February workshop. Their main purpose was in relation to the literacy measurement for the main study (not the doctoral research). However, these and other Ministry for Education officials at district and provincial level attended the August 2015 workshop and were consulted regularly on decisions such as the inclusion of the *Provinha* development team on the project, and next phase development for the project.

4.3 Research Approach

A number of potential research approaches were examined in the search for the most appropriate approach, encompassing both the wider study and this doctoral research. Action research in an educational context was ruled out at an early stage, as this form of research necessarily involves the teacher as researcher. Deep consideration was given to participatory action research (Chambers, 2010) for its suitability to intervention research in developing world contexts. Robert Chambers, who has led many participatory action research projects in the poorest communities in the world, proposes a paradigm of adaptive pluralism as being appropriate to the complexity of poor people's lives (2010). "Adaptive pluralism embraces, underpins and expresses ideas and practices of reflexivity, continuous learning, value and principle-based eclectic improvisation, co-evolution and continuous emergence" (p. 4). For working in the unpredictable circumstances in which poor and marginalised people often live, Chambers insists "practices are – have to be – adaptive, improvised and emergent" (Chambers, 2010, p. 35). While these principles and ethos will influence the study, it was decided that a research approach with a history of use in educational contexts was required for the purposes of the study.

4.3.1 Design Based Research

Further exploration of approaches identified Design Based Research (DBR) as the most appropriate for the scope and nature of the study and the context of the environment. A number of similar research approaches have been evolving since the 1990s including development research/developmental research, design research, design studies/experiments and educational design research (van de Akker *et al.*, 2006; Anderson and Shattuck, 2012; Bakker and van Eerde, 2015). These approaches are referred to interchangeably in the literature and will be referred to under the umbrella term of Design Based Research (DBR) for the purposes of this study.

Wang and Hannafin (2005) characterise design-based research as a "systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang & Hannafin, 2005. p. 6). Anderson and Shattuck (2012) suggest that quality Design Based Research (DBR) studies are defined by the following: being situated in a real educational context, focusing on the design and testing of a significant intervention, using mixed methods, involving multiple iterations, involving a collaborative partnership between researchers and practitioners, the evolution of design principles and practical impact on practice. These are the key characteristics and context of this study, and this approach provides a holistic approach and flexibility required to encompass the full complexity of the research environment, partners and wide-ranging approach of the project.

While different data sets were collected for the wider study and this doctoral research, the design-based research approach was used across the entire study led by the researcher, in collaboration with other research partners.

Design Based Research versus other research approaches.

Design Based Research is distinguished from action research in that the researcher is separate to the teacher but works (often closely) with the teacher in designing and iterating the educational material (Bakker and van Eerde, 2015). In this study, the researcher worked closely with the teacher tutor in the design of the workshops, to meet the objectives of the intervention, and of the research, and was present during all workshops.

Bakker and van Eerde (2015) characterise DBR as open, versus experimental, and interventionist, contrasting with naturalistic which examines what already exists. According to Anderson and Shattuck (2012), it is in the evolution of design principles that differentiates DBR from action research (p.17). A review meeting between the researcher and teacher tutor was held at the end of each day of workshops, as well as full team review meetings after each phase of research. The intervention was re-designed as required as a result of these meetings in terms of teacher workshops, additional involvement of partners, technology tweaks or other changes to the environment as required, such as providing whiteboards, screens, or other equipment to the school.

Barab and Squire (2004) outline the importance of the connection between design interventions and theory, and the possibility to generate and refine theory (p.5). The outcomes of DBR are highly judged for their usefulness and innovativeness, rather than solely on the rigour of the research process more characteristic in experimental research (Design Based Research Collective (DBRC), 2003, p.6). According to Bakker and van Eerde (2015) DBR is interventionist in nature, but with better ecological validity than randomised control trials (p.15).

For this study key teacher practices were identified from a socio cultural theoretical framework informing the design of the research, which in turn informed the

real life practice of these theories within the context of the use of mobile technology as a teaching tool, in a typical public school environment in Sub Saharan Africa.

Design-based research in previous studies.

Anderson and Shattuck (2012) examined studies using DBR in the context of interventions involving small improvements to design, or introduction of new technologies and practices in classroom or distance learning contexts. In a meta-analysis of ten years of studies examining ICT enhanced learning environments, The Design Based Research Collective identified the particular suitability of DBR for interventions related to educational innovation (DBRC, 2003, p.7). Wang & Hannafin (2005) found that design-based research was a suitable methodological approach for investigation of the integration of ICT into learning. MacDonald (2008) specifically examines the appropriateness of design-based research for examining the effectiveness of community of practice for ICT integration "Design-based research fits very well with a CoP as both are designed to respond to the ever-changing reality of messy educational settings" (p.432).

Anderson and Shattuck (2012) also outline the usefulness of DBR for providing "multiple entry points for various scholarly endeavors" (p. 16). This is important in the context of this research study, with multiple partners with different research interests.

4.3.2 Characteristics of Design Based Research.

Learning in context.

A key characteristic of Design-Based Research is that the research is rooted in the real-word context (Collins, Joseph and Bielaczyc, 2004; DBRC, 2003; Wang and Hannafin, 2005; Bakker and van Eerde, 2015, MacDonald, 2008). DBR focuses on "the ever changing needs of participants"(MacDonald 2008, p.437). It investigates

learning phenomena in real world contexts, examining theoretical questions around learning in context (Collins, Joseph & Bielaczyc, 2004, p.16). DBR is particularly concerned with knowledge creation around "innovative learning environments" (DBRC, 2003, p.5).

This research study is primarily concerned with the context of schools in remote areas, without access to the internet and in some cases electricity, with high pupil teacher ratios and teachers who do not have access to continued professional development. The context is central to the research, and the primary concern of the research design is in its ability to be flexible to the context and continue to develop and re-develop the research to meet the needs of the context. Research materials are generated by teachers while participating in professional development workshops. For example, in the course of learning to use presentation software on the iPads, teachers prepare presentations on the biggest challenges they face in their teaching, feeding into the research process. The study attempted to create an innovative learning environment in this complex setting, a key characteristic of the types of research projects that design-based research is most suited to (DBRC, 2003, p.5).

Progressive refinement of research.

Design-based research works on a principle of cycles of iteration and progressive refinement (Collins, Joseph & Bielaczyc, 2004; Wang & Hannafin, 2005; Bakker & van Eerde, 2015, MacDonald, 2008)). The progressive refinement works at the level of research methods (mixed methods that change according to the emergent needs of the study), the intervention itself (iterative cycles working with participants (Wang & Hannafin, 2005)) and refinements of theory (Collins, Joseph & Bielaczyc, 2004).

Rigorous documentation and reflection on processes.

In order for this research approach to be successful, rigorous documentation of each of these refinements and a continuous process of documented reflection is needed at each stage (Wang and Hannafin, 2005; Bakker and van Eerde, 2015; MacDonald, 2008). Data needs to be analyzed "immediately, continuously, and retrospectively" (Mac Donald, 2008, p.432) and contextual influences need to be documented with design principles (Bakker & van Eerde 2015; Mac Donald, 2008). This leads to each new phase of research where research methods are implemented "systematically and purposefully" (Wang & Hannafin, 2005; MacDonald, 2008).

For this study reflective diaries were kept by the researcher at each stage to document the process of the research and refinements in the teacher workshops (Appendix 3). Notes from meetings and phone conversations (Appendix 4), emails (Appendix 5) and workshop schedules (Appendix 6) and workshop design notes (Appendix 7) were kept, to provide a documentation trail for each phase of research.

Theory informing design and design informing theory.

According to the Design Based Research Collective "design- based researchers' innovations embody specific theoretical claims about teaching and learning, and help us understand the relationships among educational theory, designed artifact, and practice. Design is central in efforts to foster learning, create usable knowledge, and advance theories of learning and teaching in complex settings" (DBRC, 2003, p.5). It is particularly concerned with knowledge creation around "innovative learning environments" (DBRC, 2003, p.5).

Design Based Research places equal emphasis on theory and design; "the design is conceived not just to meet local needs, but to advance a theoretical agenda, to uncover, explore, and confirm theoretical relationships" (Barab & Squire, 2004, p. 5).

However it is a two way relationship and Barab and Squire (2004) continue to propose that if the research advances theory without showing the value of the design on local learning impact, then it is has not demonstrated the value of the theory adequately" (p.6). Similarly, Reeves, Herrington & Oliver (2005) outline the characteristics of a quality DBR study as "a commitment to theory construction and explanation while solving real-world problems" (p. 103).

Bakker and van Eerde (2015) classify theories of learning (DiSessa and Cobb, 2004) into grand theories, orienting frameworks, frameworks for action, domain specific theories and hypothetical learning trajectories, and suggest that DBR is best attached to grand theories or frameworks for action. They also explain that the theoretical development advanced by DBR is usually of a humble but significant nature, comparing it to advances in innovation in airplane design, as opposed to developing theories of aerodynamics (p.15). However, Tibergheien, Vince and Gaidioz (2009) from their work on a specific methodology for science teaching put forward that the types of theories suitable for experimentation with DBR are characterised as "theories that work" rather than grand theories.

For this study, specific teacher practices are parsed from the theory, into a usable and workable theoretical framework, rooted in a socio-cultural activity theory (Engeström, 1999) with reference to creativity and TPACK (Koehler & Mishra, 2009) technology frameworks. Teacher practice (activity) with new technology (tools) are examined in the context of teachers' interactions with other teachers and with their students (community). The theory at work provides a framework for action and for research methodology, examining activities of teachers (the subject) for three specific outcomes: (i) collaborative use of tools to engage learners in participative learning, (ii) creative use of tools to root learning in the real-life context of learners and (iii) teacher

interactions with each other to support continued professional development of teacher practices. The elements are mapped to the processes of design and re-design of the study, and the data collection methods are integrated into the implementation of the intervention across these phases.

Transferability of design.

In addition to the theory generated having to do "real work", it should also be transferable to comparable contexts (Bakker and van Eerde, 2015; p.15). MacDonald outlines the importance of the generalizability of the design being validated as a principle for design-based research into ICT integration (MacDonald, 2008). This study is designed for transferability of method and results to other similar learning contexts in Mozambique and in Sub-Saharan Africa, with similar challenges and constraints, documenting in detail each iteration of design and the impact within this environment.

4.3.3 Critiques of Design Based Research.

The Design Based Research Collective (2003) have highlighted the complications arising from sustained projects and interactions between practitioners and researcher. These include how to hold the researcher accountable in outing their "tacitly held assumptions" and the difficulty in deciphering causality. They highlight the need to use methods that "document processes of enactment", including intended and unintended outcomes. They also point to the difficulty of maintaining productive relationships over a long period of time of highly refined enactment. In order to militate against this, the period of this study covers thirteen months only, and video evidence supports written notes of narrative research, in order to objectively validate findings. The researcher attempted at all stages to be self-reflective in interrogating her relationship with the research process and outcomes.

Collins *et al*. (2004) point out some challenges of design research including; the difficulty of working in real-world environments and the complexity of the data generated, the volume of data generated by design research studies and challenges in comparison across designs. Large volumes of data have been generated over the course of this study, and elements of this data have been examined separately under separate studies. This study is concerned only with the impact of the intervention on teaching practices within the group of participating teachers, however the researcher was also responsible for data sets across the wider study.

4.4 Research Design

4.4.1 Sample selection.

Figure 10: Teaching with iPads in school

The sample was chosen in a multi-stage sampling process by Irish Aid using non-probability samples, in discussion with the researcher. In the first stage the school was chosen by Irish Aid in as a voluntary and convenience sample and also for its typicality in terms of Mozambican public schools; (i) for the willingness of school leaders to be involved in the project (ii) ease of accessibility to Maputo for co-

ordination of teacher professional workshops, technology and school visits and support (iii) for its typicality in terms of size of school, pupil:teacher ratio, progression rates, and achievements in state exams.

In a second stage of sampling, it was initially envisaged that all third-grade classes would participate in the project. However, an unforeseen obstacle arose, as the leader of the project at school level decided that it was impractical for outdoor classes to participate in the project, as children who were waiting for their school shift to begin, began to crowd around the classes using the technology, causing a distraction. At this point it was intended that random sampling would be used to choose five of the nine classes in third grade to participate in the project. All teachers would participate in the same professional development workshops, but only five had access to the technology in their classes. It was intended that the classes without access to the technology, would have be able to use the technology the following year to ensure fairness. While it was requested that these participating classes be selected on a random basis, the participating classes were chosen at school level, based on practical scheduling reasons, over which the researcher had no control, so it is unknown ultimately if there was any bias in the selection of the participating classes and teachers.

4.4.2 Cycles of inquiry.

The intention of DBR in education is to refine predictive theories of learning, whereby a model of innovation can be created through work models rather than specific artifacts or programmes (The Design-Based Research Collective, 2003; Brown & Campione, 1996). Bannan-Ritland (2003) proposes a framework to provide a broad context within which to map the design-based research process containing four broad

phases: informed exploration, enactment, evaluation of local impact and evaluation of broader impact. The enactment phase happens over a number of iterations, as does the evaluation over a number of phases of formative and summative evaluation. Phases of exploration, enactment and evaluation of local impact took place on this study, but practical limitations have restricted the ability of the researcher to evaluate the broader impact of the study. The phase of exploration took place from April to August 2015. The phases of enactment and evaluation were concurrent and took place over four visits to Mozambique from August 2015 to August 2016.

4.5 Data Collection

Design Based Research uses and triangulates multiple sources of and types of research data examining intended and unintended outcomes of the processes of intervention (Design-Based Research Collective, 2003). There is strong emphasis in DBR on methods that document the processes of enactment as critical to explaining why changes occur (Collins *et al*., 2004; Design-Based Research Collective, 2003). Rich descriptions of contexts, challenges, reasons for modifications lead to design principles (Anderson and Shattuck, 2012).

The methods used for this study are: (i) observation - video footage of group discussions (also transcribed and translated), micro-teaching sessions during teacher workshops and some classroom observation (event triggered) (Appendices 8,9,10) (ii) document analysis - researcher and participant generated including notes from meetings, phone calls and emails, workshop design notes and schedules, field notes from school visit (Appendices 4,5,6,7,11) (iii) survey – two short surveys were distributed – one to establish the challenges faced by teachers, and the second to measure community of practice events in the school (Appendices 12,13) (iv) diary –

researcher reflexive diary, used for triangulation, particularly in situations when video

was not recorded and a significant event occurred (Appendix 3).

4.5.1 Phases of research.

Phase	Implementation	Research Method	Iteration
Phase 1	-Needs Assessment -Consent -Teacher workshop 1 -Fieldtrip to school 1	(i)Observation: group discussions, micro-teaching, school visit. (ii)Document: meetings notes, workshop schedules (iii)Survey on classroom contexts. (iv)Diary: researcher reflexive diary	-Needs assessment in local context. -Introduction to technology workshop.
Phase 2	-Meetings -Teacher workshop 2 -Fieldtrip to school 2	(i)Observation: group discussions, micro-teaching, school visit. (ii)Document: meetings notes, workshop schedules. (iv)Diary: researcher reflexive diary	-Focus on class planning and integration of local examples in lessons. -Focus on building community of practice.
Phase 3	-Meetings -Teacher workshop 3	(i)Observation: group discussions, micro-teaching. (ii)Document: meetings notes, workshop schedules (iii)Survey on community of practice events. (iv)Diary: researcher reflexive diary	-Focus on developing more creative practice with technology. -Focus on more collaborative teaching practice with technology. -Focus on community of practice continuity.

Table 3: Phases of research and research methods.

Phase 1: exploration, needs assessment, teacher workshop 1, school visit 1.

This involved an initial meeting with Irish Aid and follow up email

correspondence and phone calls. During this phase sampling, needs assessment,

professional development design and technology design were completed. Detailed

notes and research narrative were recorded for all events. Before the project

commenced participants were sent information on the project, outlining their roles as

expert-becoming participants on the use of the technology in their particular context, and that their participation on the project would lead to new knowledge development that can be re-applied to other similar contexts. Participants were free to agree or refuse to be part of this process, while a refusal would not exclude them from continuing to use the technology.

The first professional development workshop occurred during this phase – a five-day workshop. The emphasis during this workshop was to introduce the technology, allow participants to become comfortable with the technology, introduce different ways in which it can be used for teaching and during the course of this workshop, to get a deeper sense of participants' requirements from the project and implications for practical implementation. During the course of the workshop data was collected through video recordings of group discussions, micro-teaching sessions. Documents preserved included notes from meetings with team, workshop schedule, tutor notes for workshops, notes from participants on their biggest professional challenges, and a short survey establishing information on the context in which teachers were teaching (class sizes, resources etc.). A reflective diary was kept by the researcher, at the end of each workshop day and other significant event. Detailed notes were recorded for all events.

Following this workshop, technology was deployed to the school. A follow up field trip to the school took place, where a classroom observation took place and meetings with the director of pedagogy in the school.

Phase 2: evaluation, troubleshooting, teacher workshop 2, school visit 2.

During this phase the second teacher professional development workshop took place and an additional visit to the school. Again, the researcher video recorded micro-teaching and group discussions, and documentation of all events were collected.

Evaluation and update meetings took place with the wider team: researcher, teacher tutor, school leaders, Ministry for Education officials and Irish Aid team. Detailed notes were recorded for all events.

Phase 3: evaluation, troubleshooting, teacher workshop 3.

During this phase further data was collected during the final teacher workshop through group discussions, video data and a short survey on community of practice events at the school. Evaluation and update meetings took place with the wider team. Detailed notes were recorded for all events. The final literacy measure was taken in the school at the end of the pilot phase.

4.5.2 Research methods.

Observation (video recordings)

Observation was used as the main data source for documenting changes in teaching practice over the course of the study. Over the course of thirteen months, three teacher workshops, ranging from three days long to five days long took place. While the primary aim of these workshops, was teacher professional development, research methods were embedded in the workshops in the form of discussion groups, teacher presentations, and teacher micro-teaching demonstrations. Observation was used in four different ways across all phases of the research.

(i) The teacher discussions focused on issues of challenge for the teachers, and potential solutions, with a view to progressive refinement of the intervention, and constant adaptation of the intervention and of the research to the needs of the participant teachers. Progress achieved, obstacles to progress and impact of the project on students and teachers were returned to

at the start of the second and third teacher workshops. These discussions were video recorded (Appendix 8)

(ii)   Teachers were asked to make presentations with the iPads, as part of the workshops in learning how to use the technology, while also outlining issues of most challenge and concern to them. These were recorded as an important data source for the exploratory phase of the research, in finding out exactly what was needed by these teachers in the challenging contexts they were working within, and participants provided further hand written notes in relation to challenges, strengths and opportunities in later workshops also (Appendices 9 & 14).

(iii)   Teachers were asked to do micro-teaching demonstrations with the technology as they learned to work on new applications or learned new techniques and skills with the technology. These micro-teaching sessions were recorded and provided evidence of the changes on teachers' teaching practice with the technology over the course of the study (Appendix 9).

(iv)   On two school visits, teachers were recorded by the researcher teaching in their classroom in the school. Field notes were also written separately for these visits, as not all aspects of the visit could be video recorded (Appendix 11).

Consent was obtained from participants for all photographs and video recordings and an explanation provided for why photographs or recordings were taken, and how they would be used to improve the project for this context and others. The researcher set up and ran the video recorder in all observation situations, taking the place of a marginal participant (Robson, 1993), at times discussing elements of the workshops with the teacher tutor, answering questions to do with logistics and organisation when required, chatting with participants and partners during tea breaks.

Distance was possible because of a certain degree of language barrier, and over time the participants became used to the video running in the background and paid it very little attention.

Video recordings were necessary for language reasons as the researcher would not have been able to ascertain how language was being used in micro-teaching, presentations or group discussions without transcription and translation at a later point for data analysis. Photos were taken of the environment and teachers working with technology to illustrate context, and photos were also taken extensively of digital artifacts created by teachers, as transfer of data between devices proved problematic without wifi. All of these video recordings are photos were used as research data. The use of these was explained clearly to participants before they were provided with consent forms for signature.

Documents.

Documents generated and recorded during the research process included: (i) detailed notes from meetings (Appendix 4) (ii) copies of email correspondence (Appendix 5) (iii) workshop schedules (Appendix 6) (v) tutor notes (Appendix 7) (vi) participant written responses (Appendix 14).

These documents formed the basis for the rigorous documentation of each phase of the research and informing each new iteration of the project stage (Wang and Hannafin, 2005; Bakker and van Eerde, 2015; MacDonald, 2008). The documents also formed a source of triangulation in the research narrative, where specific events and developments could be tracked retrospectively through the documentation trail (Bowen, 2009).

Surveys.

Two short surveys were administered. The aim of the first survey (Appendix

12) was to ascertain the teaching conditions in the school, class sizes, resources in classroom etc. as well as to ask what the teachers perceived as their biggest challenges in teaching. They were also asked for their perceptions on how the technology might benefit their teaching. The second survey (Appendix 13) asked about community of practice events that occurred in the school between the second and third teacher workshops, namely: the extent and nature of sharing and re-use of digital lessons between participant teachers.

A longer questionnaire was designed to examine the change in teachers attitudes towards collaborative and creative teaching practices. However, attempts to get the questionnaire approved by partners in advance of the last workshop when it was to be administered failed. There were concerns that getting approval for and administering the questionnaire would take too much time, and that it wasn't of benefit to the immediate aims of the wider project in terms of improving learning outcomes for Portuguese language. For this reason, the questionnaire was not administered.

Researcher reflective diary.

The researcher kept a reflective diary during all stages of research and after each day of teacher workshops and school visits (Appendix 3). The researcher's diary, as with documents, was used to feed into the overall research narrative. It is used as a source of triangulation for observation data, particularly when a significant event occurred when the video camera was not recording, or for more informal events such as during tea break discussions etc. The researcher also recorded some impressions on power dynamics within the group and how it impacted teacher participation in group discussions or other activities.

4.5.3 Research methods framework.

The framework mapping the four identified teaching practices from the theoretical framework for the research study mapped against the corresponding research methods;

Aspects of Teaching for Examination	Research Method	Data Sources
1. Collaborative practices in the classroom, specifically: (i) use of interactive exercises (ii)use of group work, (iii)use of open questions	(i)Observation: group discussions, micro-teaching, school visit. (ii)Document: meetings notes, workshop schedules (iii)Survey on classroom contexts. (iv)Diary: researcher reflexive diary	-Group discussions x 3 -Micro-teaching & teacher presentation video recordings (over 3 workshops) -Field Notes school visit x 2 -Documents; workshop schedules, emails, notes, participant notes -Digital artifacts: digital lessons -Survey on teaching context -Researcher reflective diary
2. Creative teaching and learning practices specifically: (i)creating new artifacts with technology (ii) integrating local examples into lessons with technology	(i)Observation: group discussions, micro-teaching, school visit. (ii)Document: meetings notes, workshop schedules. (iv)Diary: researcher reflexive diary	-Group discussions x 3 -Micro-teaching & teacher presentation video recordings (over 3 workshops) -Field notes school visit x 2 -Documents; workshop schedules, emails, notes, participant notes -Digital artifacts: digital lessons -Researcher reflective diary
3. Community of Practice events, specifically: (i)sharing and re-use of digital content (ii) events where knowledge or experience is shared between teachers, whether formal or informal.	(i)Observation: group discussions, micro-teaching. (ii)Document: meetings notes, workshop schedules (iii)Survey on community of practice events. (iv)Diary: researcher reflexive diary	-Group Discussions x 3 -Field notes school visit x 2 -Documents; workshop schedules, emails, notes, class plans, participant notes -Survey on community of practice events -Researcher reflective diary

Table 4: Research Framework

4.6 Data Analysis

4.6.1 Coding/identifying themes.

Data analysis occurred during and immediately after each research phase, which included video recordings and documents being transcribed, translated and read. Progress reports were written up at the end of each stage, and next phase iterations

developed in collaboration with the other research partners. Overarching themes and patterns emerged from the research, which progressively refined both the intervention and how it was handled, and the research questions and aims. Some original aims of the research emerged as too ambitious early in the research, such as the more creative and interactive elements of lesson design but were easily integrated in later stages of the research as participants became more fluent in the use of the technology.

Transcription and translation.

All the video recordings of discussion groups were transcribed and translated by a native Portuguese speaker for the first two phases. By the third phase the transcriptions and translations were originally done by the researcher and cross-checked by the translator. This provided the researcher with a more direct first-hand knowledge of the video data. Additionally, during the group discussions and workshops, by the later visits, the researcher broadly understood contemporaneously what was being discussed and was able to ask questions for clarity as required.

Occasionally the quality of video recordings was not optimal. Some of the teacher workshops took place in very noisy environments with vehicles outside, an exceptionally squeaky door that couldn't be closed, a particularly loud rooster, a local Mosque calling to prayer and of course in the workshops set in the school, hundreds of children playing outside during break-time. This inevitably affected the sound quality occasionally, and some fragments of the audio were not audible, despite multiple attempts to re-play and decipher.

Additionally, on occasion the video stopped to save battery or memory or when the researcher had to be involved in other organizational or project management tasks. While data in these cases in not entirely complete, the researcher always attempted to cross check with the teacher tutor at the end of each day in case any important issues

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were missed or mis-understood.

NVivo.

The data was initially analysed by hand by the researcher, so that overarching themes and patterns could be identified. NVivo was then used for organizing the data for ease of reference when moving between different elements of the data, and for easily accessing raw data that had already been analysed and coded. NVivo was not used as the primary analysis tool as it would have been easy for over-arching themes to be missed. However, it was a very useful tool for ease of referencing and access to data, as well as for cross-checking data to ensure none was missed.

4.6.2 Application of data.

Group discussions.

Group discussions were transcribed, translated, cross-checked by a second translator and analysed and coded initially by hand, and then additionally through NVivo. Group discussions formed an important component of the data, informing the overarching themes and development of the research. These discussions were valuable initially in identifying context and areas of challenge in the early implementation phase, and as the project developed, the discussions were the primary tool for identifying obstacles, areas for development and emergent themes on the impact of the intervention such as changes in teacher attitudes and practice. These themes were then triangulated using documents, surveys and the researcher's reflective diary.

Micro-teaching and teacher presentations.

Field notes were written up from the video recordings of the teachers' micro-teaching and presentations, providing a description of action, use of technology, interaction with 'class' and dialogue during these events and including researcher

reflections. These sessions were the primary source of data for changes in teacher practice and in demonstrating the digital artifacts created by teachers in the context of live teaching. Triangulation was provided on this data by documents such as class plans, progress reports from the school, researcher reflective diary.

Documents.

The documents are used occasionally as raw data (eg. class plans and progress reports) as well as for triangulation of observation data.

Surveys.

These short surveys were used to verify data reported during meetings and group discussions on the teaching conditions at the school, and on community of practice events at the school. Care was taken with these surveys to be culturally sensitive. Additionally, the surveys had to be short and take no more than a few minutes away from the teacher workshop schedule. Their purpose was triangulation and further detailing of information provided during group discussion.

Field notes.

Field notes were written up after each of two visits to the school, when it was not practical or appropriate to video record the full tour of the school. They provided further impressions of the school context and information on how teachers worked within that context, eg. timetables, issues around school shifts, school resources etc. These field notes were then coded and analysed with the rest of the written data.

Researcher's reflective diary.

This was used as a raw data source only in instances where a significant event occurred, such as in some of the more informal discussions, that was not video recorded or included in other documents.

4.6.3 Issues of sampling in data analysis.

Originally all third grade teachers in the school were to be included in the research, which would have included ten teachers in all. However, unforeseen issues emerged with this, as the school leaders decided that only one classroom was suitable for use with the technology. This was because only one classroom had windows and doors, and could therefore be closed off from children who were waiting outside for their school shift to begin. Scheduling of the use of this classroom was done by the director of pedagogy in the school, and selection of teachers for inclusion on the schedule was outside the control of the researcher, even though it was reported that this selection was done randomly. To counteract all teachers being unable to use the technology, all third grade teachers were included for the teacher professional development workshops, and learned to use the technology with a view to further classrooms being opened up for use with the technology at a later scaling up stage of the project.

All teachers who participated in the teacher workshops were included in the group discussions and in the teacher micro-teaching and presentations. When relevant, their contributions in these events was used in the data.

The director of pedagogy of the school was initially a non-teaching leader of the project at school level. By the third phase of the project, he had resigned from his role as director of pedagogy, and reverted to teaching. His contributions to discussions, micro-teaching sessions, and meetings are used widely in the data.

Sadly, two deaths occurred in the core group over the course of the research period. The first death was of the original teacher tutor NMS. The second death was of one of the core group of participating teachers, Marlon. His contributions are included

widely in the teacher discussions and micro-teaching sessions.

4.7 Researcher Objectivity

Barab and Squire (2004) argued that "if a researcher is intimately involved in the conceptualization, design, development, implementation, and researching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge" (p. 10). It is then the responsibility of the researcher to use practices consistent with qualitative methods to ensure the trustworthiness and credibility of findings (Barab & Squire, 2004). The DBRC argue that objectivity, reliability and validity are all present in good DBR research, but need to be managed differently to in controlled experimentation, relying on techniques used in other research approaches; "thick descriptive datasets, systematic analysis of data with carefully defined measures, and consensus building within the field around interpretations of data" (DBRC, 2003, p.7). Good research demands "skepticism, commitment and detachment" (Norris, 1997), but DBR also requires comradeship, enthusiasm, and a willingness to actively support the intervention. Thus, a certain wisdom is needed to walk this narrow line between objectivity and bias (Anderson & Shattuck, 2012).

In order to offset this potential for bias, all data that has been used in the final analysis is data that is supported by original documentation or video footage. Where any question occurred about the interpretation of video data, a second opinion was sought from a native Portuguese speaker who aided in the translation and interpretation of the data. Where impact on teacher practice was examined, only practices that are visible on video data were included.

4.8 Reflexivity

Participants were provided with information about the project in advance, setting their place as experts in identification of the challenges at hand and in working together with the researcher through some possible solutions (Appendix 15). The project was presented from the outset to the participants in its international and research context, as a field for exploration with the participant teachers as "co-generators of knowledge" (Chambers, 2012). However, even with all best attempts to democratise the relationship between researcher and researched, a power balance remained and integrity in the portrayal of this was sought.

Transparent reflexivity through all phases of the design, implementation and dissemination of this research study was critical to the integrity of the study. The study was funded by Irish Aid, who is a significant donor to the Ministry for Education in Mozambique. Expensive technology was introduced into an environment where there are not many material resources, as part of the research intervention. The researcher was clearly an outsider in this community in every respect; nationality, social and educational status, first language, even living in a different hemisphere. While the researcher was the manager and principal researcher on the project, she was clearly an outsider in the community.

The researcher's role was to guide an iterative research process. The researcher attempted to integrate partner and participant goals into the research and to ascertain at each stage what was most useful for the participants. The researcher aimed to be self-reflective in any possible biases in a desire for a successful intervention. Lather's guiding principle is important in this regard; "It is not a matter of looking harder or more closely, but of seeing what frames our seeing – spaces of constructed visibility and incitements to see which constitute power/knowledge" (Lather, 1993, p. 675).

Because of the embeddedness of the researcher in the teacher workshops

throughout the process, vigilance on the part of the researcher had to be maintained to prevent false promises, unrealistic expectations or falsely positive portrayal of complex realities. Reflexivity in itself, does not absolve the discomfort of these difficult realities, but staying within Pillow's "uncomfortable reflexivity" is the only viable path; "a reflexivity that seeks to know while at the same time situates this knowing as tenuous" (Pillow, 2003, p.188).

This insider-outsider dilemma was a constant balancing process on the part of the researcher, fulfilling a role in leading the project with the best intentions for the outcomes, the participants and colleagues, while attempting to retain an objectivity from the outcomes in terms of the research process. The researcher kept a reflective journal over the course of the research design and implementation, with a particular consciousness around these difficult realities and attempting to deconstruct the frames around the seeing (Lather, 1993), particularly in relation to maintaining a stance of "unknowability" (Foucault, 1982) of the lived reality of the research participants and clarity around her "outsider" status. Additionally, the researcher's job role changed during the third year of this study, and she ceased her role as manager of this project, which allowed for a more objective stance and ability to be distanced from the results of the study.

Power and Empowerment.

Shor (1992) argues that the introduction of a critical discourse and participative practices in education can have a contagious effect that can lead to societal change. While the scope of this research project will not examine societal change issues, it will aim to influence teachers using a more participatory approach in the classroom by means of the technology, as well as creating a community of learning within the teaching community around use of the technology. These measures potentially have an inherent capacity for empowerment, both of teachers and of learners, and aspects and

elements of power and empowerment are noted over the course of the research.

It is not within the scope of this research to examine power relations in a full ethnographical context. However, there have been occasions when power relations had an impact on decisions related to the research. For this reason, power relations could not be ignored in the context of a thick data description. However, any analysis of power relations in the context of this research project is set within an awareness that while certain power relations and imbalances of power can be observed, as an outsider, it is not possible to understand the full complexity of the power relations at play, either on a structural level or at the level of any other currencies of power. Additionally, it is not possible to be fully aware of the researcher's impact on the power dynamics in the field of study. However, the researcher has attempted to be self-aware of the possible pitfalls in creating any unintended additional power imbalances or forms of oppression through the process of the research itself. Foucault's (1982) core definition of power as action upon the action of others provided a guiding framework for tracking research actions, and their intended and unintended impacts and outcomes. The research aimed to provide the participants with the tools that may offer empowerment through transformative action, while also aspiring to be an honest conduit of participants experience of that process.

Researcher Researched Power Balance.

Prosser and Loxley (2008) discuss the range of researcher choices in the use of participant generated data and to what degree the participant is embedded in the research decision-making process:

> It can be argued that their degree of 'embeddedness' is as much a function of the researcher's political and philosophical orientation towards the whole process of research, as well as participants' willingness to engage in this activity. The range and depth of participation will logically impact across all

aspects of the research process. (Prosser and Loxley, 2008, p. 18)

While it is the researcher's intention to encourage full 'embeddedness' of the participants in the research process, invoking their expertise as the only true knowers of their own challenging teaching environment, there are many potential barriers to participants feeling free enough to do this. Moletsane *et al*. (2009) highlights power dynamics, not just at the level of researcher and participant, but additionally between participants, and particularly between "women participants and the male gatekeepers in the community" (p.328). This has been particularly relevant in this research, as the female participants in the study (apart from one older female teacher) were reluctant to contribute to group discussions, speaking in very low and difficult to hear voices and self-conscious and shy in presentations. The dynamic of group discussion was also affected when outsiders such as Ministry for Education officials were present. In these situations, the school leaders spent extra time explaining the implementation of the project at school level in a positive tone, while other teachers were more reserved in expressing their opinions. It was important however to include these officials in the workshops, for political reasons.

While there are no easy answers to where the researcher and participants sit in relation to each other, an iterative design approach allowed flexibility in adapting to what is possible culturally, politically and practically along the spectrum of participative research practices and power sharing in the research process. This is balanced with responsibility to represent the issues without causing any follow-on difficulties for participants or others involved or inadvertently affected by the outcomes. The nature of the design-based research approach is that formative evaluation of the process with participants occurred at regular intervals throughout the research design and implementation. These took the form of group discussions and feedback, and examination of participant work. These processes fed back into the re-

design phases of implementation.

Hawthorne Effect and Pygmalian Effect.

As discussed earlier, power imbalances were significant between the researcher and the research participants. The researcher had access to political influencers, expensive technology and the ability to promote the project for further investment. Other issues affecting the power balance, and outside of the control of the researcher included the provision of valuable per diems for the research participants, creating additional factors of complexity. Additionally, important officials from the Ministry for Education were frequently present at the teacher workshops as observers. As a result, the researcher was keenly aware that the school leaders and the research participants naturally wanted to give a positive impression of their work and the school. The Hawthorne effect is the impact of the knowledge of being a research participant has on participant behavior (McCambridge, Witten & Elbourne, 2014). Participants in this study knew that the possible success of this project could have further positive impact for the school and perhaps even for their future careers. Similarly, the researcher retained an awareness that teachers' advancements in uses of participative and creative pedagogies as well as advances in their dialogue with each other about their practice may have been influenced by a Pygmalian Effect (Rosenthal 1987, 1994), an interpersonal expectancy effect, whereby the positive attention and expectations of the teacher tutor and researcher may have in itself led to an improved performance on the part of teachers.

The researcher attempted to be aware of this in the interpretation of the data, and it was noted that the power imbalance on occasion may have influenced this Hawthorne Effect bias on the part of the participants. This emerged particularly in

relation to the reporting of community of practice events both in the discussion groups and in the surveys. There was some evidence in the contradictions of these reports that participants may have been attempting to give a more positive representation of how teachers worked together outside the scope of the teacher workshops than was actually the case.

4.9 Ethics

In advance of the intervention teachers were sent information about the project and their role as local educational experts in the research. Participants were informed that content created was to be used as part of the research process (Appendix 15). Many elements of the workshops and brainstorming sessions were filmed by the researcher. It was made clear to the participants that visual recordings are watched only by the researcher, translator and tutor if necessary, and not by anyone else internal or external to the school community, unless by request from the participants themselves.

There was a discussion during the first workshop on ethics in relation to the participants taking, storing and presenting of photographs of any other subjects, or any other material that may be used as part of the research process.

Situated Ethics.

The researcher received ethical consent from both TCD and IADT ethics committees (Appendix 16). Working with partners, informed consent was obtained from all participants, ensuring confidentiality and anonymity of participants as well as transparency in the representation of research. Consent was also obtained from guardians of children for the use of photographs related to the research and any promotional activities around the larger engagement between the school and Irish Aid.

Photographs were used only to illustrate context, use of the technology in a

teaching context or the digital artifacts created by teachers. Pseudonyms of participant teachers are used throughout the thesis and where a teacher features in a photograph, they are not identified by pseudonym, and therefore not identifiable in the text. The school is also given a pseudonym, and the exact location is not identified. As the school is similar to many others in the locality, it cannot be identified in the text, and no uniquely identifying aspects have been photographed in relation to the school.

While decisions were made on a partnership basis, the researcher ownership and responsibility for ethical decisions related to the research; "it is the responsibility of researchers to anticipate the direct and indirect consequences of participatory projects, and to mediate the negative impact of such consequences through project activities that are explicitly ethical" (Moletsane *et al.*, 2008, p. 328). Over the course of the study situations changed, the changing role of the researcher and the director of pedagogy of the school, and the tragic death of the teacher tutor and one of the core teacher participants. As each situation arose, requiring decisions with ethical consequences, discussions were had with the wider group, at all times attempting to make decisions within a transparent and ethical framework. Furthermore, any conversations or events that took place, whether video recorded or not, deemed to be confidential did not feature in the research in any form or reference. There were no such conversations or events video recorded, but had they been, the recording would have been destroyed.

In writing up research findings, Derrida's (1995) philosophy of the un-knowability of the other must remain a guiding principle, as in this situation an outside researcher cannot possibly pretend to truly know the reality of the daily challenges of those teaching under such testing conditions. In practice this has meant listening to what teachers had to say about their challenges and needs, and what would be useful for them, while not pretending to know the problems or offer the solutions.

4.10 Chapter Summary

A design-based research methodology was used to examine the impact of mobile technology and professional development workshops on teacher practices in the real-life context of a large public school in Mozambique. Ethnographical methods such as observation and video footage were used. Digital artifacts, documents and short surveys were used for triangulation. The researcher took the role of outsider-participant, keeping a reflective diary to document perceptions, attempting at all times to identify bias in perception and acknowledge aspects of 'unknowability' in the research.

5.0 Findings and Discussion: Collaborative Practices in Teaching with Technology

Interaction, collaboration and participation are at the heart of a socio-cultural model of learning. The participative classroom, interactive teaching, dialogic pedagogy, dialogic spaces are all terms to be found in the literature, focusing on a model of learning involving activity in social contexts. Using an activity theory as a framework for designing a learning environment requires focusing on activities of participants in relation to the tools they use, the social relationships within the context, and the objects of those activities. The starting point for change is the environment in which the teacher works, rather than the knowledge of the teacher (Jonassen, Rohrer-Murphy, 1999). Pedagogical change needs to occur in 'small steps' that recognise adjustments that teachers can make themselves within their environments, whilst also recognising the need for wider change (Sriprakash, 2010; Johnson, Hodges & Monk, 2000). In analysing changes to the objects of activity, attention is paid firstly 'to broad patterns of activity' (Jonassen & Rohrer-Murphy, 1999).

With this in mind, small measurable activities have been extrapolated from the literature, keeping in mind the feasibility of these actions within the context, and formulated into the research question that relates to collaborative practices; how does the introduction of mobile technology for teachers, supported by a programme of professional development workshops for teachers impact on teachers use of collaborative teaching practices, namely (i) use of group work (ii) use of open questions (iii) use of interactive exercises.

5.1 Collaborative Learning Practices in Development Context

The range of terms included for comparative studies on collaborative teaching practice included Freire's (2000) dialogic pedagogy, Vygotsky's (1978) activity theory and Engestrom's (1999) socio-cultural activity theory, social constructivist theories, or more broadly learner-centred or child-centred pedagogy. Learner-centred pedagogy appears frequently in the literature from recent decades related to the concept of 'quality' education in the sustainable development goals and education in the context of the developing world, with an emphasis on dialogic pedagogy and group work, both of which fit with the collaborative practices examined for this study.

The importance of a contextual understanding of educational change has been highlighted by a number of researchers working in different developing country contexts (Vavrus, 2009; Sriprakash, 2010; Abd-Kadir & Hardman, 2007; Mtika & Gates, 2010; Chisholm & Leyendecker, 2008) and others have warned of the dangers of transporting western/northern models of educational change into a development context (Sriprakash, 2010; Johnson *et al*., 2000; Tabulawa, 1997). While learner-centred pedagogies are promoted by many aid agencies working in development contexts, the difficulties of implementing a dialogic, social constructivist, or learner-centred pedagogy in typical Sub-Sahara African contexts are well documented (Abd-Kadir and Hardman, 2007; Chisholm & Leyendecker, 2008, Mtika & Gates, 2010). Large class sizes are a significant challenge to a dialogic pedagogy, with student centred methodologies become increasingly difficult to implement as class sizes get greater than fifty (O'Sullivan, 2006; Lewin, 2000). In this study the participant teachers all had class sizes greater than fifty students.

Teachers already had some familiarity with the concept of dialogic pedagogy. In particular, the director of pedagogy spoke at length to the teachers about how the iPads could be used in a Freirian approach integrating the reality of the children's lives and using dialogic approaches and group work. However, while there was some awareness

of the theoretical concepts, there was confusion expressed about the application of these concepts in the context of large class sizes. Johnson *et al*. (2000) point out that it is not a question of teacher knowledge of different pedagogical practices that is preventing new practices to develop, but rather the constraints of their classroom environments (Johnson *et al*., 2000).

Other researchers have also pointed out the difficulties of context for the application of dialogic teaching in practice. Mtika and Gates (2010) have pointed to the need to reconsider the pressure put on student teachers to use learner-centred practices in "hostile" school cultures, within "rigid" national curriculum requirements, while Vavrus (2009) calls for teachers to be commended for recognising the limitations of teaching practices that are not useful in the context. An implementation approach that accounts for contextual constraints and cultures is therefore required, which allows for a wider ranging approach for 'excellent teaching' (Vavrus, 2009; Sriprakash, 2010). Other studies provide a model for pedagogical change through 'small steps' that recognise adjustments that teachers can make themselves within their environments, whilst also recognising the need for wider change (Sriprakash, 2010; Johnson *et al*., 2000), with a starting point as the environment in which the teacher works, rather than the knowledge they possess (Johnson *et al*., 2000).

In this study, the introduction of collaborative teaching practices with the technology used a step-by-step practical approach, providing examples of class plans that could be created easily on the iPad, that provided a suitable fit with the curriculum and the level of interaction that was realistic under the teaching conditions.

5.2 Instigating Collaborative Teaching Practices with Technology

Phase 1 of the project involved several phone calls and emails with the Irish Embassy in Mozambique and in particular the education advisor there, who had deep

knowledge of the educational context in Mozambique for many years. In collaboration and discussion with her, and the Apple certified professional development tutor NMS, it was agreed that the first workshop would focus on the basic functionality of the iPads, and of three applications; Keynote (basic presentation application similar to Powerpoint), Explain Everything (interactive whiteboard application) and Book Creator (interactive book publishing application). The focus of the first teacher workshop was on the technology itself, rather than on changing teaching practice, so as to reduce any potential sense of threat or additional pressure for the teachers.

In the first workshop time was allowed for a group discussion, so that teachers could explain what their challenges were, and what they believed would most help them. Additionally, several opportunities for micro-teaching sessions with the technology were allowed in the workshops, which provided the opportunity to observe teaching style, and the type of communication and participation encouraged by teachers with their students. It also provided an opportunity to explore how changes to teaching practice could be introduced into the workshops in a way that naturally embedded with the use of the technology.

During Phase 2 of the project, a new teacher tutor was introduced to the project, JC. JC had worked as a lecturer and director in a teacher education academy in Portugal, and had many ideas on how a more collaborative approach could be introduced to the teachers, as well as some strategies for group work that might be suitable for large classes. Before the teacher workshops in February, a strategy was discussed and agreed with the education specialist in the Irish Embassy in Mozambique, the two Ministry for Education advisors who were attending the workshop, and two representatives from the local teacher training institute. It was decided that a half-day session would focus on enabling the teachers to design classes that would encourage a participative approach and some group work exercises, as well

as providing a template on the iPads for class planning. There was also an opportunity

for JC to demonstrate teaching a class with the technology, in the school with the

children, particularly focusing on how the children could be encouraged to participate

in the lesson, or work in groups.

Figure 11: Teacher tutor in the school

In the third phase of research, teachers demonstrated new lessons they had

developed and used in their classes. All of the teachers demonstrated at least two of the

forms of collaborative practice set out in the research questions without having been

specifically instructed to do so: (i) use of interactive exercises (ii) use of group work

(ii) use of open questions.

5.3 Teachers' Use of Interactive Exercises Findings

The interactive functions of the applications being used by teachers included;

drag and drop, hide and reveal, highlighting, spotlighting, animation, annotation,

storage and retrieval, integration of photos and videos, text and handwriting functions.

This afforded the teachers to design lessons with interactive features such as moving

and matching text to pictures, clustering vocabulary or pictures into groups, or students

handwriting labels or other text into the iPad.
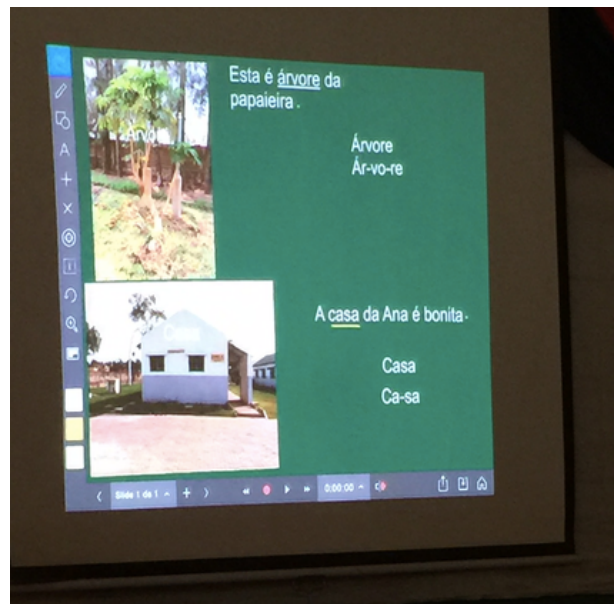
Figure 12: Example of interactive lesson created with picures taken in grounds of teacher training institute during first teacher workshop.

In phase 1 teachers very effectively used the technology in the first teacher workshops to integrate pictures and text. Towards the end of the week, following specific examples provided, teachers began to create lessons with elements of interactivity. Examples of this included creating lessons where text could be moved on the screen to change the sequence of a sentence, or to match pictures. In one sample lesson on living and non-living beings, the teacher had taken or imported several photographs of living and non-living beings. She then split the screen so that photos could be moved into the correct category.

The workshop during the phase 2 was shorter in duration and focused largely on the use of class planning on the iPads. Further examples of interactive exercises and tools were provided that could be used in literacy classes with the children. The teachers designed lessons with interactive elements in each lesson as appropriate to the class size, the space and time available.

By phase 3, in all of the micro teaching sessions, teachers created lessons that invited interaction from the whole class, individual students or groups of students. All of the sample lessons contained interactive exercises. These included matching pictures

to text, grouping elements of text for chronology, category or meaning, or finding

further examples to match lesson topic. In these micro-teaching sessions, teachers

invited individual "students" to the iPad, or requested "students" to work in groups.

Whole class responses to interactive exercises were also requested.

5.3.1 Teachers' Use of Interactive Exercises Discussion.

Northcote, Mildenhall, Marshall and Swan (2010) identified three types of

interactivity; technical (with the technology), physical (children come forward to

interact, demonstrate, present) and conceptual (constructing understanding together),

while Sundberg, Spante & Stenlunc (2011) propose technical interactivity and

pedagogical interactivity. In Redman and Vincent's (2014) study, teachers frequently

absented themselves and allowed students control of the board, allowing children to

present to their peers. Hennessy *et al*. (2007) used Rogoff's (1991) framework of

'guided participation' for breaking the task down into manageable steps so that the

child gradually increased their participation and responsibility for carrying out

activities. Whole class interaction was used with teachers and children negotiating a

shared understanding of the rules and expectations for sharing ideas and discussion.

Figure 13: Teacher tutor inviting children to interact with technology in a whole class
approach

Teachers worked with varying degrees of inviting children to the board, depending on their approaches (Hennessy *et al.*, 2007). Similarly, over the course of this study, as teachers became more comfortable teaching with the technology, they increasingly successfully integrated practices of inviting individual and whole class interaction with the lessons and using digital lessons as a catalyst to invite deeper discussion of the material. In phase 3, Jaque created a lesson on cultural diversity, integrating photos reflective of the many different cultural identities of Mozambique into an interactive digital lesson. He used the digital lesson to leverage a discussion on the children's understanding of the concepts of culture and cultural identity.

Jewitt, Moss and Cardini (2007) caution that inviting pupils to interact with the technology can become mundane and will not necessarily enhance learning unless it is orchestrated carefully. Chuang, Shen & Wang (2008) on the other hand have found that the learning benefits to be gained from the interactive whiteboard are very dependent on the level of interactivity from students on the board directly. In this study, teachers reported enhanced participation and motivation in students as a result of their interactions with the technology.

5.4 Teachers Use of Group Work in Classes Findings

This section discusses how teachers used group work in classes as evidenced by the data: group discussion, video recordings, field notes, micro-teaching observation and reflective diary.

a) Group work was not a feature of teachers' work in Phase 1.

In the first phase of the project, group work did not feature for the teachers. In the initial group discussion, none of the teachers mentioned use of group work in the

classroom. In the field trip to the school in October 2015, there was no evidence of group work being used in the school or by the teachers participating on the project.

b) Group work was introduced in Phase 2 in class planning activities

At the start of the second phase of research it was discussed how group work could be introduced as a concept for the teachers. As teachers were particularly concerned about space constraints in the room where they were teaching, and the time constraints of 45-minute classes, the researcher and teacher tutor JC, agreed to provide concrete examples of how group work could be introduced, taking into account the reality of the space and time constraints teachers were working within. Examples included getting children to work in groups during class time to answer open questions related to lesson topics or to complete tasks where they related their learning to their local environment for example.

Figure 14: Teacher tutor and teacher coteaching

JC had some very interesting ideas about working with the classroom space and groups and wanted to explore how children could work in groups, making letter with their bodies, against the projection of letters on the screen. There was much discussion between the teacher tutor and researcher on how elements of these ideas could be

implemented in the reality of large class sizes and constrained time. These ideas were also discussed in view of reservations expressed by teachers in phase one in relation to losing control of the classroom. In view of this, a step by step experimental approach was agreed, that could be adapted to the reality of the school classroom. During phase two the opportunity arose for aspects of the teacher workshop to take place in the school, during class time with the full cohort of third grade students present. JC took a literacy class with the morning group on his own and then repeated the lesson with the afternoon class, collaborating with Rita, one of the participating teachers. The following is a contemporaneous account of the class.

> *JC works from a children's short story by Mia Couto, a well-known Mozambican writer. The story is about a girl from a village in Mozambique who has never seen the sea. The word for sea in Portuguese is "mar". The story explains how the letters of the word "mar" are in the shape of the sea; the m is like the waves, the a is like a mermaid and the r is like a rock. JC reads the story and discusses the character, the setting, the story and the letters and words with the children, using examples from the names of the children in the class.*
>
> *The story is projected onto the screen as he reads. Collaborating with Rita, together they make the shapes of the letters with their bodies in front of the projected letters on screen. Then the children are invited to make the shape of the letters with their fingers, to write the word and sample sentences with the word, and then finally to make the shape of the letters with their bodies in groups.*

<div align="right">Researcher Reflective Diary</div>

The workshop was designed so that the teachers could see the reality of a participative approach in the context of 70 children sitting on the floor with no other resources. The technology was blended with other tools such as the book and the blackboard were also used, as well as continued use of open questioning and group work.

c) Group work was used by most teachers in non-directed micro-teaching demonstrations in Phase 3.

Three out of five of the micro-teaching demonstrations with the technology in the final teacher workshop integrated group work. This had not been specifically

requested for the exercise. On a lesson on different types of soil, the last element of the lesson was a group exercise with two activities; to discuss if the soil where the children live is permeable or not, and to discuss if the rainwater had ever dragged a different type of soil into their community. On a lesson on different modes of transports, the lesson ended with a group work exercise for students to discuss the modes of transport they used to travel to school. The director of pedagogy of the school created a more ambitious lesson, entirely designed around a group-work setup, dividing students into different groups with names of fruits. He then proceeded with a lesson on the diet of various animals, based on an interactive exercise pre-designed and loaded on the application Explain Everything. He brought other teachers to the board one at a time to participate in the exercise. The object of the game was to match the pictures of the various foods and with the appropriate animals, and then matching the vocabulary for same without the pictures. However, the group work element got lost later in the lesson and it was unclear what his intention had been in dividing the group at the start. Overall the simpler attempts at using group work by the teachers were easily integrated into the lessons and usable in the context of large class sizes, with limited classroom space.

Use of mixed ability groups.

One of the issues that arose in the discussion around group work related to the varied levels of ability of students. As enrolment numbers in Mozambique had increased as a result of the Millenium Development Goal of Education for All, weaker students not being left behind was a difficult challenge. Students who were not learning at school were at higher risk of drop-out (UNESCO, 2011), and school-drop out rates in Mozambique are high; survival rate data to end of primary school varies according to source; 42% according to UNESCO (UNESCO, 2017) and 52% according to EPDC (EPDC, 2014). In either case, approximately a half or more than a half of all students drop out before the end of primary school.

By phase three, the participating teachers were using mixed-ability groups, affording weaker students the opportunity to participate, as in the following example.

> *"Currently we use the iPads as instruments that help us to develop those*
> *children who (are weaker)…We make groups because the classes are crowded,*
> *so we create groups where we put mixed levels of weaker and stronger students.*
> *But we focus more on the weaker students. We give more time and more*
> *opportunities to the weaker students. So that they can participate in all the*
> *classes where we use the iPads, so they can leave with a benefit."*
>
> Max, Group Discussion.

The school did not have any Special Educational Needs teachers or resources, and providing for the needs of students who were struggling in a large class setting was a significant challenge for teachers.

5.4.1 Group Work Discussion.

Layne *et al*. (2008) carried out an eight-month action research study in Barbados and Trinidad (involving twelve teachers in eleven schools) to examine the impact of relationship group work on student attainment, teacher attitudes and student attitudes to group work. The study found significant overall improvements in student attainment, most significantly in the lowest quartile. Additionally, teachers' attitudes changed from issues around "paying attention and concentrating on the teacher" to relational terms, such as "working well in groups, getting on with others and exchanging ideas". Teachers developed a sense that areas that were previously of greatest challenge to them, such as students not paying attention, were now within their agency. Across a meta-analysis of peer-assisted learning studies in elementary schools in the USA, student participation was found to have positive effect for increased achievement, with most significant impact on students from minority or low-income backgrounds and for younger urban students, providing strong evidence of the usefulness of peer learning for vulnerable students (Rohrbeck *et al*., 2003; Portes, 1996).

Further studies highlighted the usefulness of this type of technology in providing a structure for small group work interspersed in a whole-class teaching approach. Hennessy *et al*. (2007) used Rogoff's guided participation (1995) and collaboration to develop an approach to teaching that included small group discussions within in a whole class teaching approach, with the technology opening a 'shared communication space' to support knowledge building. Mercer et al (2010b) found that effective use of the technology created a "shared dynamic dialogic space" in which children can collaborate.

Taking into account the limitations of a large classroom, elements of group work were developed for this study using a step-by-step approach that fitted the context. In most cases it involved children working together in small adjacent groups to work through possible answers to an open question, often related to applying the topic of learning to the local context. This was an approach that most teachers implemented easily into the end of their lessons, for the last five minutes of class. It allowed an opportunity for critical thinking and for students to present their answers or work after discussion, with minimal need for movement around the room, which was identified as an important factor by participant teachers.

Consistent with the findings of the meta-analysis on peer learning above, the teachers reported weaker students as particularly benefitting from group work. Max reported more time being focused on the weaker students during group work. Rita reported the benefits of this approach, saying that weaker students were more motivated and volunteering to present.

5.5 Teachers Use of Open Questions Findings

a) There was no evidence of use of open questioning by teachers in Phase 1 of the research.

During phase one, in the micro-teaching sessions teachers asked the whole class to answer closed questions or to repeat what the teacher had said. While teachers followed examples and successfully created interactive lessons on Explain Everything (the interactive whiteboard application), they continued to use their traditional teaching style in the micro-teaching sessions to demonstrate the lessons they had created. The following is a typical example of teacher dialogue in the micro-teaching sessions during the first workshop. The lesson was created using a photo of the school cat and text that could be moved interactively on the screen.

> *Students: Good afternoon, teacher.*
> *Teacher: Well, I've got you a surprise today, look at what we have on the board.*
> *What is it that we have on the board?*
> *Students: A kitten*
> *Teacher: Ok, Guys. A kitten is when the cat is small and young, but here we have*
> *a cat. Everybody repeat...*
> *Students: A cat.*
> *Teacher: So, we are going to learn how to write the word Cat (Gato in*
> *Portuguese). Guys, how do we write the word cat?*
> *Students: "G".*
> *Teacher: Ok, we have "G".*
> *Students: "A".*
> *Teacher: The "A".*
> *Students: The "T".*
> *Teacher: The "T".*
> *Students: "O".*
> *Teacher: And the "O". Great! Let's applaud you!*
> *(applause)*
> *Teacher: Let's read the word on the board:*
> *Students Ga- to (Cat)*
> *Teacher: One more time.*
> *Students: Ga – to (Cat)*
> *Teacher: Guys, you know how is the cat... how does the cat cry?*
> *Students: Meow...meow...meow*
> *Teacher: So the cats meows. What does the cat eat?*
> *Students: The cat eats the mouse.*
> *Teacher: The cat eats the mouse, then let's read out the sentence:*
> *Students: The cat meows.*
> *Teacher: One more time.*
> *Students: The cat meows.*
> *Teacher: The other sentence.*
> *Students: The cat eats the mouse.*
> *Teacher: One more time*
> *Students: The cat eats the mouse.*
> *(applause)*
> <div align="right">Anna, micro-teaching demonstration.</div>

While the teacher successfully created an interactive lesson on the technology, her teaching style continued to rely on completion of phrases, repetition of words and chorus class recitation, consistent with interaction analyses in other studies in Sub-Saharan Africa (Hardman *et al*., 2011; Abd-Kadir & Hardman, 2007; Hardman *et al*., 2008). There are no open questions or opportunities for discussion. Children respond in chorus and were not invited to participate on the interactive lesson. In the other lessons created by teachers in phase one, the teachers integrated local photographs to illustrate lessons and created interactive lessons with movable text and pictures successfully. However, at this stage their teaching style continued to rely on eliciting choral responses, either in completion of a phrase or sentence or providing one or two-word answers to closed questions.

b) Use of open questions was introduced in Phase 2 in class planning activities

During phase 2, as teachers developed their practice through the use for class plans, open questions were planned in advance, providing teachers with a useful support structure for changing their practice. While some very good examples of class plans were created by the teachers on the iPads during the second workshop, copies of those could not be transferred to the researcher at that time because of a combination of difficulties with wireless transfer of the documents between devices on the day and time constraints. However, the outcomes of those class plans were evident in phase three of the research.

c) Open questions were used frequently by all teachers in Phase 3

In all of the micro teaching sessions demonstrated by the teachers in Phase 3, all of teachers used open questions throughout the lessons. In two cases the lesson began with an open question to set the context of the lesson. In four cases the lessons ended with open questions and open questions were used by two teachers throughout the lesson.

In four of the micro-teaching lessons, questions related the topic of learning to the children's own lives, experiences and localities; diary of a schoolchild's typical day, journeys from home to school, types of soil and cultural identities. In the other two lessons, questions related to the photos and leveraging the discussion beyond the photo into the wider discussion on the topic; parts of the plant, or diet of wild and domestic animals.

5.5.1 Teachers' Use of Open Questions Discussion.

Pedagogic practice in Mozambique, similarly to other countries in Sub-Saharan Africa, has a strong reliance on rote learning and choral responses (Hardman *et al*., 2008;) with the flow of information going from teacher to learner (Tabulawa, 1997), consistent with Freire's banking model of education. Completion of phrases, repetition of words and chorus class recitation of 'understanding' is frequent practice (Hardman *et al*., 2011; Abd-Kadir & Hardman, 2007; Hardman *et al*., 2008). An interaction analysis of classroom dialogue in Nigeria showed a high incidence of choral responses for completion of sentences or direct repetition of teacher's explanation (Hardman *et al*., 2008). Pontefract and Hardman (2005) also carried out an interaction analysis in Kenya, examining in particular the use of the initiation, response, feedback open questioning technique. Analysis of transcripts revealed that discourse followed teacher explanation following by question and answer sequences. The students' answers were less than three words long in 90% of cases, and feedback or probing answers rarely occurred. They also found that less than 1% of questions asked by teachers were classed as open.

A similar interaction analysis was created for comparison purposes from a one-minute video recording of Max teaching in the school in phase two of the research. 14 choral responses were elicited from the class in one minute, in seven cases completing

a phrase given by the teacher, in the other cases repeating the teacher's explanation or in response to a closed question. No open questions were asked, throughout the longer 15-minute video recording or feedback provided.

There are many cultural and social influences on teachers attitudes to the nature of teaching and teacher-pupil relationships. Findings across different Sub-Sahara African countries and contexts show that teachers often view their role in terms of transmitting objective, fixed knowledge to pupils by means of rote learning (Abd-Kadir & Hardman, 2007; Tabulawa, 2003). Because of a strong culture of respect for authority, the notion of children questioning teachers is problematic (Mtika & Gates, 2010; Abd-Kadir & Hardman, 2007). The consequence of a high level of choral response means that less time is available for pupils to engage in more creative or higher-level thinking or participation, or for paired or group work (Hardman *et al*., 2011; Abd-Kadir & Hardman, 2007; Hardman *et al*., 2008).

Another factor is that the official language of instruction is often not the first language of the children and that this impacts on children's ability to respond to teachers. In this case, teachers are offering children the safety of choral responses instead (Hardman *et al*. 2008; Arthur, 2001). This issue was highlighted by teachers in the first phase of research who explained that children often live with non-Portuguese speaking grandparents, and only encounter the Portuguese language when they are at school.

Vavrus (2009) carried out a year-long ethnographic study with student teachers in Tanzania, to examine the integration of a social constructivist pedagogy into teaching practice, emphasising the cultural politics of pedagogy, which requires that any ambitions for pedagogical change, work within the context of the examination system, the material infrastructure of schools and the length and quality of teacher education programmes. She found the potential for a "*contingent constructivism*

attuned to the country's cultural, economic and political conditions" (Vavrus, 2009, p.203). This approach uses an appropriate amount of student-teacher interaction for the context in which they were teaching "infusing critical thinking skills into question and answer techniques" (Vavrus, 2009, p.309).

Other researchers also suggest that a more dialogic pedagogy can be developed alongside the traditional whole class teaching (O'Sullivan, 2006; Barrett, 2007; Alexander, 2008; Hardman *et al.*, 2009). Simple changes in discourse practices such as asking open questions requiring a thoughtful answer, and then following up with requests to expand on answers, connect to pupils' lives or clarify or justify opinions, can make a subtle shift in the classroom dynamic towards a dialogic pedagogy (Abd-Kadir & Hardman, 2007; Alexander, 2004; Brophy, 1999). This type of simple adjustment is one that fits within the context of a large class, short teaching time and demanding curriculum requirements.

A similar approach to dialogic pedagogy was taken on this study, encouraging teachers to design lessons that supported open questions, thinking through open questions in advance during lesson planning stage in collaboration with other teachers, and including them in the lesson plans and in the digital lesson. This acted as a 'prop' for teachers during the transition phase from the automated closed questioning that was standard, to more open questions. A study carried out by Hedberg (2011) also showed the usefulness of preparing interactive sequences in advance for lessons, during a phase of transition integrating new interactive whiteboards into rural Australian schools.

One teacher who demonstrated this trajectory of change from closed questioning and choral responses to using open questions and probing for meaningful answers, was Max. He was the teacher who elicited fourteen choral responses from his class in one minute in phase two of the study. Six months later he performed a micro-teaching session with a pre-prepared lesson plan and digital lesson. He commenced the

lesson with an open question establishing what the class already knew. He probed answers provided by individuals and returned to the question again later in the class as answers to the original question were developed over the course of the lesson. He ended with open questions to connect the lesson to the local environment, as a group work exercise. In this situation, the use of lesson plans and a pre-designed digital lesson were effective aids for moving towards a more dialogic pedagogy. This trajectory was typical of all of the teachers involved in the study.

5.6 Teachers' Reporting of Participation in Class

In initial questionnaires which asked teachers what they felt the benefit of the project might be for their students, one mentioned participation, one mentioned play and three mentioned motivation. When the tutor suggested that classes be designed to encourage interaction by students on the technology, a discussion ensued, with teachers expressing concern about the context in which they were teaching; short class time, other students waiting nearby for their school shift to start and large number of students in a small space. Children's participation on the technology was discussed in terms of its potential impact on the teachers' control of the classroom in this challenging context.

At the start of phase two, out of the five participating teachers (Rita, Marlon, Agostinho, Anna and Max) at that time, all five teachers mentioned increased participation of students when asked an open question on what they perceived as the impact of using the technology in the classroom.

During phase three, Rita, Marlon, Celia and Max again mentioned increased participation of children in the classes during a group discussion.

> *"When we interact, we talk openly, I see a different dynamic, the majority want to participate."*
>
> Rita, Group Discussion

"…the teacher does not need to do an exposition for the class, we talk less and the classes are more participative."

<div align="right">Celia, Group Discussion</div>

Increased participation was mentioned when asked about the impact of the project, and also in response to being questioned about the difficulties with the project. Because children were participating more, this further highlighted issues around lack of space in the classroom, and lack of teaching time. These issues will be discussed in more detail in the section on the obstacles to participation.

Teachers Changing Attitudes to a Participative Classroom

a) Teachers were worried about the consequences of children participating in class in Phase 1:

In phase one, a negative reaction was elicited from the teachers when the teacher tutor suggested encouraging student participation. One of the participating teachers, Rita, expressed strong concern that it would be impossible for the teacher to control a large class if the children were actively participating in the class or with the technology. The other teachers agreed with this concern. Participation was only mentioned by one teacher in a positive context on the potential impact of the project.

b) Teachers began to link student participation in class to increased student motivation in Phase 2:

At the start of the second teacher workshop, the new teacher tutor (JC) facilitated a group discussion. In response to the question on the impacts of the technology so far, the teachers spoke about student participation. There were no negative comments about student participation, and when teachers spoke about participation, it was in a more positive context than in the group discussion at the start of Phase 1. By Phase 2 of the research, teachers were frequently linking student participation in class with increased motivation.

"I think it is an instrument that is fairly encouraging for both the teacher and the student. Because the student gains a lot of motivation, looking at the images

*and they participate more directly in the class…The students also like it and
there is lots of participation, there is lots of dynamism."*

<div align="right">Marlon, Group Discussion</div>

By this phase, their early stage activities and practices with the technology and
early attempts at a new approach in the classroom had changed their attitudes towards
student participation. Other teachers used words such as "positive challenge" "curiosity
to learn" when talking about children's willingness to participate.

While participation was regarded more positively than previously, the
issue of time constraints and "time is too short" was still an issue for the teachers:

*"What I can say is about the issue of the time. Because all the students are
motivated and want to participate and we are now organized with the time, so
the time is too short. And as they are all motivated they want to participate."*

<div align="right">Lana, Group Discussion</div>

In one case the term participation was used interchangeably with the term
attendance.

*"For me, the thing that is most interesting aspect of this project, is the
participation and presence of the students. When the students use the iPad
during the class, of course they mention it to other student who missed the last
class, so this other student will feel like going to school and it reduces absences.
The participation of students is really good, they want to go to school, to use it,
to touch it (the iPad), it is really interesting."*

<div align="right">Anna, Group Discussion</div>

As attendance records are not reliably kept in the school, there was no way of
independently verifying this claim. However, the director of pedagogy of the school
had independently reported the same.

c) In Phase 3, the teachers spoke about participation as a positive.

By Phase 3, the teachers are linking participation with increased motivation of
students to learn. Here Max talks about ways in which he encouraged increased
participation from the students.

*"For me it develops a challenge in the curiosity for learning. There is always
one student who answers, and when the others realise that the teacher is happy,
they all want to answer in order to create a friendship with the teacher. So,
every time that the teacher asks them to participate, they feel chosen and special
to the teacher. Without the iPad, they would think twice before participating or
taking a risk to answer, but when there is the iPad, they have the curiosity to*

touch the object, also in a way to show that he is the teacher's friend. This is more inviting to the children."

<div align="right">Max, Group Discussion</div>

In practicing a collaborative approach of exchange and interaction between teachers and students, and between students and other students, their attitudes towards a participative classroom, even in such challenging circumstances had changed. Stepping back, they were allowing students to becoming co-generators of knowledge. The collaborative activities and shared dialogue with students had created a transformation in approach and attitude of the teacher.

5.7 Obstacles to Participation

a) Classroom space is an obstacle to participation

"The students are there, sat in the classroom, they want to talk and share but the room is too small. I mean, Sometimes, you want to choose a student who is sitting at the back of the classroom, they want to stand up and participate. It is very difficult for that student at the back to cross all the classroom and come to the front to participate. It has been one of our challenges. The number of students and the size of the classroom. Classrooms they are too small."

<div align="right">Marlon, Group Discussion</div>

This was an unforeseen obstacle as initially it was expected that the technology would be used outside, as it is designed to do. However, in reality, because of large numbers of children waiting at any given time of the school day to commence their school shift, it was only possible to use the technology in a space that could be shut off from by-standers curiosity. The majority of classes did not have a door, and had large windows without glass, outside which by-standing children could gather and talk. This reduced the available space to one classroom that had a door that could be closed, and a window high enough that other children could not gather at. This particular classroom had the director of pedagogy's office at the back, reducing the size of the classroom further. This issue was discussed in depth with the school director of pedagogy. At the end of the pilot phase, plans were in place for windows and doors to be installed in

more classrooms so that the technology could be used in several of the classrooms. Some of those classrooms were somewhat bigger.

b) Short class time is an obstacle to participation

"What I can say is about the issue of the time. Because all the students are motivated and want to participate and we are now timetabled, so the time is too short."

<div align="right">Carmina, Group Discussion</div>

The school day is just three hours long for each school shift. The school day is generally divided into three one-hour classes; literacy in Portuguese, mathematics and natural science, with some scope for local curriculum. Often ten minutes are lost from each hour for set-up of technology, writing out prescribed texts on the board etc. Attempts were made to mitigate against this, by teachers sharing pre-prepared content and prescribed texts, already inputted into the technology.

c) Fear of stronger students missing out is an obstacle to participation

"But we focus more on the weaker students. We give more time and more opportunities to the weaker students. So that they can in all the classes where we use the iPads, so they can leave with a benefit. The stronger students can feel a little bit outside of the project. So, if we could improve this and the time to improve."

<div align="right">Max, Group Discussion</div>

One of the aims of the project was to encourage teachers to focus more on weaker students, as students who were not progressing through school were more likely to drop out (Sabates, Westbrook, Akyeampong & Hunt, 2010). In the adjustment period, the teachers may have focused on the weaker students to the detriment of the stronger students. This teacher expressed the possibility of redressing this over time.

5.8 Role of Technology in Supporting a Collaborative Classroom

Several studies examine the use of the iPad or mobile device for collaborative learning group work and exercises in the developed world. In all of the studies found, several iPads were used in the classroom and the iPads were often used for research on the internet, which is not of relevance in this study, due

to the unavailability of the internet in the school (Henderson & Yeow, 2012; Fisher, Lucas & Galstyan, 2013; Falloon & Khoo, 2014; Falloon, 2015; Kukulska-Hulme & Shield, 2008). The way in which technology is used in this study (mobile device connected to a projector in the hands of the teacher) is more akin to an interactive whiteboard, and therefore studies involving the use of an interactive whiteboard have been focused on in the comparative literature, instead of mobile devices.

5.8.1 Interactive Teaching Supported by Technology.

Many researchers have examined the potential of interactive whiteboard for enacting more interactive dialogic teaching (Beauchamp *et al*., 2010; Mercer *et al*., 2010b; Hennessy *et al*., 2007; Redman and Vincent 2014; Nes & Wikan, 2013) as examined below.

Dialogic Teaching.

In dialogic teaching the teacher (i) gives students the opportunity to question and express ideas about lessons (ii) engages in discussions with students (iii) take students contributions into account in developing themes and activities (iv) uses talk to provide a frame for new knowledge (v) encourages children to recognise talk as a tool for joint construction of knowledge (Nes & Wikan, 2013). These practices are very viable for small numbers of students with enough class time to explore knowledge through discussion in this way, however will be challenging when time is limited and class sizes are large.

Other studies have examined the potential of the interactive whiteboard to enact a dialogic, interactive pedagogy in a whole class setting (Mercer *et al*., 2010; Hennessy *et al*.; 2007; Haßler *et al*., 2016; Northcote *et al*., 2010; Redman & Vincent, 2014; Nes & Wikan; 2013). The dialogic approach involves teachers orchestrating classroom talk

so that teachers and learning are commenting on each other's ideas, asking higher order questions and enabling pupils' active contributions in a whole class teaching context (Alexander, 2004; Hennessy *et al*., 2007; Mercer *et al*., 2010; Redman & Vincent, 2014). Examples include the interactive whiteboard being used as a "visual means of inviting the children to share their insights" (Redman & Vincent, 2014, p.170). In several studies, children were invited to the interactive whiteboard to interact with visual materials (Redman & Vincent, 2014; Mercer *et al*., 2010; Northcote *et al*., 2010; Nes & Wikan, 2013). All children and the teacher were involved in discussing and interrogating the material. The technology, including visual, auditory and text-based function were used as stimuli for reasoning (Mercer, Hennessy & Warwick, 2010; Mercer *et al*., 2010), using resources such as letters, poems, scientific diagrams and other resources as a reference point for discussion.

In this study, many teachers used prescribed texts as a basis for developing interactive lessons, breaking down elements of the text, using photos of local examples, interactive exercises and open questions. Other teachers designed lessons using new text, such as a diary with locally recognisable photos. Using the sample text and photographs, the teacher then asked questions and evoked discussion from the students on the topic, but related to their own lives and shared community. The class time was too short and student numbers too high for full student presentations, but under these limitations, a new space for students' dialogue and contribution was created that had not existed previously.

An essential part of dialogic teaching is the use of probing questions, building on learners' contributions, provoking children to articulate answers and interacting with the technology to share their ideas with the whole class (Alexander, 2004; Mercer, Hennessy & Warwick, 2010; Mercer *et al*., 2010; Redman and Vincent, 2014). In these studies, teachers and students were involved in generating and critically evaluating

ideas, encouraging explicit reasoning and the joint construction of knowledge (Mercer, Hennessy & Warwick, 2010; Mercer *et al.*, 2010). Northcote *et al.* (2010) have found that the interactive whiteboard can be used to initiate various types of interaction, by providing a platform for demonstration and presentation, and having children more engaged in lessons and willing to participate. Findings included the potential for students to contribute to resource development, reporting of their own learning and actively constructing knowledge.

While opportunities were more limited in this context for expansive and extensive use of student presentations, some of the teachers had created opportunities for children to present in the classroom. In the following extract Max talked about children presenting and answering questions from other children.

> *"Even weaker students are volunteering to present. They are motivated. And when you give them the opportunity to present, they go because they think they have the answer with them. And when they are there, they are asked questions; why is it this way, and not that way? And that child, at the moment, they are obliged to learn when they thought that they have all the answers. That is a positive aspect."*
>
> Max, Group Discussion.

Teachers on this study reported children becoming more confident and enthusiastic about participating and contributing the class and a number of teachers mentioned increased participation of students who did not participate before the technology was introduced.

In a study in Norway, Nes and Wikan (2013) found that the use of the interactive for inclusiveness and motivating and activating pupils was frequent and much appreciated. However, they found that its potential as a dialogic space was not fully exploited. In their study, teachers didn't actively use conversation to create a framework for the acquisition of new knowledge. "In order to develop the dialogic space, the teacher must plan, perform and involve the learners in dialogic talk" (Nes & Wikan, 2013, p.77). One of the findings of this study is that interactive practices in teaching are well supported by planning these interactions in advance and embedding

them in a class plan. The class plan was essential to change of teaching practice, especially in the early stages. Even if a teacher occasionally fell back to a more automated choral response pattern, as soon as the teacher referred back to the to the class plan, and the pre-designed digital lesson, they were able to move away from the previous pattern of teaching again.

Many of the comparative studies focused on the natural processes of teachers, already expert in enhanced dialogic interaction (Redman and Vincent, 2014; Mercer *et al*., 2010; Hennessy *et al*., 2007). This study demonstrates that technology can enhance more dialogic interaction with teachers who are not already expert practitioners of this approach, even in contexts of large class sizes (over fifty).

Stages of Integration of Technology for Interactive Teaching.

Beauchamp (2004) developed a framework for integration of the interactive whiteboard (IWB) into teacher practice that involves five stages of integration (i) blackboard substitute stage; initially the IWB is used as a substitute for a blackboard or whiteboard, with a predominant use of text and writing on the device (ii) apprentice user state; at the apprentice user stage, with a predominant use of stored teaching resources and children learning to write, highlight and drag content (iii) initiate user stage; where the teacher is beginning to use a wider range of tools and children are inputting into the IWB (iv) advanced user stage; teachers importing images from a range of sources including children's work, textbook pages, worksheets for whole calls use and children demonstrating their learning on the IWB and (v) synergistic user stage; high level of competence by pupils and teacher. Most of the teachers on this study were using the technology at the first and second stage of Beauchamp's framework until a seeming breakthrough moment somewhere between phase two and three of the study, when they moved through initiate user and in many cases, into

advanced user stage (iv). It is not known if the teachers reached synergistic user stage after the study ended.

A number of researchers have warned that unless a conscious effort is made to ensure that the interactive whiteboard promotes interactive teaching, it can just extend existing pedagogy (Nes & Wikan, 2007; Beauchamp, 2004; Sundberg, Spante & Stenlund, 2012). Mercer *et al*. (2010) have point out the challenges for teachers in attempting to transcend ingrained conventional patterns of teaching and interacting with students, even if their aim is to change. This was very evidenced in the early stages of this study, when teachers were mastering use of the technology, but had not yet integrated it with a more dialogic and interactive teaching style.

Winzenried, Dalgarno & Tinkler (2010) conducted a qualitative study with six teachers in rural schools in Australia introducing the interactive whiteboard. They found that one of the advantages of the interactive whiteboard is that it could initially be used without big changes in pedagogy, over time gradually affording larger pedagogical changes. Hennessy *et al*. (2007) also found that a 'slow evolutionary process' can occur when technology interacts with existing practices. A number of other studies suggest that teachers readily adopt the interactive whiteboard and that their use of the technology continues to develop and evolve over time (Bennett & Lockyer, 2008; Hedberg & Freebody, 2007; Winzenried *et al*., 2010). In another Australian study, Hedberg (2011) found that over a one-year period, all participating teachers had experienced changes in their pedagogical practice and focused on interaction and 'modes of representation' for improving students' understanding. Teachers who had most strongly embraced the technology, claimed that the innovations had enabled students to become more engaged in learning and performing at higher levels (Hedberg, 2011). Somekh (2007) found that attainment gains increased with

length of time that teachers were using technology, allowing time for technology to embed in their teaching practices.

The biggest changes in practice in this study were observed between phase 2 and phase 3. In teaching observation at the start of phase 2, teachers had created impressive digital lessons, but had not changed their teaching practice. However, by phase 3 all teachers were quite naturally using the new approach. A full academic term had passed between these two phases, and the teachers had the opportunity to use the technology frequently in class during this time, as well as develop and share class plans and digital lessons.

5.9 Implications

This research provides evidence that teacher-controlled use of a mobile device connected to a projector, used in a fashion that mimics the use of an interactive whiteboard, is a viable and affordable option for schools in remote and developing contexts without access to electricity or internet, and with large class sizes. This study supports previous studies demonstrating that technology can support pedagogical change towards a more dialogic pedagogy over time, even when class sizes are over fifty. This change in teaching practice can occur even when dialogic teaching is not already embedded in teaching practice.

There are a number of factors to support technology enabling pedagogical change:

1. Professional development that provides a conscious approach to an interactive pedagogy hand-in-hand with technical knowledge is key.

2. A practical, step by step approach is required, integrating small changes to existing teaching practices in a way that is fitting for the context (i)

use of open questions (ii) use of group work (iii) use of interactive

exercises (iv) enabling children to interact with technology.

3. Use of lesson plans integrated with ICT is an essential support for
   pedagogical change towards a more interactive dialogic approach,
   particularly in transition phase.

4. Change in practice leads to change in attitude in relation to a
   participative classroom in the development contexts of class sizes over
   fifty, and limited spaces and resources.

This approach over a one-year period has resulted in significant change in teaching practices, and significant impact on learning outcomes, particularly for weaker students. This approach has also had a reported impact on children's motivation to learn and to participate in class activities.

5.10 Limitations of Study

It was unfortunately not possible to implement a designed teacher attitude questionnaire, to measure changes in attitude towards collaborative teaching practice. Further classroom observation in the school at later stages of implementation would also have been very useful, but again was not possible for practical reasons. It was also intended to include attendance records for analysis, as student absenteeism was a significant issue. These records were not available, for unclear reasons, but may have to do with practical difficulties with roll taking in the school.

Many studies suggest that the time required for teacher to embed is two years (Hennessy, Mercer & Warwick, 2011; Deaney, Chapman & Hennessy, 2009; Warwick & Kershner, 2008). A longer period of study, with more detailed interaction analysis would have been desirable to measure full impact.

5.11 Chapter Summary

Technology can support a socio-cultural model of change in teaching practice in the context of a large public school in Sub-Saharan Africa. Key to the approach is small specific actions within the context of whole class teaching, including use of interactive exercises on the device, inviting participation by students, use of open questions and short focused group work exercises. Preparation of lesson plans and digital lessons in advance is key to an approach that supports longer term gradual iterative change in teaching practices, attitudes and competence in integrating technology and digital content in teaching.

6.0 Findings and Discussion: Creativity in Teaching with Technology

When a socio-cultural model of learning is thriving, teachers and learners are working together to co-create knowledge. Creativity within a sociocultural context involves the creation of new and useful artifacts in a constant interaction between different actors and audiences using whatever material affordances are available" (Glăveanu, 2013). Creativity can only emerge out of reality, and deeper levels of creativity are accessed as the relationship with reality deepens (Vygotsky, 2004). Innovation occurs when learning is relevant to the lived experiences of the learners (Woods, 1990). For children to emotionally connect to learning and become motivated to take control of their own learning, the learning must be relevant to their everyday lives (Woods, 2002). Target 6 of the Muscat GEM Agreement specifies that teachers must be supported to provide relevant content to learners in their lived contexts and are able to support learners' ability to be creative and adapt to change (UNESCO, 2014a).

Knowledge creation is positioned at the highest level of ICT integration in UNESCO's ICT Competency Framework for Teachers, where the teacher becomes the model learner and knowledge producers for their students (UNESCO, 2011). Using technology in this way requires fluency in use of the technology in the context of teaching, along with an open-minded and creative approach to using the technology to advance students' engagement with and understanding of the learning, within the socio-cultural context (Koehler & Mishra, 2009).

In a step by step, context relevant approach, the specific teaching practices examined for this thesis are: (i) creating new artifacts with technology (ii) integrating local examples into lessons with technology. In assessing new artifacts created with technology, the NEW (Mishra & Henrikson 2013) model was used, whereby artifacts

were not only Novel, but also had to be Effective and Whole in their design and appropriateness for the purpose.

6.1 Instigating Creative Teaching with Technology

The teachers adapted to using and creating content on the iPads relatively quickly and easily, but were still uncertain how they could integrate it with curriculum. The workshops in phase two of the study focused on working with class plans allowing teachers to plan creative elements of lessons in advance. A creative approach to using the surrounding environment and the context of children's lives was encouraged during these workshops. As teachers began thinking about lessons in the context of the local environment, creative ideas for lesson plans began to flow. As the teachers found the camera function of the iPads easy to use, this became an easy to use tool to integrate local examples into lessons. Other useful tools such as creating timelines or highlighting areas on maps and integrating them into lessons were explored and practiced. Explain Everything, an interactive whiteboard app, was particularly useful for creating interactive word and picture games, which the teachers found easy to create and relate to curriculum topics.

As with collaborative teaching practices, a step-by-step approach, supported by class plans and pre-prepared digital content was effective in changing practice over time, unlocking a more creative approach and attitude to teaching over time.

6.2 Teachers Creating New Digital Artifacts

One of the main aims of the overall pilot study was for teachers to access and create quality, visual, locally relevant content to supplement scarce textbooks. It was envisaged that a bank of digital content could be accumulated quite quickly and with minimum cost, creating a valuable resource for the school. Before the intervention, all

teachers had access to blackboard and chalk. In two cases teachers also had a map and in another two cases teachers had some geometry tools. A couple of teachers owned a smart phone, the rest had basic model mobile phones. None of the teachers owned an iPhone or iPad or had access to a computer at school. A measurement was not taken on teachers access to computers outside of school.

a) Participants learned to create content on the iPads quickly.

The early teacher workshops focused on basic functionality of the iPad device; writing and editing text, taking and uploading photographs, video, etc., then moving on to using the functions of specific applications and then onto designing lessons on different applications for literacy teaching, the main focus of the study. All of the participating teachers mastered the basics by the end of the week. The following extract from the researcher's journal highlights how quickly the teachers adapted to using the technology in the first teacher workshop.

> *"All the participants took to the technology very quickly without any issues. By the end of day two the participants were producing quite good quality presentations on the iPads. On day three, some participants created numeracy lessons on Explain Everything (whiteboard application) using pictures taken locally…. On day four the application of the technology in literacy seemed to fall into place with the teachers very quickly creating literacy games with sentences, words and pictures on Explain Everything."*
>
> Researcher, Reflective Journal.

b) Quality of digital artifacts produced is high.

Based on Besemer's (1998) model, Mishra and Henrikson (2013) created a NEW model to evaluate creative output. Encompassing the full range of definitions of creativity in the literature, Mishra and Henrikson have defined a creative product as firstly novel – being 'surprising or original' (p.11). However, novelty on its own is insufficient, and the creative product must also be effective (Amabile, 2012; Oldham & Cummings, 1996 and Zhou & George, 2001). To be effective it must also be

understandable, useful and logical. The third criteria for creative output is relevance, 'task-appropriateness" or "style" (p.11), in this model referred to as "wholeness".

Creative solutions are OR Creativity is a goal driven process of developing solutions that are	
Novel	Fresh, unusual, unique, surprising, startling, astonishing, astounding, germinal, trendsetting, radical, revolutionary, influential, pioneering
Effective	Valuable, important, significant, essential, necessary, logical, sensible, relevant, appropriate, adequate, functional, operable, useful, user-friendly
Whole	Organic, ordered, style, arranged, organized, formed, complete, elegant, graceful, charming, attractive, refined, complex, intricate, ornate, interesting, understandable, meaningful, clear, self-explanatory, well crafted, skillful, well made, meticulous

Table 5: from Mishra & Koehler, 2008 (adapted from Besemer & O'Quin, 1999).

Mishra and Henrikson's NEW rubric is a workable, flexible, clear tool for evaluation of digital content created by teachers, that incorporates the range of definitions in the creativity literature.

Novel.

Mishra and Henriksen (2012) define novel as creating something that did not previously exist, or did not previously exist in that particular form. By this definition even from the first workshop, the teachers were creating novel digital artifacts. In that workshop teachers uploaded photographs from the local environment into three different applications (Keynote, Book Creator and Explain Everything) to create lessons on vocabulary and mathematics.

Previously the only material used by the teachers had been one of three textbooks: mathematics, literacy or natural sciences. As there weren't enough textbooks to go around, each child got just one of these books and shared with the other children for the ones they didn't have. So already, at a very basic level, the novel lessons created by the teachers, were a new resource of value.
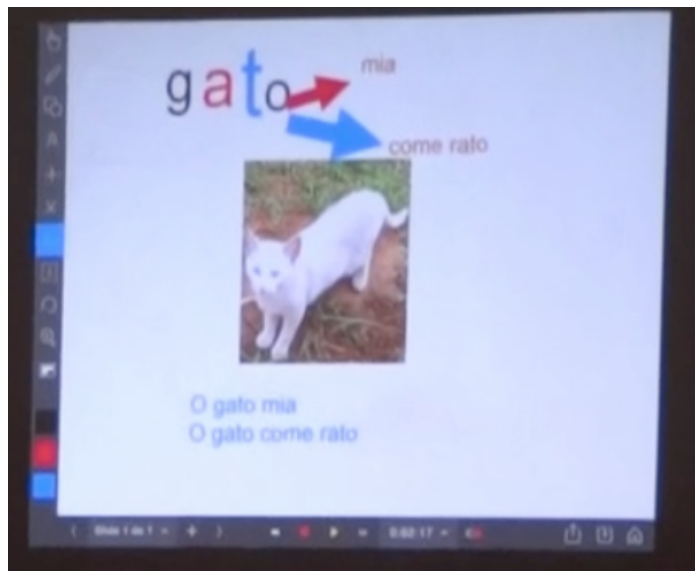
Figure 15: Example of literacy lesson created during first teacher workshop

Effective.

The second component in assessing the quality of creative products is effectiveness. Mere novelty cannot qualify as "creative", it must also be effective (Mishra & Henriksen, 2012; Amabile, 2012).

The teachers learned to use the technology quickly and there was already novelty in the initial digital artifacts created by the teachers. However, there was still confusion about how to design digital artifacts that were linked to the curriculum, many of the teachers had only ever used the text book as a guide to curriculum. In the second phase, teachers worked together in groups to create lesson plans, ensuring that the digital artifacts were developed from and linked to a well-designed lesson plan. Towards the end of the pilot, the impact of this approach was evident in the in micro-teaching lessons presented by teachers. Each of the digital artifacts created were designed in conjunction with a varied lesson plan, incorporating elements of participation, group work, local relevance and linked to curriculum.
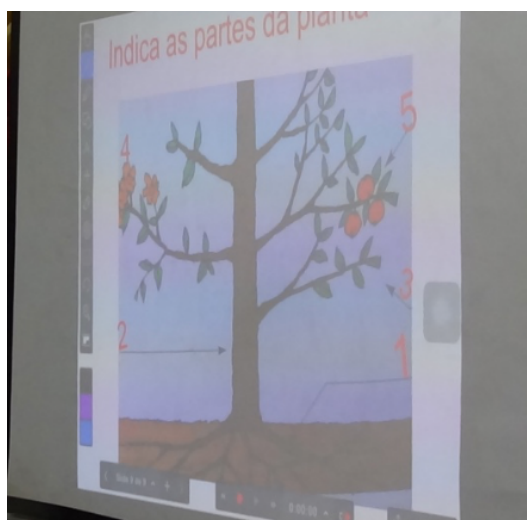
Figure 16: anna using a photo of a tree near the school in a lesson on parts of the plant

In this example, Anna created a lesson on parts of the plant, using a photo taken on the school grounds of a plant with prominent roots. Following a class plan, she asked open questions about the photograph, then brought some 'students' to the iPad to write into the application. The lesson and accompanying digital artefact was simple, and created quickly and easily, but was a very effective resource for the topic, for the teacher who had created it as well as other teachers.

Whole.

The third aspect of quality in creative output in the NEW model, is "wholeness", which includes elements of style and design, as well as appropriateness and "wholeness" for the context for which they are designed (Koehler & Mishra,

2009). By the end of the study period, digital artifacts were designed by teachers that were well organized, complex, linked to curriculum, meaningful and well crafted.

Figure 17: Max's lesson on types of soil

A particularly striking example was presented by Max. He had previously presented a lesson in the school, in which he had simply typed the prescribed text into the interactive whiteboard app, and then had read the lesson word by word, with the whole class repeating each word after him. This was how teachers had usually taught using the blackboard before they had received the iPads and projectors. After five to ten minutes, a large proportion of the children were looking at each other, or to the researcher at the back of the room, and were no longer concentrating on the projected image of the text.

Towards the end of the pilot study, he created another lesson, which was also based on a prescribed text from the book. This time he took a varied, participative and creative approach to the topic, breaking the text into parts and incorporating local photos, examples and exercises, as described in the observation below.

> *"Max designed a lesson about types of soil on the Explain Everything app. He began by asking open ended questions about soil establishing what the 'children' already knew. … He then provided a definition of soil, and a discussion on how humans use soil, and introducing the topic: different types of soils.*

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The next slide provided some prescribed text on how soil provides humans with food to survive. Then another short, prescribed text on arable and non-arable land, which led to some related discussion on living things and animal kingdom and plant kingdom. Again, he asked open questions and had a discussion with the class about this. The next slide with a short test re-established what they already know about soil – that is it partly made up of minerals and organic material. He then provided three photos representing different soil types in the local community with text titles; chalk soil, clay soil, limestone soil. Following this was another short, prescribed text: on the different contents of soil and how they relate to the type of soil.

The next slide provided photos of four different examples of sandy soils, followed by another short, prescribed text – about the principal component in sandy soils being sand, the permeability of sandy soil, and its unsuitability for agriculture. The last slide was a group exercise with two activities; to discuss if the soil where the children live is permeable or not, and to discuss if the rainwater had ever dragged a different type of soil into their community. He still used the necessary prescribed text, but with photos that related the lesson to the local environment.”

Observation micro-teaching Max

New digital artifacts are created by the teachers, developed and re-created in the classroom, and further developed by other teachers who uses the artifact with a different class in a constant re-generation of “new and useful artifacts” (Glăveanu, 2013, p.76). The learners were engaged emotionally (Murphy *et al.*, 2015; Rogoff, 2008), becoming transformed in the process (Stetsenko & Arievitch, 2014).

Mishra and the Deep Play Research group's framework for creativity in teaching based on the TPACK model of Technology, Pedagogy and Content (Mishra, 2012) is based on trans-disciplinary thinking involving “a range of specific cognitive skills including: perceiving, patterning, abstracting, embodied thinking, modeling, play, and synthesis” (Mishra & Henriksen, 2012, p.19). In this model familiar objects are viewed with fresh eyes, particularly through the use of digital cameras and video (Mishra & Henriksen, 2012). While this model is quite advanced in its aspirations, particularly in the context of this study, by the time of the last teacher workshop teachers were demonstrating skills in these areas in the types of lessons they designed using the technology. The camera function on the iPad and its easy integration of photos into apps, the easy ability to integrate with text easily facilitates this integration

of familiar objects and their scrutiny with fresh eyes. The ability to move and re-arrange text and photos extended the artifacts created by teachers into elements of game play, as in the following example.

> *"Rita designed a game called Moments of the Day, with diary entries that she created for a fictional child who is a third-grade student in the school for use on the Explain Everything interactive whiteboard app. It contained vocabulary relating to different times of the day, for example: eat breakfast, brush teeth, help prepare dinner, go to bed, etc. The phrases could be moved on the screen to match words that indicated different times of the day: morning, afternoon, evening etc. She called individual students to the iPad to participate in the game."*
>
> Rita, Observation micro-teaching

The teacher created a sophisticated lesson, integrating prescribed text, local photographs from the local context, elements of game-play encouraging active participation from children in a format that is suitable for a very large class size in a limited space, with no other resources. This teacher had practiced using the technology in the classroom for approximately eight months at this stage, with limited access to the technology outside of classroom hours.

In summary, all teachers were created *novel* digital artifacts easily after just a few days working on the technology. By the second workshop, all of the teachers were linking the new digital artifacts with lesson plans and curriculum, and integrating local examples reaching the *effective* level of the NEW model. By the third workshop, lessons were becoming more sophisticated and *whole* to varying degrees.

6.3 Integrating Local Examples into Lessons with Technology

Woods (2002) states that the more relevant learning is to "children's lives, worlds, cultures and interests, the more likelihood there is that pupils will have control of their own learning processes. Relevance aids identification, motivation, excitement and enthusiasm." (Woods, 2002, p. 7). In the context of low resource learning environments, this approach, specifically in the use of locally produced learning

materials, beyond the use of the textbook, was found to be one of the six most significant teaching practices to influence educational outcomes (Westbrook *et al.*, 2013).

Locally Relevant Content in Developing Countries.

The importance of locally relevant materials is recognized in many interventions in developing countries (Barrett *et al.*, 2007). Tikly and Barrett (2011) emphasise the importance of teaching approaches and texts and materials that reflect the socio-cultural identities of children, local languages, and communicative norms of local societies. A number of studies emphasise the importance of textbooks that are culturally relevant and inclusive and the importance of finding and using or generating material from local writers (Commeyras 2007; Jimes, Weiss & Keep, 2013; UNESCO, 2013). While the standard textbooks used in the classroom have some reference to Mozambican culture and society, Mozambique is a very large country with very diverse languages, customs, religions and local cultures, which could not be captured in one textbook. Additionally textbooks are scarce, and do not survive very well in the dusty and humid environment.

a) Using photographic capacity of the technology is an easy and effective way to create locally meaningful lessons.

During the final phase of the research, a final workshop on using the interactive Book Creator app focused on the potential of Book Creator as a tool to create additional literacy resources to support curriculum. Emphasis was placed on the importance of creating content that was relevant and locally meaningful to students. This is an example of a lesson created as part of this workshop. Designing the lesson did not take more than an hour.

> *"Marlon and Agostinho created a lesson on Book Creator, an app that allows the integration of text, photos and video in an interactive book, on transport. They re-created the teacher's journey to his job in ABC Primary school, with text and photos of modes of transport commonly used in the city and environs of*

Maputo. Photos taken in the environs of the school and roads nearby, including the school, were used. The lesson ended with a group work exercise for students to discuss the modes of transport they used to travel to school."

Observation micro-teaching Marlon & Agostinho

The lesson was created relatively quickly and easily, using the device to take photos during one of the teacher's own commute to school. The lesson integrated local vocabulary, places and familiar faces; teachers and students from the school. It was simple to use in the classroom context, integrated in a class plan that could be re-used, adapted or built upon by other teachers.

Another teacher used the example of a diary extract from a fictional, but typical, student from the school.

"Rita created a book about ABC Primary School. A fictional student in third class, writes about her class, her school, her teacher and her best friend, using photos from their school, and their class, teacher and classroom. Questions were included at the end of the chapter."

Observation micro-teaching Rita

The diary and photos were very relevant and reflective of the real lived experiences of children attending ABC school. It was created in less than an hour, and again, was adaptable and re-usable by other teachers. These lessons demonstrated the teachers' ability to create locally relevant and meaningful, highly creative quality content in under an hour.

During a discussion on the impact of the project, the school director of pedagogy here discusses the importance of the photos that are used in digital content created by teachers, and how photos that are recognizable to children from their local surroundings will have a stronger impact.

"But the real images have more impact than the ones we look up on the internet… It has the most impact when images are used from the immediate school environment that children recognise, rather than just taken down off the internet."

School Director, Group Discussion.

Overall as the project progressed, teachers spoke about the value of local content and the impact on students of seeing pictures they recognized from the local environment, projected on the screen. What was initially perceived as a disadvantage

by the teachers; the lack of pre-created content and the need to create lessons, over time began to be seen as an advantage of the technology.

      b) In some cases, use of local examples extended as a teaching practice beyond the classes using technology.

An unexpected outcome of the introduction of mobile technology in the school, was a change of teacher attitude in relation to the possibilities open to them for teaching, outside of using the technology. By phase 2, teachers were beginning to see new possibilities for their teaching outside of the textbook and prescribed texts, and beginning to see the value in the local environment and context.

> *"We need to keep in mind how we have been working. We are in the routine of running and sometimes we get preoccupied with the book and texts in the book. We don't manage to get out of that. We don't create new things, we don't manage to integrate the local curriculum. The students see everything outside of here as something separate… We get caught up in texts and we forget the local curriculum or more natural ways of learning. We work a lot in one text and we end up stressing the students and wasting the best learning moments. Let's wake up to other ways of learning. There are so many things we can use in this environment here, around the school. Let's look at other instruments for learning. Their environment is a start point for the children. They are supposed to start learning from this environment, school, toilets, water, everything that surrounds them is supposed to be a base for their knowledge."*
>
> Rita, Group Discussion

As part of a final group discussion in phase 3, the teachers were asked what had most changed as a result of implementing the project. Rita answered again:

> *"There is the possibility of planning lessons starting from the locality of the children, even if we are not working with the iPads. It is even working in classes where they don't have the iPad. We are using broader possibilities."*
>
> Rita, Group Discussion

This demonstrated that for one teacher at least, that working with the class plans and technology integrating local examples in a prescribed way had transformed her views of possibilities for teaching even in classes where she wasn't using the technology. She began to see the possibility of the local environment for all classes, with or without using the technology as a tool.

6.4 Discussion Creative Teaching

Supporting the ability of learners to be creative, to adapt to change and to learn in a context relevant to local lived experiences is recognized a key component of quality education in the Target 6 of the Global Education Monitoring Muscat Agreement (UNESCO, 2014b). Innovation, ownership and control of learning and relevance are key components of creativity in teaching and learning (Woods, 1990). Even small steps towards taking ownership of learning through participation in co-creation of lessons, participation in interactive exercises and integration of local examples have resulted in creative lessons co-created by teachers working with each other and with the students.

Most studies and interventions in development contexts relating to the use of mobile technology in education have focused on the technology, with creativity in relation to the technology coming from software developers and technology innovators (One Billion, 2018; iSchool, 2018; Eneza, 2018), with limited or no scope for creativity on the part of teachers. Yet, teachers were creating new digital artifacts after a short period of time, meeting high standards of novelty, effectiveness and wholeness, as outlined in Mishra and Henriksen's (2012) NEW rubric for creative output. Additionally, after a short period of practice of creating new digital content on the iPads, teachers were seeing more possibilities of how to create new lessons on the iPad and in classes without iPads. This indicates a transformation of competence of teachers to teach creatively in a whole class approach, even with large class numbers, and engage students in taking ownership of their own learning within the context of their local socio-cultural context.

Relevance.

Article 29(1) of the UN Convention on the Rights of the Child sets out the right of the child in relation to education that encompasses "respect for the child's parents,

his or her own cultural identity, language and values, for the national values of the country in which the child is living, the country from which he or she may originate, and for civilisations different from his or her own" (United Nations, 2010). For Vygotsky (2004), creativity is born from the experience of reality and becomes richer in relation to how deeply related to reality the creative experience is. Relevance is a key component of Woods' (1990) definition of creative learning, particularly in relation to "children's lives, worlds, cultures and interests". Children's ability to connect emotionally with learning is dependent on the learning being relevant to their lives (Woods, 2002).

> *"it is .. the moment when the student shows more interest in the classes because they talk about their environment."*
>> Rita, Group Discussion.

> *"If we are doing a lesson on fruits, a mango for example, or an orange, something they can identify, when you can project it, their own fruit, when they can see it there on the projector, it can be very interesting for the children."*
>> Jaque, Group Discussion.

Initially, the lack of developed local content for use on the iPads in the classroom presented a possible obstacle for the successful use of the technology, with lack of lack of internet access in the school as another possible obstacle. These limitations created a need for teachers to develop their own locally relevant content for the project. Initially, this was resisted because of the time requirement in the creation of these lessons. However, over time, the value of these locally created lessons, the ease with which teachers learned to create them, and share and build upon those created by other teachers, and the impact on the children who had previously failed to understand the value of school outweighed what was initially seen as a weakness of the approach.

6.5 Barriers to Creative Teaching with Technology

It was expected that technophobia would be a barrier to creative teaching with technology, this was not observed as an inhibiting factor in the group of participating

teachers. This may have been because most of the teachers included in the study were under the age of 35, with only one over that age. An older teacher, not participating in teaching with the technology attended the later workshops, and she was very nervous and hesitant in using the iPads or exploring on them. However, as she did not use the technology in the classroom, she was not included in the analysis. It was not clear why she was attending the workshops, and it may have been for political reasons.

Time required to create digital artifacts.

A large part of the discussion as the project progressed focused on the amount of time required for class planning with the technology. The teachers complained that they didn't have access to the technology outside of the school.

> *"The main difficulty is the time it takes to prepare as we don't have the instrument all the time."*
>
> Max, Group Discussion

However, the director of pedagogy in the school believed that much of that time was taken up with browsing online for photographs, and that it is more effective to take photos in the local environment.

> *"I have observed in my colleagues that sometimes it takes a lot of time, thirty minutes or more, to explore images. And so sometime the real objective of the class is not achieved because most time was spent only exploring the images."*
>
> Saul, Group Discussion

There was some conflict here between Saul's view of how teachers were working in preparing classes and the teachers' views of this. The discussion evolved and it was recognized that time was more of an issue at this stage because they were in a learning curve.

> *"The instrument was also new and it used to take a lot of time. Now with time, we are learning and I believe that there will be a time when planning the class using the iPad will be as easy as using a notebook."*
>
> Max, Group Discussion

A number of teachers had mentioned not having access to the iPads outside of school time. This was discussed between the researcher and the facilitators on the ground. Security concerns may have been an issue around this. Attempts were being

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made to allow teachers more time with the technology outside of class time, but still within the school grounds.

Teaching time constraints.

Additionally, teaching hours are very short; just three hours per day. There is short break between each of these one-hour classes where additional time is lost with students leaving and returning, and setting up their floor mats etc. Term time is also short and USAID study equated the number of direct contact teaching hours in Mozambique to thirty teaching days per year. Additionally, the curriculum is ambitious in terms of the volume of material to be covered per grade. This amounts to teachers being nervous about using precious teaching time for approaches that are more experimental and might result in the curriculum not being covered by the end of the school year.

Reluctance to move away from textbook.

Traditionally the first ten to fifteen minutes of this class time has been spent by teachers copying out prescribed texts from the book onto the board. Even, with the technology, teachers are reluctant to move away from 'prescribed' texts in the book and work with completely new material. Many of the new lessons created by teachers, were still working from these prescribed texts in the textbooks, and teachers are generally not familiar with the curriculum outside the context and structure of the text books. However, even lessons created within the structure of these texts, have allowed scope for creativity, originality and local examples.

6.6 Motivation of Students

Many of the teachers mentioned increased motivation of students as an impact of the introduction of the technology, specifically when used with photos.

> *"Children concentrate more when they can see something."*
>
> Max, Group Discussion

"Because the student gains a lot of motivation, looking at the images and they participate more directly in the class. It is not as if we were making questions out of nowhere and asking students to answer them. … It is as if the students were seeing a movie. It helps a lot. The students also like it and there is lots of participation, there is lots of dynamism."

Marlon, Group Discussion

Frequent and relevant use of visual aids were one of the consistent teaching practices found to have impact in Westbrook *et al.*'s meta-analysis (2013), and in this context, where printed or physical visual aids were not available to teachers, the iPad proved to be an easy, quick and effective way to create these aids.

In one teacher's account, this increase in motivation has extended to teachers as well as students.

"I think that, motivation for me is a first point. It as a new instrument for us teachers, with the difficulties that we have, it is a constant challenge, as much for the student as for the teacher. Now motivation is also constant. The class is supermotivated from the beginning to the end. This is an enormous challenge, as much for the student as for the teacher. The teacher is also learning and the student is learning. Therefore, everyone is very interested in the class, both the teacher and the student."

Marlon, Group Discussion

The teacher is describing a model of socio-cultural co-learning here that is both challenging and motivating for teachers and for students, both working and learning together.

According to some teachers the increase in motivation has extended to reducing absenteeism.

"For me, the thing that is most interesting aspect of this project, is the participation and presence of the students. When the students use the iPad during the class, of course they mention it to other student who missed the last class, so this other student will feel like going to school and it reduces absences. The participation of students is really good, they want to go to school, to use it, to touch it (the iPad), it is really interesting."

Anna, Group Discussion

The director of pedagogy also reported increased attendance in class during an interview after just a few weeks of the technology being used in classrooms. The researcher attempted to collect quantitative data on attendance in the participating and

non-participating classes, but attendance records are not routinely kept in the school, so it wasn't possible to triangulate this reported increase in attendance.

6.7 Limitations

The scope of the study did not allow for the development of a measure to examine the impact of the intervention on students' motivation or even on their attendance. Attendance records in the school were not available, and the researcher did not witness attendance being taken at the school at any stage.

It was not possible to measure teachers attitudes to creativity. While a questionnaire was developed to examine teachers' attitudes, it was not a priority for the wider team to allow time for testing the questionnaire or administering the questionnaire during limited teacher workshop time.

It was originally intended that digital artifacts created by teachers would be included in the wider data sets. A number of requests were made for screenshots from digital lessons to be emailed to the researcher. However, they were not sent by the director of pedagogy and a decision was made by the researcher that it would have been inappropriate to push too hard for this, given the amount of demands he had, time constraints, access to email and internet constraints and additionally in the context of the overall goodwill he demonstrated towards the researcher and the project. Attempts were made at the end of the last teacher workshops to transfer content from the iPads to the researcher's laptop. However, due to time constraints, technical difficulties with wifi and file format could not be resolved and the files were not readable in the format in which they were transferred. However, most of the digital lessons created during the teacher workshops were recorded to greater or lesser degrees by photograph or video by the researcher.

In reality, in view of the number of teaching days available to teachers, the time to embed for this project was very short. Ideally another visit a year later would have been able to examine how far practice developed over a longer period of time.

6.8 Implications

Teachers can move towards a creative teaching practice in a step-by-step approach, using lesson plans to develop interactive digital lessons.

Key to the development of creative practice is looking to the local environment for examples for lessons. The iPad and applications such as Explain Everything provides a very simple and usable interface for integration of photos into interactive lessons.

As teachers become accustomed to creating class plans and digital content on the technology, integrating elements of interactivity and local examples, this approach can extend to other classes, even when they are not using the technology, providing a wider benefit to pedagogical practice of participant teachers.

Teacher participants brought their own experience and imagination to learning situations, both teachers and learners engaged in teaching and learning through intellectual enquiry, altering the teacher learner relationship and experience in the process (Jeffrey, 2006).

A bank of content can be created very inexpensively by teachers themselves that can grow quite quickly and be shared and built upon by other teachers. This can provide a significant bank of relevant, curriculum-based content, that is linked to whole class teaching and local cultural requirements.

The cost of this is significantly lower than the cost of a one-to-one tablet to child intervention, both in terms of hardware and in terms of software development. It

is also a more holistic approach that builds the skills of teachers and increases opportunities for higher order thinking skills.

6.9 Chapter Summary

Making learning relevant is key to unlocking teachers' creativity in the use of digital technology in teaching. The photographic capacity of digital devices allows for easy integration of the local into creative lessons in an approach that is understood by teachers and learners and adapted relatively quickly and easily. It is an approach that can shorten the pathway to a knowledge co-creation approach to teaching with technology, that is relevant to and usable in the context of large classes in public schools in Sub-Saharan Africa, where locally relevant textbooks or other classroom resources may not be available.

7.0 Findings and Discussion: Teachers' Community of Practice

A community of practice between teachers is central to a socio-cultural activity model of learning, where teachers continue to learn through activity and participation in the community, in this case with teacher colleagues in the school itself. "Learning is seen as more of a process of social participation, than acquisition of knowledge. The nature of the situation impacts significantly on the process" (Lave & Wenger, 1998, p.3). The learning is embedded in the 'authentic teacher context' (Chalmers & Keown, 2006) and relevant to teachers' everyday working context (Niesz, 2007).

Professional development opportunities are rare for teachers in public schools in Mozambique, and even rarer in the domain of using technology to impact change in teaching practices. A community of practice approach in the school, is a useful and practical source of ongoing professional development for teachers. "Participation in learning communities facilitates professional development that is driven by the needs of teachers as they are naturally engaged in efforts to accomplish their goals." (Vescio, Ross & Adams, 2008. p.86).

The importance of teachers forming a community of practice was emphasized in meetings with the school leaders and in teacher workshops from the start of the pilot. As this was essentially the only project of its kind in Mozambique at that time, it was emphasized that teachers themselves would become the local and national experts on the use of iPads connected to a projector as a tool to improve teaching practice and learning outcomes.

Research question in relation to community of practice.

Informed by the literature, the research asks to what extent these activities related to community of practice were occurring, if at all, specifically: (i)sharing and

re-use of digital content (ii) events where knowledge or experience is shared between teachers, whether formal or informal.

7.1 Characteristics of a Community of Practice

To qualify as a community of practice, three characteristics need to be present in the group: (i) The domain: a shared domain of interest, of competence, even if this is not recognised as expertise from the outside. (ii) The community: members engage in 'joint activities and discussions, help each other and share information. They build relationships that enable them to learn from each other.' (iii) Members of a community of practice are practitioners. (Wenger, 2011)

In this study: (i) the domain is the use of iPads connected to a projector as a tool for a more participative and creative pedagogy, (ii) the community is participant teachers of third grade in a large public primary school in Mozambique and (iii) the members of that community are all teaching with the new technology a number of times per week.

In order to be successful Wenger identifies three essential practices (i) mutual engagement (ii) joint enterprise and (iii) a shared repertoire (Wenger, 1998). Mutual engagement relates to interactions between members of the community with a view to helping each other, which can be formal or informal events. Joint enterprise relates to the degree to which members of the group take responsibility for community of practice activities. A shared repertoire refers to the sharing of resources such as classroom resources, information experiences, stories, tools, ways of addressing recurring problems etc. (Wenger, 2011; Laksov, Mann & Dahlgren, 2008).

These practices are enacted in the school in the following ways. (i) The formal mutual engagement activities in this school are weekly meetings, and informal events are teachers seeking each other out for advice on content or class plans. (ii)

Responsibility for community of practice events lies with the school, the degree to which different members within the school community take responsibility for this, is discussed later. (iii) Class plans, digital content and experiences are shared between teachers as part of the formal or informal mutual engagement events.

A spectrum of definition.

Definitions of communities of practice vary across a spectrum from naturally occurring communities without a specific goal to structured professional learning communities set up for a specific purpose (Hoadley, 2012; Andriessen, 2005). The community of practice related to this project sits somewhere in the middle. Members of the community are all teachers who have participated in the professional development workshops for this project and are actively participating in using the technology in their classrooms for teaching. The school leadership is actively involved in encouraging and facilitating the community of practice, with the specific goal of improving teaching practice with the technology and sharing digital content and class plans.

7.2 Sharing and Re-use of Digital Content

Phase 1:

During the first teacher workshop, it was outlined to participant teachers how content could be shared between teachers, and how a lesson created by one teacher could be re-used by another teacher.

Phase 2:

During the second teacher workshop, teachers expressed concern in the group discussion about the amount of time it was taking to prepare lessons on the iPad in advance. The director for pedagogy (Saul) responded to this in the following quote, strongly suggesting that teachers needed to follow a class plan template, so that digital

content prepared by one teacher could be easily re-used by another, thus saving time

for all.

> *"For example, that teacher's class was planned, but was not really planned.*
> *What did he do? He systematically put content on the iPad. If even before giving*
> *a class, we have a template for the teacher informing what needs to be taught.*
> *Before giving the class, the teacher could sit with the class plan template, and he*
> *works with the text and the content on the class plan, only with the template. If*
> *another teacher sees my class plan and my content, they will not have much*
> *difficulty giving that class, but without my class plan the teacher will find it very*
> *difficult to give this class. So now we have these two things: we have a plan and*
> *we have content on the iPad. With the class plan everything is simple and easy*
> *to organise the content in the class. Because we will have organized it*
> *previously on the template. With this plan we have a guide on how we deliver the*
> *text and the class."*
>
> <div align="right">Saul, Group Discussion, Phase 2.</div>

In this phase the concept of sharing content had not yet taken hold, as teachers

were individually struggling to create content with very demanding timetables. To help

teachers, the tutor focused throughout this second teacher workshop on developing

digital content with class plans, that could be used and adapted by other teachers.

Phase 3:

The survey showed that all participating teachers had re-used digital artefacts

created by another teacher at least once. All teachers had created at least one digital

artefact that was re-used by another teacher. Lessons that were re-used included;

provinces and cities in Mozambique, parts of a plant, domestic and wild animals, types

of soil and reading and integration of text. While the survey was anonymous, there may

have been bias on the part of the participants to provide answers that affirmed a

positive effort to participate fully in the project. There may be a question mark over the

validity of this data, given that most of the specified lessons had also been

demonstrated during the workshop. The final category, reading and integration of text,

is controversial. The Director of Pedagogy had warned that in some cases teachers

were using the devices simply to photograph and input prescribed texts, without class

planning. Teachers consistently cited lack of time to prepare material in advance on the

devices, which may be a factor here. There seemed to be some disagreement and

tension between the participating teachers and the director in relation to this. It is unknown what degree of access to the devices teachers had outside of class time. It was also unknown if teachers were allowed to bring devices home for class preparation or learning reasons. The researcher attempted a number of times to ascertain this information, but answers remained unclear on this.

7.3 Community of Practice Events

Community of practice events included teacher meetings or informal exchanges of knowledge or experience between teachers. A decision was made by the researcher in collaboration with the wider implementation team to request meetings between teachers on a weekly basis to create a momentum for the formation of a community of practice, and to also use the mechanism of the meetings to get a direct report from teachers on their use of the technology, rather than reporting of this being filtered through the school leaders or other facilitators of the project. The researcher suggested that a whiteboard would be filled updating progress in using the technology in the classroom, documenting sharing of digital content or expertise, highlighting any problem areas and providing examples of best practice. It was requested that a photo of the whiteboard filled in during each weekly meeting would then be sent to the researcher by email after the meeting. The reasoning behind this relatively prescriptive request was that teachers' direct experiences and reports would be fed back to the researchers unfiltered on a week-by-week contemporaneous basis.

7.3.1 Formal Events - Teachers Meetings.

Phase 1:

In the first workshop, one session was set aside for teachers to discuss ways in which they could form a community of practice and share any new learned knowledge,

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experiences or digital content with each other, over the course of the pilot project. The researcher discussed this in advance with the wider implementation group, encouraging a short weekly meeting to get a community of practice started. In response a commitment was made by the school director of pedagogy (Saul) to a twenty-minute meeting between the participating teachers per week, where knowledge and experience would be shared and goals set on how they could continue to support each other's progress in the week to come. Key progress or actions were to be tracked on a whiteboard which would allow all participants to track progress and the school director agreed to send a photo of the board to the researcher each week, with an agreement that this was simpler than having to provide written progress reports or other forms of data.

On the field trip to the school three months later, the issue of the meetings was raised again. At that point, meetings had not yet taken place. The director of pedagogy (Saul) had been acting as the conduit between the teachers, observing them using the technology and sharing information on different experiences between the teachers, as outlined below by the researcher after the field trip to the school:

> *"At the moment the weekly twenty-minute meetings that were promised at the end of the workshop are not happening. Instead Saul is observing how the teachers are using the technology, and occasionally bringing the group together when there is a particular challenge for them to share. At the moment instead of the teachers self-reporting on a large whiteboard as had been planned (lack of availability of a whiteboard may be an issue), Saul is recording their activities on tables and spreadsheets and sending to us by email. All community of practice activities at present are driven by Saul, as the director of pedagogy."*
>
> Researcher field notes.

A whiteboard was purchased by the researcher and provided to the school with markers, as the researcher in discussion with the Irish Aid team identified that this may have been an obstacle.

Phase 2:

Sharing and re-using of content was discussed by teachers during the group discussion at the second teacher workshop. As it was the start of a new academic year, community of practice meetings had not yet commenced, but the director of pedagogy

remained committed to commencing regular meetings at the start of term. Teachers did

not provide their opinions about the meetings at this point.

Phase 3:

During the final workshop, the director of pedagogy (Saul) asserted that twenty-

minute meetings were taking place between the five participating teachers and that they

were mandatory:

> *"So, among these teachers, we have what we call "pedagogical journeys" weekly, where we discuss… For these[participating] five teachers who have a specific work timetable, it is mandatory that they gather together weekly to try to overcome these challenges and difficulties… We have one teacher giving the class and the other teacher is attending to the colleague's class, and in the next class they exchange. Then we sit down, at the end of the classes, to validate what were the diverse difficulties based on the class's plan. What were the difficulties they had, what do we need to repeat the class, or do we need to change the class, or do we need to plan the class differently?"*
>
> <div align="right">Saul, Group Discussion</div>

The description of the weekly meetings given above was in response to a

question from a Ministry for Education official who was sitting in on the

workshop and group discussion. However, it is difficult to establish how often

these meetings were really taking place as Saul's account differed from that of

one of the participating teachers, when discussing obstacles to the progress of the

project, when that official was not present:

> *"Another thing I would like to mention is that we are having difficulties with the timetables. Because even though we are all involved on this project, our timetables are different. Some start at six, some start at ten. In each day we have three shifts of school. Some are working in the afternoons. So, it isn't possible. We are never all together. We are never together on the timetable."*
>
> <div align="right">Marlon, Group Discussion, Phase 3.</div>

Given these contradicting accounts of the weekly meetings, it remained

inconclusive at the end of the research period whether the meetings were taking place

on a regular basis or not. On reflection, given the core principle that leadership and

responsibility for community of practice needs to come from within the group itself

and not be imposed from the outside, this prescriptive approach of requesting weekly

formal meetings and reports from those meetings, may have been doomed to failure.

The idea didn't come from within the community and therefore was not reflective of, or appropriate to the needs of the community. Because of the timetabling difficulties and the fact that many teachers taught different shifts in different schools, requesting a weekly meeting of twenty minutes may have been unreasonable, despite assurances from the school leaders that there was no problem with this. While the intention of the researcher was to cut through any filtering from gatekeepers that may have occurred in the reporting of the progress of the project and of community of practice events, in effect it was not a true community of practice event as it was imposed from the outside, and therefore did not work.

7.3.2 Informal Community of Practice Events.

However, teachers were reporting informal community of practice events between individual teachers who sought each other out for advice and knowledge sharing. Here, Rita reports how she consults with other teachers in the preparation of class plans with the technology.

> *"Now, related to the subjects, we still consult someone after preparing the classes. I always consult someone and ask for help to get images I need mainly with transversal themes, … it is also a moment when the student show more interest in the classes because the talk is about their environment. So, that is the moment when I bring my plan to the other colleagues and ask for feedback and advice."*
>
> Rita, Group Discussion.

Marlon also speaks here about the importance of sharing expertise within the school community, and of teachers supporting each other particularly in relation to solving specific problems.

> *"We all have particular difficulties. I am talking about me, for example, I have my difficulties, maybe they are not the same as my colleague's, everyone has their own weakness. In order to deal with these individual problems, we have to try to create spaces where we can interact as teachers, where each we can check which are the difficulties that everyone has. I believe that my colleague class presentation will not be 100% like mine or like someone else's, there will always be changes, there will be always small difficulties and gaps and together we can overcome. So, we can work together, to help each other to resolve our difficulties. We will each have different approaches to problems. What my colleague here will think, will be different to me. But between us we can work*

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together to resolve these problems. We can give each other help when we are
having difficulties."

<div align="right">Marlon, Group Discussion.</div>

This was an approach that worked, because it came from the teachers themselves and was in a format that was suitable to the structure of teachers' working days and natural community relationships, rather than suitable to the needs of the researcher. It was also an approach that this not require brokering or gatekeeping by Saul and was organised in a true peer-to-peer fashion between trusted insiders.

7.4 Impact of Technology as a Catalyst for Developing a Community of Practice

a) Timetable conflicts are an obstacle to formal community of practice events, but not to informal community of practice events.

As seen above, conflicting timetables were reported as an obstacle to formal regular community of practice events. The school operates three separate shifts per day in order to accommodate all students (early morning, late morning and afternoon), and the participating teachers are often on separate shifts of school, with some teachers also teaching another shift at a different school. However, while this interfered with a formal weekly meeting, it didn't seem to interfere with informal community of practice events, such as teachers seeking each other out for advice, which were beginning to build momentum by the end of the project.

b) Attempts to impose formal community of practice events by the researchers and by school leadership were resisted.

Attempts to impose formal community of practice sharing of expertise from the school leaders were difficult to instigate during phase one and into phase two of the research, despite the director of pedagogy's best efforts. The following quote reflects the frustration of the researcher on the slow progress of these events three months into the project.

> *"Saul started reporting the use of the device on a spreadsheet, rather than on a whiteboard. And rather than holding weekly meetings, he has been observing the teaching, and troubleshooting directly with each teacher. There has not been an opportunity for teachers to create a community of practice and peer learning supports between themselves."*
>
> Researcher. Reflective Diary.

After this, it was unclear to what extent the director managed to implement weekly formal meetings, as he reported that the weekly meetings were happening every week, but teachers did not report the same.

Timetable conflicts and other factors such as the perception of meetings as extra unpaid work, or everyday teacher management constraints may have led to staff resisting these types of events when imposed from the top down. The following discussion provides an illustration of how such everyday conflicts were playing out at school level. Saul was frustrated that teachers were not planning classes in advance.

> Saul: *"The other different thing is the class plan, which was not done. Teachers only prepared content. That is why we were lost. Because we have content and how much time are we spending on motivating? How long will it take to assimilate? We didn't have this. We were not doing this planning."*
>
> Rita: *"We always planned the classes, but now we need to use the template, it is the same planning but more adequate because we are using the template. This is the first step. Then we can do the next steps."*
>
> Saul: *"There have been huge improvements, even for me, of how to work with a big text in class, but I am doing my part, and these are the aspects that need to be on your template. How are you going to explore the text on the iPad? If you don't have a class plan, the teacher is just going to project the text and read and repeat. The children will be bored, and they will not learn. The class plan will allow the teacher to integrate group work and reading in groups. The class has to be planned on the class planning template..."*
>
> Saul and Rita, Group Discussion.

This tension was at its height about mid-way through the project, but dissipated later during the pilot period, as the project naturally found its own community of practice. Towards the end of the pilot period the School DOP reverted back to a teaching position, on a par with the other teachers, and no such tensions were evident in the last teacher workshop.

c)Informal community of practice events formed spontaneously between teachers as the project developed.

At the end of the one-year pilot period, teachers were spontaneously sharing expertise, without any imposition from school management or from the researcher, and this type of practice was proving more effective.

> Marlon: *"We have to try to create spaces where we can interact as teachers …*
> *We can give each other help when we are having difficulties."*
> Tutor JC: *"A community of practice is this, we all have different strengths in different areas, we demonstrate our work and we learn from each other."*
> Rita: *"And we also share our experiences…"*
> Marlon and Agostinho: *"Yes, yes"*
>
> Teacher Discussion.

At this stage, the motivation for these meetings was coming directly from the teachers, to the extent that they were willing to take part in these meetings during their own time.

> *"So maybe we could open an exception and meet on a weekend, even if it was only once a month, this kind of meeting is really good."*
>
> Marlon, Teacher Discussion.

As teachers were becoming more confident and experienced in using the technology, as well as becoming practiced in using dialogue to discuss their teaching practice during the professional development workshops, they were more comfortable in discussing their practice with each other and in understanding how they could benefit each other in sharing new experiences and knowledge as it developed. The power dynamics also changed when Saul reverted from the position of director of pedagogy back to teaching and was on a more equal level with the rest of the community of teachers.

7.5 Discussion Community of Practice

Research supports the value of teacher participation in communities of practice for students' learning. In a longitudinal study of elementary schools in the USA, it was found that teachers perform better when their peers are better (Jackson & Bruegmann, 2009). A meta-analysis carried out by Vescio, Ross and Adams (2008) examining the impact of teacher participation in professional learning communities and student

achievement, found improvements in student learning in all studies as a result of teacher participation in a professional learning community.

Developing a community of practice between the teachers in the school was identified as an important factor to the longer-term continuation of the project beyond the pilot phase. In a study conducted by Deaney and Hennessy (2007) over three years, it was found that dissemination of practice between teachers was an important factor in the sustainability and evolution of ICT supported classroom practice. These dissemination practices included integration of practice into schemes of work, providing guidance, moral and practical support for peers, providing examples of practice at department meetings, observing lesson and training colleagues. "To effect lasting educational change, teachers must come together around common interests, which must also be based in authentic teacher contexts" (MacDonald, 2008, p. 437).

Laksov, Mann, & Dahlgren, (2008) identified internal agents of change as key to sustainability of educational development. While an educational developer may initiate the project, the leadership for change must come from within the community where the change is to happen. (Laksov, Mann & Dahlgren, 2008) A teacher from within the community will act as an internal agent, using key words in dialogue to trigger engagement and interest in other staff (Laksov, Mann & Dahlgren, 2008). Saul initially took on this role in the early stages of the researcher project, but as he was in a director role in the school, he did not have the full impact of an insider or 'internal agent' as he was in a position of authority over the others, and had access to resources they didn't, such as control over timetables, resources etc. It was Rita who emerged as the natural 'internal agent of change', as she had true insider status in the group, and was in a position to speak in a language which the group related to as entirely relevant to their issues and concerns.

A community of practice may also lead to further growth and innovation from within the community of teachers. A community of practice allows for reflection and evaluation of current teaching practices, as well as scope to invent and share new ways of teaching and supporting learning (Laksov, Mann, & Dahlgren, 2008). This emerged in the group clearly by the third phase as they were able to talk critically about their practice and share experiences, content and knowledge.

7.5.1 Factors facilitating a Community of Practice

Strong interpersonal relationships.

Strong interpersonal relationships between teachers emerges consistently in the literature as an important facilitator of teacher communities of practice (Borg, 2012). Trust between teachers, a key component of relationships was also found to be one of the largest factors facilitating the development of teacher professional communities (Bryk, Camburn and Louis, 1999). In this study, as the project developed, teachers began to seek each other out naturally for advice, knowledge and collaboration. It is not known to what extent the teachers involved in the project knew each other before participation on the project, or the extent to which relationships developed over the course of the project and participation on the project. However, relationships were sufficiently strong as the project developed for teachers to feel comfortable enough to seek each other out for advice.

Teacher personal attributes.

Another factor determining the level of success of a teacher community of practice related to teacher's own personal attributes. Individuals who were committed to their own personal learning were key to the success of the community (Borg, 2012). In this study one teacher in particular, Rita, stood out in this regard as an 'internal agent of change'. When she spoke the other teachers listened. She was the oldest and most

experienced teacher in the group and the younger teachers referred to her affectionately as 'Mother'. In the first teacher workshop she was skeptical about many aspects of the project, particularly in allowing increased student participation. She was worried about the consequences of this in the particular environment of this school: large class sizes, confined spaces, other children waiting nearby for their school shift to begin and children who were behind in learning because of their lack of fluency in the Portuguese language, which is the official language of instruction in the school (compounded by the fact that there were many minority languages in the school, not just one). However, by the third phase of the project, Rita had experienced a transformation in her views on teaching and passionately advocated for change in the discussion groups. Because she was able to draw on her experience of many years teaching in the school, and on a dialogue that the other teachers could relate to, her influence as an agent of change within the school community became very strong. She spoke passionately about how teachers should wake up to other ways of learning, using the environment of the school and being prepared to be open to flexible and innovative approaches in classes where the technology is used, and also in classes where the technology is not in use.

Rita was able to draw on her seniority and position of respect within the school community, as well as her own passion and commitment to learning and improving her own practice, to make this confident call to action, using language that struck a chord with the other teachers, consistent with the characteristics of internal agents for change (Borg, 2012; Laksov, Mann & Dahlgren, 2008).

Role of leadership.

The role of leadership is recognised as key in the literature. Leaders create the environments, culture and expectations for a community of practice through their own actions (Smith & McKeen, 2004). These actions that support a community of practice include building trust, making knowledge easy to use and establishing co-ordinating

rules (Smith & McKeen, 2004). Important facilitating variables include principal leadership and supervision, with regular involvement with teaching staff, encouraging teachers to take risks and to innovate (Bryk, Camburn and Louis, 1999).

The director of pedagogy in the school took a clear leadership role on the project. He took responsibility for co-ordinating community of practice events and for leading the development of the project as a whole in the school, scheduling use of the equipment, distributing information and content, and reporting on progress

However, the literature also recognises that leadership cannot force the development of a community of practice to a set schedule. "Like gardens, they respond to attention that respects their nature… You can't tug on a cornstalk to make it grow faster or taller… you can however, till the soil, pull out the weeds, add water and ensure… proper nutrients." (Wenger and Snyder, 2000, p.143). Borg (2012) identified leadership as both a facilitating and constraining factor, consistent with the above quote, in the extent to which leadership can encourage and create the right conditions for a community of practice, but cannot force the pace or extent of its development.

Leadership in this study was a key facilitating factor in building a community of practice, particularly in the early stages of the project. The director of pedagogy in the school, understood the benefits and potential of the project for the school and was immensely supportive of the project from the beginning. He continued to work directly with the teachers after each workshop, following up on progress and facilitating sharing of digital content between teachers. Towards the end of the pilot period, Saul stood down from his position as director of pedagogy, and reverted to teaching. He stated his reasons for this as being to do with wanting to be more involved in this project, and less involved in school administration and administration to do with other schools in the cluster of seven schools in the community. In effect, he still led the community of practice within the school.

7.5.2 Factors constraining a Community of Practice.

Time pressures.

Again, time pressure was the biggest constraint in adopting this project, not just in adapting to using technology in classrooms, but also in developing a Community of Practice. Laksov, Mann and Dahlgren (2008) identified additional workload or external pressures and accountabilities as constraining factors for teachers in forming communities of practice. In this study teachers were constrained in a number of cases by working more than one shift and in some cases across more than one school. Conflicting timetables exacerbated the problem of creating a time in the working day for teachers to meet as a community of practice. Additionally, pressure to follow prescribed texts squeezed out the ability to focus on longer term gains on improved teaching practice for short term pressures of covering all the prescribed texts on time.

Staff or leadership turnover.

Staff or leadership turnover has been recognised by a number of studies as a key constraining factor (Laksov, Mann & Dahlgren, 2008; Bryk, Camburn & Louis, 1999). Over the course of the twelve-month pilot study, the director of pedagogy stepped down from his role in the school to concentrate on teaching and Marlon, one of the participating teachers who spoke about the need for a space for teachers to work together to solve problems and help each other, passed away suddenly and unexpectedly during the last teacher workshop.

Individuals in peripheral roles in community.

Lave and Wenger (1991) identified an additional problem with the emphasis on participation in community, that an individual may find themselves in a peripheral role if they are outside the community norms (Lave & Wenger, 1991; Laksov, Mann &

Dahlgren, 2008). In this study this was observed in two of the younger women. These younger female teachers had difficulty in relating their experiences to the group and spoke as little as possible. They were very quiet-spoken and could barely be heard when participating in the group. In general, it was the male members who took the predominant role in the group, apart from Rita, who was looked up to by the younger female teachers. It is not known if this crossed over into the community of practice events and exchanges in the school itself.

7.6 Limitations of Study

Self-selecting nature of community of practice.

One of the key differentiators identified between a community of practice and a team is that its members are self-selecting (Smith and McKeen, 2004). Participation in community of practice activities was encouraged for all participating teachers to ensure the long-term sustainability of the project, both by the researcher, the school leadership and the wider team. This is contrary to the core principles of a community of practice being led from within the community and was recognized retrospectively by the researcher as a weakness of how this aspect of the research was approached. Within the school it is also unknown to what extent participation in those events at school level was voluntary or imposed by the school leadership. It is also unknown to what degree continued participation in these activities after the pilot phase was voluntary or imposed. In this aspect of the research the outsider impact was potentially significant and make the ultimate findings in relation to community of practice unclear.

An additional complicating factor was that there is a tradition of paying teachers per diems for participating on training courses. The value of these per diems is significant in relation to monthly salaries, and is a significant motivating factor for participation on a training course. While all third-grade teachers were equally provided

training, whether they were using the technology in class or not, a few additional teachers were included in the training who were not third grade teachers. It is not known the impact of this on the community of practice formation and development.

Time scale of pilot project.

A community of practice dissolves when its members lose interest or are no longer benefiting from participation in the group (Smith and McKeen, 2004). As this study only ran for twelve months, it is unknown what happened to the community of practice activities after this timescale, particularly in light of one of its key members passing away at the end of this time phase.

Challenges of Context.

The context of this study presented some unique challenges that might not be an issue in other Sub Saharan African contexts. The most significant of these were related to the school running three school shifts per day and participating teachers often teaching on different school shifts, and therefore not having the opportunity to meet or communicate over the course of the school day. The school also did not have a room or space where teachers could meet for community of practice events. As teachers didn't have access to the internet, it wasn't possible to set up an online community for sharing experiences or resources. And because this community of teachers was unique in teaching with iPads in a primary school context in Mozambique, there wasn't a wider community of practice for teachers to participate in, or a wider community of support for ongoing professional development. However, that situation was continually changing as smart phones became available and 4G data networks became more accessible in Mozambique, and as in time, hopefully more schools would begin to adapt similar approaches to the integration of mobile technology into teaching.

7.7 Implications

This study suggests that community of practice is an important component of the growth and development of innovative practice at school level and that teachers provide valuable support and learning opportunities for each other on the specific context of their own teaching environment and conditions.

Leadership and school support is vital to the ongoing survival and growth of a community of practice, while also recognising that leadership cannot impose a community of practice without motivation and understanding of its benefits coming from the teachers themselves.

Leadership and responsibility for the community's events and activities must come from within the community of teachers themselves to be sustainable and grow over the long term, and must take account of local environments, spaces, timetables, personalities and teachers' needs.

Time is required for communities of practice to take root and embed, but as teachers develop skills, experience and confidence to share dialogue and resources on their teaching and technology knowledge, they will support each other through mutual engagement to improve their use of the technology and their pedagogical practices.

7.8 Chapter Summary

Research suggests that school is the best level of intervention for improving the quality of teaching and learning by involving the school head and all the teachers in creating a genuine learning community through ownership of the process (Anderson, 2002; Carron & Chau, 1996; Verspoor, 2008). In-school communities of practice are a vital source of continued professional development that is relevant and rooted in the authentic context of teachers, particularly in remote environments inaccessible to the internet. Additionally, internal agents of change coming from the community itself will

be a much more influential for sustained educational change, than any changes imposed from outside the school.

While the researcher and wider team of stakeholders can set up, encourage, support and monitor the project, the local community of practice is vital to the longer-term sustainability and growth of the project can only come from within the school. The context is so specific, and so challenging, that it is only teachers working within the school on a daily basis who have the knowledge or moral authority to advocate for its specific usefulness for this situation. Without a local community of practice sharing relevant digital content and expertise, it would be very difficult, if not impossible, for individual teachers to continue to work with the technology on their own. It would certainly not be possible for the project to continue to innovate and develop without a local community of practice, supported by the management of the school.

8.0 General Discussion

This chapter returns to the broader context of the Sustainable Development Goal of Quality Education for All in the context of public schools in Sub-Saharan Africa.

The main findings are outlined and their implications for the achievement of the goal. Two large cross-cutting themes are discussed; the role of teachers in the quality education debate in the context of Sub-Saharan Africa and the role of technology in the quality education debate in the same context. The potential of mobile technology in the context of Sub-Saharan Africa, comparatively with other forms of ICT interventions are discussed, as well as wider context issues, such as internet access, cost and ICT infra-structures. The discussion then develops to examine the role of the teacher with the technology.

The goal is further discussed from the perspective of Quality Education for ALL, examining the role of technology on student motivation and participation, and on reaching the children at highest risk of school drop-out.

The discussion then returns to the theoretical framework of a Socio-Cultural Activity Theory (CHAT) (Engestrom, 1999) of learning, and how this study supports the theory. The discussion expands into an examination of how practice in a CHAT framework developed teacher competency in a Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2009) framework, over time creating a transformation in teachers practice that becomes a cultural change.

The wider context of the study is also discussed and the impact on this study of the wider objectives and enabling political partnerships.

8.1 Role of Teachers in Achievement of Sustainable Development Goal 4 – Quality

Education for All

Teachers are counted in the Global Education Monitoring reports, the purpose of which is to monitor progress on Sustainable Development Goal 4, in terms of their numbers, their ratios in relation to students in the classroom, their salaries, years of education, gender, number of days and hours teaching, and number of days absent. However, discussion is almost non-existent in the same education monitoring reports on what it is that teachers do in the classroom to impact the quality of education. Debate on the role of teachers in quality education focuses on low education levels of teachers and high rates of absenteeism and discussion on how to support teachers in engaging in practice that impacts quality education is largely absent. Focusing on number of years of teaching education as a proxy measure for teacher quality, avoids tackling the issue of how teacher practice can change in the classroom.

Previous chapters have shown that an iterative approach to change in practice can have a large impact over the course of a year. When teachers engage with students, enabling them to form connections in their skills, understanding and knowledge, students become active agents in their own learning (Layne *et al*., 2008). As learning becomes more relevant to children's everyday lives, children connect emotionally with their own learning processes and begin to take more ownership over these learning processes (Woods, 2002; Barrett *et al*., 2007; Tikly and Barrett, 2011). In time, a cultural change can evolve to teachers creating a more open atmosphere, where students are not afraid to make a mistake is an essential component of a classroom environment where students take some ownership over their own learning (Layne *et al*., 2008). Taking the emphasis away from the 'correct' answer, and towards finding examples, connections, new ideas removes the pressure and fear of giving the 'wrong' answer and thereby changes the culture of the classroom towards curiosity and the joy of learning for its own sake.

Teachers working to optimise peer relationships within the classroom is another important motivating factor. Peer-assisted learning and socialisation with peers have been found to have an impact on academic motivation and learning achievement (Light & Littleton, 1999; Steinberg, Dornbusch & Brown, 1992; Wentzel, 1999). As teachers see the impact of these practices on students learning and motivation to learn, it reinforces their belief in the practices, which in turn makes their use of them more confident and creative.

Professional development of teachers.

Change in practice is closely linked to change in beliefs about the role of teachers in the classroom (Abd-Kadir & Hardman, 2007; Hardman *et al.*, 2011). School based teacher development programmes, can support teachers in examining their own beliefs and how they interact and dialogue in the classroom, enhancing dialogue around teaching practice and collaborative problem solving with colleague teachers, in order to bridge the gap between practice and theory (Abd-Kadir & Hardman, 2007). The Global Education Monitoring Report 2018 acknowledges the importance of peer learning for teachers in improving practice, through sharing knowledge and creating a culture of accountability between teachers (UNESCO, 2018).

As teachers developed in their practice and ability to reflect on and discuss their practice, they began to take ownership of their role in impacting quality of education. This is consistent with similar studies in Sub-Saharan Africa, such as a study in Kenya that demonstrated how teachers' beliefs as well as their knowledge, understanding and skills can change through a well-designed, school-based professional development programme (Hardman *et al.*, 2011). Practice and reflection fed into each other, with teachers becoming more confident to talk about their practice as they implemented changes in the classroom, and in turn becoming more confident to implement changes as they talked more about their practice and shared their experiences with each other.

Over time, this led to a transformation in practice, with teachers becoming more confident to depart from the text book and prescribed texts, or to apply them to the appropriate local context. This study demonstrates that teachers' practice can change over relatively short periods of time if supported by school leadership and professional development programmes and communities.

8.2 Role of Technology in the Achievement of Sustainable Development Goal 4 – Quality Education for All

UNESCO, UNICEF and others and others recognize the potential of mobile technology in addressing educational inequality. Africa is recognized as a continent ripe for leapfrogging in its use and development of technology across all sectors, not least of which is education (World Bank, 2017). Use of mobile technology rather than traditional ICT in schools provides a solution to a number of issues.

8.2.1 Mobile Technology for Education – Approaches.

Many NGOs, technical start-ups and government agencies in different countries have used different approaches to harness the power and flexibility of mobile technology to provide stimulating high quality digital learning content in remote environments where textbooks and other resources are few.

One device per child approach.

A number of projects using mobile technology have taken the attitude of using technology to replace bad teachers with applications that do the teaching. The One Billion maths application which has been piloted in Malawi and is now expanding into Kenya and Ethiopia with a one-to-one tablet to child intervention. iPads or other tablet devices with headphones are provided to the school, pre-loaded with a game-based learning maths appliction. Children are scheduled for one hour on the devices per day.

Impressive gains in learning outcomes were achieved over an eight-week period, particularly for children who were classed as 'low achievers' (Pitchford, 2015). In another project called Mwabu in Zambia, millions have been spent on putting the Zambian curriculum on a game-based learning software programme. Again, children spend time in rotation on the tablet devices on a one to one basis, combined with group work and a teacher professional development programme. Significant gains in literacy and numeracy were measured over a one-year period, in comparison to normal delivery (Mwabu, 2018). In both of these cases many years of development and investment have been put into developing game-based learning software specific to the curriculum requirements for early learners. As the software and records are held locally on the devices, there is no need for internet access. These projects show the potential of mobile technology where significant funding can be invested in curriculum relevant game-based learning software development. However, as learning becomes more sophisticated at higher grades of learning, these software systems become more and more expensive and difficult to design, and do not provide scope for a more holistic educational approach or adaptation to local needs and culture. Innovative use of technology for education is coming from the technology sector rather than from the education sector and is therefore focused on the technology rather than on teaching with technology as an enabling tool. This type of innovation largely excludes the teacher from the solution and when money runs out, the solution stops. Investment is focused on the technology, rather than on support for the wider context, including teachers and ongoing running costs.

Some other mobile learning projects in the region use simpler earlier generation mobile devices to create learning through text projects. Eneza Education (Eneza, 2018) and Yoza Cellphone Stories (Walton, 2019) use the texting capacity of mobile phones to provide additional reading content where books are scarce and surrounding

environments are not text rich. Stories or exercises are texted to parents' mobile phones after school, children read these as homework to be discussed in school the following day, or for children who have had to drop out of school to work, they can continue learning through the programme. This approach uses the technology that already exists in the environment to provide supplemental content in a form that doesn't require large investment in technology. Both these projects were developed locally within Sub-Saharan Africa, and have grown organically according to local needs. The business models for these range from paying per text to privately funded NGOs. Studies on the impact of these models have not been found, but this approach has been applauded for its sustainability and appropriateness to the environment during UNESCO Mobile Learning Week 2016 and the Eneza Education project has gone on to win the Best Mobile Innovation for Education 2018 Global Mobile Awards at the Mobile World Congress. It demonstrates that simple approaches, developed within local communities, are sustainable because they listen to local needs and work within the existing technology environment.

Whole class approach (akin to Interactive Whiteboard).

Most studies on use of mobile devices in education, are centred on learners use of the device directly to access the internet. More recently, advances in the use of iPads or similar tablet devices in classrooms, have provided some research and practice on the use of these devices in small groups, or individually with the teacher directing project work, either directly by walking around the classroom, or indirectly through mirroring technology, i.e. where the teachers screen is mirrored onto a large monitor or directly onto the students' devices (Falloon, 2015; Falloon & Khoo, 2014; Fisher, Lucas & Galstyan, 2013; Henderson & Yeow, 2012). As already outlined, the mobile technology connected to a projector is used in this study in a manner that is similar to a teacher using an interactive whiteboard. Hennessy *et al*. (2007) found that the strength

of the interactive whiteboard technology is in its support for collaborative work, shared articulation, evaluation and re-working of ideas and constructing new knowledge). The three potential benefits of the interactive whiteboard most discussed in the literature relate to an increase in student engagement (Morgan, 2008, Winzenried, Dalgarno & Tinkler, 2010), more effective visual representation (Holmes, 2009; Schmid, 2008) and learning through greater classroom interactivity (Chuang, Shen & Wang, 2008; McCormick, 2007, Winzenried, Dalgarno & Tinkler, 2010).

In this study, the whole class approach to using the mobile technology yielded a number of advantages.

The user interface on the iPad was intuitive and easy to use and learn. Teachers who had no experience of ICT use were able to learn to use and teach with the devices over a relatively short period of time. As all the devices used in this project were iPads, it is not known what additional issues might arise with other mobile devices. Over the timeline of this project and the researcher's visits to Mozambique, it became more common for teachers to own a smartphone rather than an earlier generation mobile phone. As teachers become familiar with this type of technology outside the classroom, it invariably has an impact on the ease with which teachers adapt to using similar technology in the classroom.

The teacher is central to this approach. The teacher's competency develops, not just in using the technology, but in teaching and in developing themes and knowledge on subject matter content. The technology becomes a tool for the teacher, rather than the focus of the project. As a tool, the technology can be adapted to local needs, rather than teachers and learners working with content and designs created by outside technological innovators. The teachers and learners become the innovators, designing and adapting content from the local environment.

Something initially considered to be a failure of this project – the attempt to get a larger number of devices in use inside and outside the classrooms, resulted in realizing that results can be achieved with a very small number of devices shared between teachers. As teachers worked on shared devices and passed on their content from teacher to teacher, each teacher added to and built on content developed by other teachers, creating a bank of locally created content on the same shared device.

Technology for access to content.

The biggest opportunity afforded by mobile technology is access to the limitless resources of the internet, including Open Educational Resources (OER) and online peer learning communities for teachers. Teachers on this project had very limited access to the internet through mobile data cards, and used that time almost exclusively to search for images relevant to lesson topics. School libraries, public libraries and book shops are very scarce in the context of rural Sub-Saharan Africa. The internet provides a rich and accessible source of valuable texts. Even when school textbooks are provided, their survival in humid, dusty environments, without appropriate storage conditions, is short (Drajea & O'Sullivan, 2014). Therefore, the potential capacity of mobile technology to open the lock to this potentially limitless source of content is highly attractive.

However, locally relevant educational text or multimedia content is scarce (Unwin 2014) and a significant barrier to the cultural usefulness of the internet in rural African schools. A recurring theme at the UNESCO Mobile Learning Week 2016, was the lack of locally relevant content online for Sub-Saharan Africa, particularly in relation to children's stories and literature. African Storybook (African Storybook, 2018) is a South African non-governmental agency collecting stories in African languages, about Africa or written by African writers. The stories are compiled into a mobile application, creating a mobile and robust source of locally relevant textbooks. Further developments and calls for funding to commission African writers to collate

local cultural content such as myths, stories, folklore and to write new children's stories are ongoing.

Mobile technology for teacher professional development.

Mobile technology also provides enormous potential for teacher professional development through online communities of learning, Online Distance Learning (ODL) and Open Educational Resources (OER). Examples of projects in such as The Gansu Basic Education Project in rural China (Europe Aid, 2018) involve the use of texting, online chat rooms and discussion boards as well as Online Distance Learning (ODL) and Open Educational Resources (OER) use of via teachers' own personal mobile phones. Such communities can also provide the potential for teachers to share and build on each other's locally created digital content resources. Such online communities were not at the time of this study developed locally in Mozambique, but as mobile networks and smart phone usage becomes more accessible to all teachers, the potential is there for teachers to collaborate on a regional or national level in relation to their own professional development.

This study demonstrates the value of mobile technology in providing a catalyst and central focus for continued professional development that also impacts teaching practice. The focus on the technology in the professional development allows scope for new pedagogical practices and discussions, as well as concrete and usable mechanism through the technology for implementing those new practices, such as a means to integrate local content easily using the camera on the device and ability to easily create interactive content. The mobile device itself when shared between teachers becomes a peer to peer learning support as teachers continue to develop and build on digital artifacts created by colleague teachers.

8.2.2 Advantages of Mobile Technology.

Cost.

Traditional ICT infrastructure requires dedicated computer labs, stable connection to electricity and broadband and initial investment in purchase. Traditional PCs or other computers require significant investment in training for users and IT technicians, as well as ongoing support. In remote areas, finding individuals with the required technical literacy can be challenging and costly. Previous attempts to provide traditional ICT infrastructure to schools in Africa were stymied early into the projects by a lack of investment in ongoing support and training at school level. This has resulted in the phenomenon of rural schools in Africa, with a closet or room of dusty and obsolete laptops locked away and unused, many from the One Laptop per Child project (OLPC News, 2014).

Electricity.

Access to electricity is perceived as a significant barrier to the integration of ICT in education in Sub-Saharan Africa. Most schools in rural Africa do not have access to electricity and many urban schools have unreliable access to electricity. Traditional school computer labs rely completely on reliable electricity sources, in cool, dust-free environments, factors that are problematic and expensive to maintain in rural Africa. Mobile technology, on the other hand, can be pre-charged from other electricity sources, or use solar or other batteries such as car batteries. Mobile devices do not need special rooms or continuous electricity supply. The challenge arises when the mobile device is connected to a projector. Projectors do need to be connected to an electricity source, and they also require more dust free, cooler and darker environments. While they can work successfully under the shade of a tree for example, further research is required on the long term impact on the equipment of dusty environments, and high temperatures. Even with relatively powerful projectors, projecting at a small size, visibility is still a challenge in outdoor environments. The

technology solution provided for in this study included solar panels to power the projector, and charging of the iPad, this adds to the expense of the overall cost, as well as increasing the weight and thereby reducing the mobility of the overall technology solution. As the school in this study had intermittent access to technology, and only used the technology in one room which was able to block out light and dust to a large degree, the full technology solution was not tested as originally envisaged in outdoor classrooms.

Access to internet.

Broadband networks are nascent in Africa and mostly confined to large urban centres. Traditional computers are limited in their potential without access to the vast resources provided by the internet. However, mobile devices can access the internet through rapidly developing 3G and 4G networks in Africa, without requiring broadband or wifi connections to rural schools.

This study was designed to work without any access to internet at all, with a focus on using pre-loaded applications, for teachers and students working collaboratively to create interactive lessons integrating local examples through the photographic capacity of the device. The study did not examine the potential of the internet in providing additional access to resources. The potential of the usefulness of the devices as an access route to potentially limitless resources has therefore not been tapped in this study and is an area ripe for research potential into the future.

8.2.3   Challenges of Mobile Technology.

While the devices themselves were easy to learn how to use and maintain, problems arose in the maintenance and updating of applications and data transferring and storage between devices. This was particularly challenging during the set-up stage with uploading and updating applications, and issues around the administration of

Apple accounts. In order for operating systems and applications to be kept up to date, they had to be purchased through the local country app store, which did not have many of the required applications. Additional complications arose around the ongoing updating of applications and downloading of new applications in group licenses for the iPads. It was important that this ownership remained locally with the school. However, a local credit card was required to purchase apps on the app store in country, and neither the school nor the researcher had access to a Mozambican credit card. A solution was eventually found through the Irish embassy in Maputo, but for the long-term sustainability of mobile technology in environments such as these, alternative local means of payment and updating of applications would need to be possible. It was in these aspects, rather than in the functionality of the technology, that technical support and outside help was needed.

Internet access while feasible technically through cell networks, is expensive and a considerable ongoing maintenance cost for schools in the use of mobile technology in the classroom. While the technology can be useful through the use of offline interactive apps, the full benefit in the technology lies in its access to the internet. Supporting the cost and administration of internet access, whether through broadband, satellite, 3G or 4G mobile networks, is bound to be a restraining factor for many rural African schools, with limited resources. The school in this study funded a number of pay-as-you-go mobile data cards for use in the devices, which are easily purchased from street vendors in Mozambique. However, iPads that are accessible to mobile networks are more expensive than wifi only devices, another cost factor over and above ongoing internet costs.

A final ongoing concern in relation to the mobile devices, was to do with security. Apple technology is expensive by any standards, and is significantly more expensive in Africa, given the lack of local distributors and high import duties. The

high cost of the technology is in stark contrast to the environment, where classrooms are outdoors under a tree, or in rooms without windows, doors, desks or chairs. The high visibility of the project in the community and the general knowledge that this technology was in the school, created justifiable security concerns for the school. Technology was under lock and key when not in use. It was not known the extent to which this created additional costs or pressures for the school and teachers.

Technophobia.

It was expected that technophobia would be a significant barrier in this study. Much has been made of negative attitudes towards mobile technology, and a perception of mobile phones in particular as being used by students for negative purposes such as pornography or bullying (UNESCO, 2012). Agbatogun (2010) found that computer anxiety had a significant correlation with teachers perceived attitudes towards ICT. However, in the group of teachers who participated in the project, most of the teachers did not exhibit any fear of using or learning on the technology. The caution in relation to the technology was around not dropping it or damaging it, and caution around security arrangements in the school. Only one older non-participant teacher who attended all the teacher workshops, did not really engage with the technology. As outlined in the methodology chapter, the researcher was not involved in the final selection of participating teachers, and it is possible there may have been bias in the selection of teachers by the directors of the school towards teachers with a positive disposition towards technology.

However, in the researcher's experience in working on projects using mobile technology for educational digital storytelling projects with teachers in Ireland, fear of technology or teachers proclaiming themselves as 'not techie' was much more common in Ireland. These fears were mostly in relation to the perception of students as 'digital-

natives' and much more advanced in their use of technology than teachers, exposing teachers to potential embarrassment in front of their students. This psychological barrier did not exist in the context of Mozambique, as children generally didn't have access to mobile technology in their home environments during the duration of this study and therefore had no advantage over the teachers. Of course, this will change over time, but in the immediate future will probably continue to be an advantage for the integration of technology in public schools in Sub-Saharan Africa.

8.3 Quality Education for ALL?

Dropout factors.

58% of students do not complete primary school in Mozambique (UNESCO, 2017, with less than 5% of all pupils completing secondary level of education (Fox *et al.*, 2012). While many socio-economic, family and cultural factors are responsible for drop-out from school, evidence of learning and progression become strong influencers on a pupil and their family's decision to continue with full time education or not (World Bank, 2015). Mozambique scored in the 15th percentile worldwide for literacy and numeracy results in 2014 (EPDC, 2014). Large class sizes, with an average teacher to pupil ratio of 55 to 1, combined with scarcity of resources make the context very challenging for teachers to make significant progress. Additional complexity in the learning context is created by the need for teachers to teach in the official language Portuguese, which is often not the first language of the children they are teaching. While provision is made for teaching in local languages, in an environment such as Maputo, which is the capital city of Mozambique, children's first languages originate from many different regions of the country, and there is no one language the teacher can teach in, understood by all children. Teachers explained that many of the children

with the poorest understanding of Portuguese are those being raised by grandparents, whose parents have either died or are economic migrants. It is therefore the most disadvantaged students, who are at highest risk of drop-out from school.

Disengagement is a major predictor of low academic achievement (Anderson & Keith, 1997; Steinberg, Dornbusch & Brown, 1992). Teachers in the study reported the impact of this project on children who they described as "weaker students" as positive, saying that they were more likely to volunteer to present and participate in the class than previously. Teachers and the director of pedagogy alike, reported that attendance increased in the participating classes, while evidence was not provided to support this as it wasn't clear if regular attendance records were kept. Other studies have also found the impact of peer-assisted learning to be highest for the most disadvantaged students (Rohrbeck *et al*., 2003) and those in the lowest learning quartile (Layne *et al*., 2008).

If the Quality Education for All goal is to be achieved, steps must be made to ensure provision is made for the most disadvantaged children who are at risk of dropout within the reality of the contexts of public schools in Sub-Saharan Africa, while not disadvantaging and de-motivating children who are learning. Further research is required into differences in impact of an intervention like this according to student achievement levels, pre and post intervention. Further research on student motivation to learn and self-efficacy in learning are also areas ripe for research.

8.4 Contribution to Theory

The bedrock of a developmental research study is theory, supporting the research structure and practice, which in turn feeds back into theory, developing theory and practice in a virtuous circle. The theoretical framework for this study was a socio-cultural model of education.

8.4.1 Socio-cultural Model of Education.

The introduction of technology provided a catalyst for a change in teaching practices in the classroom. While teachers had no problem in learning how to use the technology, it was a slower process that required ongoing effort for each teacher to find how the technology could be integrated into their teaching. Part of the reason for this was that it required changing long embedded teaching practices of writing prescribed texts on the blackboard and eliciting whole call repetition of teacher's reading of text and choral responses to closed questions.

The technology was only able to provide added value when teachers examined how they were teaching and used the technology in a different way to how they had used the blackboard. A complete change in thinking about interaction with students and the role of students as active participants in their own learning was required. Teachers were initially quite fearful and apprehensive about the consequences of changing their approaches in this manner, particularly in relation to class control with such large numbers of students. The researcher and teacher tutor were also apprehensive about this as neither had worked in this environment before, evidence was not available from other similar projects and it was unknown about how it would work in practice. However, it emerged over time as small changes were made by teachers to their practice, supported by pre-prepared digital content and class plans, their confidence to use this approach increased. Over the course of the study, teachers spoke about the motivation of students changing, and related this directly to children participating more in the classes.
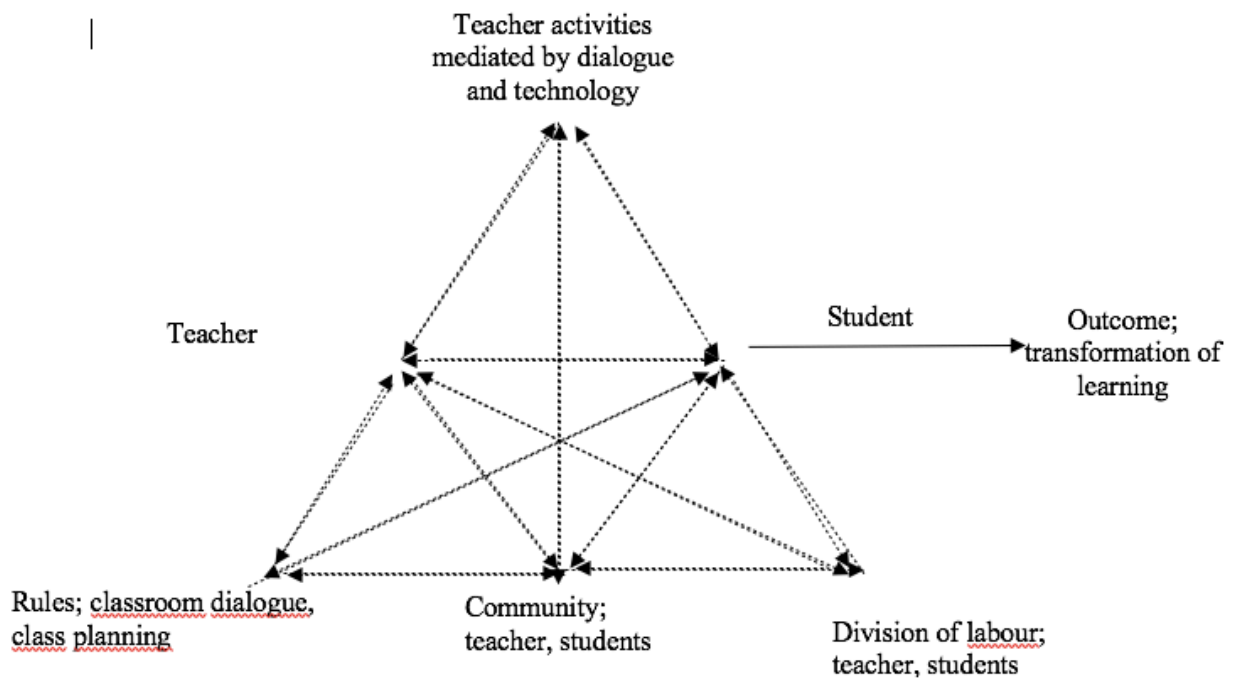
Figure 18: Application of Engeström's (1987) CHAT model to teacher practices in the classroom

The teacher created lessons that allowed space for interactive dialogue between teacher and student and between students. The context for the lesson was provided in a pre-designed digital lesson, integrating visual images, text and local examples of subject topics. Initially the direction of interaction between teacher and student moved in one direction only; from the teacher to the student. However, over the course of the study teachers reported themselves speaking less and students speaking more.

The community involved all the teachers and students of third grade in the school, supported by the school leaders, the researchers, teacher tutor and wider implementation team. Over the course of the study rules evolved to include teachers preparing class plans and digital lessons integrating scope for student interaction, open questions, group work and use of local examples.

In a division of labour, the teachers prepared class and digital content in advance, students interacted and worked to identify local examples with teachers, school leaders aided scheduling, maintenance of technology and equipment and

supported teachers' professional development and sharing of practice in the school. The wider school community became involved in a multi-directional structure to support and engage students learning.

8.4.2 Creativity Model of Education.

This research study aimed to advance the socio-cultural model of education to include creativity and innovation. Vygotsky's (2004) view of creativity as innovation out of reality was an activity that teachers were regularly engaging in as the project progressed. Glăveanu's socio-cultural model of creativity expands Vygotsky's theory into the domain of creation of new artifacts.
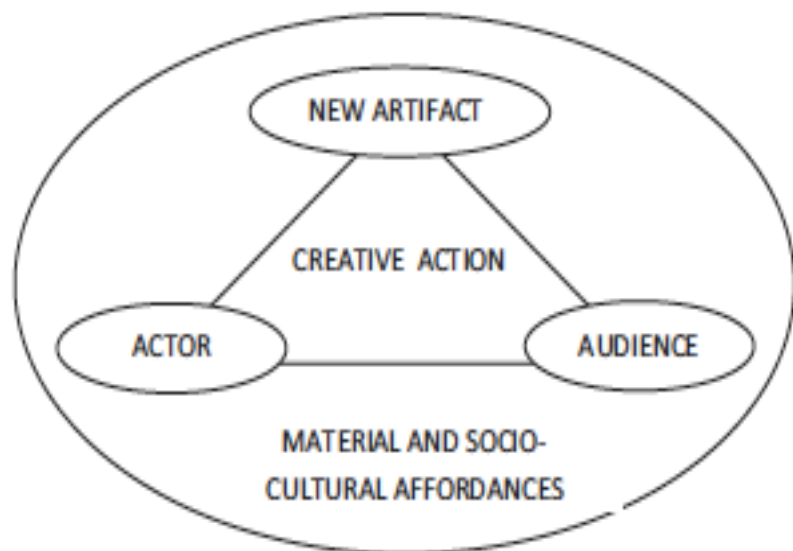
Figure 19: Socio-cultural model of creativity. (Glăveanu, 2013, p.71)

The enactment of this socio-cultural model of creativity in teaching and learning with the technology in the classroom is reflected in the following diagram, where the teacher and students worked together in collaborative lesson building to create new digital artifacts. These artifacts could then be re-used by other teachers and students, re-enacting this process and advancing the artifacts to the next stage of development. The starting point for developing new digital artifacts was looking at the

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local environment and how it could be linked to the lesson topic, whatever that might

be. The photographic capacity of the iPads allowed for easy integration of photos from

the immediate environment into interactive lessons. This enactment of the creativity

model, using the environment as a starting point for creativity, embeds the creativity

model further to a socio-cultural model of education.
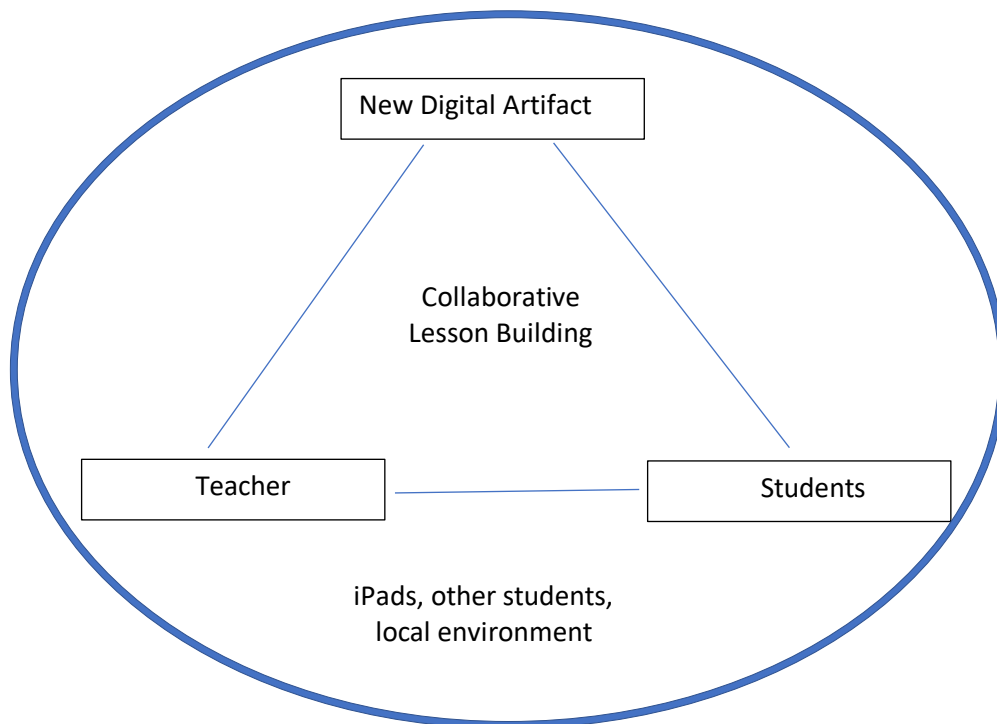
Figure 20: Glăveanu's Socio-Cultural model of Creativity applied to this study

In the enactment of this, teachers spoke about the power of an image children

recognize from the community in which they live, projected on a screen.

8.4.3 Socio-Cultural Model of Teacher Professional Development.

The socio-cultural model extended outside of the classroom to the community

of practice between teachers in the school. Engestrom's (1999) socio-cultural activity

model "encourages us to ask what happens to the knowledge and skills developed in

the professional development project and whether the intended outcomes are realized

in practice (e.g., sustained improvements in teaching and learning outcomes;

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dissemination of new knowledge, tools, and practices)," (Schlager & Fusco, 2003, p.209). Schlager & Fusco (2003) expanded Engestrom's model to show how a school-based community of practice can sustain ongoing learning and growth of the community of practice itself. A school-based community of practice involving teachers who have participated in a professional development programme can bring new knowledge back to the community in three ways (i) values, skills and knowledge being used in new activities with other members of the community (ii) new artifacts (eg. lessons, rubrics) created and becoming part of the knowledge base of the community and (iii) new tools used by the group and knowledge of how to use them in the specific context of the community (Schlager & Fusco, 2003, p.210).

Participant teachers on this project continued to develop artifacts in the form of digital lessons and class plans, the knowledge how to use the new tools (iPads and projectors) along with values, skills and expertise in pedagogy and an ability to dialogue about teaching practice. The skills and knowledge obtained could be shared with non-participating teachers and contribute to the culture of the entire school. It is unknown if these activities led to the continued expansion of the project and of the community of practice in further years, but the school leader had stated this desire.

8.4.4 Community of Practice as Context for TPACK Framework.

The final expansion of the socio-cultural and creativity framework applied in this study was to encompass technology in the model. Phillips (2017) examined the TPACK (Technological Pedagogical Content Knowledge) framework (Mishra & Koehler, 2006) of integration of ICT into teaching within Wenger's (1998) context of a community of practice. In a case study examining teacher's skills in using technology in the classroom, mutual engagement (Wenger,1998) between teachers over time allowed teachers skills to move towards the middle nexus of the TPACK model,

encompassing technological, pedagogical and content knowledge of teachers and revealing TPACK as 'knowledge in the making' (Phillips, 2017). In other words, teachers improved their ability to use technology competently with their content and pedagogical knowledge, by mutually engaging with other teachers in "wide-ranging discussions about technological, pedagogical and content aspects of their upcoming classes" (Phillips, 2017, p. 1787).

While this group of teachers were not observed in their community of practice activities and events in the school, by the end of the pilot programme, teachers were readily engaging in dialogue with each other in group discussions on pedagogy and technology. They reported that they were consulting each other for advice on classes prepared using the technology and helping each other when they ran into difficulties. Improvements in teachers' knowledge and practice with the technology was observed from one workshop to the next, and teachers were all following a similar lesson format that allowed for prescribed texts but also provided scope to integrate group work and local examples. This would imply that mutual engagement was occurring between teachers at school level, in a way that proved effective in the integration of technology in teaching that was suitable for local needs.

8.4.5   Transformational Model of Education.

The final outcome of a socio-cultural model of education as transformative practice, where practice is the driver of theory. This is borne out in this study as teachers became transformed through the practice (Stetsenko and Arievitch, 2014). In the process of changing their environments, people also transform themselves. The transformations happen at the level of students and also at the level of teachers. From Max's lesson in the school where students were passive and distracted, he presented a very different account of lessons later in the project.

"They are motivated… Without the iPad, they would think twice before participating or taking the risk to answer, but when there is the iPad, they are curious to touch the object…"

<div align="right">Max, Group Discussion</div>

In this extract, Rita, who expressed most reservation about children participating in the class in the first teacher workshop, speaks about how using the iPad in the classroom has impacted the children's attitudes towards reading and writing.

"With the iPads, when we introduce a new text. Usually when we are working with text and reading I read the text and the children would follow my reading. One day the children surprised me. I put the text on the screen, and I was going to read to the children. I didn't have to read that day, because the children started reading. I had to stop and allow them to read. It was a long text, three pages, and they were reading it. As a teacher, I have to say that sometimes I don't know when, at what moment, the children are evolving. It is difficult to understand in which moment they improved, but they are evolving. Another situation is with dictation, If you are going to work dictation with the children, I don't know how to explain it, but they were not taking it seriously when they had to write works or small phrases. With the iPad it is the contrary, when there is an image of a fruit or something we are doing, the children want to write, So even when the children are in a different class, they already have a concept of what they have to do now. The students are more participative and they try to write some words."

<div align="right">Rita, Group Discussion</div>

This transformation is facilitated by teachers taking a different approach to learning as Rita outlined how her practice had changed over the course of the project, and the impact this had on students on how they made connections in their learning across different themes.

"The possibility of opening a bit, because before I used to plan the class and it was too strict, I had to talk about that exact content and stick to this plan. Now with the iPad, the transversal themes emerge… I am more relaxed and they are making connections in the knowledge. Before they only learned what I planned. But that has opened out. They start to learn from others, from home, from the community at school, the wider community. This change for me is relevant. This is the possibility. This is what has changed for me."

<div align="right">Rita, Group Discussion</div>

The changes in practice deepened over time to a change in perspective and a transformation in 'being' (Stetsenko & Arievitch, 2014; Rogoff, 2008). Teachers became more confident in their own ability to depart from the text book, to link cross-cutting themes in their teaching and to depart from the class plan when a spontaneous improvement from the class plan opened up.

8.4.6 Connecting Competency and Socio-Cultural Models of Teaching and Learning.

Changing practice in a step-by-step approach within a socio-cultural model of activity creates a transformation in 'being' in teachers. This is related to teachers' knowledge and competence in technology, pedagogy and content knowledge. In a virtuous cycle of practice, building teacher competency, the teacher moves towards the middle nexus of the TPACK model. Translating this outcome to the theoretical model, creates an extension of the CHAT model to include the TPACK model as its outcome. This is represented visually as follows:
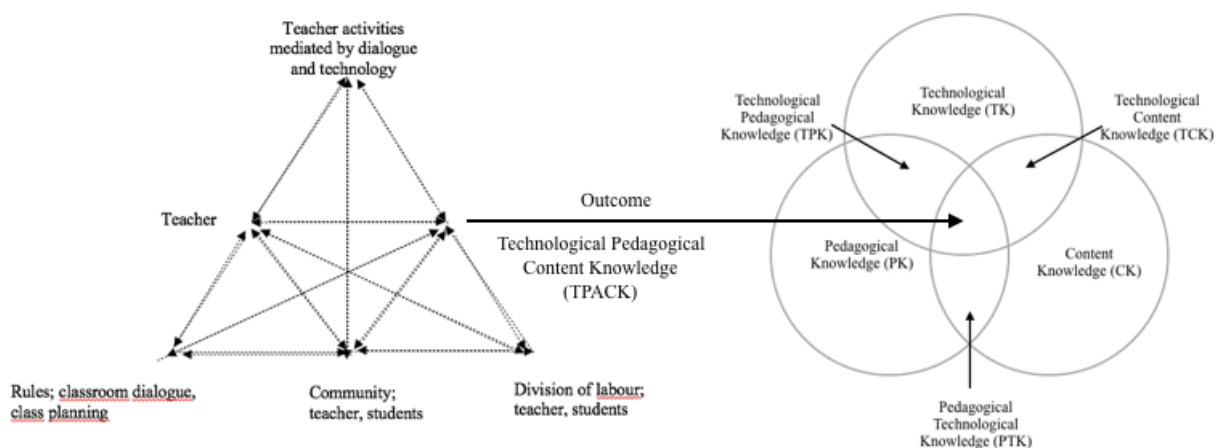
Figure 21:TPACK as an outcome of a Cultural-Historical Activity Framework
(Engeström, 1999; Koehler & Mishra, 2009)

A virtuous circle of practice leading transformation of teacher competency and student motivation and self-determination is created, with teacher and students working together in activities that create higher levels of knowledge, thereby improving

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competence and working on further activities to further increase levels of co-generated knowledge and competence.

8.5 Implications for Educational Change

The broad findings of the study have a number of implications for technology as a catalyst for educational change in the context of large public schools in Sub-Saharan Africa:

(i) The introduction of technology into the most challenging educational environments, in a model of socio-cultural activity can be the catalyst for change of deeply embedded teaching practices.

(ii) A step-by-step approach to change in teaching practice achieves transformation over time. Small changes to practice such as use of open questions, group work, interactive exercises with the support of class plans is useful.

(iii) Practice leads transformation; teachers attitudes change after their practice changes, as they see the impact of the practice on the students and on their own practice. This in turn leads a transformation of competence in teachers in technological, pedagogical and content knowledge.

(iv) Community of practice is a critical support for successful change, but leadership for a community of practice must come from within the community.

8.6 Chapter Summary

The context of this study presented some unique challenges that might not be an issue in other Sub Saharan African contexts. However, many of the findings are

applicable across typical public-school contexts in Sub-Saharan Africa, where large class sizes, short teaching hours, and lack of books or other teaching resources are daily challenges faced by teachers. For change to be meaningful in the context of public schools in Sub-Saharan Africa, the teacher needs to be central to any approach hoping to harness the vast resources provided by mobile technology. The technology must be approached as a tool for teachers to co-create educational change with students, rather than as a distinct entity that will broker educational change by itself. The broad findings of this study, show that a mobile device connected to a projector can be a catalyst for a cultural transformation in teaching and learning practice, moving classrooms towards a model of collaborative co-creation of knowledge between teachers and learners and peer learning between students and teachers.

9.0 Conclusion

This chapter provides an overview of the findings in relation to the research questions they set out to answer. Limitations of the study are discussed from the perspective of method, context and implementation. The researcher's reflections are discussion, particularly in relation to power and empowerment. Recommendations for practice, for policy and for further research are provided with some final concluding remarks.

9.1 Overview of Findings

This research questions are uniquely related to setting and context, typical in Sub-Saharan Africa. While studies exist on the use of mobile technology in developed contexts, mostly with multiple devices used by both teachers and students, these research questions are specifically related to the use of one mobile device by the teacher which is connected to a projector, in classrooms with over fifty students, (in this case without tables or chairs), with limited access to electricity, a blackboard and chalk, no other teaching resources and shared textbooks. The study took place over thirteen months, with four research visits, including a total of 11 days of teacher workshops, and was conducted in parallel to a larger study, examining the impact on learning outcomes of the technology intervention.

Research Question 1 – How can mobile technology support participative teacher practices in the context of a large public school in Mozambique, if at all?

To what extent, if any, does the introduction of mobile technology for teachers, supported by a programme of professional development workshops for

teachers impact on teachers use of collaborative teaching practices, namely (i) use of group work (ii) use of open questions (iii) use of interactive exercises?

One iPad connected to a projector was used as a teaching tool by the teacher, with a whiteboard application in a manner that mimicked the use of an interactive whiteboard. In the early stage of the study, teachers used the whiteboard application on the iPad, in the exact same way that they had used the blackboard; transcribing texts and eliciting repetition and choral responses to closed questions from the class. Through multiple iterations of practice, change began to be instigated in the use of participative practices when teachers began to design and plan for these practice in advance through use of class plans.

In an iterative approach, in the second phase of implementation, teachers were encouraged to design classes in advance with a class plan which included open questions to be asked to the class. In many cases the class was planned around a number of open questions. In the next phase, short group work exercises that were suitable for the context of a large class in a small space (i.e. that didn't require students to move around) were designed, often also designed around an open question or an exercise relating the topic to the experience of the student. Finally, the interactive exercises were designed, building on the open questions and returning to them. The iPad was used to design the lesson, integrating photos, text and interactive exercises.

Key to change was following the class plan and pre-designed lesson, with conscious inclusion of the practices. The class plans provided an essential support structure during the transitionary period of change of practice, and over time, through careful class planning and following planned classes routinely, change in practice began to embed.

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By the later stages of the period of study, these changes in practice had become embedded and teachers were able to be more spontaneous in the use of these practices. In effect the change became a cultural, more permanent change through practice over time. The study demonstrates that introduction of mobile technology can be a catalyst support towards a more dialogic pedagogy over time in class sizes over fifty in the context of a typical large public school in Sub Saharan Africa. These changes can occur where dialogic teaching practices were not in use before the introduction of the technology, and significant changes can become embedded over the course of one academic school year. Professional development that provides a conscious step-by-step practical and context specific approach to interactive pedagogy along with providing learning on the use of the technology is the key to the enabling of pedagogic change.

Research Question 2 – How can mobile technology support creative teaching and learning practices, if at all?

In a step by step, context relevant approach, the specific teaching practices examined for this thesis are: (i) creating new artifacts with technology (ii) integrating local examples into lessons with technology. In assessing new artifacts created with technology, the NEW (Mishra & Henrikson 2013) model was used, whereby artifacts were not only Novel, but also had to be Effective and Whole in their design and appropriateness for the purpose.

One of the perceived advantages of mobile technology in the context of schools where there are few teaching resources, textbooks or other books, is the potential of mobile technology to provide access to content. Even without access to the internet, teachers on this study were able to create lessons with photographs, text, interactive exercises and questions providing an alternative source of rich content outside of the

supplied school textbooks. This concept and practice of creating new artifacts with the technology took hold when teachers embraced two enabling concepts that worked hand-in-hand; use of the photographic capacity of the iPad to link lessons to local and relevant examples that were recognizable to children from the local setting. Key to the approach is the importance of making learning relevant. The interactive whiteboard application allowed for very easy integration of photos into interactive lessons and teachers reported the positive impact of this on students, being able to recognise the local environment on projected lessons.

Mishra and Henrikson's (2013) NEW model, provided a simple framework to evaluate the effectiveness of these artifacts. Artifacts needed to be novel (had not existed previously), effective (useful in the context) and whole (meaningful, well crafted). Teachers personalities, experiences and knowledge were reflected in the final artifacts, with teachers and learners both contributing to the artifacts through a collaborative approach.

Research Question 3 – how can mobile technology support school-based teacher-to-teacher continued professional development, if at all?

To what extent, if any, did activities related to community of practice occur, specifically: (i)sharing and re-use of digital content (ii) events where knowledge or experience is shared between teachers, whether formal or informal?

The researcher was particularly concerned to put in place a strong community of practice element on the project, seen as vital to the ongoing sustainability of the project beyond the life of the pilot study. In an attempt to formally instigate this, the researcher requested weekly meetings in the school between the participating teachers and the director of pedagogy. It is unclear to what extent the formal weekly meetings occurred, as reports from the director of pedagogy and teachers were sometimes

contradictory. Given that one of the key characteristics of a community of practice is that its members are self-selecting (Lave & Wenger, 1998; Smith and McKeen, 2004), it is clear in retrospect why this attempted imposition of weekly formal meetings may not have taken hold in the school. The main reason weekly meetings did not take hold was to do with teachers' timetables, many of the participating teachers were on different school shifts and finding a suitable time for a weekly meeting was not possible. However, teachers did report informal events of seeking out each other's professional advice and opinions in the design and implementation of new teaching practices with the technology.

Leadership was critical to the implementation and ongoing development of the project on the ground. However, leadership alone is not enough to support the long term thriving of a community of practice and can be both an enabling and restricting factor for the development of a community of practice, depending on the relationships on the ground between teachers and the school directors. Motivation and understanding of the benefits of a Community of Practice must come from the teachers themselves.

Internal agents of change, teachers who embrace and practice innovation are also a key factor for driving a school-based community of practice and long-term cultural change. Two of the teachers stood out as internal agents of change, as well as the director of pedagogy himself. Communities of practice take time to embed, and the pilot study duration was insufficient to determine if a long-term sustainable community of practice had taken hold in the school or not. Teacher turnover and changing roles also had the potential to have a crucial impact on the development of a community of practice locally.

However, it is hard to see how the long-term success of the project could be guaranteed without a strong school-based community of practice supporting it. The challenges of setting and context are so specific that it is only other teachers working in

the same setting who can have a true understanding of the supports required for ongoing development of practice.

9.2 Reflexivity

Over the course of the study, the researcher had to repeatedly examine and expose her own previous biases in how she viewed people living in the developing world. She attempted to constantly interrogate a tendency to take patronizing view, or a position of superior knowledge. She also attempted any inappropriate impulses to help and make better, to be the "missionary". In fact, among NGO workers she met there, she was introduced to others as being in Mozambique "visiting on a mission", still a common viewpoint and parlance. While recognizing that the impulse to help, does not necessarily reflect something negative or self-serving, the researcher attempted to be reflexive in relation to this, and to ensure that help was provided on the recipients' terms and not on the researcher's terms. There were of course times when that balance was lost, for example in the researcher's over-enthusiasm to near-enforce weekly meetings in an attempt to get community of practice events off the ground, forgetting the core principle of community of practice, that it needs to be led from within the community to succeed. It was in moments of recognition of this uncomfortable reality (Pillow, 2003), and attempting to interrogate frames of seeing (Lather, 1993), that the researcher learned most about the nature of the context and environment.

The researcher very clearly was an outsider in the research project, with a very different frame of seeing to the research insiders. At the end of each teacher workshop, with perhaps an extra day for field visits or meetings, the researcher returned to Ireland. She didn't live in Mozambique over any period of time, and significantly never stayed in the community in which the research was taking place. This wasn't deliberate, it was simply because there was no place to stay there. She stayed in hotels in Maputo during

each stay, specifically hotels with wifi connections so that iPads could be updated or new software uploaded to them, far removed from the reality of life in the communities in which the teachers lived. This meant that it was impossible to frame the research from a participant teacher's framework, who lived every day in a completely different context, who commuted to the workshops every day in a totally different way to the researcher, and who went home every evening to a very different environment with many additional challenges to that of the researcher in a comfortable hotel with running water, electricity and wifi.

Another unconscious bias on the part of the researcher was a desire for the project to be useful for the teachers and the school in a real way that would transform the difficulty and challenges of their context. It was challenging occasionally, to examine the real success of various measures, and pull back and change direction when something was clearly not working or not wanted or needed by teachers. Part of that was the researcher dealing with her own disappointment in these situations, such as when the weekly meetings between teachers were not happening, or when the technology was not used outside as envisaged. After leaving IADT at the end of 2016, the researcher was able to re-interrogate the success or otherwise of the project, with more distance and objectivity.

The death of NMS, who had been the Portuguese teacher tutor on the first teacher workshop and previous workshops in Mozambique with other groups, and the subsequent death of Marlon, one of the participant teachers, had a profound impact on the researcher. At the end of the research period, the researcher took a break from the project for a number of months in order to process these events emotionally, before beginning to write up the thesis. After this break, it was more possible to engage with the research objectively again.

As Pillow states, reflexivity in itself does not mean that the research process or findings become objective, unbiased or free from the difficulty of uncomfortable realities (Pillow, 1993), but it does allow for the frame of seeing to be visible and interpreted within the context of what is not known or might have had an influence.

Power.

Foucault's (1982) definition of power as action upon the action of others and context of the unknowability of another's life forms the basis for an examination of power relations in this study. A discussion of power relations in this study is set within the context of the unknowability of the context from the researcher's perspective, given the outsider's frame of seeing, and inability to understand the lived experiences of the participant teachers. Additionally, the language difference created a further barrier between the researcher and the research participants.

Having set the limitations of this observation above, there were some noticeable power issues in the group observed during the teacher workshops. The first was that the female members of the group were noticeably less vocal than the men and deferred to the men. Two of the female teachers spoke so quietly and meekly that it was impossible to hear them at the time or on multiple replays on the video recordings. The exception was Rita, who was older and well respected by the entire group, and by virtue of seniority was confident to express her opinion. The impact of this was that the male participants experiences of using the technology are most frequently reported in the study. The female teachers in question spoke freely and insightfully about other issues during coffee and lunch breaks and demonstrated competent and imaginative teaching with the technology. While the researcher attempted to engage with them in these more informal settings, language barriers made this difficult. As a result, descriptions of their experiences and learning are virtually absent from the group discussions and some valuable insights and learning may be missing from the study.

The second observation of noticeable power issues in the group was when any observers from the Ministry for Education were present. Some of the group discussions skewed in their focus while the Ministry official was there, attempting to portray the school and its management in a positive light to the Ministry. This is discussed further in the research limitations under the Hawthorne Effect.

Researcher Researched Power Balance.

The researcher was in a higher position of power on the project in relation to the participating teachers, as she had access to Ministry for Education officials and school leaders, unlike teachers in the school. Additionally, she was in a position of decision-making in relation to technology provided to the school, a huge position of power in the context of a school with extremely limited resources. While the researcher was careful to make those decisions based on the voice and requested needs of teachers and the school, it is inevitable that her frame of seeing was very different to that of a teacher with limited control over these decisions. In order to militate against that, decisions were discussed with all stakeholders, including school leaders and teachers, when appropriate.

Additionally, as participant teachers were in a position of little or no power relative to the researcher, school leaders and Ministry and other officials in the room during group discussions, they may well have felt a perceived need to make a good impression for their own sakes as well as for the sake of the continuation of the project in the school. The researcher attempted to be reflective of this in the presentation and interpretation of data, particularly when interpreting the data from the surveys and discussion groups.

Unintended impacts.

At the end of 2016, the researcher left her position as manager of the project. It

is unknown what unintended impacts this may have had on the project afterwards. Because the study had finished and leadership in a number of the partner organisations had changed, it was unfortunately not possible to continue to get detailed updates on the progress of the project. Guarantees were made by school leaders, that the classes who were not chosen for selection in the pilot programme, would be have access to the technology the following year. It is not known if this happened. It is also not known what the impact of selection or non-selection might have been on the students or teachers. These are all areas of uncomfortable and unknown reality that the researcher was very aware of but had no control over.

Empowerment.

Freire (2000), Shor (1992), and Stetsenko & Arievitch (2014) among others, argue that a dialogic pedagogy with teacher and students co-generating knowledge leads to empowerment of both learners and teachers and in a process that can transform themselves and their environments. This empowerment was observed to varying extents in different teachers over the course of the year. Teachers became more confident in talking about their practice to each other and presenting their practice and talking about it to others. They changed how they thought about engaging with children in this classroom and this extended to classes in which they weren't using technology. It is not known the extent to which this may have had an impact on the wider teaching culture in the school.

Research participant embeddedness.

The researcher attempted to get full involvement from research participants in the design and re-design of the project and the research throughout the process. Participants were to greater and lesser extents willing to become involved in this. Some of the participants had to be gently probed for their opinions, while others seemed to speak more freely about their concerns and ideas for the project. As outlined earlier, the

younger women in particular, apart from Rita, seemed un-used to giving their opinions in such contexts and became very self-conscious and timid.

9.3 Limitations of the Study

The study was limited by the specifics of the context and the unique partnerships, pilot study period and supports received as well as some methodological limitations.

9.3.1 Methodological Limitations.

Many elements of this study were outside the control of the researcher, particularly in relation to the selection of the school, of the sample within the school, the ongoing relationships between the funder and the school and within the wider political context.

Gatekeepers.

Irish Aid, through the embassy in Maputo, brokered relationships with the school and were the primary conduit through which communication with the school occurred. Specialists in Irish Aid were deeply embedded in educational structures across Mozambique and had a strong understanding of political relationships as well as being knowledgable about structural issues, processes, curriculum as well as more local issues. They proved to be an invaluable partner and broker between the researcher and the school and wider political structures.

However, the researcher did not have control over how the sample was selected. Originally it was intended that all third-grade classes would participate and enough technology was supplied to allow this to happen. However, an unforeseen issue

emerged when the school leaders decided that it wasn't appropriate for the technology to be used outside. This reduced the sample size to five of the ten third grade teachers. While assurances were given that selection of participating teachers would be random, it was not entirely clear if this had been the case or not. It is unknown the extent to which teachers may have been hand-picked by the school leaders for their perceived suitedness to participation in such a programme. It was important to the school leaders that the project was ultimately successful and details of how selection of teachers was made was never outlined. Additionally, one teacher from outside of third grade was present throughout, and another teacher moved out of third grade over the course of the academic year. It was understood that the reasons for many of these situations was complex and to do with the internal politics and management of the school.

Due to the work load of the Irish embassy, it was often not possible to get communication when the researcher would have liked. Occasionally decisions were delayed while they were processed through the necessary local political channels. As many of the local structures and processes were complex, the precise nature of these were not always clear to the researcher. To deal with this the researcher attempted to focus on the aspects of the research that were under her control, rather than push too hard on elements of the project outside of her control. Over the course of the project these roles changed also, the director of pedagogy stepped back into the role of teacher, teachers changed roles within the school and roles within the Irish embassy changed.

Language and culture.

The researcher's own limitations as a researcher were in terms of cultural and contextual knowledge, and linguistic in terms of understanding of Portuguese, the official language of education in Mozambique. This was exacerbated by the researcher's geographical distance from the project's running

on a day to day basis. Especially in the early stages of the project, while design of the project was discussed jointly from a research perspective, many of the group discussions with participants were not understood by the researcher. The researcher was very heavily reliant on the teacher tutor for translation and explanation, and at times his interpretation of events and conversations. It was only when group discussions were transcribed and translated back in Ireland after the visit, that a full understanding was gleaned. As the project progressed and the researcher's understanding of Portuguese improved, there were fewer situations where she was completely at sea in terms of what was going on. As the project progressed, the researcher began to understand the role of different partners, organisational structures and processes and the dynamic between partners, school leaders and participant teachers, which also greatly aided in understanding discussions and the contexts of discussions. As the project progressed the researcher was in a position to make the first draft transcriptions and translations, that were later verified or corrected by a translator, which helped greatly in a more first-hand understanding of the dynamics at play. However, even apart from contextual and linguistic limitations, there were certainly cultural issues that the researcher wasn't even aware that she may have been mis-reading.

Hawthorne effect.

As discussed earlier, significant power imbalances between the researcher and the research participants, as well as between the participants and government officials who were often present at the discussion groups and the provision of expensive technology to the school created a heightened risk of information in discussion groups being affected by the Hawthorne effect. An example of this was particularly related to the case of the director of pedagogy in the school worked very hard on the scheduling, preparation and ongoing monitoring of teachers use of the project. He was very

invested in the success of the project, which may have occasionally influenced an overly positive or optimistic reporting of how the project was being integrated into the school. In a number of cases what teachers said contradicted what the director of pedagogy said, particularly in relation to teachers' meetings in school during term time. Additionally, the information gathered in the survey about digital lessons that were shared between teachers frequently mentioned lessons that were demonstrated in the teacher workshops. This aroused a concern that teachers might not have been sharing digital content as frequently as they were proclaiming, as they mentioned lessons that they had witnessed during the teachers' workshop. While the survey was anonymous, teachers may still have felt a need to provide positive responses in order to present the school well and ensure its ongoing participation in the project. However, changes in practice and attitudes demonstrated by teachers in their teaching and in the development in their dialogue related to their practice lay outside the influence of a possible Hawthorne effect.

Voice of the child.

Originally it was intended that the research methods include the voice of the child. However, a number of circumstances mitigated against this; lack of space for working with children in the school, school timetables and shifts, lack of time during short visits, and inability to broker the complexity of organising child research advisory groups, or otherwise including the voice of the child in the research through the project partnerships. Including the voice of the child, would provide a crucial point of view in future research of this nature.

9.3.2 Implementation Limitations.

The technology was not rolled out and used as envisaged, primarily because the decision was made by school leaders not to use the technology in the

exterior classrooms. The scope and scale of the project as implemented was much more limited than what was originally envisaged and what was allowed for with the technology. This was because of the decision by school leaders that the technology could only be used in one classroom which had adequate windows and doors to provide shade and privacy from students who were waiting for their school shift to begin. The reach of the project could have been much larger in terms of numbers of students otherwise.

There was not enough time over the course of the pilot study to meaningfully conclude if a community of practice had embedded in any kind of a sustainable or integral way in the school. The real moments of embedded change in practice had occurred in the last number of months of the project and at that point it was unclear to what extent teachers were working together on the ground. The lack of a central meeting area for teachers, the fact that teachers were working different shifts at different schools, and very full timetables, with little time to prepare, provided a very challenging context in which to develop a meaningful community of practice.

Teachers had limited time on the technology outside of class time, which constrained their fluency in using the technology seamlessly in the classroom while teaching. It was unclear what the reasons were for this, and it may have been related to security arrangements for the technology outside of the school. In any case, it also limited the teachers' ability to advance their practice to the degree that could have otherwise been possible with time to become more familiar with the basic functionality of the device in out of school hours.

Replicability.

The study was specific to one school and pilot study research period during which the teachers and school were provided with supports from an

international research/teacher tutor team, supported strongly by the leadership of the school. This is not a usual context for the implementation of educational change at a local level. It is unknown to what extent the findings can be replicable in a context where the same supports are not provided. However, use of the technology and iterative, collaborative and localised approach to implementation can be replicated in other settings, using the key findings as a basis for implementation.

9.4 Recommendations for Practice

ICT implementation attempts in Sub Saharan Africa have a legacy of expensive failure. The reasons for this may have been related to mimicking approaches common in more developed countries, such as computer labs in schools or students one to one use of devices. However, solutions in countries where secure supply of electricity, equipment, technical support and secure air-conditioned sand and dust free buildings are the norm, may not easily transfer to contexts where these resources are not the norm. The solution may be much simpler and more affordable than computer labs or one device in the hands of each child, and one that puts the previously missing critical component back at the centre; the teacher.

9.4.1 Mobile Technology Implementation Approach.

One mobile device in the hands of the teacher connected to a projector can be a catalyst for a cultural change in teaching towards a more collaborative, child-centred pedagogy. However, providing the technology on its own will not engender this change, and will probably result in teachers using the technology as

if it was a blackboard, without any change in teaching practice, or alternatively cause stress and be abandoned.

Needs-based professional development.

A critical success factor for professional development workshops is for the design of these programmes to be sensitive to context. A needs assessment period must involve listening carefully to teachers themselves and their needs within the context of their daily teaching lives.

Supports for incremental change.

Specific small changes in practice, tried, tested and adapted in the context can be developed over time by facilitators working collaboratively with teachers. Providing class planning templates is an important support during the change period. A supported approach introducing small changes in practice using the technology to plan varied and interesting classes in advance builds teacher confidence, supports small changes in practice and over time a change in teachers and students' attitudes and beliefs that creates a more lasting cultural change in the socio-cultural context of the local school. This practice over time leads to a more fluent approach to creative teaching, that can be less slavish to pre-designed class plans as competency with technology, pedagogy and content develop.

The significance of the local.

Teachers can create high quality local content with simple digital technologies in a way that is very cost effective comparatively to very expensive software development one-to-one digital device to child-based projects. A bank of content can be created very inexpensively by teachers themselves that can grow quite quickly and be shared and built upon by other teachers. This can provide a significant source of relevant, curriculum-based content, that is linked to whole class teaching and local cultural requirements.

School-based communities of practice.

Communities of practice at local level are a crucial support for teachers, who need the support of peers attempting the same changes in the same environments. Communities of practice need time and space to develop. Any provisions made to support their growth by school leaders in creating time in the timetable and space in the school, will increase the chance of these communities taking hold and supporting the long-term sustainability of educational change.

9.5 Recommendations for Policy

Teachers at the Centre of the Policy Debate.

Policy debates have largely focused on the views of NGOs, ministries, educational, technology and industry experts, but very rarely is the voice of the teacher heard. In fact, when teachers are mentioned at all, it is usually to focus on quantitative data in relation to teachers; pupil teacher ratios, years of teacher education, rates of absenteeism, turnover, rates of pay etc., much of the focus being negative. Yet, teachers are the people who know most about the environments in which they teach, about what works, what doesn't work, what needs to be fixed, and what solutions have the potential to work or not. The teachers in this study cared passionately about their school, their community and their students. They had compassion for the difficulties of their students' lives and understood many of the factors behind the challenges they faced in their daily teaching lives.

Teachers need to be given a voice in the debate and listened to. They can save policy makers many years of wasted time and money, with their insights and knowledge of the contexts on the ground. Policy solutions for the achievement of quality education for all, must tap into the knowledge and experience of teachers

working in the most challenging environments, and must work within the realities of those environments.

Technology Cannot be Separate from Teachers.

Technology has enormous potential to bridge the inequality gap in education. But, technology alone will not achieve this. Any solution involving technology in supporting learning, must include the teacher. Teachers can unlock the potential of technology and digital content for learning, just as technology can be a catalyst to creative, collaborative and ultimately, transformative teaching. Solutions that focus on technology, to the exclusion of the teacher, are destined to be expensive and short-lived. Solutions that focus on how technology can work with the teacher in a problem-posing approach, engaging children in collaborative learning, linking learning across topics and curriculum and returning always to the local environment and the application of learning to the reality of children's lives, are solutions that engage teachers, learners and the wider community in a virtuous cycle of learning and increasing creativity and competence. Teachers have the capacity to be innovators, when supported and listened to. Over time, there is potential for this innovation to lead to real and lasting change.

Incremental Approach to Change.

Expectations of immediate change are unrealistic. Change must be incremental, iterative and supported on the ground. Change in teaching practice and longer-term cultural change in attitudes and approach will take time. Goals must be set that are clear, and achievable, and small changes, such as use of open questions by teachers, will over time set in place a series of larger changes in teaching approach. The use of technology can provide an essential support and tool for teachers in this transition into the long term, but only if the impact for teaching is clear and well-supported. The

measurement of success needs to be examined across a wide range of factors related to teaching and learning, not just learning outcomes or progression rates.

Investment in Technology is not Enough.

Investment in the technology alone is not sufficient. Investment in professional development at local level and ongoing support of teachers is crucial for long term change. Policy encouraging schools to support communities of learning in terms of timetable and priorities doesn't have to have a cost. Teachers themselves can provide valuable support for each other, when supported by the school. Districts can support learning communities, sharing expertise and experience between schools, forming a crucial part of professional development programmes, and raising standards across schools and districts. Purchasing and deploying technology without this investment in teacher support structures, will result in frustration and confusion and ultimately devices locked away un-used in storage.

Local Solutions.

Policy makers need to recognize local expertise and allow scope for local excellence and local solutions. Teachers have the knowledge to relate learning to the local environments, and technology can provide a very useful tool in this integration of the local into lessons through the photographic capacity of the device. Teachers can furthermore work together to share this experience and knowledge, building on each-others' expertise and working collaboratively with students to relate learning to the local, thereby building new knowledge, along with students' ability to look at their own environments for solutions to problems and new opportunities.

9.6 Further Research

Research opportunities in examining the role of teachers in exploring the possibilities of technology in education, and the role of mobile technology as a catalyst

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for teacher creativity and innovation working in collaboration with students are vast, in the context of Sub-Saharan Africa and other contexts.

Communities of Practice.

Further research is required to examine the longevity of communities of practice for ICT integration in teaching in remote environments, the longer-term use of digital artifacts and class plans amassed by communities of practice and the growth potential for communities of practice between local schools.

Furthermore, the scope of this research did not extend to either (a) supporting remote communities of practice with online content or (b) online professional learning community support. The reason for this was lack of accessibility to the internet from the location of the school. However, there is plentiful research to suggest that this may further enhance the activities and sustainability of an onsite community of learning (Keats & Schmidt, 2007; Thakrar, Wolfenden & Zinn, 2009; Pimmer *et al*., 2014). This was beyond the scope of this study but is an area ripe for further research.

Technology

Further research is possible using a range of different elements of technology. An iPad was the mobile device used in this study, which has a number of advantages in intuitive use and learning. The size is also significant as it is a similar size and weight to a book. Particularly useful would be a similar study substituting alternative mobile devices, cheaper tablet devices, and even smartphones, to examine their feasibility in this context in terms of intuitiveness of learning, visibility of the screen, availability of suitable applications, reliability of hardware and software, and ease of use.

It was one of the original purposes of this study to examine the use of the technology in outdoor classrooms, which made up half of the classrooms in the school in this study, and are very common across Mozambique and Sub-Saharan Africa. The decision not to use the technology outside in this study was based on the experience

and professional opinion of the school directors. However, in another school, the structure may be different, where crowd control factors may not be an issue, or be less of an issue. Considering the number of classes being taught outside under the shade of trees in Africa, research examining the feasibility of the technology in this context, using the full solar components to power the projector and charge the device batteries has the potential to make a significant contribution towards educational development for these teachers and students.

Internet Access

The mobile device in this project was used largely without access to the internet. It was reported that occasionally teachers did access the internet for images that were not available locally. Unrestricted access to the internet would have very significantly changed how the technology was used and deserves further study. As teachers in this study had no, or very limited, access to the internet, they were obliged to be creative in their use of the device, creating interactive lessons themselves, using the environment around them for images. It is possible that teachers were more creative in their design and delivery of lessons as a result of not having access to the internet, which would make a valid and useful research question in a similar setting.

Impact on Students

The impact of the technology on the motivation of students was mentioned repeatedly by participating teachers on this study. There was no scope to consider a measurement of motivation in this study. It was intended that attendance would be measured, but this proved to not be possible in the setting. Further study examining quantitative factors such as attendance and drop-out as well as a more qualitative examination of students' motivation is an obvious next phase for an examination of the impact of mobile technology used in this way. This study did not include the voice of the child, a clear gap in providing an in-depth perspective from all points of view of the

technology intervention. Learning outcomes were measured in the wider pilot study in Portuguese literacy, but are not included in the scope of this doctoral research.

9.7 Concluding Remarks

Barrett (2007) and Alexander (2008) call for the need to develop research into the specific complexities of pedagogic practice in developing world contexts. The developmental methodology employed in this study proved to be a useful, rigorous and flexible framework for carrying out research on the introduction of new educational practices and tools in a complex environment. It allowed for an iterative approach providing scope for changes in design and direction as deeper understanding of the environment and context emerged. Additionally, use of qualitative methods provided the scope for in-depth examination of contextual issues and an exploration of barriers to and enablers for the use of mobile technology for pedagogical change, in an approach that would not have been possible with quantitative methods. This study therefore demonstrates the usefulness of a qualitative approach to understanding indicators for the achievement of the Sustainable Development Goals, in particular Goal 4, in a development context.

Debate on ICT in education and excitement around the possibilities for ICT in Africa's educational achievements have often omitted the teacher. There is almost an assumption that ICT on its own can transform learning in Africa, without any input from teachers, and regardless of context. This study demonstrates that meaningful educational change can take place over a short period with the introduction of mobile technology, but the teacher has to be at the centre of this change.

Mobile technology is already taking hold in Africa. Over the course of two years of visits, the researcher observed a change from 0% smart phone users in early teacher workshops and workshop rooms to approximately 25% of teachers using

smartphones. Since the completion of this study, that figure most probably has risen by the same percentage again. The perception that teachers are not digital natives and therefore cannot learn technology has been disproved with well-designed mobile technology. Teachers learn to use the technology very quickly and easily. The problem is not with the technology, but rather with how teachers are supported to use the technology to improve the teaching and learning experience for both teachers and students.

This thesis bears out that a cultural historical activity theory framework (Engeström, 1999) for educational change can have an improving teacher competency framework as its outcome. In simpler terms, change in practice supported within the school, leads to change in teaching competency with technology as the tool and the catalyst for change.

A single mobile device in the hands of a teacher, connected to a projector and powered by solar energy, is a viable and affordable option that is appropriate for schools in remote and developing contexts without access to electricity or internet, and with large class sizes. The cost of this is significantly lower than the cost of a one-to-one tablet to child intervention, both in terms of hardware and of software development. Furthermore, it is a holistic approach that builds the competency of teachers working with students to co-generate knowledge.

Funding for education in the contexts of developing countries has been reducing steadily over the last decade (STATS). Mobile Learning Week in UNESCO, is a welcome annual event dedicated to examining the potential of mobile technology to address educational inequity, but projects tend to be small NGO projects or isolated research findings. The X prize is dedicated to exploring and championing creative solutions to using technology to reduce inequity in access to education, with the focus on the search for innovation on big solutions in the technology and enterprise sector.

However, technology can also enable teachers to be innovators and agents of change on a smaller and potentially more sustainable scale within the specific needs of their own contexts and settings.

It is hoped that this research can provide some contribution towards the meaningful integration of mobile technology towards pedagogical change and the achievement of the sustainable development goal of quality education for all.

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Appendix 1

Concept Note IADT Irish Aid Research Project

School in a Box Intervention

This study aims to look at a specific use of mobile technology *School in a Box*, designed for remote learning environments without access to electricity. *School in a Box* has been developed by the Institute of Art, Design and Technology (IADT) Dun Laoghaire, to examine the possibility of the use of mobile technology in remote schools there. The technology solution is designed as a low cost tool for teachers working with large class sizes, few if any books or other material resources in the classroom and no access (or intermittent access) to electricity. The technology consists of a single iPad connected to a small powerful projector and powered by a mobile solar panel. The iPad and apps loaded on it are easy to use for teachers who may not have previously used a computer or smart device. While access to the internet can greatly enhance the functionality of the technology, it is not always available in very remote environments, therefore the device is pre-loaded with a small number of easy to use apps that can function as a whiteboard, presentation software and interactive book publisher, with or without internet access. The photographic and video recording capacity of the iPad is used to capture local examples relevant to topics of learning, and to be integrated into interactive lessons.

Since 2012, *School in a Box* has been deployed in a very remote secondary school high in the Himalayas in the Humla region of Nepal in collaboration with the NGO Karuna Shechen, in remote adult literacy centres in Maputo province in Mozambique in collaboration with UNESCO, and in field farm schools in Pemba province in Northern Mozambique in collaboration with the Aga Khan Foundation. The practice context for this study is a collaborative research project with Irish Aid to examine how *School in a Box* technology and methodology might have impact on the quality of teaching and learning in a large public primary school in Mozambique.

School in a Box Methodology

Using a community engagement ethos, School in a Box works with on-the-ground educational and community partners to assess needs and co-design technology deployment, teacher professional development and content requirements suitable for the environment, everyday constraints and most immediate needs of teachers. The end goal of each intervention is that the project is owned and led by the local partners, and facilitated, according to their needs, by the School in a Box team. The aim is to build local capacity and expertise in the application of the technology in the local context, in a community partnership model. In return it is explained at the outset to community partners that their

learning experiences on the project will inform development of the wider School in a Box project and its application in other contexts.

The iPads are used both in the classroom and to create content; using the local environment for examples relevant to the learner's world in a problem-posing and language experience approach (Freire, 2013) on very easy to learn apps that facilitate high quality interactive content creation and use on the iPad. The photographic and video making capacity of the iPad allows easy integration of examples from the immediate environment or brought by children into projected lessons.

School in a Box Teacher Professional Development

The teacher professional development programme aims to support and scaffold teacher skills in a very practical and simple way to allow the tool to be useful and relevant to the classroom and community environments teachers are working in. Helping teachers to overcome technophobia is emphasised in the initial training and at the end of a week long workshop, participants are comfortable with using the iPads and setting up the projection. Additionally they are able to quickly and easily create lessons on the aforementioned apps, using photos from the immediate environment and text in Portuguese or local language. The focus of the workshop is to equip teachers in a very practical way to make the learning relevant to the lived experiences and local environment of their students, as well as experimenting with creating interactive and problem posing lessons on the iPads.

ABC school project

Context of Study:

The study is a pilot action research project working with Grade 3 teachers in ABC Primary School. The school was chosen by Irish Aid because of its easy access from Maputo, and because of its typicality as an urban public school in Mozambique. There are 5000 students in the school and 72 teachers. Approximately half of the classrooms are exterior under the shade of some trees, and the rest are interior. Interior classrooms for the most part do not have desks, chairs, windows or doors. Electricity is available in interior classrooms but can be intermittent. Teachers for the most part are qualified. The school is the head school in a cluster of seven schools and some of the teachers involved in the study teach across a number of schools. Eight teachers from the school were trained in 2015.

The study will run from early 2015 until the end of 2016 over three phases: needs identification and teacher training, implementation, and assessing success factors and potential for scale.

Research Questions:

The specific research questions are:

- Do teachers engage in more participative practices in the classroom as a result of using the SIAB project?
- Do teachers engage in more peer support activities as a result of SIAB intervention?
- Do students learning outcomes improve following use of SIAB?
- What are the factors that contribute to successful implementation?
- What factors are to be considered for scaling-up of the project?

Research Design/ Methodology:

The research will be carried out in three phases; preparatory, pilot implementation and examination of feasibility for scaling up and sustainability. The study design is an iterative developmental design, examining process factors in quality education as well as qualitative and quantitative outcomes. Qualitative methods will set the context for triangulation by quantitative methods, providing an opportunity to tease out the complexity of issues, as well as triangulation for research rigour. Research ethos will be culturally sensitive and based on a human rights and children's rights approach, emphasising the teachers' voice and children's voice. (Hennessy *et al.*, 2015).

Roles and Responsibilities: (IADT, ABC school, IFP, INDE)

IADT:

Teacher training
Technology Deployment
Budget Management
Progress Reporting
Qualitative data collection

ABC School:

Local in-school management
of project Regular
communication with IADT
Provinha data collection
Reporting on peer support activities
Keeping of attendance records for all third grade students

IFP:

Local support of school in the form of monitoring visits

INDE:

Provinha training

Mozambican Partner Organisation:

Co-ordination of monitoring and evaluation with school
Co-ordination of mentoring and support visits from IFP to
school Analysis of IFP training and support needs
Co-ordination of training organization; dates, venues, per diems,
catering etc. Trouble shooting, identification of any barriers or
obstacles to progress.

Joint Responsibilities

Communication; commitment to regular planning calls, clear reporting of issues, clear communication of expectations from each partner.

Project management and reporting structure

Principal Investigator: IADT (Linda O'Sullivan)
Project Co-ordinator: Mozambican Partner Organisation

Communication:
- Weekly Communication between Mozambican Partner and School and IFP as necessary
- Weekly Communication between Mozambican Partner and IADT
- Monthly reporting to Embassy

Financial management:

IADT (financial management of IA budget for ABC School Pilot):
Responsible for:
- Trainer costs for workshops
- Travel and accommodation
- Technology costs and their shipping
- Costs of research collation, data analysis, report writing.

Mozambican Partner Responsible for:
- Venue hire, transport, per diems and catering for workshops
- Local monitoring and evaluation visits
- Customs costs in relation to equipment shipping
- Local credit card needs
- Stationary & miscellaneous, local.
- Stakeholders conference local costs

Appendix 2

School in a Box White Paper

School in a Box White Paper
Institute of Art Design and Technology
Dun Laoghaire, Ireland

Linda O'Sullivan
N. Miguel Seabra
Philip Penny

March 2015

1.   Introduction

School in a Box (SIAB) is a community digital engagement project developed by the Institute of Art Design and Technology (IADT), Dun Laoghaire, Ireland (www.iadt.ie). IADT has over a decade of experience working with Irish teachers in supporting and facilitating the use of film and digital technologies to enhance learning in the classroom (www.fis.ie), and hosts the National Film School in Ireland.

SIAB is a mobile solar powered digital education solution suitable for any learning environment in remote locations without access to electricity. It is a flexible and inclusive solution that can be used, for example, in primary or secondary schools, outdoor schools, field farm schools or other vocational training environments, community clinics, adult literacy or community learning.

The *ethos* of School in a Box is in community engagement and capacity building, working with a Design Driven Innovation (DDI) (Verganti, 2009) approach to providing a solution for the needs of end users; from primary school teachers and students high in the Himalayas, to young mothers or illiterate farmers in remote villages in Mozambique, to teachers in over-crowded low resource classrooms.

SIAB Around the World

2. SIAB Technology:

The technology consists of an iPad®[1] connected to a powerful projector – small lightweight projectors at 500 lumens, capable of projecting in high light situations – and powered by a solar battery and solar panel – a 240 watt battery has 2000 cycles and provides 5 hours of projection time; it can be charged by solar panel, mains electricity or in a car. The configuration of the hardware will vary according to the needs of the project and, as a kit, it can be provided in a canvas bags or in hard cases.

Pedagogical applications (apps) and content are pre-loaded on the devices, again in accordance with the needs of the specific project. SIAB technology training is remarkably fast and intuitive with participants who might not have used technology previously.

3. SIAB Methodology:

FIGURE 2 SIAB 'KIT' MAJOR COMPONENTS

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[1] iPad is a trademark of Apple Inc., registered in the U.S. and other countries.

Using a community engagement ethos, SIAB works with on-the-ground educational and community partners to assess needs and co-design technology deployment, training and content suitable for the environment, everyday constraints and most immediate needs of end-users. IADT staff work with partners to monitor, evaluate and support the sustainability of the project, measuring impact on educational participation and learning outcomes in different environments.

FIGURE 3 TEACH FOR INDIA PRIMARY CLASSROOM USING SIAB

FIGURE 4 ADULT LITERACY TEACHERS MOZAMBIQUE

FIGURE 5 STUDENTS IN YALBANG SCHOOL, HUMLA, NEPAL

Design Driven Innovation, User Needs, Feedback and iteration

Focusing on a DDI approach[2], SIAB uses an inclusive and reflexive methodology in direct collaboration with local partners. Teachers and facilitators are trained in the use of SIAB technology and methodology to find creative solutions to optimise learning outcomes in their particular contexts. High quality, engaging and interactive content, specific to local needs is created in a very short time, using simple content creation apps.

Blended Approach to Content Use and Content:

The SIAB approach to content is a blended approach; using the native photographic, video making and audio recording capacity of the iPad to integrate local examples into lessons. Problem posing methods (Freire & Macedo, 2013), language experience approaches in the creation of digital stories, as well as game based learning call all be used as tools to enhance learning. Once content is created in the course of a lesson it can be shared and re-used by other teachers and learners.

The focus is on using the device to learn "how to learn" and creating a zone of proximal development (Vygotsky, 1986) for learners. Once the learner becomes a creator and author (regardless of literacy level), they have voice and agency, thus building confidence, creative and critical thinking skills, an appetite for and the necessary skills to become an active learner.

3.1   SIAB Content:

Content can come from useful pre-existing apps or other sources, be co-created between partners, or completely designed and created by participants depending on the nature and requirements of the community. In some cases, such as in the case of health literacy for maternal healthcare, custom content has been created.

Anyone, even with no previous ICT experience, or with limited traditional literacy, can learn to use very simple content creation apps over the course of a few days to create customised content, or to integrate existing offline content into a new interactive format.

Examples of some of the content creating apps used by SIAB:

Book Creator

(http://www.redjumper.net/bookcreator/)

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[2] As a continuous and collaborative process *vis-à-vis* 3 major stages: Challenge - Observation, collaboration and research; Ideation/Creation; Implementation/Reflection/Evaluation.

An intuitive way to create interactive books.

Keynote

(https://www.apple.com/ios/keynote/)

A simple presentation app that allows participants to very quickly create

professional presentations.

Explain Everything

(http://www.morriscooke.com/applications-ios/explain-everything-2)

This app transforms the iPad into a smart board, allowing full interactivity

with content as well as being a content creator.

iMovie

(https://www.apple.com/ios/imovie/)

An intuitive video editing tool, this allows professional production of video,

of particular use in health literacy and agriculture learning, where content users

may be illiterate. Can be learned easily by facilitators and healthcare workers and be adapted and updated as required in local environment.

Examples of some of the content apps used by SIAB:

One Billion Maths App

(https://onebillion.org/apps)

Game based learning app practicing basic mathematics concepts for young children.

Hooked on Phonics

(http://www.hookedonphonics.com)

Game based practices of the building blocks of reading

Sentence Builder

(http://www.abitalk.com)

This app allows children to compose and create printed text with the teachers help, building vocabulary, confidence and the building blocks of literacy.

Human Body

(http://tinybop.com/apps/the-human-body)

This beautiful basic anatomy app can form the basis for health lessons as well as building vocabulary, science knowledge and providing access to exciting and stimulating content.

National Geographic World Atlas

(http://www.nationalgeographic.com/apps/)

An important tool in any classroom, this atlas app can provide as much detail or wide context as required.

Star Walk Kids

(http://www.vitotechnology.com/solar-walk.html)

A beautifully produced app, setting the earth in its context in the solar system, provides a wonderful wow context in any learning environment and a motivational force to learn.

Examples:

Here is a range of examples of how content is created and used in the SIAB methodology in a variety of contexts:

a) In a Numeracy class for young children;

The teacher will conduct a projected exercise introducing the mathematical concept to be taught with the help of apps such as One Billion Maths App. Children then find examples in the surrounding environment; counting, dividing, angles, symmetry, 2D and 3D shapes, patterns etc. The teacher or children can take photos of the examples and integrate them into the lesson in a whiteboard app. Again the children can participate directly on the iPad; in this case to draw a line of symmetry through a recognised everyday object. The learning objective is to develop a deep and relevant understanding of a mathematical concept.
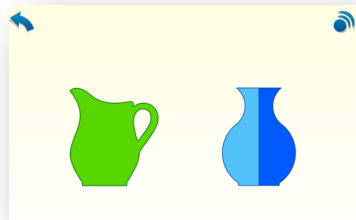
FIGURE 6 ONE BILLION MATHS APP AND EXPLAIN EVERYTHING IN LESSON ON LINE OF SYMMETRY USING A COMBINATION OF GAME BASED LEARNING AND EVERYDAY LIFE TO REINFORCE LEARNING

b) In a Literacy class for young children;

The teacher practices phonics using a phonics game based learning app or whiteboard app, children coming to the iPad to contribute, then children in groups search for things in their environment starting with that sound (or bring in the next day). These are photographed and integrated into Explain Everything

FIGURE 7 TEACH FOR INDIA PRIMARY SCHOOL TEACHER USING SIAB ON EXPLAIN EVERYTHING

FIGURE 8 EXAMPLE OF SENTENCE BUILDER APP USING PHOTOS FROM ENVIRONMENT AND SENTENCES CREATED BY CHILDREN

app, where the word and letter are

revised and the words are set in context.

Building on this using a language experience approach, children participate with the teacher on the technology writing or dictating a sentence using Sentence Builder app. The sentence is projected on the screen, building confidence in their ability to create text and meaning from text. The sentence can then be turned into a game, and other children come to the board to practice putting the sentence back in order. Word order, sentence structure, grammar, vocabulary and word recognition are all practiced, while children receive constructive feedback as well as growing in their confidence to learn and have impact.

c) In a Literacy class for older children;

The teacher assigns children to work in groups to write a story. Using a language experience approach, each child contributes sentences, and then pictures are created (drawn, imported or photographed) to enhance the story. The teacher encourages the children to use as rich a vocabulary as possible, as well as to self-correct text created. The effect is to build oral skills, sentence structure, grammar, self-efficacy, self-confidence and motivation to learn and thereby impact the world. The end result becomes a locally relevant picture story that adds to the bank of text and literature available to all teachers and classes
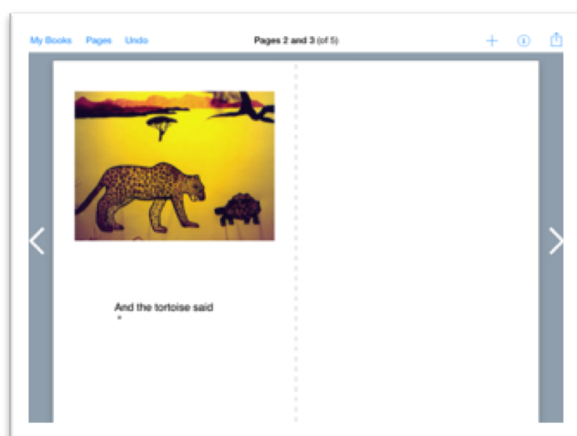
d) In a Science classes for older students without a science lab;

The teachers can encourage discovery learning by asking groups of students to observe, record, analyse science phenomena in the natural environment. Results are imported into Keynote and shared as a resource for other teachers. Information and visual resources can be supplemented by use of online research in this case. In Burkina Faso the facilities of a local university were borrowed for a while, experiments were carried out there, filmed and taken back to the classroom. These resources are then available for all teachers in

the school to use.

e) In an adult/adolescent literacy and economic empowerment class

In a literacy lesson that aims to economically empower adolescent girls, the lesson starts with a word, building into families of words, social and economic contexts of words, reflection on problems related to the word, and proposal of solutions. The content will include participant created images from

photos, text, video, graphic images, voice and music, which can be can then be moderated, adapted, shared with other participants, teachers and re-used in different contexts, but importantly through the creation of this content, participants develop skills in literacy, numeracy, business development, marketing, digital content creation and presentation skills. The impact is to build confidence and empowerment in problem solving and self-efficacy around technology and learning.
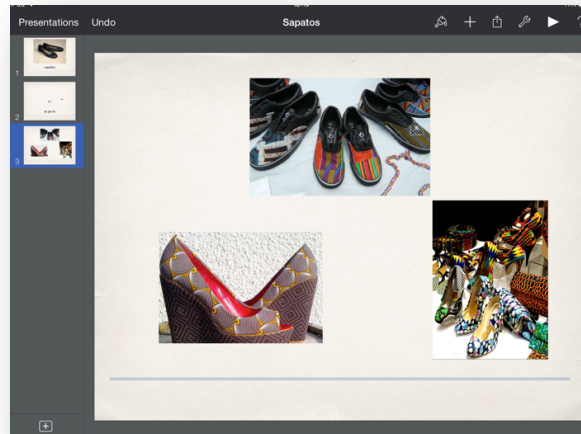

FIGURE 10 IMOVIE USED TO FILM SCIENCE EXPERIMENTS IN LOCAL UNIVERSITY LAB. THE CONTENT IS THEN BROUGHT BACK TO THE CLASSROOM AND SUPPORTED WITH CURRICULUM CONTENT

FIGURE 11 EXAMPLE OF KEYNOTE APP USED TO BUILD LESSONS INCORPORATING ECONOMIC EMPOWERMENT AND LITERACY LESSONS

f) In a Health Literacy context

iMovie, Keynote and Book Creator can all be used to create, update and deliver health messages to healthcare workers or end users in healthcare clinics or remote villages. As the projector can work in high light situations, group learning situations can be created in the most basic environments, such as projecting onto a white sheet. Content can be localised, updated regularly and provided in first language.
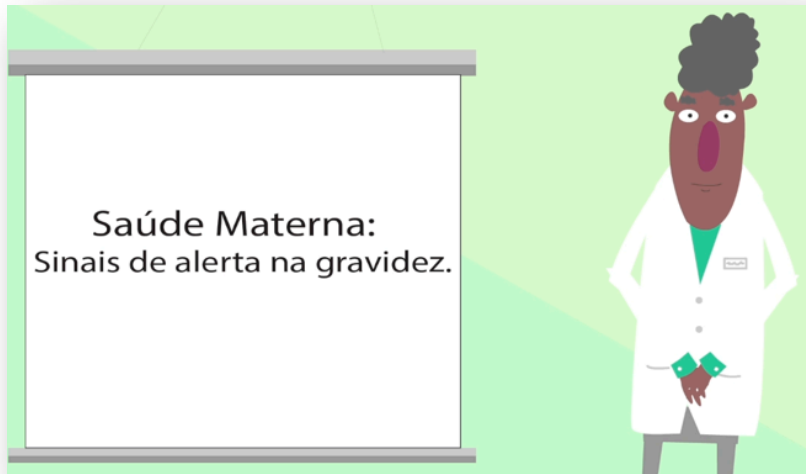
FIGURE 12 CUSTOM CREATED CONTENT FOR MATERNAL HEALTH LITERACY PROJECT IN COLLABORATION WITH UCD MEDICAL SCHOOL AND CLINTON HEALTH ACCESS INITIATIVE

g) In an Agricultural learning environment

The native video making capacity of the iPad and easy to learn editing app iMovie can be used to record, edit and update videos providing agriculture information and education; using local soil, crop and climate conditions. Where multiple first languages

FIGURE 13 AGRICULTURAL FACILITATORS CREATING VIDEO TUTORIALS ON IMOVIE IN MOZAMBIQUE IN COLLABORATION WITH AGA KHAN FOUNDATION AND BILIBEZA AGRARIAN INSTITUTE

or limited traditional literacy are issues, content can be created without any need for text.

3.2   SIAB Training:

The training approach used by SIAB is designed to build digital, literacy and numeracy skills embedded in local lived experiences, involving reflection, critical thinking and problem solving approaches.

Training participants are teachers, healthcare workers, facilitators and staff from partner organisations.   The focus of training is in capacity building of local partners and participants, and sustainability, building participant's skills to create the next generation of trainers.

We believe that technology can never replace the teacher; it can only provide a tool to enhance the teachers' skills. Our training approach is to build on skills that teachers already have and work to teachers' strengths, and to set up structures where a community of teachers can support and learn from each other, as well as sharing created content and lessons.

At the end of a training workshop participants will be comfortable with using all SIAB kit components: using the iPad, setting up the projection and solar energy components. They will also be able to create quality content themselves or easily import offline content. Most importantly, the training aims to engender an attitude of learning "how to learn", and ICT self-efficacy; using ICT as the powerful enabling tool it can be.

FIGURE 14 TRAINING CERTIFICATES FOR ADULT LITERACY TEACHERS MOZAMBIQUE

3.3 SIAB Implementation:

Using a Cultural Historical Activity Theory framework (Engeström, 2014) allows the SIAB team to evaluate outcomes taking into account the complex environments and systems that learning interventions are taking place within.

Assigning roles, responsibilities and duties in the successful implementation of the project is a key part of the training, and ownership of the project is handed over locally at the end of the pilot period.   A School in a Box champion is assigned to the project to ensure that any problems are reported back to the SIAB team, and to create a structure to enable participants to share content and skills with each

FIGURE 15, ANASTASIA ASSALE, MINISTRY FOR EDUCATION MOZAMBIQUE AND ROSALINA RUNGO, DIRECTOR IFEA MATOLA MOZAMBIQUE, SIAB CHAMPIONS

other.

Throughout that period the SIAB team are available to provide remote support, mentoring and troubleshooting.

Partner organisations must sign up to a Memorandum of Understanding to allow the SIAB development team to gather data in order to continue to iterate and improve the project.

4.   SIAB in Practice:

The following are a range of applications of SIAB in relation to a number of pervasive issues:

4.1 Range of issues SIAB can help to address:

a) Urban-rural divide:

In Sub-Saharan Africa urban-rural differentials in literacy are as high as 40% (World Bank, 2013).

Solution: SIAB can provide high quality educational technology and content in very remote environments that are off the electricity grid.

b) Lack of content:

Shortage of textbooks and access to text is an on-going issue in many countries (UNESCO, 2014). Where instruction is in first language, availability of textbooks is an even greater problem.

Solution: SIAB can provide simple tools for the creation and sharing of texts and books in any language.

c) Gender disparity in access to education;

Distance of travel to school can be a barrier to girl's education for reasons of safety and parental concern (Porter, 2011).

Solution: As a mobile learning solution, SIAB can bring learning content into remote communities

d) Teacher skills and teacher support:

Upgrading knowledge and skills, distance education and mentoring provide valuable support to rural teachers. (UNESCO, 2014; Buckler, 2011)

Solution: Remote monitoring, mentoring, training and feedback loop can be provided through the SIAB technology and 3G or satellite connection.

e) Public health messages in remote communities:

Getting health messages into the community as public health issues arise, or health messages of key importance to particular members of the community such as post-partum mothers can be challenging.

Solution: SIAB can facilitate the creation of key health literacy messages in video format for use in the community in first language, using locally relevant scenarios.

4.2 Projects and Partners to Date:

School in a Box is used in health literacy, agriculture, adult literacy and school environments. A community engagement approach and ethos informs holistic individualized design in each environment we work in.

In Mozambique, School in a Box is deployed in 5 Adult Literacy centres in Maputo province in collaboration with UNESCO, the Ministry for Education in Mozambique and Matola Adult Literacy Training Institute. Already a bank of lesson plans and content created on the iPad linked to local literacy, numeracy and life skills curriculum have been developed by teachers piloting the project. In Cabo Delgado province School in a Box in being piloted in collaboration with the Aga

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Khan Foundation and The Agrarian Institute of Bilibiza, with a view to equipping the future generation of agriculture technicians with the skills to use IT in agriculture extension.

In Nepal, School in a Box is deployed in primary and middle school environments in collaboration with the Karuna Shechen charity and Himalayan Children's Society. At 3000m altitude and without access to grid electricity, Yalbang School uses SIAB across a range of classes and curriculum.

In Burkina Faso, School in a Box is in use in Juvenat Saint Camille secondary school in Ouagadougou in collaboration with Teng Tuuma Geoservices.

4.3 Upcoming Projects:

The School in a Box project is about to commence further pilots and research with Clinton Health Access Initiative and UCD Medical School, in a number of maternal healthcare facilities in Mozambique, and with Irish Aid and the Mozambique Ministry for Education in a primary school in Maputo.

The project continues to iterate and develop with each new project, and next iterations will focus on providing more remote feedback, support, updated content and mentoring for teachers and partners through network connections on the devices.

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White Paper Appendix

Institute of Art Design and Technology
Dun Laoghaire, Ireland

The appendix provides a photographic overview of SIAB projects around the world: Burkina Faso, Mozambique and Nepal.

SIAB Maputo/Pemba, Mozambique
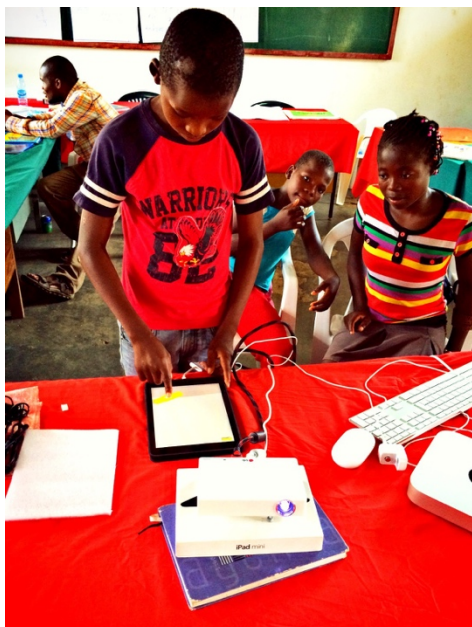
Appendix 3

Sample from Researcher's Reflective Diary

Monday - 17 August 2015

The room is decked in the Mozambican flag with a very formal portrait of the new Mozambican president. The first teachers arrive at 8am. These are all teachers of 3rd class in ABC Primary School. NMS and I have the opportunity to do informal greetings and introductions to put people at ease. At 8.30am NMS begins to introduce the workshop and the week ahead.

At 9am, we have to stop proceedings for formal speeches by the ambassador and the Director of the Teachers Institute and a senior official from the Ministry for Education. I also have to make a speech on behalf of IADT in broken Portuguese. I would much prefer if it could be more informal as it is important that the teachers are relaxed and at ease. But I understand that the culture here is very formal, and that the Irish Embassy has to formally recognise its partners on the project. However, the ceremony very clearly sets out the dilemma of difference: those on behind the long table and those in front of it. Those with the power and the money, and those without power and hoping to receive expensive equipment, in a school without desks, chairs or whiteboards.

The head of education in the Irish Embassy, who is from Mozambique, sits separately to register the teachers, so they can receive the standard per diems for attending.

The break time takes place in a gymnasium across from the training room. This is the only gym of its type in Mozambique and is the pride of the school. The national basketball team trains here. Plastic round tables are set with white table cloths, and plastic chairs are covered in white linen as if for a wedding. The teachers sit together and NMS and I are invited to sit at the table where the representatives of the Ministry, the Embassy and some observing NGOs sit.

When we go back into the classroom, teachers are given the opportunity to express their idea about what they want to achieve. They have clear ideas about how the technology might help their teaching and their students. Very quickly, one of the participants, Teacher 11, is identified as separate from the rest of the group. He is the Director of Pedagogy at the school, and he wants to do a Masters in Curriculum Design, incorporating the outcomes of this project. He is very tuned in, insightful and clear thinking in terms of the application of the technology in the school. The representative from the Embassy informs him on how to apply to the Embassy for a scholarship for the Masters.

Tuesday - 18 August 2015

Today the workshop will focus on the interactive whiteboard app; Explain Everything. We also record a focus group on identifying potential problems in the implementation of the project. During this discussion, there is some argument regarding the participation of children, in particular inviting children to the teacher's desk to touch the iPads. There is a lot of fear that teachers will lose control of the classroom.

Later the teachers present some very good projects on Explain Everything. They have grasped how to use the technology very well. However, in some cases, they are using it like a blackboard, and are failing to grasp the more interactive features. More work will be required from us in the coming days to show how this technology is different to a blackboard.

I am feeling the language barrier. When the teachers speak quickly and argue among themselves, I don't understand. For this reason, I am recording a large amount of material, so that I can get verification at transcription and translation stage.

I am anxious to achieve more, to accelerate the process. I am worried that we are repeating too much and going too slowly. But feedback at the end of the day is positive and they don't want to change anything.

Appendix 4

Sample Notes from Planning Meeting

LOS, LM and D - Notes from Phone Conversation

29th April 2015

LM and D were just back from the school.

Basic information about the school:

- It is in the periphery of Maputo, about a half an hour from the city.
- It is on the electricity grid, and electricity supply is stable and connections working well.
- It is a very typical large urban school, neither notable for being particularly good or bad, so therefore very typical and representative of many urban schools.
- There are 71 teachers and 5000 students.
- It is a full primary school with grades 1 – 5 (ages 6 – 11 if students are at appropriate age for class). First Cycle (EP1) contains grades 1 and 2. Pupil teacher ratio for these grades is 72:1. Second Cycle (EP2) contains grades 3,4 and 5 and has a pupil teacher ratio of 60:1.
- There are 3 shifts of school per day: early morning, late morning and afternoon, so pupils get 3 hours school per day.
- There are 49 teachers in First Cycle and 22 teachers in Second Cycle.
- Most teachers have secondary school education + one year teacher training. Some have degrees.
- The school director was enthusiastic about the project and was keen to include all grades.

Discussion followed along these lines:

- Discussion was had about how many teachers we could realistically train in a meaningful way in 1 week.
- From our previous experience training teachers on School in a Box, 10 seems to be the optimum number of teachers to allow adequate practice and feedback for meaningful learning to embed.
- As there were too many teachers in First Cycle this was ruled out.
- Ethical considerations were discussed in relation to choosing which teachers would be part of the study, and it was agreed that the fairest way to choose teachers was to choose a grade, and train all teachers teaching that grade, so that all children in one grade would have access.

- As literacy is an issue, it was discussed if Grade 3 would be appropriate as we could include literacy intervention in the project design before content became more complex.
- We agreed to wait for more information on numbers of teachers for each of the second cycle grades in order to choose which grade.
- Discussion around a local partner teacher training institute was also discussed; LM is exploring this further on the ground. One is quite far from the venue (2 hours away) but the school has a strong relationship with this institute. The other is closer, but has a stronger focus on training managers of schools. LM's preference is for the latter as they will be practically in a better position to provide support for the project.
- The rest of the discussion was around agreeing suitable dates, venue, catering, per diems and security arrangements for equipment.

Appendix 5

Sample Email

24 April 2015

Hi LM and D

It was great to speak with you this morning.

Just to summarise the call as we managed to discuss quite a lot:

Equipment:

- There is electricity supply to this school, so we do not need to include the solar batteries or panels in this instance.
- There is 3G access where the school is located so we can include network access and remote support and monitoring as part of the project.
- LM is due to speak with the director of the school today to find out exactly how many teachers from the school will be involved in the pilot programme and the training so that we can determine firstly how many kits we need to provide.
- We briefly discussed security, in other projects in Maputo province the kits are locked away by school directors after use. In this case, without the solar batteries the kits will be very easy to store, as they are quite small. We will take advice from the school director on appropriate security measures for the equipment.

Participants on Study and Training:

- LM has copies of academic programmes, including manuals on the way to Dublin via a diplomatic bag.
- LM is also finding literacy measures if they exist, or school exam results for the school and comparative results for the region, so that we can have some comparative measure of literacy levels in advance. This is important so that we can pitch the content and training design at the correct level.
- We also need to find out pupil teacher ratios, and class schedules, school shifts etc.

Sustainability:

- LM suggested that we link the project with the teacher training institute and I think this is a really wonderful idea, as it will give the project the greatest chances of sustainability. In this case it would be good to include one equipment kit for the teacher training institute and have one professor and one technician or technical supervisor attend the training.
- Ideally it would be great if the teacher training institute became a full partner on the project, and participated in the design and carrying out of the monitoring and

evaluation activities. We can provide additional support and training for the teacher training institute to be able to continue training teachers on the project.

- LM suggested a tripartite memorandum in advance of the project to ensure all parties are in agreement on responsibilities, duties etc. This will be very useful and it would be great if possible to include data to be collected as part of this.

- I suggested that once we have agreed the timeline for the study, that it would be useful to schedule an event in the school at the end of the study that will include the pupils, their parents, members of the community, as well as staff from the Ministry for Education and teacher training college in a celebratory event to showcase the work achieved by the teachers and their students. This can be as simple as an outdoor event with work produced by the students projected onto a wall. It is important to have an event to focus on, and an opportunity for the community to be involved, as well as a sense of ownership of the project and sense of achievement for the pupils. It will also provide an opportunity to demonstrate to the ministry the potential of the project.

- We also discussed involving some teachers from the school in Maputo province where the kits are already being used by the adult literacy teachers. I think this is a wonderful opportunity to ensure continuity and sharing of expertise and I will follow this up with UNESCO, and get back to you on the details of this.

Measurements, Assessments, Monitoring and Evaluation:

- It will be good to discuss again on Monday from Irish Aid's point of view what indicators would measure success for the project, and how we might be able to take these measures.

- We briefly discussed to what degree we should use the devices to monitor teacher activity and it would be good to discuss this further on Monday. D mentioned Ministry plans to use devices to track and monitor teachers, and we could certainly introduce an element of the study to examine this in the form of a very simple class log to be uploaded to the network at the end of every class. We want to be sensitive about this however, and will take advice on this.

- When we have more information on literacy levels, and the program of study we will design measure and assessments around this in agreement with you.

- It would also be good to discuss what wider measures could also be included: attendance, teacher attendance, progression etc.

Costs:

In order to scope out our budget we need to get information on:

- the number of teachers who will require a SIAB kit
- the number of additional participants on the training
- the training venue, catering or per diem costs and who is responsible in relation to different participants
- training dates confirmation as soon as possible so that travel and accommodation can be arranged
- any information you might have about network I would really appreciate, does Irish Aid work with a particular mobile provider?

Thank you again so much for all of this and I look forward to speaking with you both again on Monday at 11, Irish time.

Best wishes

Linda

Appendix 6

Sample 1 Workshop Schedule

School in a Box and Irish Aid
Pilot project
Maputo, August 2015
SIAB Trainer & Researcher: Miguel Seabra & Linda O'Sullivan

Monday 17 August

Morning session (approx. 4 hours)
- Introductions
- School in a Box presentation;
  - What is SIAB
  - SIAB in other settings
  - Purpose of training
  - Purpose of research
- SIAB Kit: introduction of what the components are. Solar components only mentioned at this stage.
- Hands on practice with iPad - getting the know the basic functions;
  - Finger gestures, power functions, switching between apps, writing text, copying, pasting, use of camera

Afternoon session (approx. 3 hours)
- Introduction to Keynote app
- Importing of photos into keynote
- Integration with text
- Paired work; each participant create presentation about their teaching working to a sample format of 5 – 6 slides using photos and text:
  - Who are you?
  - Who are your class?
  - Where do you teach?
  - What do you teach?
  - What do you love most about teaching?
  - What do you find most challenging?
  - What would you like to achieve with this technology?
  - Presentations and group feedback (to be filmed for research purposes; this video will only be watched by the SIAB trainer and researcher and will not be viewed by anyone else)
- Setting some homework; take the devices home and take some time practicing and getting to familiar with the functionality

Day 1 key learning outcomes:
  - Hardware: iPad functionality
  - App: Keynote
  - Reflection: teaching challenges and setting context for technology

Sample 2 – Workshop Schedule

SCHOOL in a BOX

22 – 25 Fevereiro 2016

Dia 1

Local	Embaixada da Irlanda, Maputo
Formadores	João Couvaneiro e Linda O'Sullivan
Observadores/Formadores	Irlanda)
Formandos	

Manhã

- Visão geral e experiência com iPad para os colaboradores do IFP
  - Aplicações (Apps)
    - o Explain Everything;
    - o Book Creator;
    - o Keynote;
  - Todas estas apps utilizadas para promover a literacia.

Tarde

- Estabelecimento de objetivos e metodologia do projeto;
- Workshop colaborativo para o staff do IFP numa metodologia relacionada com o currículo e ajustável às condições da instituição;
- Acerto dos papéis e responsabilidades ao apoio piloto e mentorado, desenvolvimento da capacidade de formação para o IFP, e exigências técnicas

Dia 2

Local	Embaixada da Irlanda, Maputo
Formadores	João Couvaneiro (
Observadores/Formadores	Irlanda) e Linda O'Sullivan
Formandos	Staff do IFP 1 \ Professores 12

Manhã

- Informações sobre a utilização que os professores fazem do iPad
- Definição de obstáculos e possíveis soluções
- Trabalhar com grelas de planificação e preparação
- Integração com o Currículo

Appendix 7

Workshop Design Notes

Appendix 8

Sample Transcription Group Discussion

Clip 52
School Director of Pedagogy
So children are reaching the end of the first cycle with this problem. We want to see if in this pilot project, if School in a Box can help us to surpass this problem. It is a pilot project and its main goal is to solve this problem, to which point can this project help with the literacy problems.

Because the kids had passed first class and second class and they should have been able to read. Now they are in third class.

We are all third class teachers. We need to focus on how can we use this instrument to resolve this issue of not all children reading in 3rd class?

Clip 81 in ABC School
Teacher1:
(00:00 to 00:16 inaudible)

I think that this project is a challenge, but I realised some points that I will put in practice next time when I am working with the kids, mainly during reading and interpretation classes.

We are hardly able reach the objective and to find this moment where the kids concentrate, as happened today, for example.

During text interpretation we demand extreme concentration from students and we can not reach the objective. But at least today, it was possible to realised we can reach the objective from the text and get the kids to concentrate more in the text, in a less distracted way. It was a very positive point that I could observe here, we will try to improve to find ways of interpretation the texts. But it was very positive.

What we could learn, was exactly what the teacher (referring to teacher 1) said, we found this way of ** going out, so the kids do not have to be so concentrated. The use of the iPad is not necessarily that the kids needs to be handling the own instrument. The simple fact that we have the change to bring the iPad the classroom is already something good.

Because what was giving us extra work, was that we wanted to bring exercises where the kids would be the ones using the iPad, but we can see that doesn't need to be like this. The most important think is to make the class possible with the use of the iPad

Appendix 9

Sample Transcription Micro-Teaching

NMS: Hi Teacher, make yourself comfortable as it is your class.

TEACHER 8: Hi colleagues, now the topic of your lesson is: formation of sentences. Who will help me based on that picture you are seeing? - The first impression we had is that when children see that picture they will be able to infer by themselves – There is a person washing his hands, after that, the teacher can ask: "What is that man doing?", and the child will say "that man is washing his hands". "Who is able to make up a sentence based on what the man is doing?". It can be one by one, you have to organize the sentence based on those shuffled words. If someone makes a mistake, we can ask another child to try, until we get a correct sentence.
  For that I call Nadessa, to form a phrase based on the words you can see on the board.

NADESSA: John...Hands

TEACHER 8: Can you point?

NADESSA: ... John. John is here... wash... Hands... Now that "the" (*as* in Portuguese) John... teacher! Should I make up this sentence: John wash hands?

NADESSA: There is no "the" in the picture.

TEACHER 8: There isn't.

NADESSA: John is washing hands. John washes hands.

AUDIENCE: John washes "the" wands.

NADESSA: Ah… Ok.

TEACHER 8: The girl Nadessa was able to read. Now I need a someone to say the full sentence based on the words you see here.

NINA: John washes "the" hands. (Note: based on direct translation of Portuguese phrase)

TEACHER: Nina is right, isn't she? A round of applause for

her!

Applause.

Appendix 10

Sample Classroom Observation

Setting:
The classroom is L shaped to accommodate Saul's office at the rear in the corner. It has two windows to the left that are covered with black material that blows a little in the wind. The door is to the rear at the back and open onto the central sandy courtyard area, where passing children waiting for the next shift of school stop curiously to stare in every so often. There is a soft cloth material attached across the top left hand corner of the room onto which the images are projected from the iPad which sits on a small table in the centre of the room with the projector. At first the teacher is out of sight, sitting down with the students who are slightly out of our eye line to the right L of the room. There are approximately fifty to sixty students in the room. They are all approximately nine years old. Most are wearing uniforms, some are not, and some are wearing partial uniform. Most are wearing shoes, but some are not. They are all sitting on the floor, quite close together.

As we sit down, no reference is made to us by the teacher, regarding who we are or why we are there. They are curious, but still maintain good attention on the screen and the class.

At the start of the lesson, children are practicing reading an obligatory text about the importance of balanced nutrition and exercise for health. The text has been transcribed into Explain Everything app. The teacher (out of our eye line) calls pupils to the screen one by one to read from the fairly long paragraph. The pupils use a long stick to point out one word at a time, and the whole class repeats each word, one at a time. The pupils sitting maintain fairly good attention at the start of the exercise but towards the fourth reading start to become increasingly fidgety and particularly curious about us. When we sit down first, the pupils called to read can call out the words without hesitation and without mistake. As the class progresses, the pupils called to read, become more hesitant and make more mistakes. (We don't know exactly what the rate of literacy in this class is, but understand that that teacher has called the most literate pupils to the board first for our benefit). As the pupils become more faltering, the teacher stops this part of the lesson and moves on to the next part.   So far there has been no engagement with the pupils except to call them to the board and hand them the pointing stick.
 (The Human Body app would have been a perfect context setting interactive resource for them to use for this lesson. I wonder why the teacher did not consider using this. I wonder if she has had enough time with the iPads outside of class time to explore the possibilities of the technology)

The teacher emerges from behind the corner and stands to the front of the classroom. She puts on the next slide on which she has key information from the required text in a cause and consequence format. On the left are short sentences relating to food, in the middle a red arrow, and to the right the result of eating certain types of foods (e.g. stronger bones, protection from disease etc.).   At this point the teacher begins to ask students questions related to the lesson, such as asking for different types of foods. The pupils are again more attentive. They become quite animated and excited when they are asked questions, putting up their hands and competing with each other to provide the answer. She also asks the children to open their books on the page of the food wheel. (Every third child has one book, which they share with those around them).

Now the teacher moves on to the next part of the lesson. She has obviously put significant time into planning and preparing the lesson in advance. This part of the lesson is still on Explain Everything and shows pictures of several foods; fish, eggs, various fruits and vegetables, cereals, bread etc. clustered together on the screen. Across the top are three headings: Construction foods, Energy Foods and Protective Foods. One by one she enlarges each food, and asks a pupil to come to the screen and point with the stick into which category the food belongs. The teacher than moves the food into the correct place on the screen. This part of the lesson has the classes full attention, and we are forgotten for the moment.

She then moves the lesson to the chalkboard where she creates the same table with three columns, one for each group of foods. She calls children to the board who write out examples of foods in each group. She helps out with spelling when required, sounding out the word again to help. The best writers are called first and as the lesson progresses, some of the latter children struggle more with writing, until the teacher calls a halt to the lesson again. At this point the children are getting restless again and a trickle of them start asking permission to leave to go to the toilet. The class has run over time, as a result of our presence. We become aware of this and return back into Saul's office so the teacher can finish the class.

Appendix 11

Sample Field Notes School Visit

We arrive at the school during break time and my first impression is the sheer number of children. There are around eight children hanging out of a tree as we are driving into the school, and scores of other children spilling over the periphery of the school. As we drive into the school grounds, there are hundreds of children running around the school grounds, and many of them stand and stare at us. They are curious, friendly and smile and greet us when we greet them. Saul comes out to greet us wearing the School in a Box T-shirt that we gave him on the last visit. He ushers us into the only classroom with windows and doors, which has a space at the back for his office.

On the way into the office we meet the teacher who is setting up the technology. As we sit in the office with Saul, the children file into the classroom beside us. We discuss some house-keeping issues with Saul (notes minuted separately, including more detailed discussions after observation), and once the class is well underway, we go out of the office to sit at seats set out for us at the back of the classroom.

The school has a number of long buildings with galvanised roofs in a U shape, with individual classrooms. The doors of the classroom open onto the centre of the U shape, which is a large area of dusty sanded ground. The children run around here and play. Some of them centre around a single tap from which they can drink and a puddle of spilled water has formed around this. There are a couple of latrines interspersed between buildings. All of the classrooms have open windows with bars. They all seem to have doors, even though Saul has told us that the classroom we are in is the only one with doors. (see photos). There are two tuckshops in little huts, one close to where we drove into the school grounds and the other at the other side of the U shape of school buildings.

After our meeting with Saul, I ask if I can see the outdoor classrooms, as I know approximately half of the classes are held outdoors. He takes me around to the right of the U shape of buildings, where I see over a hundred children sitting under three trees, and in the distance at the far periphery of the grounds, another large group of children sitting under another copse of trees. In the closer group there are three distinct groups with a blackboard and teacher each, and in the farther away group, there seems to be two classes. The children are curious and when we show up the teachers struggle to keep them sitting in their class groupings.

Before we visited the school Saul and arranged for permission with all parents regarding photographs (this was already in place at the school), so told us that we could freely take photos. However when the children noticed me taking photos, they swarmed towards me wanting to be in the photo. I was struck by the levels of curiosity and playfulness of the children, and additionally at the at frequent sight of children going around arm in arm or hand in hand. I am familiar with reports of Mozambican children sharing whatever they are given with friends. I got an impression of strong friendships and loyalties among friends.

We realised we were disrupting classes and so returned to the car. My shoes were full of orange coloured sand and had to be emptied before getting back in the car.

Appendix 12

Survey 1

This feedback form is anonymous, it is just to help us to improve our SIAB training.

1.   What class do you teach?

2.   How many classes do you teach per day?

3.   How many school shifts do you teach per day?

4.   How many pupils do you teach per day?

6.   How many children are absent on average per day?

7.   Do you teach in an interior or exterior classroom?

8.   What resources do you usually use in your classroom? (eg. blackboard, chalk, etc)

9.   Have you found the SIAB training useful?

10.   What is the one thing you want to impact most by using SIAB in the classroom?

11.   What activities will you do with the SIAB technology to achieve that?

Thank you very much for your participation in this project. You can contact us at any stage with any question you may have : linda.osullivan@iadt.ie and n.miguel

Sample Response Survey 1

Agosto 2015

1. Qual a disciplina que ensina?

Eu ensino as disciplinas de: Português, Matemática, Ciências Naturais

2. Quantas aulas ensina por dia?

Por dia eu ensino cinco aulas.

3. Quantas turmas diferentes ensina, ou quantas turmas existem por dia de escola?

Eu ensino uma turma apenas por dia.

4. Quantos alunos ensina por dia/Quantos alunos tem a sua classe?

Eu ensino 56 alunos por dia.

6. Aproximadamente, quantos alunos costumam faltar por dia à sua classe?

Por dia costumam faltar seis alunos por dia.

7. Ensina numa sala de aula no interior ou no exterior?

Eu ensino no exterior da sala de aulas.

8. Quais são os recursos que dispõe na sua sala de aula (quadro, sólidos geométricos, etc.)?

Os recursos que dispõe são: quadro preto

9. Acha que a Escola na Caixa é útil para o seu ensino, para a sua classe?

Acho sim, que o ensino de Escola na Caixa é útil para o meu ensino.

10. Qual o aspecto que acha que terá mais impacto com o uso da Escola na Caixa na sua sala de aula?

O aspecto que terá mais impacto com o uso da Escola na Caixa na minha sala de aulas é na observação ou interação da matéria com a imagem no decorrer da aula.

11. Quais as actividades em que irá usar a Escola na Caixa para atingir melhor resultados com os seus alunos?

Irei usar a Escola na caixa para atingir melhores resultados com os meus alunos nas actividades de amostra dos objectos ou matérias/conteúdos que mais relevantes de (Port. Mat e C. Nat).

Appendix 13

Survey 2

August 2016

1. How frequently do you teach with School in a Box technology?

2. What topics have you taught using the School in a Box technology?

3. Have you taught your class using digital content created by another teaching? If so, what was the topic?

4. Has another teacher taught a class using digital content created by you? If so, what was the topic?

Sample Response Survey 2

Agosto 2016

1. Com que frequência usas o ipad da Escola na Caixa?

- Uma vez por semana,

2. Quais são os temas específicos em que já utilizaste o ipad para auxiliar o ensino?

* As províncias e as respectivas cidades capitais
* As principais partes da planta
* Tábuada de 2 a 10 - Numeração

3. Já usaste material criado por um outro professor nas suas aulas? Se sim, qual era o tema?

- sim e o tema era " As principais províncias e cidades capitais de Moçambique " ciências socias da 4ª classe

4. Já, algum outro professor utilizou um material criado por si para suas aulas? Se sim, qual era o tema?

- sim e o tema era "as principais partes da planta" 3ª classe na aula de ciências naturais.

Appendix 14

Sample Handwritten Notes from Participant Teacher

(on challenges as a teacher)

Appendix 15

Information Provided to Participants

Pre-Participation Pack for Teachers

What is School in a Box?

School in a Box is a kit designed to be a useful teaching resource in your classroom. In the School in a Box kit there are 4 main pieces of technology; iPad, projector, solar battery and solar panel, connected by some simple cables.

On the iPad, there will be some applications that are particularly useful for primary school classrooms. These applications will allow you to access new and interesting teaching materials, to import teaching resources you already use, and will also allow you and your students to create interesting and new content.

The iPad connects to the projector and can be projected onto a white surface, such as a white wall or a white sheet.

Most importantly, the School in a Box kit doesn't require any knowledge of technology in advance and is very simple to learn to use. It is mobile and can be moved from classroom to classroom, and as it doesn't need an electricity source, it can even be used outside.

How is it used?

School in a Box is a tool, to be used the same as any other tool, such as books, pencil, chalk, or oral teaching. It will not replace the way you have taught in the past, but it is a tool to be used by you, as you find useful, to enhance your existing skills, experience and strengths as a teacher.

School in a Box can be used in a multitude of ways depending on your and your students needs; classroom projector, blackboard, whiteboard, calculator, computer, camera, video recorder, encyclopedia, library, presentation creator or book creator.

What happens during the training?

The training is designed to allow you to become skilled enough with the technology to be able to set up and use the technology easily in your classroom.

You will explore how to integrate the technology into your lessons in a way that is useful and enhances understanding and learning for your students.

You will learn how to access content that is useful for your teaching, as well as to create content that is directly relevant to your students needs.

You will learn techniques using the iPad and projector that will get students more actively engaged with their learning.

Over the course of the training you will work directly with the technology, completing exercises and projects to build your skills.

You will practice teaching with the SIAB kit and integrating the technology into your classroom lessons.

At the end of the training you should be very comfortable with using the iPad, projector and solar battery and have a strong understanding of how this technology will help you in your classroom.

Before the training

The most important thing to remember is that the technology is designed to be a useful tool for your teaching needs. There is no need to have any knowledge of technology or any special talent for technology, this will be taught from the very

beginning. All you need is an open mind, a willingness to learn, to have some fun, and for each teacher to be open to sharing their learning and experience with each other.

In advance of the training we ask you to do a little bit of thinking about the challenges you face in your classrooms and how SIAB might be able to help.

This should help you to get the most from this opportunity, and will help the trainers to adapt the training to your particular needs.

- Think about the 3 biggest challenges in your classroom.
- Think about 3 things that would help you most in the classroom.
- Think about 3 things you would like to achieve from the training.
- Bring in 3 samples from books or content that you use, that your students find challenging to learn.

After the training:

Weekly Meetings

The main purpose of weekly meetings is to create a formal structure that allows teachers to share their experience, learning, skills and content with each other. The five days training are just the start of the learning journey for teachers, and the weekly meetings act as ongoing training and support, but from within your own group of peers.

Each teacher will stumble upon new tricks and solutions and ways to use the technology as you each deal with unique situations in your own classrooms. It is important to share these tips and skills with your fellow teachers to keep the momentum going and maximize the opportunities that the technology offers to your students.

Monitoring and Support

The SIAB research and support team will be available at any stage to provide feedback, information or further resources as required and as problems are

encountered. New learning usually arises in the solving of problems, and the SIAB

team will learn as much from your experiences using SIAB in the classroom as you will.

A final word

School in a Box is an international project used in different environments in

different countries and settings. The purpose of this pilot study is to learn how to

optimize the usefulness of the technology and training for school settings similar to

yours. As such, the SIAB team will continue to adapt and aim to improve the

technology, the training, the content and the monitoring and support activities to

improve the usefulness of the project for teachers and to improve learning outcomes

for students.

Your learning and experience will feed into the overall project and be used to

enhance the experience for other teachers and schools participating in the project in

future, as well as to enhance the quality of the project being delivered to your school.

Sample Consent Form

Formulário do Professor
Escola na Caixa (SIAB) formação/capacitação e projecto de investigação

Nome do participante:

☐ Li e compreendi o documento acerca das informações do projecto Escola na Caixa e tive a chance de pensar sobre essas informações.

☐ Entendo que não existe qualquer problema se decidir não participar directamente na investigação/estudo e que posso participar na formação/capacitação da Escola na Caixa.

☐ Entendo que me pedem para tomar parte integrante na investigação/estudo como um professor, cuja opinião, conhecimento e experiência será respeitado e servirá para informar como é que a tecnologia da Escola na Caixa pode ser usada para ajudar os professores em Moçambique e em outros locais do mundo.

☐ Entendo que os investigadores podem recolher citações, gravações de vídeo ou de áudio dos meus contributos e que podem guardar o conteúdo que crio como parte do processo de formação/capacitação da Escola na Caixa, a fim de melhorar a tecnologia e como ela é usada em ambiente de sala de aula.

☐ Entendo que quaisquer citações ou informações da minha autoria usadas ou publicadas na investigação/estudo serão anónimas e o meu nome ou o nome da escola não será usado.

☐ Entendo que qualquer informação relacionada a mim será mantida confidencial e privada.

☐ Entendo que posso fazer perguntas, solicitar alterações e que a minha opinião é respeitada, valorizada e muito importante como parte do processo integrante da investigação/estudo.

☐ Entendo que posso sair investigação/estudo em qualquer das suas fases sem ter que dar uma justificação e isso não afectará a minha capacidade de continuar com formação/capacitação e com a utilização regular do equipamento da Escola na Caixa.

☐ Concordo em participar nesta investigação/estudo.

Nome

Date

21.08.15

Assinatura

Contacto do Investigador SIAB: linda.osullivan@iadt.ie

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Appendix 16

Ethics Approval TCD

((MYzone))

Mary O'Sullivan <osullm45@tcd.ie>

Approval Mary Linda O'Sullivan (D.Ed. 14328361) 11th September 2018

4 messages

Phdrsrch <PHDRSRCH@tcd.ie>   11 September 2018 at 13:05
To: Mary O'Sullivan <OSULLM45@tcd.ie>
Cc: Colette Murphy <colette.murphy@tcd.ie>

Approval Mary Linda O'Sullivan (D.Ed. 14328361)   11th September 2018

Dear Mary Linda,

The School of Education received and considered your application in June 2015 for ethical approval of your Ph.D. research project entitled "School in a Box – Teacher Training Phase 1".

It was the decision of the committee, prior to current policy and processed in accordance with School policy at the time that no additional information was needed regarding your application. Therefore, approval was granted for your research, on the condition that it was carried out as indicated on your application. Should there be a change in the design of your research project, you will need to re-apply again for approval from the School of Education's Ethics Committee.

You are required to include a copy of this letter as an appendix to your thesis.

If you have any queries regarding this decision, please contact the current Chair of the School of Education's Ethics Committee and Director of Research, Dr Ann Devitt (devittan@tcd.ie).

We wish you all the very best with your research project.

Kind regards,

Fiona McKibben

Research Officer at the School of Education

on behalf of Professor Ann Devitt

Director of Research