Twenty-first century skills development in rural school learners

Bongani A. Mabaso (Researcher), MBSBON008

Martin Hall (Supervisor)

June 20, 2017

Abstract

The aim of this study is to explore the relationship between connected learning environments and rural learners' development of 21st century skills. The driving question for the research is, "what is the impact of introducing a technology supported connected learning environment on rural learners' development of 21st century skills?" The need arises out of the undesirable state of education in South African public schools, particularly in poor, rural and marginalised areas. The literature shows that the learning environments in these contexts are stuck with an old education system that needs radical reinvention for the 21st century. The connected learning framework is used as a model for learning and a reference for design of the intervention that is employed. The study uses a qualitative and experimental approach for data collection, using semi-structured interviews, focus groups and data collected through a social media platform. The results show that connected learning is a possible approach to education in rural contexts, with learners showing evidence of 21st century skills development over the period of the study. Theoretical insights generated include the mechanisms with which connected learning environments promote 21st century skills development. The study also generated helpful insights for organisations and practitioners wanting to introduce modern learning environments in rural schools in South Africa.

Key words: connected learning; rural education; 21st century skills;

Contents

List of Tables

List of Figures

Part I

Context

1 Introduction

"21st *century education should prepare students for a world in which almost all types of routine cognitive tasks are done by computers and in which expert thinking and complex communications are the core intellectual capabilities by which people attain prosperity and economic security individually, as a region, and as a nation"* (Dede, 2010).

21st century education is one that prepares learners for the challenges of employment, civic duty and life in the 21st century (Saavedra & Opfer, 2013). Learners need to be equipped with new skills, dubbed 21st century skills, for successful economic and social engagement in this technological and information age. This is because world economies are becoming flatter, with a greater push for globalisation than ever before. The main asset required for employability is now knowledge, as routine work is increasingly processed through automation. In order for learners to successfully navigate this new and ever changing world, they need 21st century skills such as problem solving, collaboration, critical thinking and technological fluency. There is a general consensus in the literature that technology can play a crucial role in transforming education in classrooms, especially with regards to teaching 21st century skills (Botha & Herselman, 2015; Saavedra & Opfer, 2013; Dede, 2010). Technology enables learners to create, collaborate and reflect on their own work, as well as that of their peers. This technology supported creation, interaction and collaboration is essential for learning 21st century skills. However, technology alone is not sufficient, and entirely new classroom designs and teaching practices need to be introduced in order to effectively teach 21st century skills (Saavedra & Opfer, 2013).

In South Africa, Dzansi and Amedzo (2014) note that there have been numer-

ous government and public/private sector initiatives to increase access and use of Information and Communications Technologies (ICTs) in education, but these have largely been based in urban centres where the required infrastructure and supports for ICTs are already in place. When turning one's attention to rural and poor schools in South Africa, however, the situation is less optimistic. This has led to a digital divide between urban and rural areas, something that is not only prevalent in the South African context, but the entire African continent (Fuchs & Horak, 2008). Despite the uptake of smartphones and other mobile devices, access to the internet and ICTs remains too expensive for many South Africans, especially those living in poor and rural conditions (Dalvit, Kromberg, & Miya, 2014). This digital divide has affected how many schools are run in rural contexts, with many still heavily dependant on the dominant model of education, where the teacher leads the class and the learners acquire as much information as they can from the teacher. Research has shown that this kind of learning environment is not conducive to 21st century skills development (Kumpulainen, Mikkola, & Jaatinen, 2013). Many rural areas are affected by multiple issues (see Section 2.3) that make learning challenging, and teaching difficult. As a result, many rural schools under-perform in key subjects such as Mathematics, Home and First additional languages. (Department of Basic Education, 2014).

In response to this challenge, some institutions have started to introduce ICTs in rural and poor contexts in South Africa. However, many have tended to focus on the technology alone as the main driver for enhanced and 21st century learning. Many of the schools that have received ICT donations have struggled with integrating them into their pedagogical practices (Dlodlo, 2010; Dzansi & Amedzo, 2014; Hlalele, 2014b; Mathevula & Uwizeyimana, 2014). These issues have an impact on learning, including the learning of 21st century skills, and they will need to be solved if the gap between rural and affluent schools in South Africa is to be narrowed (Dzansi & Amedzo, 2014; Fuchs & Horak, 2008). The challenge then for rural education research in South Africa is how to equip learners with 21st century skills, given the contextual challenges that they face.

One approach to learning that is contextual, relevant and promotes 21st century skills development is described by Ito et al. (2013) in their work on *connected learning* theory. Connected learning is about integrating the spheres of personal interest, peer relationships and academic orientation through the use of digital and open media networks in order to enable learners to achieve academic, civic and career success. The theory has seen widespread adoption in the global North, with almost no application in the South, particularly in rural contexts. A driver for this study was to gain a deeper understanding of connected learning theory and to test its applicability in a rural schooling context. The goal was to investigate, through the use of a small intervention, whether or not connected learning supports 21st century skills development in learners in rural schools, especially given the contextual challenges that they face.

In order to achieve the goal stated above, this study employed the use of an intervention, a connected learning Mathematics club, wherein learners participated as part of an after school programme. Mathematics was chosen as a subject because it is critical for learners to master it in order to get into careers such as Engineering, Computer Science and Information Technology. The intervention provided a platform on which the causal links between connected learning and 21st century skills development could be explored, especially within a rural context. Data was collected using a combination of observation, interviews of both the learners and the class teacher, as well as the data acquired from the Facebook social media platform, where learners collaborated and answered questions online.

The findings of the research show positive causal links between the intervention that was introduced and 21st century skills, despite the contextual challenges with which learners were often faced. The findings further gave insight into how connected learning actually leads to 21st century skills development, something implied, but hardly ever articulated in the literature. Connected learning leads to an increase in the number of opportunities that learners have to learn and practise 21st century skills, and an increase in learner engagement, which further intensifies and deepens

the skills. Practical implications of the research are also considered for the sake of practitioners that may seek to introduce connected learning environments in rural schools.

The rest of this dissertation is structured in the following way: Part I discusses the context for this study; Part II discusses the literature and the theoretical and design frameworks; Part III discusses the research strategy, methodology and design employed in this study, which leads to a detailed discussion of the results and findings in Part IV; Part V discusses a possible business model implementation of some of the findings of the research. This adds an extra dimension to the research, and gives it a directed and practical application. In the upcoming section, the reader is given context about 'rurality' as well as the generalised features of rural schools in South Africa, both of which are important to understand before delving into the details of the study.

2 Rurality and the rural school context in South Africa

2.1 Understanding rurality

The concept of 'rurality' in South Africa can be difficult to define as it means different things to different people (Myende, 2015). Some researchers define 'rurality' in terms of location or place (e.g. proximity to a city), while others define it from a demographic perspective by looking at variables such as household income, population size, population growth rate, and distance to travel to access good healthcare or education (Ebersöhn & Ferreira, 2012). The Nelson Mandela Foundation (2005) notes that the distinction between what constitutes a rural and an urban area in South Africa is difficult to make. It often depends on who is making the distinction and for what purpose. It further states that the movement of people between rural and urban centres makes it all the more difficult to pin down a precise definition for 'rurality'. This acknowledgement alludes to another view of 'rurality' as a mindset of living that people intentionally abide by. This is the view that prominent rural education researchers like Hlalele (2014b, 2012) take. This has led to a reconsideration of 'rurality' from a deficiency-based paradigm to a strength-based (sometimes referred to as a resource or asset-based) paradigm (Moletsane, 2012). Clearly, regardless of the view that one adopts, 'rurality' is complex and needs to be looked at from various perspectives in order to understand it properly. For this reason, this research adopts a dynamic definition of 'rurality'.

One such conceptualisation of 'rurality' is given by Balfour, Mitchell, and Moletsane (2008) in their work on the *generative theory of rurality*. The theory provides a framework for conceptualising 'rurality' dynamically, especially useful due to the multifaceted nature of the lived experiences and core identities of those who identify with being rural. Balfour et al. (2008) list two reasons why the generative theory of 'rurality' could be useful. Firstly, the generative theory could be useful in allowing

researchers to be able to interpret and understand the results of their work in rural contexts. Secondly, it can enable people in rural contexts to act as both subjects and transformative agents of change in their environment. The former reason is particularly important for this research because it shows that learners, teachers, families, community members and other stakeholders have to play a role in improving rural education.

Balfour et al. (2008) identify three aspects of 'rurality' based on their generative theory: forces, agencies and resources. They describe the forces as being both "centripetal and centrifugal" and involving "the movement of labour and production from the rural to the urban and back again". They use the concepts of space, place and time to further define the forces. Space is defined as not only a habitat, but also the physical 'space' within which one moves. Place is defined based on the work of Budge (2005), cited in (Balfour et al., 2008), with the following components that contribute to an individual's "sense of place": "connectedness, development of identity culture, interdependence with the land, spirituality, ideology and politics, and activism and engagement". Lastly, time is considered an important component of the forces as it takes 'time' to travel from one place to another (e.g. to access a healthcare facility due to isolation in rural communities or the sparse distribution of resources). Balfour et al. (2008) explain this well when they write *"...space not only is an enculturated and organizational concept in any discussion of rurality but also the one feature that changes or elongates time. This elongation of time in turn affects identities, since these are mostly constituted in relation to communities that exist in relative isolation in space and time from each other, and in greater isolation from urban centres".*

The second aspect that Balfour et al. (2008) identify through their generative theory of rurality is agency. This concept is helpful as it paints a picture of the 'agents' that are active in the community. These are either agents that actively participate in changing the community, or passive agents that allow change to occur through compliance. Balfour et al. (2008) identify examples of possible "agencies" in

the community - such as the religious authorities, tribal authorities, state, families and individuals. Clearly, an understanding of the power structures and systems in rural communities is critical for research conducted in that context.

The third aspect identified in the generative theory of rurality is resources. According to Balfour et al. (2008), these resources have multiple shared meanings that need to be understood. The resources could be material or emotional and conceptual or physical. Conceptualising 'rurality' through the lens of resources is useful as it helps the researcher appreciate what resources the community already has (a strength or asset-based paradigm) as opposed to only seeing 'rurality' as a place of want and need (a deficiency-based paradigm). It is especially useful when linked with the concepts of forces and agencies that were already discussed. Balfour et al. (2008) illustrate this in their work by giving an example of deploying a new resource in a rural context. If a new resource is purchased, one has to consider the agents or stakeholders of the resource in the community. The resource will also interact with the forces of space, place and time in that community. The resources will now be located in that particular area (place), altering the space or habitat in which people live and move. If that resource was not present in the community before (e.g. a new healthcare facility), it will significantly alter the time that it takes to access such a resource compared to before.

The main thrust of the work of Balfour et al. (2008) is that although it is easy to view 'rurality' as a 'static-passive' context, they argue that *"rurality is an actively constituted constellation of forces, agencies, and resources that are evident in lived experience and social processes in which teachers and community workers are changed"*. It is of particular relevance to this research that they applied their theory to a rural education context, concluding quite strongly that education needs to be seen as a "placed resource" - just because it works in one context does not necessarily mean that it will work in another; it may, in fact, become dysfunctional in a different context. This speaks volumes against the myriads of literature and failed rural projects that have viewed the solution to rural education as simply replicating urban

school structures and curricula in those contexts, whilst ignoring the very real and dynanimc forces, agencies and resources that exist in that context (Hlalele, 2014b; Moletsane, 2012; Balfour et al., 2008).

2.2 The rural schooling context

The general state of rural education in South Africa has been well researched and articulated in the literature (Hlalele, 2014b, 2012; Gardiner, 2008; Nelson Mandela Foundation, 2005; Ministerial Committee on Rural Education (MCRE), 2005). The consensus in the literature is that rural education is not at a level that is acceptable, especially when one looks at learner pass rates. To illustrate using one performance metric, recent data by the Department of Basic Education (2014) shows that quintile 5 schools (i.e. affluent schools in urban areas) significantly outperform quintile 1 schools (i.e. the poorest schools mostly located in peri-urban and rural areas) in Grade 9 Mathematics, Home and First Additional Languages. According to their data, affluent school students achieved an average percentage mark in Mathematics of more than double that of their peers in the poorest schools for the 2014 South African school year.

Rural education in South Africa is historically linked to the legacy of apartheid and the segregated education system that was implemented at that time (Hlalele, 2012; Gardiner, 2008). Separate schools were created for the different racial groups, with national expenditure on education tremendously biased towards white schools. The non-white racial groups received a lot less, with black schools in general getting the least. The quality of education was also significantly better in the white schools, especially when contrasted to black schools, due to increased budgets, better teacher training, relevant curricula and decent schooling facilities (Timæus, Simelane, & Letsoalo, 2013). After the collapse of the apartheid regime in 1994, the government moved swiftly to remove the segregated education system and established a united education system across the country. This meant that all pupils in public schools, regardless of whether they were in urban or rural areas, affluent or poor areas, would

theoretically receive the same education (Timæus et al., 2013; Gardiner, 2008). Despite this perceived ideal, this has largely not happened. Education in rural and poor areas in South Africa has continued to suffer, and performance evidently remains poor relative to urban and affluent schools (Maringe, Masinire, & Nkambule, 2015). Prominent education researchers are calling the situation a human rights and social justice issue, recognising that government's failure to provide one of the fundamental human rights (the right to education) to a large population of South Africa as defined in the country's Constitution is a big challenge for both public and private parties interested in resolving the situation (Hlalele, 2012; Gardiner, 2008; Spreen & Vally, 2006).

2.3 Generalised issues in rural schools

This section moves on to discuss what the literature says about the rural education context in South Africa. Given that 'rurality' is a dynamic concept, it is important to understand that much of the literature makes generalisations on the features of rural education in South Africa. Each rural school will have its own unique set of features that differentiate it from other rural schools. Furthermore, a lot of the generalisations about the issues in rural schools are themselves reported from a deficiency paradigm. This likely explains why so many have attempted to solve rural education challenges following deficiency paradigm based solutions. Having said this, a discussion about the generalised features is still useful to paint a picture of some of the challenges and opportunities that one might encounter in that context. The features will not all be present at every school to the same extent.

1. *Poverty.* Statistics South Africa (StatsSA for short) published a study where they looked at the trends of poverty in South Africa during the period 2006 to 2011 (Statistics South Africa, 2014). StatsSA define poverty from an objective perspective, based on the level of income and consumption. South Africa uses three national poverty lines, namely the food poverty line (FPL), the

lower-bound poverty line (LBPL) and the upper-bound poverty line (UBPL) (Statistics South Africa, 2014, p. 7). The FPL is the level of consumption where people are unable to purchase enough food for an adequate diet. The LBPL is the level of consumption where people can afford non-food items, but they need to sacrifice food-items in order to get them. The UBPL, which is usually the one StatsSA quotes when reporting on poverty levels, is a level of consumption where people can afford some food and non-food items, but at a level which is still regarded as "in poverty". In 2011, the inflation adjusted UBPL was pegged at R620 per capita per month.

StatsSA found that level of poverty in rural areas was at *68.8%*, more than double the level of poverty in urban areas at *30.9%*. They also found that the majority of poor people (*58.6%*) lived in rural areas (Statistics South Africa, 2014, p. 33). This statistic shows that rurality and poverty usually intersect in the South African context. This intersection obviously has an impact on education. In the same study, Statistics South Africa (2014) found a strong relationship between poverty and education level. In general, the higher the level of education that people had attained, the less likely that they were to be cosndeired poor. This link is crucial to understand, especially when one considers that some of the factors that determine student achievement at school are their socio-economic status and the level of education of their parents (Timæus et al., 2013; Christie, Butler, & Potterton, 2007).

2. *Educational Tools and Facilities.* Many rural schools have little or no access to ICTs for education and school management purposes (Hlalele, 2014b; Dlodlo, 2010). Even in cases where marginalised and rural schools have received access to ICTs through donor agencies, this has not resolved all the issues as the same schools now struggle with integrating the ICTs into their pedagogical practices (Dzansi & Amedzo, 2014; Chingona, Chingona, Kayongo, & Kausa, 2010; Mathevula & Uwizeyimana, 2014). Given that ICTs that are integrated

into pedagogical practices are essential for 21st century learning, many students are not privileged to receive that kind of education in South Africa. Special educational facilities (e.g. labs, computer rooms, etc.) are either lacking or dysfunctional in some rural schools (Maringe et al., 2015). Some have inadequate buildings to accommodate all their learners, and yet others struggle with basic services like electricity and running water (Hlalele, 2014b).

3. *Teacher related issues.* Hlalele (2014b) notes the challenges that rural schools face with regards to teacher qualification, training, motivation and morale. Good teachers may be unwilling to move to rural areas due to the challenges of commuting, living or teaching in that community. Good teachers may be unwilling to stay a long time at the school due to the prevailing circumstances and want of better conditions. Masinire (2015) notes the limited success that the Department of Basic Education (DBE) has had in training and recruiting teachers for rural contexts. According to Maringe et al. (2015), learners in rural and poor schools are the ones who suffer the most (academically) due to teacher related issues.

4. *Learner-teacher ratios.* Some rural schools have unreasonably high learner-teacher ratios, where one teacher has to teach a large number of learners at a time. This could be because there aren't enough teachers to teach a particular subject (e.g. Mathematics), or that there aren't enough classrooms, which means learners have to be combined into fewer classes. In either case, the teacher cannot provide sufficient attention to each child to ensure that they have grasped the lessons (Maringe et al., 2015; Hlalele, 2014b). Other rural schools, particularly farm schools, experience relatively few learner numbers, as well as struggling to attract experienced and qualified teachers (Hlalele, 2012). In those cases, unreasonable learner-teacher ratios may still exist, especially if classes are combined in order to maximise the available teaching resources.

5. *Service Delivery.* Poor service delivery is an issue that many rural schools, as

well as the communitues that they are located in, experience. Writing about schools in rural Kwazulu-Natal, Limpopo and Mpumalanga, the Nelson Mandela Foundation (2005) states that learners in many rural areas have to walk long distances every day in order to reach school. Sometimes basic road structures like bridges and road drainage systems are missing, making it difficult for the learners to access the schools. There are many other service delivery related issues tied to government's (relative) failure to provide basic services in rural communities in South Africa (Mtshali, 2008).

6. *Curriculum relevance.* Hlalele (2014b) also identifies the relevance of school curricula to rural schools in South Africa as an issue that negatively impacts learners in this context. Education policy setting is made at a provincial and national level in South Africa, and this makes it difficult to develop customised curricula for rural communities (Gardiner, 2008). Although there may be certain key elements that make a community rural, this does not mean that they are all the same (Hlalele, 2014b). Learners at rural schools thus have to learn curricula that may not necessarily be relevant or applicable to their immediate context. Maringe et al. (2015) state in their paper that the 'broad-brush' policy approach fails to recognise the unique challenges that rural and poor communities experience. Lack of relevance of the curricula could well be a prominent issue, as Hlalele (2014b) states that learners in rurual schools are faced with the *"competing priorities between accessing education and domestic chores"*. This is supported by Boix, Champollion, and Psicologia (2015), who argue that *"compared with urban students, rural students seem to experience greater conflict between educational goals and their family connections, a condition associated with lower educational aspirations and delay of post-secondary education"*.

The issues and challenges discussed above paint a grim picture of rural education in South Africa. One would imagine that it would take very gifted students to achieve

in those circumstances, but research has shown that even they may not realise their potential in rural schools (Howley, Rhodes, & Beall, 2009). These issues affect the quality of education in rural contexts, and they will need to be considered in order to introduce interventions that will be sustainable over a long period.

Part II

Literature and theoretical framework

3 An ecological and networked approach to rural education

3.1 Introduction

This section contains a detailed discussion of the literature relevant to the research topic. Three intersecting topics in the literature will be discussed in relation to the problem area in order to critically uncover insights that are relevant for this study (Huff, 1999). The first is a discussion on (rural) learning ecologies, which describes an ecology and networked approach to rural education, and lays the groundwork for locating connected learning naturally within a rural context (Sections 3.3 & 3.2). The second is a discussion about 21st century skills, including their definitions, why they are needed, learning environments that are conducive to them and how they are assessed. Criticisms of 21st learning environments are briefly looked at, and these are discussed in the light of a rural context (Section 4). Finally, Section 5, discusses connected learning as a theoretical and design framework for this study, which unifies the literature discussion and gives direction for the rest of this dissertation.

Sections 2.1 and 2.2 gave a broad overview of 'rurality' and rural education in South Africa. It is within this context that this research seeks to explore, experiment on and understand connected learning from a theoretical and practical perspective. Ito et al. (2013) describe connected learning as an ecology and networked approach to education. They use the ecology metaphor to signify the interrelated and connected learning contexts of peers, home and school. Interestingly, recent work has been

published on the concept of learning ecologies within a rural context (Hlalele, 2014a). The following sections will give an overview of the literature on learning ecologies, and in particular, rural learning ecologies in the South African context.

3.2 Learning ecologies

The learning ecology framework is based on perspectives and insights from sociocultural and activity theory. It was popularised by Barron (2006, 2004), whose seminal work provided a detailed description and the theoretical underpinnings of the framework. Barron (2004) defines a learning ecology as *"the accessed set of contexts, comprised of configurations of activities, material resources and relationships, found in co-located physical or virtual spaces that provide opportunities for learning."* This definition emphasises the need to understand how learning occurs across different contexts and spaces, and how this insight can potentially be used to supplement or support the traditional classroom based learning which is still the norm in many schools, particularly in rural areas. According to Barron (2006), when learning is constrained to formal settings such as classrooms, we miss the opportunity to investigate learning that originates from one context (e.g. a peer initiative) across time and various other contexts and settings. The main insight is by recognising that learning happens across different contexts, we can potentially enhance the way students learn by leveraging both formal and informal contexts in their learning ecology. Barron (2006) identifies examples of different learning contexts which include home, work, peers, distributed resources (e.g. online or books), school and community.

Barron (2006) notes that the need to investigate a framework for a type of learning that crosses contexts was based on case studies and surveys of high school students. The findings showed that students depended not only on their classroom content, but also often on people they knew, distributed resources and online resources, amongst others, to augment and enhance their classroom learning (Barron, 2006, 2004). Experienced students tapped into a wider and cross-contextual resource pool, both inside and outside of the classroom. This suggests that a critical interdependency exists be-

tween learning contexts. This is to say that the learning and support structures that a student has in one context have a critical influence on their learning, or application thereof, in different contexts. To illustrate, Barron (2006) found that over 65% of the boys, compared to only 15% of the girls, took programming as a class in the high school that he conducted his research in. Interestingly, of the girls who did take a programming class, 76% of them had a parent who was involved in the computer science field, which suggests that the context at home can have a strong influence on what they learn at school. Strong findings like these signify the interdependency between various contexts, and how these interdependencies could potentially influence learning. This is perhaps the biggest strength of the learning ecology approach; it recognises that learners exist and move between different contexts and spaces, and that the insights, perceptions and knowledge that they acquire from one context, can have a profound impact on what they learn in a different one.

A substantial amount of what a learner actually learns, takes place outside of the classroom context. As a result, the learning ecology framework is positioned to support out-of-school and interest driven learning (Barron, 2006). Some of the earliest research on out-of-school and informal learning was done by Scribner and Cole (1973), which is reported in their article titled *"Cognitive Consequences of Formal and Informal Education"*. In their work, they conclude that the problems and techniques of formal education are not the same as those in informal education settings. They make this distinction by stating that the values, norms and dominant learning situations in formal education settings all conflict with those in the learner's cultural (or informal) setting. They further argue that the disconnect between the formal and informal education systems creates a heavy burden for learners that have to transition between both, sometimes daily. They conclude by saying that a more responsive education system that moves everyday life into the school and school life into the everyday life, is essential. Besides the work of Barron (2006), later works were written with regards to out-of-school and cross-contextual learning; the works of Resnick (1987), titled *"Learning in school and out"*, J. Bransford and Schwartz

(1999), titled *"Rethinking Transfer : A Simple Proposal with Multiple Implications"*, and J. D. Bransford et al. (2006), titled *"Foundations and Opportunities for an Interdisciplinary Science of Learning"*, are some of the most notable ones. The application of the learning ecology framework within a rural context is discussed next.

3.3 Rural learning ecologies

In his paper titled *"Creating Sustainable Rural Learning Ecologies in South Africa"*, Hlalele (2014a) argues that rural education research needs to find its own voice and create a body of knowledge of its own. Hlalele (2014a) calls for the creation of "sustainable rural learning ecologies", where learning takes place "within, between and across contexts". His definition of a rural learning ecology is based on the work of Barron (2006, 2004) and his definition of a learning ecology. Hlalele has taken Barron's work and conceptualised what a learning ecology would look like in a rural context. He alludes to the ineffectiveness of using urban education models in rural contexts and calls for a more contextual approach to rural education. Boix et al. (2015) agree, as they argue that teaching and learning at rural schools is significantly different to urban contexts. Hlalele's work on rural learning ecologies acknowledges the context and conditions that rural learners find themselves in, and seeks to reinforce learning within, between and across the rural school, home and community.

Hlalele (2014a) notes that rural education is usually limited to the classroom context where teachers teach and learners learn from the teacher (the classic knowledge transmission model). Furthermore, most rural schools in South Africa teach the same subject and syllabus content as what is taught in urban schools. This is due to a policy decision to standardise all content at a national level for all South African public schools. This rigid approach to rural education creates a mismatch between the learners' immediate context and the content that they are taught. This conflict of context and content often manifests in students having to choose between

"accessing education and completing their domestic chores" (Hlalele, 2012).

Boix et al. (2015) discuss this same issue in their work *"Teaching and Learning in Rural Contexts"*. They indicate that rural learners may be confronted with conflicting messages from their school and the local community. For example, they list conflicting messages such as *"valuing urban work-place skills versus local occupational skills; valuing mobility and acquisition and status versus family, stability and local roots"*. Rural learners are often taught skills they need to survive in an urban workplace and environment, instead of skills that can be used in their own context to solve local problems. This mismatched skilling of rural learners is a contributing factor to the poor motivation of rural learners to excel at school, as well as the out-migration into urban contexts of those that do successfully complete their education. This creates a situation where a rural brain-drain occurs (Boix et al., 2015; Hlalele, 2012), which leads to a decrease in the effectiveness of the rural learning ecology (Hlalele, 2014a). It is also worthwhile to note that all the generalised features in rural education discussed in Section 2.3 have a (negative) impact on the effectiveness of rural learning ecologies in South Africa (Mapesela, Hlalele, & Alexander, 2012).

At the heart of the learning ecology approach is an understanding that learning is not something that can be easily planned . It is an often random and even messy process (Mapesela et al., 2012; Williams, 2011). The definition of a learning ecology makes it clear that learning takes place through the interactions of learners with various resources and people in physical and virtual spaces. Perhaps the most important of the interactions happens with people, as partnerships can be made to help sustain learning over time. Mapesela et al. (2012) suggest that learning cannot simply be left to individuals, involvement from the community is required. This means that learners, teachers, parents, community members and other stakeholders need to be involved in the learning process. Community engagement and partnership in education may be more crucial for rural schools, given that they lack the typical resources and assets that urban schools have. Nevertheless, a strong sense of community may exist in many rural areas, and this could be exploited to create

community engagement and partnership in education. To this end, Mapesela et al. (2012) identify relevant stakeholders and the roles that they need to play in creating sustainable rural learning ecologies. Key insights from this work and other literature are discussed next.

The *learners* have an important role to play in sustaining rural learning ecologies. Barron (2006) specifically mentions the role of peer networks in sustaining learning. Peer networks allow students to discuss their work in a group setting, reflect on feedback that others give them and in turn give feedback to others. Learners also have a vast wealth of experiences and 'learnings' from contexts that are outside of the formal school setting which can add value to the learning process within the peer network (Mapesela et al., 2012; Barron, 2006; Resnick, 1987; Scribner & Cole, 1973). Thus it is important for learners to be supportive of one another, and for teachers to create an environment where peer supported learning is recognised and encouraged.

The *family* unit plays an important role in the learning lives of children, and thus, in sustaining rural learning ecologies. It is well established in the literature that the family is responsible for teaching the child the culture(s), values and norms of their society. This 'socialisation' represents the first and most foundational form of learning for many children (Scribner & Cole, 1973). The family can play an important role in supporting the learner with resources, advice, guidance and encouragement throughout their learning lives. Furthermore, partnerships between families and schools are crucial to ensure that learners receive the best possible education.

Schools play a vital role in the learning ecology, and they are perhaps the most important component for long term sustainability. Schools are often the most important institutions in rural communities, as they represent the potential for future growth and rural economic development (Malhoit, 2005; Hlalele, 2012). Schools are central hubs where learners from different families within the community can meet and share a common life experience. It is within this interaction between peers, teachers and the content itself, where learning takes place. Recent research by Bhengu and Myende (2015) shows an example of a rural school in the Kwazulu-Natal Province of

South Africa, where learner performance improved through inspirational and visionary leadership, school-community engagement, and parent-teacher communication. Although the research was conducted at only one school, it certainly does serve as a practical example of where key insights from the learning ecology framework were used successfully.

Within the school structure itself, *teachers* play a critical role in ensuring the sustainability of learning ecologies. Teachers need to help develop and sustain a culture of learning and exploration (Mapesela et al., 2012). In the learning ecology framework, teachers need to be more flexible in their style of content delivery. They need to be able to play the role of the facilitator; sometimes even take the backseat, and allow learners to explore and discover with their peers within the learning environment, which can enhance learning (J. D. Bransford et al., 2006; J. Bransford & Schwartz, 1999). Teachers will also need to continuously invest in their own development through formal training in order to ensure the long-term sustainability of the learning ecology. According to Mapesela et al. (2012), they can also develop themselves informally through engaging with peers in "analysis, evaluation and experimentation". Other stakeholders could also include government, and public and private sector institutions, which need to carefully define their roles, and ensure that they support, and not inhibit, the creation and sustaining of the local learning ecology.

Building on the discussion of the key stakeholders that are essential in sustaining rural learning, Hlalele (2014a) further identifies aspects that are necessary to sustain the ecology over time. The most relevant to this study are discussed briefly, along with insights from other literature. The first aspect that Hlalele identifies is *mapping and maximizing inherent assets in rural learning ecologies"*. Hlalele taps into behavioural psychology theory and argues that communities that are empowered to take the initiative to solve their problems are less likely to develop an unhealthy dependence on outside help. This view is consistent with asset-based paradigms of 'rurality'. Rural education researchers have argued that using local resources and

people to solve problems may lead to better and more sustainable results (Myende, 2015; Moletsane, 2012). The asset-based paradigm is a departure from the traditional view of rurality, where it was seen as a place of want and need (a deficiency paradigm), to a strength or asset based paradigm. Fundamental to this view is that local communities are critical in identifying and solving their own problems, using the inherent assets that already exist within the community. It recognises that people need to be producers (or a least part of the production) of the solutions to their problems, and not simply consumers of solutions given to them by people from outside their community (Myende, 2015). The asset-based paradigm is critical for creating sustainable rural learning ecologies because it emphasises the strengths of the ecology itself (Hlalele, 2014a), and uses them to build and sustain it over time.

Creating and sustaining learner support networks is also identified as an important aspect. In addition to building community support and partnership, more specific social supports for learners need to be established. This involves building support systems that connect learners with one another, family members, community members, industry players, employers and others. The advantage is that this can connect learners to employment, funding, mentorship and further education opportunities. Barron (2006) notes that learning takes place across many contexts through interaction with various parties, and that technology plays a significant role in enabling this engagement.

The emergence of new open media networks provides opportunities to connect learners in ways that were not previously possible. To illustrate, technology platforms could be used to connect rural learners with those who have migrated out of the rural context into urban spaces to find employment as engineers or accountants, amongst other professions. This could, for example, provide an opportunity for mentorship. Hlalele (2014a) identifies many other aspects, and only the most relevant for this study were discussed. What is clear from the discussion is that rural learning ecologies require involvement from all community members, coupled with effective views of local assets, which can be connected to form a sustainable learning ecology.

3.4 Conclusion

The learning ecology framework is largely about exploiting the opportunities for learning that exist between contexts. By recognising that learning is not only restricted to the classroom, and that it takes place in different contexts that can have a profound impact on the learning that occurs at school, learners can experience enhanced and often contextual learning that moves with them in the various spaces and locations in their lives. Barron (2006) recognises the role that technology can play in achieving this, especially with regards to connecting the learner with various resources, people and other agencies that can increase the information pool that can be accessed for learning. Of relevance to this study, is the application of the learning ecology framework by Hlalele (2014a, 2013) within a rural context. For effective rural learning ecologies to thrive, learners, teachers, family, schools and the community need to work together as a collective to enhance learning. Rural assets can also be used, in conjunction with the aforementioned stakeholders, to further enhance the learning ecology and make it sustainable.

The learning ecology framework is deeply rooted in learning theories such as socio-culturist and situative learning, and it could well lead to a re-conceptualisation of what rural education and learning should look like. Critically, approaching learning from an ecological perspective provides a framework for deploying educational interventions that support, instead of hindering or inhibiting, the sustainability of (rural) learning ecologies. Technology supported rural learning ecologies could also provide a lens through which to introduce an intervention that is conducive to 21st century skills development. This, along with the theoretical and design framework discussed in Section 5, will provide the parameters and variables that need to be considered when deploying the intervention. Section 4 moves the discussion from rural learning ecologies to a 21st century skills literature review. Whilst much of the discussion is generic, and applies to various contexts, key insights that are applicable to the rural context are discussed where relevant.

4 Twenty-first century skills

4.1 What are 21st century skills?

There has been a fair amount of debate regarding the definition of 21st century skills. Everyone agrees that they are skills required for the 21st century, but this has also led to people and organisations classifying any skill that they feel belongs in the 21st century as a 21st century skill. Part of the issue is that 21st century skills are a collection of individual skills, meaning there is no single definitive 21st century skill. As a result, many definitions of 21st century skills have tended to define the individual skills in the collection, as opposed to trying to define the umbrella term. In order to have a consistent and clear use of the term, alignment around its meaning is required. As Dede (2009) notes, many educational reforms have failed because of what he calls the "reverse Tower of Babel effect", where many people use a common term, but actually mean very different things.

So what are 21st century skills, and are they new skills that learners need to suddenly know and master? Rotherham and Willingham (2010) provide helpful insight to this question by stating that 21st century skills are nothing new, but they do need to be taught with far greater emphasis than before. They note that many of the common 21st century skills, such as critical thinking and problem solving, have existed in human progress for a long time, and no doubt were important skills for past centuries. What seems to be at the heart of this new emphasis on these skills is the changing economic and labour markets, which demand far more cognitive skills than was traditionally required in the 20th century.

Over the years there have been various attempts at defining frameworks for 21st century skills. The rationale was that they would serve as a helpful reference for people and organisations wanting to either define 21st century skills, introduce learning environments that support them, or to serve as a basis for assessing them, amongst other reasons. The KSAVE model, for example, defines ten separate 21st century skills and classifies each under one of four categories (Marilyn et al., 2012): "Ways of

thinking" representing higher order skills such as creativity and innovation; "Ways of working" representing the skills needed for working in a 21st century work environment; "Tools for working" which include ICT and information literacy skills; "Living in the world" encapsulating skills needed for personal and career success in an ever changing world.

Another example of a framework is by the OECD, which takes a slightly different approach to the KSAVE model. The OECD defines two skills and competencies for the 21st century known as the information and communication dimensions. Each of the dimensions are further subdivided into sub-dimensions. The information dimension consists of ICT and information literacy skills. The communication dimension consists of effective communication, collaboration, virtual interaction, social responsibility and social impact skills (Ananiadou & Claro, 2009). There are other frameworks that exist, and Dede (2009) provides a helpful comparison of the main ones. The main point is, defined frameworks exist that can be used as references for 21st century skills, and they bring a level of standardisation to the definitions of 21st century skills.

The framework that seems to have received the most support and widespread adoption is the Partnership for 21st century learning (P21 for short) (Partnership for 21st century learning, 2015; Ledward & Hirata, 2011). P21 was founded in 2002, and their mission is to "build collaborations with indviduals, institutions and goverments to enable every learner to acquire the skills they need to thrive in an ever changing world" (P21.org, 2016). The framework is a collection of skills, knowledge and expertise that learners ought to master in order to succeed in life. There are two main components to the framework, from a learner perspective. The first is key subjects and 21st century themes which include Mathematics, Economics, Science, Geography, History, Languages, and Governments and Civics. The key themes are global awareness, financial, economic, business and entrepreneurial literacy, civic literacy, health literacy and environmental literacy. These themes are not necessarily skills, but they are cross-disciplinary knowledge, awareness and perspective that a learner

should attain through effective 21st century learning. The second component of the framework is learning and innovation skills, which is akin to 21st century skills definitions by KSAVE and the OECD. These skills include creativity and innovation, critical thinking and problem solving, communication and collaboration, information literacy, media literacy, ICT literacy, flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, and leadership and responsibility.

The P21 framework is particularly helpful because it goes as far as defining each 21st century skill from the perspective of the key subjects, including Mathematics (P21.org, 2012), which will be particularly helpful for this research. A summary of 21st century skills definitions based on the P21 framework, with useful additions from other relevant sources, are presented next:

1. *Creativity and innovation* is about finding new and alternative ways to solving problems, comparing them to traditional and other learners' approaches. Learners also need to have the ability to communicate these new found ways to others (Partnership for 21st century learning, 2015; P21.org, 2012; Marilyn et al., 2012).

2. *Critical thinking and problem solving* is primarily about making complex decisions and being able to defend one's point of view. Learners ought to be able to "identify and ask significant questions", critically analyse and reflect on their work and that of others as well as analyse and synthesise problems, or parts thereof, based on evidence (Partnership for 21st century learning, 2015; P21.org, 2012). This ability has often been called systems thinking (Marilyn et al., 2012).

   The researcher further groups skills one and two under the banner **ways of thinking**, to make it easy to refer to them later on (Marilyn et al., 2012).

3. *Communication and collaboration* skills require learners to be able to articulate mathematical concepts, critically listen to the reasoning of others and be

able to work in teams. It is also about being able to communicate effectively through digital and media platforms (Partnership for 21st century learning, 2015; P21.org, 2012; Ananiadou & Claro, 2009).

Communication and collaboration skills are also known as **ways of working**, which will make it easier to refer to them later (Marilyn et al., 2012).

4. *Information literacy* is about identifying sources of data, accessing them, evaluating them and using them to answer questions. It includes the ability to use reliable web sources, media environments and physical sources to answer questions at hand and being able to share the information with peers (Partnership for 21st century learning, 2015; P21.org, 2012; Marilyn et al., 2012).

5. *ICT literacy* is about using technology effectively to research, organise, evaluate and communicate information through the use of digital technologies like smartphones and laptops (Marilyn et al., 2012).

   Media literacy is about understanding media messages, how they are used and how the could be interpreted. This also includes an understanding of the ethical and legal issues with the use of media (Partnership for 21st century learning, 2015; P21.org, 2012; Marilyn et al., 2012; Partnership for 21st century skills, 2009)

   The researcher combines ICT and media literacy into one because they are closely related, and the use of the one is often accompanied by the use of the other, such as when using a tablet to access information on popular media platforms.

   The researcher further groups skills four and five under the banner **tools for working** to make it easy to refer to them later on (Marilyn et al., 2012).

6. *Flexibility and adaptability* is about the learner's ability to work in pairs and small groups to tackle problems and to be able to work with ambiguity and uncertainty (Partnership for 21st century learning, 2015; P21.org, 2012).

7. *Initiative and self-direction* is about the learner's ability to prioritise and complete their tasks on time whilst keeping in mind past experiences in solving problems to guide future decision making (Partnership for 21st century learning, 2015; P21.org, 2012).

8. Social and cross-cultural skills, also referred to as citizenship and social responsibility, are about being able to interact with others and work respectfully in diverse teams (Partnership for 21st century learning, 2015; P21.org, 2012). Marilyn et al. (2012) further add that social responsibility skills are about participating in community activities, showing solidarity with the issues in the community and how they can be solved. This is linked with career opportunities, either within the wider country or in the community itself.

9. *Productivity and accountability* is about setting goals and targets, prioritising them and meeting deadlines (Partnership for 21st century learning, 2015; P21.org, 2012).

10. *Leadership and responsibility* is the ability to leverage the "strengths of peers to solve mathematical problems in the community" (Partnership for 21st century learning, 2015; P21.org, 2012).

    The researcher further groups skills six through ten under the banner **life and career skills**, to make it easy to refer to them later on (Partnership for 21st century learning, 2015).

The researcher adopts the list and definitions discussed above for this study. The definitions will serve as useful references for observation and analysis of 21st century skills.

4.2 Why are they needed?

Having defined 21st century skills, the next step is to discuss common reasons regarding their need in modern education. A scan of the literature reveals at least three

reasons why learners ought to be equipped with 21st century skills, viz. economic systems where the main asset is knowledge (Dede, 2010; Ananiadou & Claro, 2009; Dede, 2007), employability (De Fruyt, Wille, & John, 2015; Saavedra & Opfer, 2012; Dede, 2010) and globalisation (Saavedra & Opfer, 2012; Dede, 2010). Technology has played a big role in the way economies have developed, with computers and machines able to replace human beings at basic and routine work, often doing it better. In a world where routine and non-cognitive tasks are continually replaced by machines, the main asset of trade in the labour market has shifted to knowledge and complex higher order thinking skills (Dede, 2010). Education systems need to be updated to reflect this changing dynamic, more specifically, curricula need to be modified to include 21st century skills as a new learning outcome.

For much of the same reasons given above, employability in the 21st century has drastically changed (De Fruyt et al., 2015). For a young person to have a successful and fulfilling career, they most certainly need to be competent in many 21st century skills. The rapid change of objectives, tasks and priorities in modern workplaces means that skills such as flexibility and adaptability are now as crucial to successful employment as having the right qualification for the job. Globalisation, too, has played a big role in the increasing requirements for 21st century skills in civic and career engagement (Saavedra & Opfer, 2012). For starters, economies are more connected now than they have ever been before, with trade of goods and labour constantly occurring. This has resulted in a far bigger cultural and ethnic mix in workplaces than ever before. Employees are now required to engage with people with diverse cultures, in person or virtually through the use of ICTs. This has meant that social and cultural awareness skills have become relatively more important, compared to the 20st century (Saavedra & Opfer, 2012).

The reasons given above are likely the minimum, and more could certainly be identified. The crux of the need for 21st century skills, however, is premised on the fact that the set of skills that was required in the 20th century, where production was the main driver of economic development, are becoming less critical as the world

moves to the trade of information, knowledge and technological innovations.

In South Africa, researchers and institutions have started to realise the need for 21st century skills, and although most of the focus has traditionally been on urban contexts (Dzansi & Amedzo, 2014), initiatives like ICT4RED (Botha & Herselman, 2013), which developed an intervention to support teachers' development of 21st century skills in a deeply rural Eastern Cape context, have produced promising results. However, more needs to be done, especially at a provincial or national level to effect real transformation, particularly in poor and marginalised schools. At the time of the writing of this dissertation, the Department of Basic Education in South Africa did not have a formally adopted framework for 21st century skills development, thus more work, even at the policy level, still needs to be done.

4.3 21st century learning environments

"Twenty-first-century learning requirements, such as critical thinking and problem solving, collaboration and communication, creativity, and new literacy and media skills are challenging or even impossible to promote in an educational environment that is restricted in specific space and time and is purely teacher-led and controlled" (Kumpulainen et al., 2013).

The general consensus in the literature is that the dominant, teacher-led model of education is not well suited for 21st century learning (Bates, 2015; Kumpulainen & Sefton-Green, 2014; Kumpulainen et al., 2013; OECD, 2006). Many agree that 21st century learning needs to take place in both formal and informal settings that encourage interaction and a sense of community (Ito et al., 2013; OECD, 2006). The presssure to move away from traditional teaching approaches have implications for pedagogy (Saavedra & Opfer, 2013; Beetham & Sharpe, 2007), curriculum design (Voogt & Roblin, 2012; Rotherham & Willingham, 2010) and outcomes assessments. (Marilyn et al., 2012; Tucker & Silva, 2009; Partnership for 21st century skills, 2007). In terms of pedagogy, Beetham and Sharpe (2007) suggest the adoption of a design for learning approach, where teachers structure a plan for any given learning situation

based on the desired outcomes. Depending on the intention, either the learning materials, learning environment, educational tools or activities could be the focus of the design. Others such as Saavedra and Opfer (2013), developed principles for teaching in 21st century learning environments. Some of the key principles include making the curriculum relevant to the learners' lives, teaching them how to learn (meta-learning and meta-cognition), treating teamwork as an outcome in itself, and leverage technological supports for learning.

A common requirement for a 21st century learning environment in the literature is the use of technology to support learning. Technology enables learners to create, collaborate and reflect on their own work, as well as that of their peers. This technology supported creation, interaction and collaboration is seen as essential for learning 21st century skills (Saavedra & Opfer, 2013). Despite this, technological supports for education are quite varied, and many depend on the overall intention of the classroom design. Dede (2010), for instance, describes immersive simulation environments based on multi-user virtual environments used in an educational context, as possible technological supports for acquiring 21st century skills. For others, the use of a tablet as a tool for teaching and production is also a means for changing the classroom to reflect 21st century learning (Botha & Herselman, 2013). In the end, it seems the specific type of technology used will depend on the environment and specific objectives that are pursued. As Voogt, Erstad, Dede, and Mishra (2013) argue, it is not about building competencies around being able to operate specific hardware and software, but rather about technology's ability to create new conditions for learning and the facilitation of the building of knowledge.

Despite the open for interpretation nature of the specifics of learning environment designs for the 21st century, there have been a couple of attempts at defining, implementing and testing them in practice. The most prominent of these are Personal Learning Environments (PLEs) (Dabbagh & Kitsantas, 2011; Attwell, 2007; Wilson, Johnson, & Sharples, 2007) and Connected Learning Environments (Ito et al., 2013). PLEs are a way of designing learning environments centred around the learner in an

attempt to blend formal and informal pathways to learning using e-Learning systems. The key to PLE designs is the use of 'social software', social media and various software packages (Attwell, 2007; Dabbagh & Kitsantas, 2011), which allow learners to be able to connect, collaborate and access information over computer networks. The teacher then takes a facilitator's role in the learning process, and simply guides learners in their individual learning experiences.

PLEs have traditionally been used for e-Learning and virtual learning environments/classrooms, which might limit their applicability in certain contexts, such as the rural. However, interesting research by García-Peñalvo and Conde (2015) shows promising results of the use of a blend of a mobile PLE and a classroom setting. They designed a framework, which was partially implemented through an Android mobile application, and incorporated it in a classroom context. This allowed for a mobile PLE experience, especially when the learners were away from school. Their results show that learners prefer this style of learning, and in many cases it increased their motivation to learn and perform better. The biggest strength of PLEs, however, is also its biggest weakness. It depends heavily on technology, including software applications, which may limit its applicability in poor and marginalised contexts.

Connected learning environments are based on much the same rationale of blending diverse pathways for learning in both formal and informal contexts. Unlike PLEs, connected learning environments do not necessarily depend on technological supports for learning. Instead, connected technologies and new media platforms are seen as one of the sites for learning amongst others such as home, school, neighbourhoods and learning institutions (Ito et al., 2013). This implies that connected learning designs could be implemented in technology constrained environments, such as in a rural school. Connected learning is not only a theoretical framework for conceptualising and researching learning that spans multiple sites (Kumpulainen & Sefton-Green, 2014), but also a framework for the design of a 21st century learning environment. To this end, Ito et al. (2013), the main proponents of connected learning theory and design, have put together six connected learning design principles, with detailed

examples of each. Although the principles are a work in progress, they do provide a framework for researchers, institutions and schools that want to introduce connected learning to their contexts. It is for this reason, and others discussed in Section 5, that it is chosen as a theoretical and design framework for this research.

As can be expected, the push to adopt 21st century learning environments is not without its criticisms. The most obvious one is that 21st century learning environments are significantly dependent on technological supports for learning, although theories like connected learning claim otherwise. The Forum for Youth Investment (2009), for instance, point out that learners in poor contexts may end up with an education with lower standards due to not being able to afford all the technological supports. Even in South Africa, this issue has proved to be true in many schools where initiatives to introduce and integrate technological supports have failed, and often left the schools with more problems than they began with (Dlodlo, 2010; Dzansi & Amedzo, 2014; Hlalele, 2014b; Mathevula & Uwizeyimana, 2014). Other schools have not been so lucky, as they still struggle with lack of access to basic ICTs and technological supports. Add to it the teacher training that is required to operate the technologies, and the problem becomes even more apparent (Dzansi & Amedzo, 2014; Hlalele, 2014b). Other issues include the increased time commitments from teachers on a practical and pedagogical level, the difficulties of adapting the curriculum to include 21st century skills as a fundamental outcome and the potential sacrificing of other curriculum objectives in pursuit of 21st century learning outcomes (Ryan, 2014; Reinders, 2012; The Forum for Youth Investment, 2009).

4.4 21st century skills assessments

The final aspect to be discussed briefly is the assessment of 21st century skills. According to Pellegrino, Chudowsky, and Glaser (2001), cited in Marilyn et al. (2012), effective assessments are built on knowing models of learning, creating situations to observe the learning, and methods of interpretation to draw conclusions from the evidence collected. This can be achieved through formative and summative assess-

ments of 21st century skills (Partnership for 21st century skills, 2007). Formative assessments, which are usually done during the course of an instructional unit and usually between the teacher and the learner, remind the learners about learning goals, give learners critical feedback, and allow learners to make adjustments based as they progress. Summative assessments, on the other hand, are done at the end of an instructional unit in order to certify a learner's achievements and potentially allocate grades to them. Summative assessments can be done at a school, district and even national level, in order to assess learners' performance on 21st century learning outcomes (Saavedra & Opfer, 2012). Both formative and summative assessments are usually performed together, because the one can provide useful insight that can enable better extraction of insights from the other (Partnership for 21st century skills, 2007).

21st century skills assessments, however, are still in their infancy and many challenges still remain. To quote Greiff and Kyllonen (2016), *"when it comes to actually measuring these skills, many questions on how tasks that sufficiently reflect the theoretical frameworks, on how these skills can be meaningfully and effectively assessed, on how performance can be scaled and scored, and on what the implications and the utility of these assessments are, still remain largely unanswered"*. Formative assessments are largely qualitative in nature, and are used to reinforce learning to the learner. This puts the teacher or observer as the main point of risk or failure. If they are not well trained, the results of the tests could be ineffective and undesirable. Summative assessments tend to be expensive, and require lots of time and effort to administer. Results also need to be standardised in order to serve as useful metrics, but this task is often far tougher than it seems (Saavedra & Opfer, 2012). How do you create standardised metrics for highly complex, sophisticated and cognitive skills, applicable to every learner? Admittedly, organisations like P21 have created guidelines for performing formative and summative 21st century skills assessments, but they still require a great deal of implementation and trial and error in order to get them right.

A final word on assessments, regarding costs. Setting up 21st century assessment capacity for a school or group of schools can be expensive, and schools or districts with smaller budgets may not be able to effectively measure all the skills due to financial constraints (Soland, Hamilton, & Stecher, 2013). When one looks at the costs of training teachers, hiring assessment experts, the administration involved in running the assessments and the considerable effort required to standardise the results into useful metrics - these can be quite daunting and expensive for many schools and education departments. Perhaps the costs of setting up the assessments, coupled with the many challenges of actually performing them, are the biggest barriers to adoption. Despite these challenges, the latest research into new techniques for doing formative and summative assessment seem to indicate that these issues will be resolved in the future (Greiff & Kyllonen, 2016). The researcher expects that, over time, more robust and inexpensive tests will become standard, which will allow for adoption by smaller schools and districts.

4.5 Summary

The discussion in this section has shown that 21st century skills are important for life and career in an era where knowledge is the main asset of trade in the labour market. Popular frameworks like P21 have sought to identify a collection of skills and define them as 21st century skills, as well as to provide guidelines for implementing learning environments that are conducive to them, and how to effectively assess them. Popular 21st century learning environments include PLEs and connected learning environments, although many variations of implementations exist according to the specific objectives that are pursued. Lastly, 21st century skills assessments were briefly looked at. As can be expected, both formative and summative assessments of 21st century skills exist, and they are typically used in conjunction in order to get better results. However, many issues exist with these assessments, which have prevented their adoption by smaller schools and districts. It is likely that, over time, more inexpensive and standard tests will be developed, which may improve

the situation.

Section 5 moves on to discuss the theoretical and design framework for this study, and further seeks to unify the discussion on 21st century skills, rural learning ecologies and connected learning.

5 Connected learning: A theoretical and design framework

5.1 A framework for learning

Connected learning has its grounding in sociocultural learning theory, and thus emphasises how learning is situated within social relationships and cultural contexts. Connected learning can be approached as an analytical framework to reconceptualise learning environments for the 21st century, or as a phenomenon in its own right, which can be observed through the lives of individuals and groups of people that learn in environments that exhibit connected learning design principles. (Kumpulainen & Sefton-Green, 2014). It is no surprise then that Ito et al. (2013) include numerous case studies in their work that showcase connected learning environments, and no doubt use these to compile their framework for connected learning. Connected learning has gained traction in the global North, and it has been successfully applied in many cases in America and Europe (see case studies from Ito et al. (2013), Davis and Fullerton (2016) and other examples listed in Table 2).

Ito et al. (2013) describe connected learning as an ecology and networked approach to education and learning. It is about promoting "socially embedded" and "interest driven" learning. It occurs when learners pursue their interests and passions with support from their peers and caring adults. This learning is then directed towards achieving academic, civic and career success. According to Ito et al. (2013), learners flourish when their personal interests, coupled with engaged and inclusive social exchanges with their peers, are connected to academic, civic and career opportunities. It is this intersection of different learning contexts, i.e. interest-powered , peer supported and academically oriented, that makes the learning experiences relevant, contextual and directed towards practical outcomes. By recognising that there are different and diverse pathways to learning, the gap between in and out of classroom learning can be closed.

Ito et al. (2013) recognise the role that technology, especially new open media networks, can play in creating and sustaining connected learning experiences. However, connected learning does not necessarily depend on technology, rather it is seen as a different context through which learning can take place. To quote Ito et al. (2013), *"unlike efforts at educational change that focus on technology deployment or institutional reform, connected learning takes a networked approach to social change that aligns with our ecological perspective. We believe that systemic shift requires linked efforts across different sites of learning, and that our best hope for educational change lies in connecting like-minded reform efforts across sectors of home, popular culture, technology, and education"*. They further state that connected learning is not defined by any particular techniques or institutional context, but by "a set of values, an orientation to social change, and a philosophy of learning".

Conceptually, connected learning addresses the issues of context and relevance that Hlalele (2014a) points out is missing in much of rural education. Crucially, both theoretical frameworks (i.e. connected learning and (rural) learning ecologies) seek to contextually address the disconnect between in and out of classroom learning by promoting learning across the contexts of classroom, personal lives and community. This is no surprise as both Hlalele (2014a) and Ito et al. (2013) cite Barron (2006) as one of their sources for their 'ecology' and 'networked' approach to learning. Therefore, an opportunity exists to introduce a connected learning design in a rural context with the idea of supporting the creation of rural learning ecologies.

The individual outcomes of connected learning include: (1) learners pursuing their interests with "greater depth and breadth"; (2) greater supports for learners in the learning process; (3) "greater academic orientation", which suggests that learners should do better at school when they learn in this format. However, of great importance to this research is the potential of connected learning supporting 21st century skills development. Connected learning appears to be aligned to the efforts to support deeper learning and higher order thinking skills. However, Ito et al. (2013) still do recognise that more work is required to *"investigate the degree to which connected*

learning experiences result in these forms of deeper learning, which include systems thinking, information literacy, creativity, adaptability, conscientiousness, persistence, and self-regulation" (Ito et al., 2013). Based on the above, it would seem the model of 21st century skills development based on connected learning can be represented through the basic causal model depicted in Figure 1.

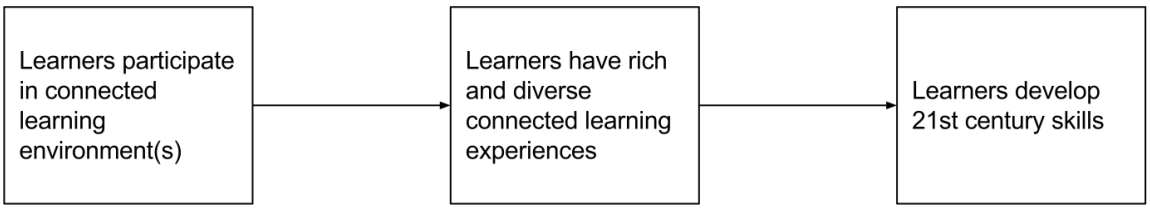

Figure 1: A basic model of 21st century skills development based on connected learning

Based on this simple model, participating in both formal and informal contexts for learning and experiencing rich and diverse pathways to learning can lead to or support learners' 21st century skills development. Many researchers would seem to agree with this model as they all write about its potential to support the development of these skills (Davis & Fullerton, 2016; Kumpulainen & Sefton-Green, 2014; Wilson et al., 2007). The OECD mention something similar as they write *"twenty-first century learning environments promote this integration of formal and informal learning, for when it comes to learning, there is no final bell"* (OECD, 2006). Given that connected learning is already theoretically aligned with conceptualisations of rural education such as proposed by Hlalele (2014a), the framework would appear to be suited for application within a rural context in order to evaluate its impact on 21st century skills development. It certainly would be a first in South Africa, and such an endeavour has the potential to generate useful insights on both a practical and theoretical level.

Despite the apparent fit of the model to the challenge at hand, there are still some issues, both on a theoretical and practical level, that need be to acknowledged. Firstly, from a theoretical point of view, the exact reasons why the model of connected learning leads to 21st century skills development has yet to be explicitly

documented in the literature. It seems to make sense, but will it actually work in practice? Secondly, on a practical level, although technology is seen as a support to learning, the literature suggests the use of it to be advantageous over implementations that do not depend on it, at least in part. As Ito et al. (2013) note in their report, new media ecologies can potentially "scale, diversify and expand the reach" of connected learning environments, thus creating more opportunities for learners to have connected learning experiences. Given that Hlalele (2014b) strongly recognises the role of technology, especially in creating learner networks, in creating and sustaining rural learning ecologies - employing it would seem the logical conclusion. However, given the expected challenges with ICT access in many rural communities and schools, will this model of learning work in an environment with technological constraints? Lastly, the general contextual challenges that learners face in many rural contexts may also affect this model of learning which was conceptualised in a different and largely western and urban context.

Based on the discussion above, a revised model of 21st century skills development is depicted in Figure 2. It is still largely based on the work of Ito et al. (2013), but has been updated to reflect the **factors** in the context it is applied in. The question-mark before the outcome of 21st century skills development is placed there because the way in which connected learning supports 21st century skills development still needs further study. This model will serve as a framework for this research, as it seeks to explore the impact of introducing a connected learning environment in a rural schooling context. The framework will also help identify the research questions and methodology that is to be employed in this study.

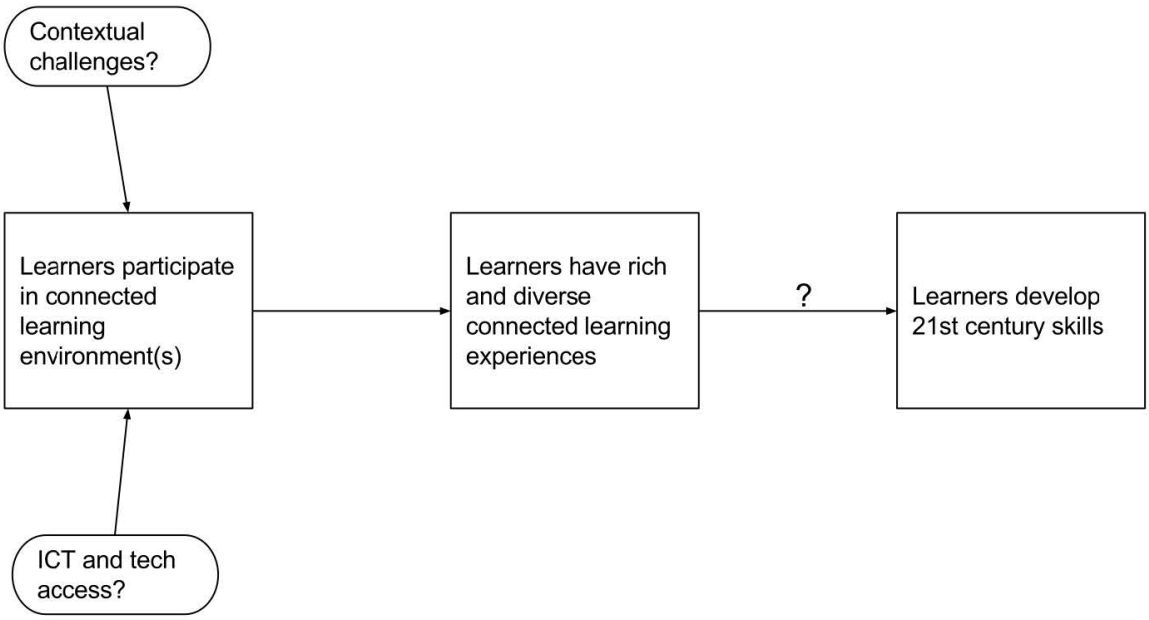

Figure 2: A revised model of 21st century skills development based on connected learning, reconceptualised for rural contexts

5.2 A framework for design

In their research report, Ito et al. (2013) also provide helpful and practical design principles for creating connected learning environments. The principles that they provided are meant to be experimented and iterated on, and so it is possible that some of them may change depending on the need. Each of the principles is discussed next, with examples from practice or literature:

1. *Peer supported.* The researchers argue that peer culture (for young people) is centred around popularity, spending time with friends and developing relationships. Open media ecologies such as WhatsApp and Facebook take advantage of the peer culture by supporting these activities through communication. They argue that if peer cultures are interest driven (e.g. the chess players, swimmers or maths nerds), this can be exploited to achieve an academic outcome. For instance, the maths nerds could connect on an open media platform to share knowledge, problems and solutions. These activities could be tied to a form of

recognition (e.g. e-badges) that could be given some form of academic recognition at school. This is also a form of social recognition and gaining status in the peer group.

2. *Interest driven.* Interests could include hobbies, academic subjects, sports, arts, amongst others. Peer networks that are interest driven create a sense of purpose, belonging and allow for passionate, expertise driven involvement and engagement. In conjunction with peer support, individual interest can be leveraged for greater opportunities for learning. An interesting example of this is found in a study by Korobkova (2014), where they investigated connected learning in a group of One Direction fans. All the participants were bonded together by their common support of the popular band One Direction.

3. *Academically oriented.* This means linking peer supported and interest driven engagement to academic, civic and political involvement. This is possibly the biggest strength of connected learning. It aligns learner interest with peer groups and academic achievement. An example of this is found in the After School Network's Expanded Learning Environments (ELE) program, which uses an after school program to teach subjects in the curriculum, and recognises achievement in the program by using digital badges and partnering with schools to give the badges academic recognition (Davis & Fullerton, 2016).

4. *Openly networked.* Connected learning needs to be openly networked in order to allow the learner the opportunity to engage with a broad range of stakeholders in their learning lives. Ito et al. (2013) state that virtual spaces need to be as open as possible, and built on open standards in order to have wide connectivity. This means creating cross-institutional networks that have multiple forms of entry and exit. For physical spaces, this means creating open-door policies and using open media networks to expand the reach beyond the physical. An example of this is students' use of Facebook for academic purposes (Dalsgaard, 2014).

5. *Production focused.* Connected learning needs to be production and performance oriented. This means that learners should be challenged to conceptualise, design, develop, test and deploy their work. Ito et al. (2013) note that open media networks are important in that they allow students to post the progress and results of their work - allowing other learners (peers) and stakeholders to provide feedback and recognition.

6. *Shared purpose.* Ito et al. (2013) argue that a shared purpose can bring about intergenerational engagement around areas of interest (something that is typically difficult to do in a classroom context). They also mention that projects with collective goals are important to bring about collaboration and participation in an attempt to solve a common problem within a community. An example of this is a community blog which was leveraged for learning (Stephens, 2016).

The design principles outlined above provided a helpful framework on which to design and introduce the connected learning intervention. The results of the design process are presented in Section 7.1. Having completed the discussion on the literature, coupled with considerations of the theoretical and design frameworks, the next step is to unpack the research questions, methodology and design. This is discussed next.

Part III

Research methodology and design

6 Research objectives, strategy and approach

6.1 Objectives of the research

The objectives of the research are derived from the the theoretical framework presented in Section 5, and specifically the model presented in Figure 2. The main objective of this research is to explore the impact that designing and introducing a connected learning environment in a rural school has on the learners' development of 21st century skills. The intervention will also allow the researcher to explore some of the challenges of designing and introducing technology supported connected learning environments in a rural school, given the many contextual challenges that they may face. Since this is the first time that connected learning and 21st century skills are studied in a rural South African school context, and not just research on the integration and use of ICTs as has tended to be the focus of many studies, new insights regarding these two important areas may well be generated.

6.2 Research questions

1. What is the impact of introducing a technology supported connected learning environment on rural learners' development of 21st century skills?

   The secondary questions are:

2. Does a technology supported connected learning environment have an equal impact on all 21st century skills in rural learners?

3. What are some of the challenges of creating a technology supported connecting learning environment in a rural school?

6.3 Research site

The research was conducted at Madonsi High School, which is located at Gija-Mhandzeni Village. The village is about 15 kilometres away from the rural town of Malamulele in the Limpopo province. There were several factors that played a role in the school being selected. The first was that it should be a rural school, relatively isolated from other schools, especially urban and affluent schools. Secondly, there had to have been no similar research conducted on site for a period of at least five years. Having spoken to the principal and teachers, no similar research had ever been conducted at the school. Thirdly, that the school should have an active feeding scheme so that learners would not participate in the research whilst hungry. Lastly, the school should be logistically convenient, both in terms of finding accommodation near the school (Malamulele town) and acquiring permission to conduct the research from the Principal and the manager of the Malamulele East Circuit of Schools, to which the school belongs.

Founded	1981
Grades	8 to 12
Number of learners	164
Number of teachers (including Principal)	8
Number of Maths and Science teachers	2
Socio-economic status of school community	Quintile 1[a]
Location	Gija-Mhandzeni Village

Table 1: Characteristics of Madonsi High School (2016)

[a]The DBE categorises schools according to quintiles (ranging from 1 to 5 in an ordinal scale). Quintile 5 indicates 'affluence', and quintile 1 indicates 'poverty'.

Table 1 shows key characteristics of the school. The school is quite hard to get to by car, as it requires travelling for a distance of 5 kilometres on uneven gravel road. Most of the teachers commute to the school daily by car and public transport,

whilst most of the learners walk to school as they live in the local community. The classrooms, except for the newly built block for higher grades, are quite old and have not been maintained very well. Most have broken chairs, tables, windows and teaching equipment. The school has an electricity supply, but only in a select few classrooms and the staff room. The school also has access to running water, but it is not integrated into the school infrastructure. Instead, water has to be fetched from the central tap in the middle of the school. The water has to be boiled/purified before it can be drunk. The toilet facilities are the open pit type, with no access to running water inside.

Figure 3 below shows some pictures (reproduced with consent) from the school. Walking out of the school yard, one is immediately confronted with the context within which the school is located. Standing in front of the main gate, one can see a 'kraal', an open field and a mixture of rondavels, zinc and tiled roof houses. To the left of the front gate is a primary school barely a stone's throw away. It is the main feeder for the high school. It is not uncommon to see cows or goats walking past the school yard, sometimes even ending up inside the school. Figure 4 shows some pictures of the context within which the school is situated.

Figure 3: Madonsi High School (2016)

Figure 4: Context around Madonsi High School (2016)

6.4 Research participants

The research participants were the 2016 Grade 8 and 9 learners at Madonsi High School, who formed part of the experimental intervention. In total, there were 27 learners that took part in the research, 24 of whom participated in all the activities. All of the 27, however, participated in at least one activity at some point during

Figure 5: The learners who participated in the research

the research. The average age of the learners was 14.5, which is at the lower end of South African high school age groups. Usually, learners start high school at age 14, and finish their matric year (grade 12) around the age of 18, assuming they do not drop any subjects. Figure 5 shows a picture of the learners who participated in the intervention.

6.5 Ethical considerations

Prior to the commencement of any research at the school, explicit confirmation of ethical clearance was acquired from the University of Cape Town Ethical Clearance Committee. Permission to perform research was also granted by the DBE, through the local Malamulele East Circuit of Schools office. The Principal of Madonsi High

School also granted explicit and written confirmation of approval to conduct research at the school. The Principal also discussed the purpose of the research as well as any required participation from learners at the School Governing Body meeting which parents are invited to attend. All the learners who participated in the research were younger than 18, hence explicit and written consent forms were required to be filled in by the parents prior to the commencement of the research. A copy of the consent form can be found in Appendix B.

Even with the above check boxes ticked, there still existed a risk that the research participants would develop a dependency on the intervention, and thus an unethical situation would be created when the research was completed and the intervention was decommissioned. Whilst it is not always possible to determine the extent to which research participants become dependent on an intervention, great care was taken in this research to ensure that agency still remained in their hands post-intervention. This was done in two ways. Firstly, the school teacher that the researcher was assigned to work with was empowered to contribute to the setup and running of the intervention. Secondly, instead of bringing in assets from outside, the teacher and learners were encouraged to use assets and resources sourced within the school and community as part of the intervention.

This helped to minimise the number of assets brought in from outside (besides the researcher and certain mandatory research equipment like recording devices and a laptop), hence these assets are still in the possession of the research participants. They could choose to continue to use them in the manner suggested to them through the research intervention (as has actually happened) or any other way they saw fit. This is consistent with the asset based view of 'rurality' articulated by Moletsane (2012), Hlalele (2014b) and others, as well as the definition of 'rurality' that Balfour et al. (2008) gave, which recognises that people in rural areas need to be given (or rather empowered to have) agency to make changes to their own destinies. See the stance on 'rurality' that the researcher takes in Section 2.1.

6.6 The challenges of researching connected learning

Having discussed the research objectives, site and participants, including a thorough consideration of the ethical issues involved, the next step is to delve deeper into the research methodology employed. Perhaps the most helpful contribution towards approaches to researching connected learning comes from Kumpulainen and Sefton-Green (2014). In their research, they identify three related challenges to researching connected learning and suggest possible approaches to research design. The first challenge relates to understanding learner engagement and agency as they move (physically and psychologically) through different spaces and time. The second relates to understanding how knowledge is learned, transferred and applied in different contexts, boundaries and locations. The third challenge relates to the concept of learning lives. Ideally, the connected learning researcher needs to take a lifetime view of learning, and thus has to deeply understand the journey that individuals or groups have gone through in their learning experiences. In essence, the connected learning researcher will need to track learning experiences through time, space(s) (whether physical or virtual), contexts, and across boundaries and locations. Since the researcher cannot possibly follow an individual every time of day, let alone see complex cognitive processes taking place in their minds, research methodologies and designs that can shed some light on learning experiences will need to be used.

Kumpulainen and Sefton-Green (2014) suggest three principles to approaching connected learning research:

1. *Capture process and duration.* The connected learning researcher should be able to observe learning experiences over time and space(s).

2. *Capture movement between contexts.* The connected learning researcher should be able to observe movement across complimentary social spaces and domains.

3. *The concept of learning lives.* This means taking a considerably more in-depth approach to the study of individuals or groups of people in order to better

understand their learning journeys, and to understand those journeys within the context of who they are.

It is not clear from the work of Kumpulainen and Sefton-Green (2014) whether all three of the above mentioned principles need to be taken into account in order to constitute effective connected learning research. For example, it is considerably more difficult to take a learning lives approach when your research participants are learners in a classroom. In South Africa, classrooms will easily have 25 or more learners in them, thus making it difficult to have an in-depth investigation of all their learning journeys. One possible approach to this might be to conduct an ethnographic study with one research participant, and have them convey the learning experiences in relation to those of their peers. However, this approach is quite limiting in that connected learning is intrinsically about the complex and often unpredictable social webs of learning that can happen at different spaces, boundaries and locations over time. Exploring these diverse learning experiences from multiple perspectives may prove more useful in the long run than focusing on one individual. A similar line of thinking can be said of points 1 and 2.

Perhaps connected learning can be studied from various perspectives, of which the three principles that Kumpulainen and Sefton-Green (2014) identified are one of each. It seems likely then, that certain connected learning studies might emphasize learning experiences and how they occur over time and space(s). Others might seek to explore the movement of people between different contexts of learning, whilst others might take a more in-depth approach and investigate the learning journey(s) of one or more individuals. Whichever approach, or combination of approaches, one takes, it is abundantly clear that connected learning research is about observing, conveying and understanding learning experiences over time, space, contexts, boundaries and locations within the learning journeys of people.

6.7 How similar studies have approached the research

The purpose of this section is to briefly examine what other connected learning studies have done in terms of research strategy and methodology. Insights from these studies will help to locate the type of connected learning research that this researcher has conducted.

Table 2 shows a few recent examples of connected learning research, including their chosen research methodologies. As would be expected, in cases where existing environments that support or display elements of connected learning, researchers have simply chosen to conduct their research within these environments. In cases where such environments did not exist, but a particular target group of interest was there where potential opportunities for improved learning were possible, researchers have introduced an intervention in order to allow them to investigate connected learning. This is the case for the researchers that have followed an experimental research design. Regardless of whether an intervention is introduced or not, connected learning research can be qualitative or quantitative in nature, depending on the focus of the study. Those studies that are exploratory and/or ethnographic in nature have tended to take a qualitative approach to the research, seeking to gain deeper insight of connected learning experiences within the chosen environments. The quantitative studies have tended to be empirical in nature, especially because their outcomes tend to be measurable, thus more prone to statistical analysis.

6.8 What is most appropriate for this research

Connected learning theory and practice was, to the researcher's knowledge, applied for the first time within a rural school in South Africa during the course of this study. In order to investigate the applicability of the theory in such a context, the researcher applied connected learning principles to design and build a learning environment which takes into account the specific circumstances of a school within a rural context (see Section 7.1). The intervention was introduced through an experimental research

Study	Description	Intervention	Methodology	Data Collection
Schooling the directioners: Connected learning and identity-making in the One Direction fandom (Korobkova, 2014).	"The purpose of the study was to investigate learning and networking in a teenage, female-dominated fandom" (paraphrased).	No - study conducted within existing environment	Qualitative; Ethnographic	In-depth structured interviews.
I want to be a Game Designer or Scientist: Connected Learning and Developing Identities with Urban, African-American Youth (Ahn et al., 2014).	"Findings from a two-year, research project where we designed, implemented, and conducted case study research in an after-school program for inner city, middle school students" (paraphrased).	Yes - study introduced an intervention (SciDentity afterschool program).	Qualitative; Experimental; Case study	Video recording; Observation; Artifacts; Data from social media site; Final Interviews
Connected learning in the library as a product of hacking, making, social diversity and messiness (Bilandzic, 2016).	" findings from a study that explored implications for design of interactive learning environments through 18 months of ethnographic observations of people's interactions at Hack The Evening (HTE)".	Yes - Hack the evening social intervention.	Qualitative; Ethnographic; Experimental.	Observations; In-depth interviews; Focus groups.
Connected learning in and after school: Exploring technology's role in the diverse learning experiences of high school students (Davis & Fullerton, 2016).	"Exploration of the efforts of one network of after school programs to leverage new media technologies to promote out-of-school learning among high school students from non-dominant backgrounds and connect this learning to their school contexts" (paraphrased).	No - study conducted within existing environment (After School Network Expanded Learning Experiences (ELE).	Qualitative; Exploratory	Interviews and focus groups.
Students use of Facebook for peer-to-peer learning (Dalsgaard, 2014).	"findings from an empirical study of five non-institutional Facebook groups created and managed by students in Danish upper secondary schools".	No - leverage existing environments (learner created and run Facebook groups).	Quantitative; Empirical	Questionnaire; Data from Facebook groups.
Connected Learning: Evaluating and Refining an Academic Community Blogging Platform (Stephens, 2016)	"This study investigates the benefits of a community blogging platform for students in an online LIS program" (paraphrased).	Yes - refinement of an existing platform (Community blogs).	Quantitative; Empirical.	Online survey.

Table 2: Examples of connected learning studies and their chosen methodologies

design. This is similar in approach to the studies that introduced an intervention as seen in Table 2, and this is perhaps to be expected. Many learning environments across the world, but especially in poor and marginalised areas in South Africa, are stuck with an education system that needs radical reinvention. Many have not been updated to reflect a 21st century learning environment. The study was inductive and exploratory in nature, seeking to gain a deeper understanding of how connected learning experiences could support the development of 21st century skills in poor, marginalised and rural schooling contexts.

In concluding the discussion about the appropriate methodology for this research, it is worth noting that an experimental design (to an extent) addresses the principles suggested by Kumpulainen and Sefton-Green (2014) (see Section 6.6 on challenges of researching connected learning). *Process and duration* will be captured by design in the experiment, as it will have a clearly defined start and finish time. Anything that happens in that time period (within certain controls) will be related to the process of learning. The intervention uses a mixture of physical and virtual spaces, and blends in and out of classroom learning for the purposes of learning which will help *capture movement between learning contexts*. The last principle, i.e. the concept of *learning lives*, is perhaps the hardest to address in an experimental design. The class size was not something the researcher had control over, and hence it could not be minimised to a manageable number of learners to facilitate deeper investigation of individuals' learning journeys. The time to conduct the research was also limited by certain aspects such as exams and holidays. Nevertheless, the voices and experiences of the learners that participated were recorded in order to capture as much of their learning experiences as was possible.

6.9 Qualitative experimental research

Classical experimental research in education has tended to follow a quantitative experimental design in keeping with the Campbell-Stanley tradition (Campbell & Stanley, 1963). This classical view of experimentation in social science research has

its origins in the positivist realm of natural sciences that affirms the belief that knowledge is objective and that it exists in the world independently of conciousness. That may be true in natural sciences, however, much of education research in the social sciences is about understanding the cognitive and unseen processes of learning and learning experiences. This requires allowing the voices of the participants to be heard, and thus requires more interpretivist approaches. Circumstances may also force the researcher to take an interpretivist approach, for instance, when randomisations or the ethics of providing a treatment to one group whilst ignoring another are simply not acceptable (He, Johnston, Zeitlinger, City, & City, 2015).

In his critique of classical experimentalism in education, Howe (2004) proposes what he calls mixed-methods interpretivism, which "reverses the primacy of quantitative-experimental and qualitative-interpretive methods such that quantitative methods play an auxiliary role in an overarching interpretivist-qualitative framework". The mixed-methods interpretivist approach makes sense in cases where mixed-methods experimentation, which tends to emphasise quantitative methods, or classical quantitative experimentation, is not possible. These can be applied, for instance, in the introduction of certain policies or interventions that seek to make an impact that is hard to measure empirically.

King, Keohane, Alford, and Verba (1994), in writing about causal inference in qualitative social research, state that neither qualitative nor quantitative methods are better for establishing causality. However, the same rigour applied in quantitative designs is needed for qualitative ones in order to ensure valid causal inferences. A general principle that has seemed to emerge in education research is the use of qualitative interpretivist or mixed-methods interpretivist approaches in early stage research in order to explore the causal inferences between intervention(s) and outcome(s), whilst later stage research has seemed to follow mixed-methods experimental or classical quantitative experimental approaches in order to establish the causal relationship(s) between intervention(s) and outcome(s), and to measure the effectiveness of the intervention(s) (He et al., 2015).

Since the subject of this study is about early stage research in an area and context that needs broader investigation, it has followed an early stage qualitative interpretivist experimental approach. Practically speaking, this means that this study will use a largely qualitative interpretivist framework to collect and analyse the data, whilst relegating quantitative methods to an auxiliary role. It is envisaged that a follow up study would reverse the trend and go beyond exploration of causal inferences or descriptions of cause and effect, to also measuring (empirically) the actual impact and effectiveness of the intervention.

7 Research intervention

7.1 Description of the intervention

The study introduced an intervention, called the connected learning Mathematics club, in which learners would participate during the school study period (two hour lecture slots in the afternoon, where learners are meant to be doing revision work), and online via the Facebook platform. The Facebook platform was chosen because many of the learners were already familiar with it, and it has been succesfully used for academic purposes by learners across the world (Dalsgaard, 2014). Mathematics was chosen because it is a critical subject required by many higher education institutions for admission to careers like Engineering, Computer Science, Astronomy and the like. P21 has also done a study that shows that the skills and attitudes that Mathematics subjects ought to instil in learners are actually aligned to 21st century skills (P21.org, 2012), hence it seemed fitting to use the subject as an avenue within which 21st century skills development could be explored.

The design of the connected learning Mathematics club closely follows connected learning design principles identified by Ito et al. (2013), viz. interest powered, peer supported, academically oriented, openly networked, production focused and shared purpose (Section 5.2). The club was designed to exist in both a physical (classroom) and a virtual (Facebook) space, where the learners and the teacher could collaborate (*openly networked; peer supported*). A typical learning cycle would start with the teacher giving a lesson on a Mathematics concept based on the National curriculum (*academically oriented*). Learners would interact with the teacher as per normal, however, with the knowledge that there would be an online component to the club.

At the end of the day, the teacher would then post exercises or assignments onto the Facebook platform, where a private connected learning group was created, so that learners could collaborate and answer the questions (*production focused*). The teacher would then examine the progress on the platform, and also participate by answering questions and making announcements, etc. Membership to the club

became a "cool" thing in the school, and learners were excited by the prospect of participating in a learning format where they could revise Mathematics concepts (which might help them do better at the end of the year) and potentially develop 21st century skills (*interest driven; shared purpose*).

To participate, learners had to bring their own mobile device that could access the internet, or partner with a peer who had a device if they did not have one. Data for access to the internet was provided using a Wifi hotspot created at the school for the purposes of this research. It was left up to the learners to decide if they wanted to pair up to tackle the questions, or have a go at it alone. Learners were also not given any strict submission milestones for the questions, only that they had to have completed all the questions by a certain date. Learners could also choose to answer questions directly on the platform, or first write the answers in their notebooks, but they had to post the final answers on Facebook.

The experiment ran for a period of just over two months, from the middle of August 2016 to the middle of October 2016. The timing was limited by the exam and holiday periods. A total of eight classes were given to the learners, two of which were introductory (i.e. introducing the concept and the learning platform). The rest of the lessons were on specific Mathematics syllabus material, viz. *basic algebra*, *simplifications*, *probability theory*, and *numbers and sequences*. The lessons and content were selected because they had already been covered in class (learners would only be doing revision) and the format of the answers was relatively straight forward to enter into a mobile device. The benefit of participating in the experiment was revision for the learners and peace of mind for the teacher, knowing that learners had covered certain topics more than once.

7.2 The research design

A major argument in the last chapter was that a qualitative experimental design was the most appropriate for the study. However, as explained in Section 6.9, qualitative experimentalism needs to have the same level of rigour in design as classical experi-

mentalism (King et al., 1994). The strength of the classical experimental design lies in its high level of reliability as well as internal and external validity, which speaks to the level of rigour one has to apply in designing such experiments (Campbell & Stanley, 1963). In order to apply the same level of rigour to a qualitative experimental design, the researcher employed the structure of the classical experimental design, whilst retaining the qualitative interpretivist approach that is required in qualitative experimentalism.

The structure of the classical experimental design (the "pre-test post-test control group") can be denoted as follows, using notation from Campbell and Stanley (1963):

$$\begin{array}{cccc} R & O_{1a} & X & O_{2a} \\ R & O_{1b} & & O_{2b} \end{array}$$

In this research design, people are randomly assigned (denoted with R) into either the experimental or control group. Both groups are pre-tested (denoted as O_1) in order to establish a baseline for comparison after the experiment is complete. The experimental treatment is introduced to one group (denoted as X), whilst the control group does not receive the treatment. After the experiment is complete, a post-test is done (denoted as O_2) on both the experimental and control groups.

Since only the structure of the classical experimental design is used in order to apply sufficient rigour to the qualitative experimental design, several modifications had to be made to allow for a qualitative interpretivist approach. Firstly, the ethics, or lack thereof, of letting one group of students participate in a cool and trendy classroom design, whilst others continued with the status quo proved the deciding factor for all the research design modifications. In the end, both the school management and the researcher decided against dividing learners into a control and an experimental group. Secondly, randomisation proved to be not only an administrative nightmare for the school and learners involved, but it also would have resulted in learners being displaced from their normal classes, thus creating an artificial environment that could adversely affect the results. In the end, the experiment was modified in the following way, following notation from Campbell and Stanley (1963):

$\underline{O_{1a}}$ $\underline{X}$ $\underline{O_{2a}}$

In this design, a control group is not employed, and only the experimental group is pre-tested and receives the experimental treatment. Randomisation is not done at all, but all the members of the classes participated in the research. This participation by the entire population of Grade 8/9 learners removes any selection biases (one of the purposes of randomisation). The experimental group will also undergo a post-test, in order to determine the difference between O_2 and O_1. Once this is done, it will need to be conclusively proved that any difference is due to the experimental treatment, and not due to other (rival) hypotheses. In order to do this, the design will need to consider internal and external validity threats, and employ certain controls to ensure that the outcome is a direct result of the experimental treatment. These internal and external validity threats, including the associated controls, are discussed next.

7.3 Research reliability and validity

Campbell and Stanley (1963) identify and define several factors that can affect the internal and external validity of experimental designs. The following section will briefly discuss these as well as indicate the mitigating factors for this research.

7.3.1 Internal validity threats and controls

Internal validity controls are done in order to ensure that the intervention (independent variable/experimental variable) is the actual cause of the effect (dependent variable/desired outcome), and that the outcomes cannot be reasonably explained through an alternative hypothesis.

1. *History* - this refers to any external factors and events that may affect the experiment between the first and second measurement, thus jeopardizing the validity of the results. This internal validity threat is mitigated by the fact that any historical events that may happen between O_1 and O_2 will affect all

learners equally. This does not, however, account for intra-session historical events. In hindsight, no such events occurred during the life of the experiment. The school and the researcher had a good working relationship, and school proceedings were kept as standard as possible.

2. *Maturation* - this happens naturally as a result of the passage of time. Learners may get hungry, tired or the class could be at a time when most learners are thinking about going home. To mitigate this threat, the experimental class was run during the afternoon studies period (a time that learners would need to be present doing revision work as per usual). The school also had a feeding scheme.

3. *Testing* - this can happen when taking another test after an initial test has been taken. To illustrate, during the pre-test, learners may become familiar with the questions and know how to answer them so as to give the right answer. Great care was taken, however, to design the questions in such a way that the desired behavioural outcome or the design of the experiment was not betrayed by the pre-test questions.

4. *Instrumentation* - this can happen through changes in the calibration of instruments or changes in the observers which may affect the obtained measurements. Multiple recording devices and notes were used to record all sessions. Data collection was performed by the researcher only.

5. *Statistical regression* - where groups are selected based on extreme scores (all the bright students in one group, etc.). This was mitigated by selecting the entire population of Grade 8/9 learners, thus making the selection fully representative of those grades.

6. *Experimental mortality* - where there is subsequent loss of members of the experimental group due to various circumstances. The unique benefit of the study was that all twenty-seven (27) learners had to attend the class during

normal school hours, and thus no loss of any participants was expected. In the end, most of the 27 learners participated in the entire research, with a few absences in some sessions due to illnesses and other expected issues.

7.3.2 External validity threats and controls

External validity controls are done to ascertain whether, given similar contexts and circumstances, it would be possible to generalise the findings of the research.

1. *The reactive effect of testing* - where the effects of pre-testing can potentially increase or decrease the respondents' responsiveness or precondition them to answer the questions in the right way. This would make the results of the experiment inapplicable to other settings (not generalisable). Based on observed anecdotal evidence, this did not happen. If anything, the learners' eagerness to participate was observed to be only a function of the experiment itself, and not the questions. The questions were also designed with care so as not to offend or affect any participant negatively.

2. *The interaction effects of selection biases and the experimental variable* - where the selected rural school or class population is already unique to all other rural schools or classes, thus making the results specific only to that population. According to Campbell and Stanley (1963), the likelihood of this increases the more a researcher is refused access to a school, thus making the subsequent school that grants them access almost certainly unique to the rest. The mitigating factor for this research is that no difficulty was experienced in getting access to the school, and the anecdotal evidence from the school reveals a striking similarity to the generalised features of rural schools discussed in Section 2.3.

3. *The reactive effects of experimental arrangements* - where the artificial nature of the experimental setup can cause the selected groups to behave in a manner that is not usual, thus jeopardizing the possibility of generalising the findings.

In this study, typical experimental activities like randomisation and separating members of the population of interest into control and experimental groups were foregone due to ethical reasons, which also helped in keeping proceedings as close to normal as possible. Having said this, most experimental interventions in education are bound to feel artificial as learners know that things will probably return to normal after the research is complete. This is a difficult threat and it is hard to control. It may well have happened in this research, despite the efforts to mitigate or minimise it.

4. *Multiple treatment interference* - where multiple levels of experiments are performed (e.g. X_0, X_1, X_2, etc.), where the effects of X_0 affect the results of X_1, and so forth. In this research, only one experimental treatment was applied.

7.3.3 Reliability

A major benefit of the Campbell-Stanley experimental design for educational settings is the high level of repeatability, meaning that another researcher could reasonably expect to get similar results if the research were conducted in a similar context. This repeatability is at the heart of what researchers often mean by reliability (Yilmaz, 2013; Ritchie, Lewis, Nicholls, & Ormston, 2013; Lincoln & Guba, 1985). However, since this research took a qualitative interpretivist approach to the experimental design, issues of reliability from a qualitative perspective will also need to be considered.

There has been a lot of debate around the usefulness of traditional quantitative research criteria like reliability and validity in qualitative research. Rather than go into a thorough analysis of the merits of prominent arguments, something that is outside the scope of this work, the researcher simply points to works that have done a thorough analysis of the the landscape, viz. Yilmaz (2013), Creswell (2013), Golafshani (2003). What has seemed to be a trend in the literature is the use of new criteria for judging qualitative research, viz. credibility instead of internal

validity, transferability instead of generalisability, dependability instead of reliability and confirmability instead of objectivity (Yilmaz, 2013; Lincoln & Guba, 1985). These are briefly discussed next:

1. *Credibility* - this refers to the sense of confidence in the truth of the collected research data, its interpretation and representation of the participant's original views. In this study, data gathered from both the learners and the teacher was used as a form of triangulation and cross-check. The study findings were also peer reviewed by members of the research community that are familiar with the context.

2. *Transferability* - which is the equivalent of generalisability in quantitative methods. Section 7.3.2 on external validity has adequately shown that the results of the study can be transferred to similar contexts.

3. *Dependability* - this refers to the sense with which the results will remain applicable over a period of time, hence dependable. It remains to be seen whether the results of this study will remain dependable over time, but the attempts to gain external validity as explained in Section 7.3.2 would suggest that it will remain dependable, especially if the context does not change.

4. *Confirmability* - this refers to the degree to which results could be corroborated by other researchers. In this study, all the raw data, process of data reduction and analysis can be fully disclosed to facilitate an audit trail process.

The researcher believes that the strong experimental design approach followed, coupled with the attempts to gain reliability from a qualitative perspective, shows the amount of academic rigour and due care that has been taken in doing this research. Add to this the researcher's own personal story (i.e. coming from that context and wanting to make a difference in it) shows a great deal of authenticity.

7.4 Data collection

Table 2 is referred to again to indicate what data collection methods similar and recent studies have employed. Generally, the qualitative studies have employed a combination of focus groups, interviews and observations for collecting the data. Those who conducted their studies with an online component also used their respective platforms to collect data. In this study, a combination of observation, group interviews and data collected through the online platform was used. Each are discussed briefly below.

1. Observation (prior to the experiment) - this was done in order to witness the Mathematics class in action, prior to any intervention. The researcher immersed himself in the context and classroom, and observed the teacher providing lessons and interacting with the learners. This was done in order to get a better sense of the current learning environment.

2. Experimental group interview (prior to the experiment) - this was done to get a sense of the learning environment, both in and out of the classroom, from the learners' perspectives. This would be contrasted with their experiences of the connected learning environment after the experiment had beeen concluded. When conducting the group interviews, the researcher embedded himself in the class discussion in order to gain a deep and thorough understanding of the learning experiences that were shared. This is in keeping with a qualitative interpretivist framework. As noted by Howe (2004), qualitative methods such as interviews are much more adept at promoting dialogue, something that was fundamentally required for this research. A normal quantitative experimental method like surveys, for instance, would have missed the point of the research and would not have allowed for the voices of the learners to sufficiently come through. One-on-one interviews would have been ideal, but time and logistics did not make it possible. Instead, the group interviews were used to encourage dialogue between the researcher and the learners. Learners answered the

questions in a round-robin manner, allowing for everyone to participate and contribute. This also made it easy to count the number of responses to a particular question.

3. Teacher interview (prior to the experiment) - this was done for two reasons: Firstly, the insights that the teacher gave would provide a useful and sometimes broader context to supplement the information collected during the interview with the learners and the class observation conducted prior to the intervention. Secondly, this would serve as a useful cross-reference of the data collected in the learner interviews, further strengthening the validity of the research.

4. Observation (during the experiment) - this was used during the experiment to give an outsider's view of the experiment as it ran, in keeping with the Campbell-Stanley tradition (Campbell & Stanley, 1963). The researcher observed the learners and teacher interact during the connected learning classes and kept detailed notes of the various exchanges.

5. Data collected through the online platform (during the experiment) - Facebook proved a useful data collection tool as it allowed data collection beyond time and space(s) that the researcher could access. This also addresses some of the challenges of researching connected learning that were identified by Kumpulainen and Sefton-Green (2014) (see Section 6.6).

6. Experimental group interview (post the experiment) - this was done in order to get feedback and experiences on the connected learning environment. This data was contrasted with the data collected before the research began.

7. Teacher interview (post the experiment) - this was done to get the teacher's insights, comments and experiences on the connected learning environment. Furthermore, the teacher was interviewed on the business model, and his insights were helpful in designing the initial business model (see Part V).

The recording instruments used were two smartphones with dual mics for noise cancellation, the researcher's notebook and the online platform. The engagement with the learners was in Xitsonga (the predominant language of instruction at the school), which meant that all the data had to be transcribed and translated before it could be used for data analysis.

7.5 Data analysis method

Thematic analysis was selected for this research for its simplicity of application and ability to represent complex, seemingly unrelated pieces of information together and identify common themes and trends. According to Boyatzis (1998), thematic analysis is a way of seeing, and it is applicable to a wide variety of information sources. The researcher also used thematic network analysis (Attridge-Stirling, 2001), a branch of thematic analysis, which uses network diagrams to unearth or "see" salient themes, classify them into theme hierarchies (basic, organising and global themes) and illustrate the relationships between them. A possible alternative analysis approach that has been used in connected learning research is discourse analysis (Gee, 2004), however the focus of this research is less about the situated meaning of language and how it is used in specific texts, but more about the tracking of learning experiences between different contexts. Thematic analysis is well suited to identifying various themes based on learning experiences, and relating these themes to higher organising themes.

The analysis was done in two parts, with the first done to expose the features of the learning environment (normal class vs intervention). This was done using a thematic network analysis, following a largely inductive approach. The driving question for the analysis was: What are the features of the learning environment, based on the learners' experiences?. This would result in a thematic network with basic themes (explaining different aspects of the learning environment), organising themes (features of the learning environment) and global themes (which are top level summary themes). A step by step description of the method of analysis is described

next (Attridge-Stirling, 2001):

1. Data reduction through identification of emergent codes.
2. Classification of codes into basic themes.
3. Grouping of common and similar themes into organising themes based on the research questions and objectives.
4. Deduction of global theme(s) based on the organising themes.
5. Description and exploration of the resulting network diagram .

The second part of the analysis follows a deductive thematic analysis approach (Braun & Clarke, 2006; Boyatzis, 1998), where themes or summary codes are decided on prior to the analysis according to the purpose of the research. In this case, the 21st century skills themselves are used as themes. The driving question for this analysis was: Based on the learner experiences in the given learning environment, are there any skills exhibited that were consistent with 21st century skills?. To do this effectively, the codes used to generate the basic and organising themes are revisited, but this time to explore the underlying experiences to unearth skills, attitudes and behaviours that the learners exhibited. These skills, attitudes and behaviours are then grouped under a theme (i.e. 21st century skill) based on the definitions of each 21st century skill. P21.org's 21st century skills definitions for Mathematics are chosen as they provide detailed descriptions, examples and explanations of the skills that learners ought to exhibit (P21.org, 2012). All the data was captured in the Nvivo 11 data analysis software package for further exploration.

7.6 Summary

The research design choices made in this study are by no means unique and novel, but they do go against a trend of classical experimentation, which has often emphasised randomisation, control group designs and a reliance on quantitative methods of

data collection and analysis. The researcher has labelled the design followed in this study qualitative experimental research (Section 6.9). In order to ensure that the distinction is clear, a helpful summary of the key design choices is presented next:

1. The basic structure of classical experimental designs was employed for the research design, mainly for its rigour and emphasis on both internal and external validity controls. Essentially, the experimental design structure was used as a vehicle through which to introduce and test the intervention (connected learning Mathematics club) that was described in Section 7.1.

2. Randomisation and the use of a control group were not employed in the design. This decision was based on the ethical consideration of randomisation and control group designs, as well as the administrative constraints that were placed on the experiment (Section 7.2).

3. Research validity was considered and strengthened by employing effective controls that are typical in classical experimentation. Reliability was also considered from a qualitative perspective, through the honest consideration of criteria such as credibility, transferability, dependability and confirmability (Section 7.3).

4. The data collection method emphasised qualitative techniques, including observation and interviews. Data were also collected through the Facebook social media platform (Section 7.4).

5. The data analysis method employed a combination of inductive thematic analysis, used to discover features of the learning environment prior to and after the intervention, and deductive thematic analysis, which was used to classify the observed skills, attitudes and behaviours under a specific 21st century skill (Section 7.5).

The findings of the research, based on the design described in this section, are discussed next.

Part IV

Results, discussion and conclusion

8 Results

8.1 The learning environment

The findings are presented in two parts, with the first covered in this section, and the second in Section 8.2. The first part is a presentation of the *features of the learning environment* before and after the intervention. The features will help identify aspects of the learning environment that are conducive to 21st century skills development. In order to identify the features of the learning environment, thematic analysis was performed according to the methodology and exact steps presented in Section 7.5. The analysis revealed key organising themes, which are akin to the *features of the learning environment*, and basic themes, which provide the detailed aspects of each feature/organising theme. The global theme for the learning environment, both before and after the intervention, was the learners' experiences.

A description of each of the organising themes, which are key to exploring the thematic network, is presented in Table 3. The resulting thematic networks are presented in Figures 6 and 7; they provide a helpful summary of the analysis, as well as facilitate the reader's immersion into the findings. The networks should be read from the top down, starting from the global theme (it is about the learner perspectives, experiences and realities), then on to the organising themes (the features of the learning environment) and then finally on to the basic themes, which provide rich descriptions of the learners' experiences of each features of the learning environment. The thematic networks are explored and described in detail next (starting from Section 8.1.1), as a way of presenting the findings.

Organising theme	**Description**
Context for learning	This refers to all the places, locations and spaces where learning took place, whether physical or virtual, and with peers or adults.
Learning and production	This refers to all the ways of learning (meta-cognition and meta-learning) and how production work was done both in and out of class.
Perceptions	What the learners believed about Mathematics as a subject, and their experience of the Mathematics class or club.
Class dynamics	This refers to the interaction between learners, as well as between the teacher and the learners.
Engagement	This refers to the level of academic engagement, participation and critical discussion from the learners.
Platform	All aspects that were coded as related to the platform used in this experiment.
Learner initiatives	This refers to unusual and surprising (based on interviews) actions learners took for academic and other interests.

Table 3: Description of summary codes or organising themes for the resulting thematic networks

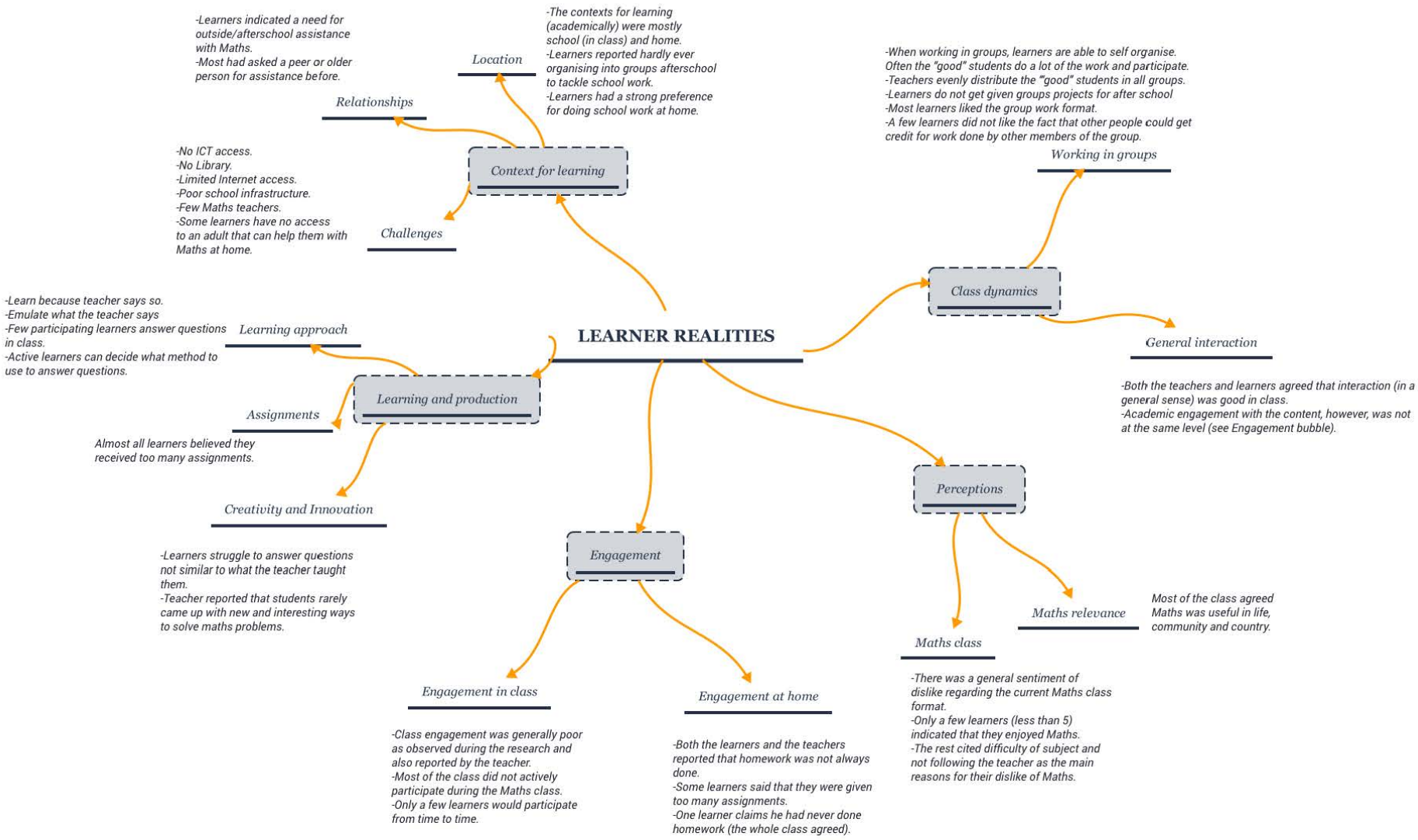

Figure 6: Summary of key findings (pre-intervention)

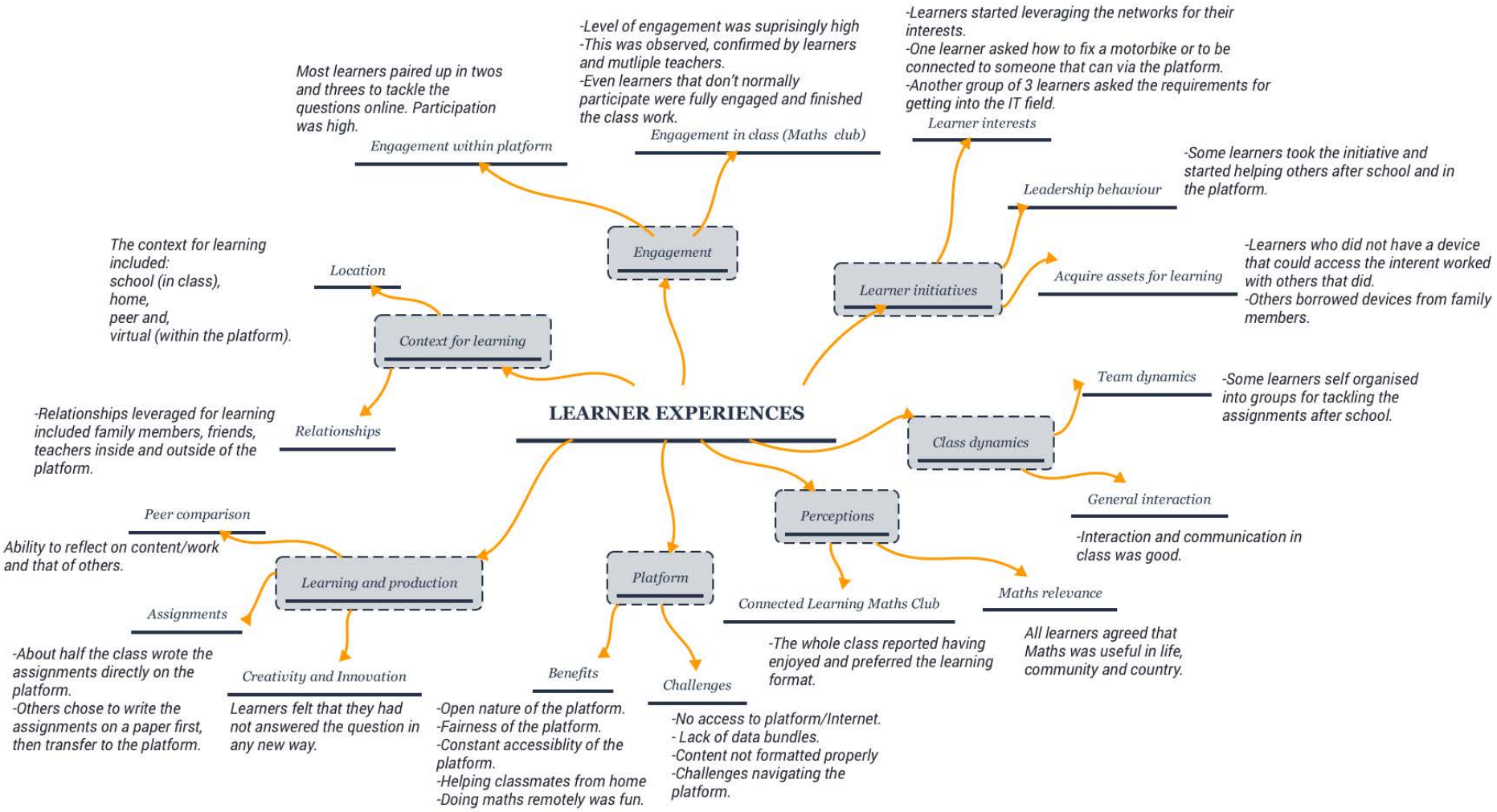

Figure 7: Summary of key findings (intervention)

8.1.1 Context for learning

NB: In order to make it simple to distinguish between the two learning environments, **Mathematics class** will refer to the current learning environment before the intervention, whilst **Mathematics club** will refer to all activities in the research intervention.

Location

The exploration and explanation of the thematic networks will begin with the learning context. The locations for learning in the Mathematics class were school and home. When learners were at home, they reported hardly every getting together to tackle school work. Everyone did their own work and they would only get together and discuss in class. As a learner noted in an interview, the class also does not get group work for after school.

> Interviewer: Does the teacher give you group assignments that you will have to do over the course of say a week, where you will have to meet up after school to discuss the questions and answer them?
>
> Learner X: No! We don't get group work like that.

In the Mathematics club, the learning contexts also included school and home, but two more contexts for learning were added. Firstly, learners collaborated on the platform, asking and answering questions. Learners also formed peer groups to tackle the questions on the platform (See Figure 8). The peer groups were either physical (learners met at someone's home or after school) or virtual (learners collaborated on Facebook).

Relationships leveraged for learning

In the Mathematics class, most learners had asked an adult or family member for assistance at least once in the past, but they were not always able to access them.

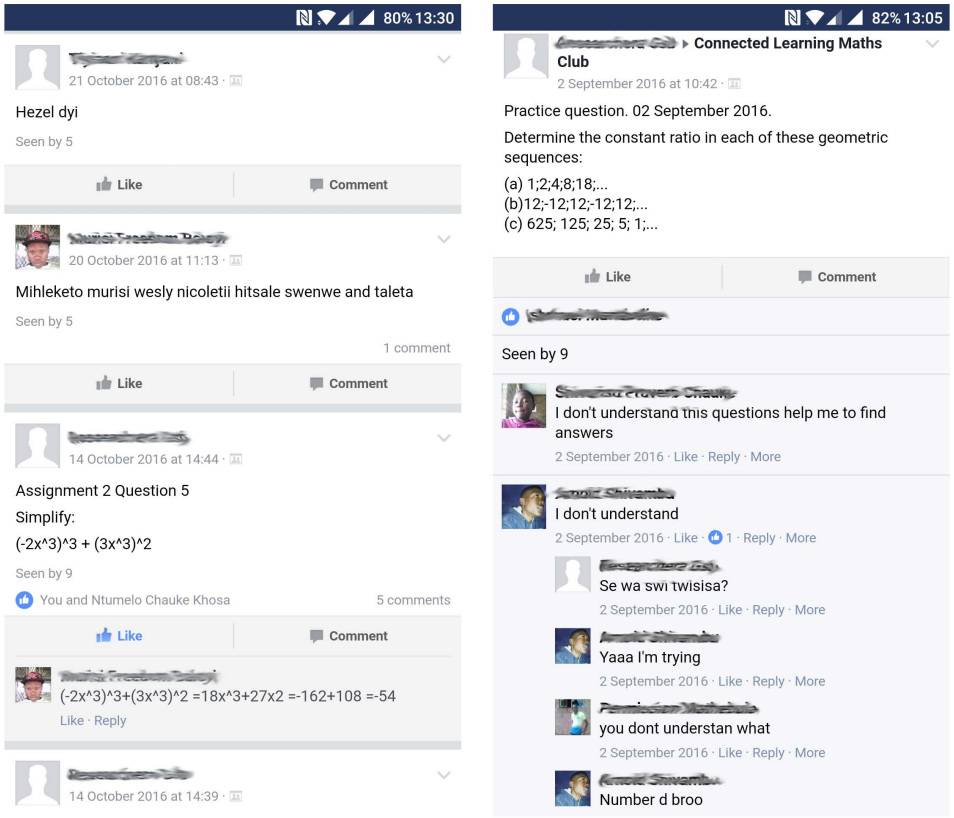

Figure 8: Left: Learner reporting to their peer group. Right: Learners requesting assistance

Learners had also asked peers in higher grades before. Both the learners and the teachers acknowledged a need for mentors that could assist the learners after school, a service that is not currently available in the area. The teacher captured the need well,

> Teacher: ...Yes, many don't have someone who can help them at home. Some don't have parents at home. Others have parents that work in the city and only come back home at night. At that time they can't look at their children's work because it is already quite late. Some live alone for various reasons.

In the Mathematics club, learners also asked peers, family and teachers for assistance. More than 10 learners accessed a relationship that they had never accessed

before for assistance through Facebook, whilst others accessed new relationships outside of Facebook and in rival platforms (WhatsApp). The majority of learners reportedly enjoyed being able to remotely connect with friends even when they were not sitting next to them.

Contextual challenges

The learners faced a myriad of issues in the Mathematics class, including lack of access to ICTs and the internet, no functioning library at the school, few Mathematics teachers at the school (only 2) for all grades, and poor school infrastructure. A lot of the classrooms where learners attend Mathematics have broken furniture and facilities for learning. These various challenges seemed to have taken confidence away from the learners, leaving them feeling robbed of the privileges other more affluent schools seemed to enjoy. When asked about the use of the internet for educational purposes, for instance, the class simply responded in this way,

> Class: (After a long period of silence ...one voice speaks out) We don't know how to do that.

These challenges did not magically disappear in the Mathematics club, and they continued to affect the learners. What was noticeable, however, was the initiative learners took in repurposing old cellphones, tablets and laptops borrowed from friends and family, and using them to connect to the internet as part of the Mathematics club. This was both unexpected and surprising, given the contextual challenges, but it was good to see (Figure 9).

8.1.2 Class dynamics

General interaction

General interaction in the Mathematics class was very good. Learners communicated very well with each other as well as with the teacher. Learners could communicate verbally and in writing. Interaction in the Mathematics club was just as good, if not more engaged than before.

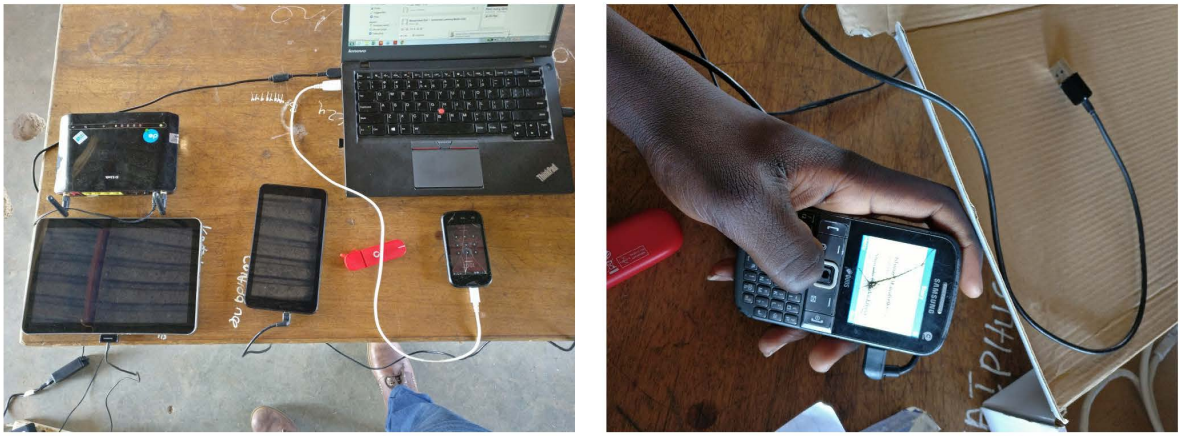

Figure 9: Learners sourced old tablets, phones and laptops from within the community

Team dynamics

In the Mathematics class, when the teacher asked the learners to break up into groups, they were able to self organise and assign specific tasks to members of the group. During the observation, learners tended to let those who usually participated in class do all the work, whilst the majority of them would simply not be engaged. This was a general problem across all the groups observed. It was also confirmed by both the teacher and the learners that this was a general problem in the Grade 8/9 Mathematics classes. One learner stated that they do not like working in groups because others can simply copy your work and present it as their own.

In the Mathematics club, learners were not given specific mandates to tackle the problems in groups, but still some learners chose to organise themselves into a group to tackle some of the assignments. One of the main reasons for organising into groups was to share scarce resources, e.g. a smartphone or tablet. Participation in the groups in the Mathematics club class sessions was high, with each member of every group making an effort to present answers to particular problems.

8.1.3 Academic engagement

Engagement in class

The level of academic engagement in the Mathematics class was very poor. Not only were there few learners that participated by asking meaningful questions and responding to the teacher's questions, but the majority did not even have basic instruments such as pens, notebooks, rulers and the like. This issue was captured well by the teacher during the interview,

> Teacher: Sometimes they (learners) do not even have pens. Instead of saying they don't have a pen, they don't even raise their hands to say that they need one. They just sit there and not write anything. ...we give them friendly permission to go find a pen or borrow one from other learners. ...some of them go out the class, go to the toilet or something and never return back to class.

In contrast, engagement in the Mathematics club was surprisingly high, and all learners participated by asking meaningful questions and turning in the class work. This was observed and confirmed by learners and the teacher. Figure 10 shows a picture of one of the sessions. Almost all learners are involved in answering the questions and trying to finish the class exercise before the end of the session. It was surprising to see the learners that were not participating in the normal Mathematics class fully engaged and actually finishing the class exercises.

Engagement at home

In the Mathematics class, the majority of learners did not always do their homework. Even those that did, tended to submit it late. During the learner interview, one learner even claimed that he had never done Mathematics homework, to which the entire class responded by laughing in agreement. It also seems that the teachers at the school did not prefer giving the learners group work for after school. The reason for this may have been to prevent learners from simply copying each other's work and presenting it as their own. The learners, however, reportedly preferred the after school group work format, as discovered in the interviews.

Figure 10: Learners answering class exercises in one of the connected learning Maths clubs (2 September 2016)

In the Mathematics club, engagement from learners was generally high, even after school. Several learners would submit their assignments at night, and others even during the school holidays (see Figure 11). The teacher remarked that he had seen an improvement in the number of learners that turned in their homework. Some learners also formed groups to tackle the assignments after school.

8.1.4 Learning and production

Learning approach

During observations of the teacher and learners interacting in the Mathematics class, it was noted that the majority of learners did not participate and engage with

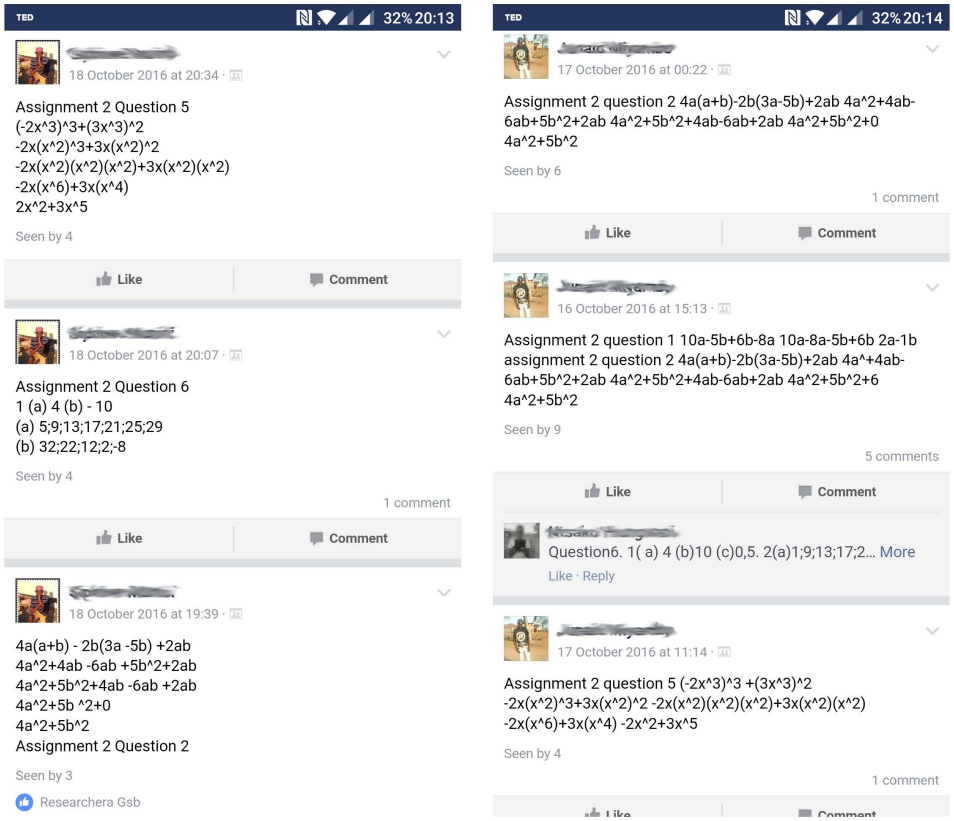

Figure 11: Left: Learner turning in assignment at night. Right: Learner turning in assignment at midnight, during the weekend.

the material by asking meaningful questions and providing answers to problems. Most learners seemed to emulate what the teacher said and tried to closely replicate that when asked questions. There were consistently four learners that would provide answers and ask questions from time to time, but never the whole class unless the teacher picked out an individual learner. The following segment from the teacher interview also sheds some light on this,

> Interviewer: Do you feel your learners are learning how to learn? Does my question make sense?
>
> Teacher: I think more than 90% of the learners that we teach, they learn because there is somebody telling us how to do it, so we do it. Some things are very simple, that we teach them, and we expect that after

some time they would still understand those principles. Sometimes we give them a topic, so that at the next lesson we will discuss it. Go home and read about this and we will discuss in the next lesson. Most of them don't.

In the Mathematics club, most learners were engaged academically as discussed in Section 8.1.3. An extra dimension to learning seemed to have been added through the openness of the Facebook platform (all the learners could see others' comments and questions). During the 'in class' sessions of the club, learners commented on having learned something from the way others were answering or asking questions online, which is evidence of peer supported learning.

Assignments

Besides the issues of lack of turning in of assignments (see extract from teacher interview below), learners also believed that they received too many assignments in the Mathematics class, and that this impacted on their ability to complete them on time. It was unclear whether this was simply a perception from the learners, or if they actually did receive a lot of assignments. The view of the researcher is that this was simply their perception, caused by a variety of issues, such as some learners' beliefs that Mathematics is a hard subject.

Teacher: ...I will give an example using grade 9. They were given an assignment out of 50, that will contribute to their year mark. When the schools closed for the June/July holidays, most learners did not do it and still asked for more time to do the assignment. What ended up happening was that one learner asked a grade 12 student to write the answers for them, and the other learners simply copied them.

In the Mathematics club, learners were initially resistant and did not always participate, but as time passed and they became more familiar and comfortable with

the Facebook platform, they started participating more. By the last assignment, nearly every learner was actively turning in their work, and on time too. This was a surprising, but helpful, finding in the research intervention.

Creativity and innovation

The majority of learners felt they had not answered any questions in any new or novel ways. This was the same in the current Mathematics class as well as in the club. This was a rather curious finding which will be explored further in the discussion section.

8.1.5 Perceptions

Mathematics relevance

Learners believed Mathematics was useful in their community (learners gave examples of how they could help community members with it), in their careers (learners believed that the 'good' careers required Mathematics) and in the country in general. This sentiment remained the same in both the Mathematics class and the club.

Mathematics class

Learners had a general sentiment of unhappiness about the current Mathematics class. When learners were asked their perception about Mathematics and the current class, a learner simply responded in a sentiment that was shared by the majority of learners,

> Learner Y: Maths is quite difficult and we don't always follow the teacher.

In the Mathematics club, however, learners enjoyed doing Mathematics, and expressed a preference for the learning format. Learners enjoyed being able to do Mathematics on Facebook (it was a first for many of them), and others liked being able to interact with their friends whilst doing Mathematics.

8.1.6 Platform

Platform challenges

The contextual challenges that learners were faced with in the Mathematics class were discussed in Section 8.1.1, but the use of the Facebook platform in the Mathematics club also brought challenges of its own. Some learners struggled to get a device that could connect to the internet, with most resorting to sharing with other learners. Lack of data bundles was also a big challenge, and although Facebook was zero-rated on the Cell-C cellular network, some learners used cellular services from other providers who did not zero-rate it. Learners also reported that the formatting of the content on the platform was not ideal and they could not always easily enter their answers in a way that was intuitive. Figure 12 illustrates the issue with formatting.

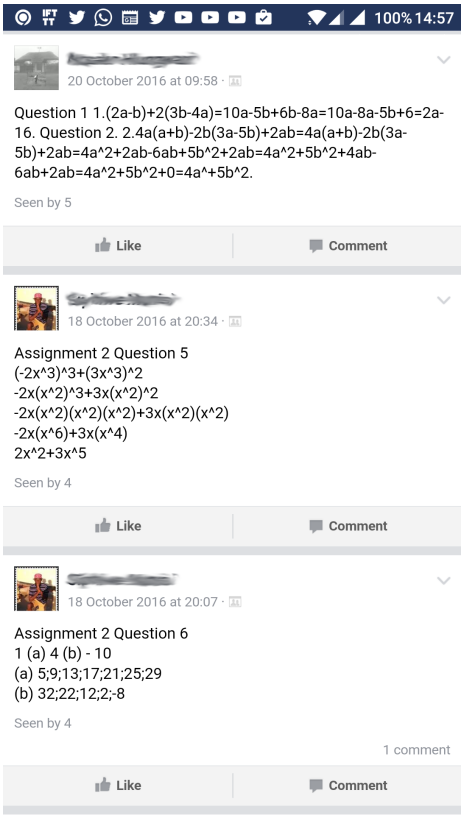

Figure 12: Trying to write maths solutions on Facebook can be challenging

Platform benefits

Despite the challenges discussed above, the platform had some clear benefits. Learners enjoyed the fact that they could access the platform at any time and from anywhere. They also enjoyed the fact that everyone saw the same thing and that they could revisit past solutions if they did not understand something. The single biggest benefit that learners reported was the ability to collaborate with classmates at any time, even from home.

8.1.7 Learner initiatives

During the experiment, learners acquired assets (tablets, laptops and smartphones) from within the community, and used them for learning purposes. This was particularly surprising given the contextual challenges in the area. Some learners also used the Mathematics club platform to ask the researcher about their own interests (how to fix a motorbike and how to get into the IT field), further stressing the need for learner mentorship. Another learner, who appeared to have been familiar with Facebook and was relatively more comfortable with the Mathematics concepts discussed in the club, went out of his way to help other learners navigate Facebook and also assist them with the assignments.

> Interviewer: What was it like, being part of the Maths club?
>
> Learner X: It was nice because I could help some of my fellow classmates with Maths at home.
>
> Interviewer Who was assisted by Learner X?
>
> Interviewer: 1, 2, 3, 4, 5 (Counting).

8.2 Effects on 21st century skills development

The second part of the results is a presentation of the analysis of the effects that the learning environment had on the learners' 21st century skills development. The analysis is done for the environment before and after the intervention in order to assess the actual effect of the connected learning environment. The analysis is done using deductive thematic analysis, according to the method described in Section 7.5 (the second part). Table 4 provides an example of the analysis that was performed across 48 distinct codes from the data generated during the intervention and 29 distinct codes from the pre-test data. Each code is also shown alongside its corresponding basic and organising theme.

A qualitative estimate of impact is also included in the table for each code that relates to a particular 21st century skill. This impact, which indicates a percentage of the total number of learners, refers to the number of learners that responded positively to the relevant interview question. The interview questions, which are included in Appendix C, were structured in such a way that each question would be related to a particular 21st century skill, which simplified the data analysis process. This made it simple to count the number of positive responses to a particular question. Where applicable, the interview responses are also backed-up by data from the observations, Facebook and teacher interviews. This further strengthened the case for each impact and minimises researcher bias. Any use of the word impact in all the tables in this section will be consistent with the brief description above.

Organising Theme	**Theme**	**Code**	**Skill**	**Impact**	**Description**
Context for learning	Location	Virtual	ICT Literacy	Positive; Over 90% of learners	Learners used smartphones, tablets and laptops to access the platform, answer questions and collaborate online.

Table 4: Example of thematic analysis performed across all codes

The data was taken through several passes of deductive thematic analysis, and some of the rationale from that process will be exposed in the presentation of the

Theme (21st century skill)	**Positive**	**Negative**
Communication and collaboration	20,0%	16,0%
Critical thinking, problem solving and decision making	8,0%	8,0%
Citizenship and social responsibility	4,0%	0,0%
Information literacy	0,0%	16,0%
Productivity and accountability	0,0%	12,0%
Creativity and innovation	0,0%	8,0%
ICT and media literacy	0,0%	8,0%
Flexibility and adaptability	0,0%	0,0%
Initiative and self direction	0,0%	0,0%
Leadership and accountability	0,0%	0,0%

Table 5: Distribution of codes grouped under each theme (prior to intervention)

Theme (21st century skill)	**Positive**	**Negative**
Communication and collaboration	27,5%	0,0%
ICT and media literacy	25,0%	10,0%
Information literacy	10,0%	2,5%
Critical thinking, problem solving and decision making	5,0%	0,0%
Flexibility and adaptability	5,0%	0,0%
Leadership and accountability	5,0%	0,0%
Citizenship and social responsibility	2,5%	0,0%
Initiative and self direction	2,5%	0,0%
Productivity and accountability	2,5%	0,0%
Creativity and innovation	0,0%	2,5%

Table 6: Distribution of codes grouped under each theme (intervention)

results in this section. The final synthesis, however, will still be covered in the discussion (Section 9). Section 8.1 on the learning environment is crucial to understanding these results because it essentially describes the context in which learners would either get opportunities to practise 21st century skills (a conducive environment) or not (a non-conducive environment). Furthermore, because the learning environment has multiple features, the analysis was done from the perspective of the learners' experiences, through the lens of each of the features. As a result, the effect of the intervention on 21st century skills will be presented from multiple perspectives which reflect the different features of the learning environment.

8.2.1 Communication and collaboration

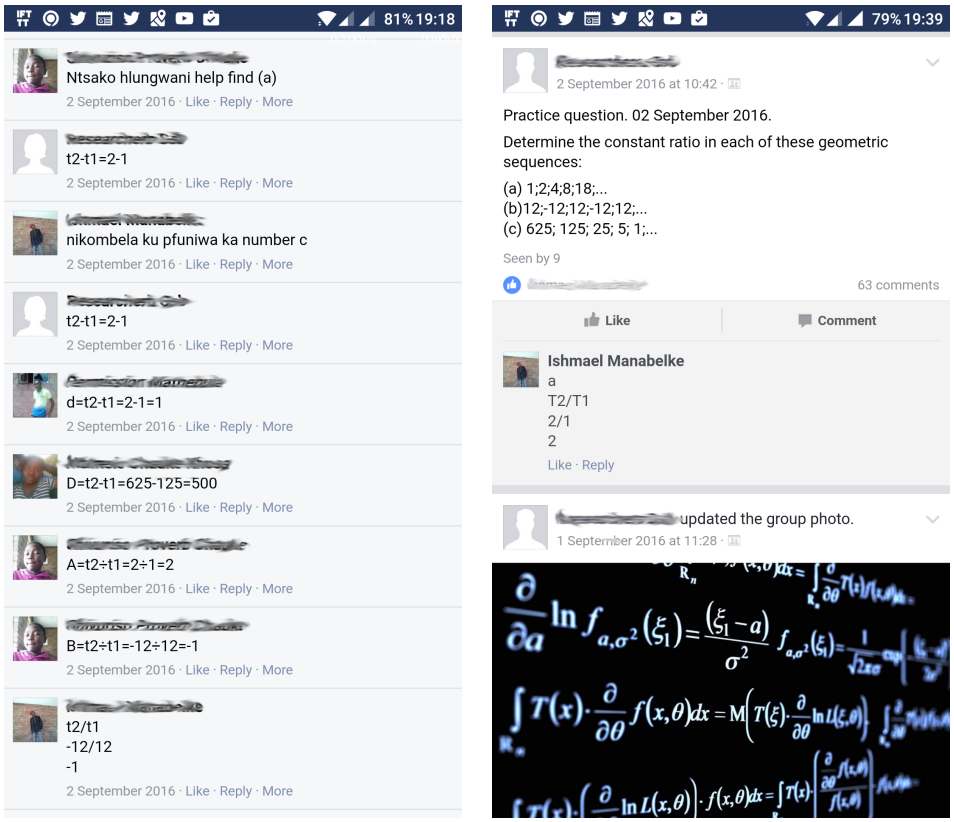

Figure 13: Left: Learners collaborating on the Facebook platform. Right: A Facebook post which generated 63 comments from learners.

According to P21.org (2012), *Communication and collaboration* skills require learners to be able to articulate mathematical concepts, critically listen to the reasoning of others and be able to work in teams. It is also about being able to communicate effectively through digital and media platforms.

- In the Mathematics club, learners had opportunities to communicate and to collaborate virtually through the Facebook **platform** (see Figure 13), something that was novel to the class and had never been used for learning before. This provided learners multiple opportunities to collaborate and communicate, as was discovered in the results in Section 8.1.

- **General interaction** was excellent in the Mathematics class as well as in the club. This provided learners with opportunities to communicate and collaborate, although not necessarily around academic content.

- However, when it came to **team dynamics**, learners in the Mathematics class did not actively participate, leaving only a few of the 'usual' learners to do most of the work in groups. This trend was completely reversed in the Mathematics club, and nearly all the learners were able to contribute to the group work given during the 'in class' sessions. This would have contributed positively to their group communication and collaboration skills.

- **Academic engagement**, both at school and home, in the Mathematics class was generally poor, and learners hardly ever worked in teams to tackle assignments after school. This gave them little opportunity to work in teams and collaborate. In the Mathematics club, however, learners self organised into teams. Furthermore, they used the Facebook platform to collaborate and critically evaluate each other's work, regardless of the physical location in which they were. This gave them numerous opportunities to practise working in teams and to collaborate.

- Learners had opportunities to access **relationships**, including peers, for learning purposes in the Mathematics class, and many reported that they had used these relationships to good effect, a positive sign for communication and collaboration, at least from this perspective. However, in the Mathematics club, learners also used the Facebook platform to extend their reach and access new relationships that they leveraged for Mathematics knowledge and insights. This not only gave them a new context (virtual) within which to communicate and collaborate, but it also seemed to scale these opportunities.

The summary of the analysis is given in Table 7. Based on the information provided, learners clearly had more opportunities to communicate and collaborate in the Mathematics club, compared to the normal class.

Skill	**Organising Theme**	**Theme**	**Effect (prior)**	**Effect (intervention)**	**Description**
Communication and collaboration	Platform	Platform benefits	N/A	Positive: Over 85% of learners	Learners enjoyed that they could talk to nearly anyone in the platform (Facebook) and potentially ask them for information.
Communication and collaboration	Class dynamics (non-academic)	General interaction	Positive: 100% of learners	Positive, 100% of learners	Class interaction was excellent on both the Mathematics class and the club. Learners had very few issues communicating verbally and in written form.
Communication and collaboration	Class dynamics (non-academic)	Team dynamics	Negative: Over 85% of learners	Positive: Over 90% of learners	The level of participation and communication from every member in the Mathematics club was noticeably higher than group work in the normal class.
Communication and collaboration	(Academic) Engagement	Class	Negative: Over 85% of learners	Positive: 100% of learners	Engagement in the Mathematics club 'in class' sessions was immeasurably more than in the normal class.
Communication and collaboration	(Academic) Engagement	Home	Negative: Over 60% of learners	Positive: 100% of learners	Learners often did not do homework, or participate in after school group activities in the Mathematics class. In the Mathematics club, all learners turned in homework. Learners also did work after school, even in groups, collaboratively on the Facebook platform.
Communication and collaboration	Context for learning	Relationships	Positive: Over 70% of learners	Positive: Over 95% of learners	In the Mathematics class, learners were able to access people (teachers, adults and peers) for assistance with maths problems, but within the club, learners approached new people through the platform. The open nature of the platform also encouraged collaboration.

Table 7: Effects on communication and collaboration

8.2.2 ICT and media literacy

According to Marilyn et al. (2012), ICT literacy is about using technology effectively to "research, organise, evaluate and communicate information" through the use of digital technologies like smartphones and laptops. Media literacy is about understanding media messages, how they are used and how they could be interpreted. This also includes an understanding of the ethical and legal issues with the use of media.

- In the Mathematics class, learners had little to no opportunity to work with ICTs and related media due to the **contextual challenges** that they faced. Learners were hardly ever exposed to ICTs whether they were at home or at school. In the Mathematics club, however, learners were exposed to ICTs and the Facebook social media **platform**, which gave them opportunities to practise these skills.

- The learners and teacher, surprisingly, continued using the Facebook **platform** to practise Mathematics questions even after the research was completed (see Figure 14). This would have given them even more opportunities to practise ICT and media skills, and it shows that they found the digital learning format helpful.

- The **relationships**, some of which were new, that they accessed in the platform would have helped them to practise media skills and the interpretation of information therein.

- The negative aspects of using the platform were the **contextual challenges**. Some learners struggled with access to a device to access the internet, and they often ran out of data bundles. Some learners also struggled with the formatting of the questions and answers on the platform. These cases would have contributed negatively to their experience and would have reduced the

opportunities they had to access the platform, thus limiting their development of ICT and media skills.

A summary of the results is shown in Table 8. Based on this information, learners clearly had more opportunities to practise ICT and media skills in the Mathematics club, compared to the normal class.

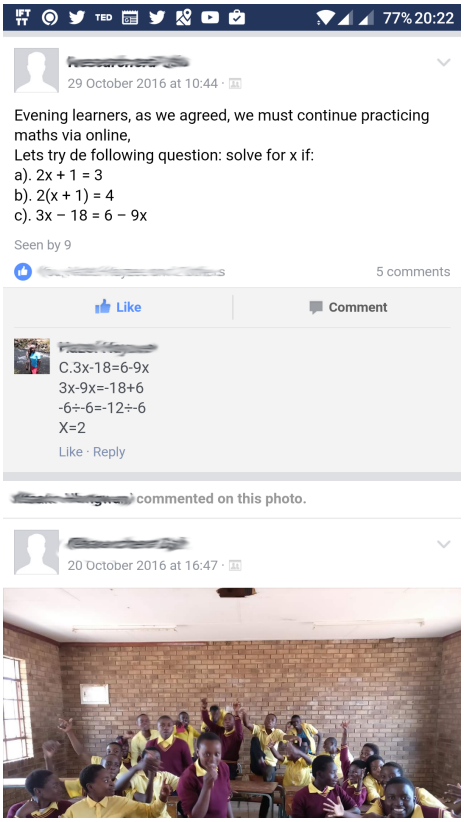

Figure 14: Teacher and learners decide to continue using Facebook to practise mathematics nearly 10 days after the research ended.

Skill	**Organising Theme**	**Theme**	**Effect (prior)**	**Effect (intervention)**	**Description**
ICT and media literacy	Context for learning	Location (School, home, virtual)	Negative: Over 90% of learners	Positive: Over 95% of learners	Learners have little to no access to ICTs in the current environment. In the club, however, learners leveraged rural resources for ICT and academic purposes. Learners used the platform to access new resources and people for assistance with assignments from home (virtually)
ICT and media literacy	Perceptions	Connected Learning Maths club	N/A	Positive: Over 95% of learners	Nearly all the learners reported that they enjoyed participating in the platform. For some, it was a first to use a social media platform for academic purposes
ICT and media literacy	Platform	Platform challenges	N/A	Negative: Over 20% of learners	Lack of data, mobile device, unfamiliarity and formatting of content on mobile were the top complaints about the platform
ICT and media literacy	Engagement	Platform	N/A	Positive: Over 95% of learners	Learners continued using the platform and getting better at it
ICT and media literacy	Context for learning	Relationships	N/A	Positive: Over 95% of learners	Learners were able to use a social media platform for academic and social purposes

Table 8: Effects on ICT and media literacy

8.2.3 Information literacy

According to P21.org (2012), information literacy is about identifying sources of data, accessing it, evaluating it and using it to answer questions. It includes the ability to use reliable web sources, media environments and physical sources to answer questions at hand and being able to share the information with peers (Marilyn et al., 2012).

- In the Mathematics class, learners had access to a limited variety of information sources. Learners could ask peers and adults (**relationships**) for extra information, as well as consult the teachers and the text book. However, the lack of a library at the school was not ideal, as learners had no physical space to source information. Learners could use virtual sources to access information, but the challenges regarding ICT and internet access limited their ability to do so. These challenges reduced the learners' opportunities to practise this skill, especially through internet and digital media. The teacher captured the issue well in the interview,

  > Teacher: Another thing is that most of this century requires learners to have certain things in order to reach the required standard. For example, a tablet so that a learner can be able to open certain information. ...but if they had a tablet, they could open the files on PDF and be able to practise.

- In the Mathematics club, learners also asked peers and adults (**relationships**), but they also leveraged the Facebook platform to ask even more peers and adults for assistance with Mathematics. Others leveraged other platforms (WhatsApp) to connect to people who could give them the information that they required. Since the questions were answered in an open environment, other learners also benefited from the extra hints, tips and information that was brought in. Some learners also leveraged the Facebook platform to consult

new relationships that they had never accessed before. All these actions show that learners had increased opportunities to practise information literacy compared to the normal class setup. The extract below captures some of the learners' responses,

> Interviewer: So what did you do when you needed extra information?
>
> Learner A: I asked my grandparent.
>
> Learner W: I sent someone my question on Facebook.
>
> Interviewer: Are they in this class?
>
> Learner W: No they are in a different class.
>
> Learner U: Ni pfuniwe hi mhani mhani ka WhatsApp.

A summary of the analysis is presented in Table 9. Based on the discussion above, the Mathematics club exposed learners to greater information sources by design, and gave them more opportunities to practise information literacy skills.

Skill	**Organising Theme**	**Theme**	**Effect (prior)**	**Effect (intervention)**	**Description**
Information Literacy	Context for learning	Relationships	Negative: Over 90% of learners	Positive: Over 60% of learners	Learners have little to no ICT access in the current environment, hence they rarely ever consulted other information sources to supplement what they are taught. In the club, however, learners were able to access Facebook and leverage that platform as well as other sources to acquire information.

Table 9: Effects on information literacy

8.2.4 Critical thinking, problem solving and decision making

According to P21.org (2012), critical thinking and problem solving is primarily about making complex decisions and being able to defend one's point of view. Learners ought to be able to "identify and ask significant questions", critically analyse and

reflect on their work and that of others as well as analyse and synthesise problems, or parts thereof, based on evidence. This ability has often been called systems thinking (Marilyn et al., 2012).

- During the interview, the teacher commented that learners in the Mathematics class could make decisions about their preferred method of solving mathematical problems. The researcher did not have an opportunity to witness this first hand. Admittedly, the more cognitive skills are harder to observe and are not always detectable based on visible external actions. Nevertheless, the teacher was very confident that learners were able to make these choices,

  > Interviewer: Are the learners able to make a decision on how to solve a problem, and follow up on the selected method? For example, if there are two ways to solve it, be able to select the one they feel most comfortable with and follow through with that?
  >
  > Teacher: Yes, a lot of them are able to do that. I'd say more than 90% actually prefer that - they like seeing different procedures so that they can select the ones they feel most comfortable with. There are still those that , of course, will still play a more active role, and we do still give them a chance to answer a question their way before we show them the teacher's way.

- The extract above shows evidence that learners in the current Mathematics class were applying critical thinking, and most certainly decision making regarding solving mathematical problems in the way they approached **production and learning**, and thus they had opportunities to practise this skill.

- However, from the perspective of **academic engagement** (see Section 8.1.3), the majority of learners in the Mathematics class did not participate in the class discussions. Most did not answer questions when asked by the teacher, and they in turn did not ask meaningful questions in class. From this perspective,

learners were not getting opportunities, or rather they were not using their opportunities, to practise critical thinking and problem solving.

- In the Mathematics club, learners continued to show evidence of decision making regarding the selection of the preferred method of solving a mathematical problem, just as in the normal class. However, learners also enjoyed being able to participate in an open platform where they could see others' comments, questions and the information that was shared. This helped the learners to be able to critically evaluate their work against that of others, reflect on their own work and make decisions regarding how best to solve the questions. This seemed to have added a new dimension to their approach to **learning and production.**

  Interviewer: How was the experience of being part of this Maths club?

  Learner E: It was nice because I could see others' workings on Facebook.

- In the Mathematics club sessions, learners were more **engaged** in the content, asking meaningful questions, responding to the teacher's questions and critically evaluating the answers given by other learners. This was one of the surprising results of this research. Learners that apparently did not participate much in class were engaged and turning in assignments on time. This culture of **engagement** from most learners in the Mathematics club also gave them more opportunities to practise critical thinking, problem solving and decision making, a culture which was not present in the Mathematics class.

A summary of the analysis is given in Table 10. Once more, learners in the Mathematics club appeared to have more opportunities to practise critical thinking, problem solving and decision making. The difference is largely due to the surprisingly high level of engagement in the Mathematics club, compared to the normal class.

Skill	Organising Theme	Theme	Impact (prior)	Impact (intervention)	Description
Critical thinking, problem solving and decision making	Production	Learning approach	Positive: Over 90% of learners	Positive: Over 90% of learners	Learners can make a decision about preferred method to solve problems. However, when answering questions in the platform, learners could easily reflect on their work and that of others. This contributed to a peer learning approach
Critical thinking, problem solving and decision making	(Academic) Engagement	Class	Negative: Over 85% of learners	Positive: Over 95% of learners	Learner engagement in the Mathematics class was generally poor, with few learners participating. The majority of learners in the Mathematics club were more engaged in the content, asking meaningful questions and giving thoughtful answers, even if not always correct.

Table 10: Effects on critical thinking, problem solving and decision making

8.2.5 Flexibility and adaptability

P21.org (2012) defines flexibility and adaptability as the learner's ability to "work in pairs and small groups" to tackle problems and be able to work with ambiguity and uncertainty.

- In the Mathematics class, the researcher had no opportunity to observe behaviours consistent with flexibility and adaptability, so it is difficult to say with certainty that learners did not exhibit this skill. In the Mathematics club, however, learners paired up in **teams** and small groups to tackle the questions on Facebook. The main motivation for this was that not all learners had access to a device that they could use to connect to the internet, and so got around the issue by working together.

- Learners also showed flexibility and adaptability by first writing the answers in their note books, and either borrowing a device from a friend to connect to Facebook, or joining a group of learners that did have a device. Given that

there were 16 Facebook accounts that were part of the Mathematics group, just under half of the class did not have access to a mobile device. Despite this, they still participated in the Mathematics club and sent in all their assignments on the Facebook **platform**.

The summary of the analysis is shown in Table 11. During the Mathematics club, learners showed signs of flexibility and adaptability.

Skill	**Organising Theme**	**Theme**	**Effect (prior)**	**Effect (intervention)**	**Description**
Flexibility and adaptability	Class dynamics	Team dynamics	No opportunity to observe	Positive: 40% of learners	Learners that did not have access to mobile devices that could access the internet paired up with those that did and tackled the problems together
Flexibility and adaptability	(Academic) Engagement	Platform	No opportunity to observe	Positive: Over 7% of learners	A few learners did the assignments on paper: got the questions from friends or the class teacher.

Table 11: Effects on flexibility and adaptability

8.2.6 Leadership and responsibility

P21.org (2012) defines leadership and responsibility as the ability to leverage the "strengths of peers to solve mathematical problems in the community".

- In the Mathematics class, the researcher did not get an opportunity to observe this skill, possibly due to the fact that observation happened in the classroom only. In the Mathematics club, learners took the **initiative** to self organise into **groups** and also help other learners complete the assignments on the online platform. Others elected students that they knew were good with Facebook as leaders of groups and completed assignments as a team,

  Interviewer: Who wrote down the answers for this group?

  Learner R: Another learner who is not here today. We chose them because they understood Facebook better than us.

The summary of the analysis is presented in Table 12. During the Mathematics club, learners showed signs of leadership and responsibility.

Skill	**Organising Theme**	**Theme**	**Effect (prior)**	**Effect (intervention)**	**Description**
Leadership and responsibility	Learner initiatives	Leadership behaviour	No opportunity to observe	Positive: Over 18% of learners	A few learners helped others with the assignments. 1 learner in particular helped at least 5 learners via the platform and in person
Leadership and responsibility	Class dynamics	Team dynamics	No opportunity to observe	Positive: Over 88% of learners	Learners took the initiative and self organised into groups to tackle the questions on Facebook.

Table 12: Effects on leadership and responsibility

8.2.7 Citizenship and social responsibility

A helpful definition of citizenship and responsibility comes from Marilyn et al. (2012), who state that it is about "participating in community activities, showing solidarity with the issues in the community and how they can be solved". This is linked with career opportunities, either within the wider country or in the community itself.

- In both the current Mathematics class as well as in the club, learners believed that mathematics was useful in the community, life and country. Several learners gave examples of how they have either assisted community members in the past, or how they could assist them in the future. The summary of the analysis is presented in Table 13.

Skill	**Organising Theme**	**Theme**	**Effect (current class)**	**Effect (intervention)**	**Description**
Citizenship and Social responsibility	Perceptions	Maths relevance	Positive: 100% of learners	Positive: 100% of learners	Learners believed mathematics was useful before and after the experiment

Table 13: Effects on citizenship and social responsibility

8.2.8 Initiative and self direction

Initiative and self direction is about learners' abilities to prioritise tasks and complete them on time, whilst keeping in mind past experiences in solving problems to guide future decision making (P21.org, 2012).

- It seems logical to assume that there are at least a few learners that may already be comfortable with this set of skills in the Mathematics class, but there were no obvious opportunities to observe them. This may be owing to shortcomings in the research design.

- In the Mathematics club, however, nearly all learners showed various levels of initiative and self direction by completing assignments on time, something that was not a feature in the Mathematics class. They sent in their assignments through the Facebook platform, and leveraged peer and adult relationships to assist in completing them.

- Learners in the Mathematics club also drew on past experiences in solving mathematical problems in order to participate in the club. All lessons taught in the club were revision, however, even the learners that historically did not participate in class or complete assignments, did so in the club. The extract below shows a learner who had allegedly never done homework before,

  Interviewer: How was the experience of being part of this Maths club?

  Learner V: It was nice because I had never written Homework before, but now that it was on Facebook, I find myself writing it.

  Interviewer: He had never written homework for real?

  Class: Yes (laughter).

Table 14 summarises the results of the analysis.

Skill	Organising Theme	Theme	Effect (prior)	Effect (intervention)	Description
Initiative and self direction	Context for learning	Relationships	No opportunity to observe	Positive: Over 85% of learners	Learners completed assignments on time. They also drew on past experiences to solve Mathematics questions in the club

Table 14: Effects on initiative and self direction

8.2.9 Productivity and accountability

Productivity and accountability is about setting goals and targets, prioritising them and meeting deadlines (P21.org, 2012). Although the definition is quite similar to that of initiative and self-direction, this one emphasises the number of tasks completed over a period of time.

- In the Mathematics class, learners not only failed to turn in assignments on time, but they also complained about the volume of work that they received, which is an indication of their lack of productivity.
- In the Mathematics club, nearly all the learners turned in assignments on time. Their productivity also increased as the experiment continued, as they managed to complete a relatively large number of questions. This was one of the surprising findings in the research, and it will be discussed further in the discussion section.

Table 15 summarises the analysis.

Skill	Organising Theme	Theme	Effect (prior)	Effect (intervention)	Description
Productivity and accountability	Production and learning	Assignments	Negative: Over 85% of learners	Positive: Over 95% of learners	Nearly all the learners turned in their assignments online and on time, as opposed to the normal class context where there was a general problem with homework being turned in late or not done at all.

Table 15: Effects on productivity and accountability

8.2.10 Creativity and innovation

Creativity and innovation is about finding new and alternative ways to solving problems, comparing them to traditional and other learners' approaches. Learners also need to have the ability to communicate these new found ways to others (P21.org, 2012; Marilyn et al., 2012).

- In both the current Mathematics class and the club, learners felt they had not answered any questions in any new way. During the interviews, when learners were asked about this, in both instances there was a certain quietness in the class that suggested learners did not have the answer. The teacher agreed with this observation, and had this to say about it,

  Teacher: Sometimes, maybe in which we can say, maybe 5% per term you will have some learners that will come up with something different. Usually, they bring methods that they have been taught in class. I think it is because they don't have someone helping them with homework. And they don't have somewhere where they can go after school to get help on subjects, including Maths.

The analysis is presented in Table 16.

Skill	**Organising Theme**	**Theme**	**Effect (prior)**	**Effect (intervention)**	**Description**
Creativity and Innovation	Production	New approaches	None: 100% of learners	None: 100% of learners	The majority learners reported that they had not come up with new ways to solve problems. This did not change in the club

Table 16: Effects on creativity and innovation

8.3 Summary

To summarise, this section began with a detailed look at the learning environment, both before and after the intervention was introduced. The analysis of the learning

environments revealed detailed features of each, and Figures 6 and 7 provide a helpful graphic overview of the findings. The features of the learning environments are then used as a basis for the analysis of the impact on the learners' development of 21st century skills. The analysis of the impact on each 21st skill was discussed in detail, with useful insights and examples from the experimental intervention to help strengthen the case. A summary of the impact is given in Table 17 (p. 117), which provides a helpful aggregation of the findings in this section. The next section is a detailed discussion and reflection on the findings of this study.

9 Discussion

9.1 Introduction

Thinking back to the introduction in Section 1, the main objective for the study was to investigate a means for equipping rural learners with 21st century skills, despite the inhibiting contextual challenges that they are often faced with. In reviewing the literature, it became clear that connected learning (Ito et al., 2013), both as a theory for learning and a framework for design, could be a potential fit for a rural context. Hlalele's work on rural learning ecologies (Hlalele, 2014a), provided the necessary theoretical grounding to locate connected learning within a rural context. However, despite the apparent fit of connected learning within a rural learning ecology, many questions still remained regarding its applicability in this context.

On a theoretical level, there was uncertainty regarding the way connected learning actually promotes 21st century skills development. The mechanisms by which connected learning leads to 21st century skills development were not sufficiently covered in the literature. This raised questions regarding whether these underlying mechanisms would still apply within a rural context. On a practical level, connected learning is best enabled through connected technology, something that is not readily available in many rural contexts. Connected learning was also conceptualised and mostly tested in the global North, in mostly (sub)urban and western societies (Ito et al., 2013). It has never been applied in a poor and rural context in the global South. This raised questions regarding its effectiveness within a rural context. It was unclear whether or not the technological and other general challenges in rural contexts would actually minimise, or even inhibit, the effectiveness of connected learning environments and the desired outcome of 21st century skills development.

These uncertainties necessitated a qualitative experimental design, through the use of an intervention called the connected learning Mathematics club[1], which allowed a study to be carried out with learners at Madonsi High School. This allowed the

[1]For the sake of consistency, Mathematics club refers to all activities in the research intervention.

researcher to investigate whether or not the connected learning intervention would indeed be conducive to the learners' 21st century skills development. The results of the study were presented in Section 8, and they seem to suggest that the connected learning intervention employed in this study was indeed conducive to the learners' development of 21st century skills. The implications of the findings are discussed in detail in the following sections.

9.2 The impact of connected learning on 21st century skills development

Table 17 is presented as the synthesis of the findings. It is an aggregation of all the results presented in Section 8.2. The table presents the suggested impact of the intervention, i.e. the connected learning Mathematics club, on the learners' 21st century skills development. It also compares the results with the impact that the learning environment in the Mathematics class[2] potentially had on the learners' 21st century skills development. The classification of the skills under simple banners from the literature review is included in the table, in order to make it simple to refer to a collection of skills.

A close examination of the results reveals evidence that, in general, the connected learning environment that was designed and used in this study was indeed conducive to the learners' development of 21st century skills. Based on the analysis, there were two underlying mechanisms by which the connected learning design used in this study promoted 21st century skills development. The first is by increasing and scaling the opportunities that learners have to learn and practise 21st century skills. The second is by promoting high learner engagement, which further intensifies and deepens the skills. These two mechanisms are explored further in order to understand some of the underlying causes and effects.

[2]For the sake of consistency, Mathematics class refers to all activities in the current class (prior to the intervention).

Classification	21st century skill	Suggested causal direction of impact	Comparison with impact the Mathematics class
Ways of working	Communication and collaboration	Positive	Higher
Tools for working	ICT and media literacy	Positive	Higher
	Information literacy	Positive	Higher
Ways of thinking	Critical thinking, problem solving and decision making	Positive	Higher
	Creativity and innovation	Neutral / (Negative?)	Same
Life and career	Flexibility and adaptability	Positive	Could not determine
	Citizenship and social responsibility	Positive	Same
	Initiative and self direction	Positive	Could not determine
	Productivity and accountability	Positive	Higher
	Leadership and responsibility	Positive	Could not determine

Table 17: Synthesis of findings on the impact of the intervention on 21st century skills development

9.2.1 Opportunities to learn and practise 21st century skills

A key theme that seemed to reoccur during the analysis of the impact on the individual skills is number of opportunities. It appears that, for the most part, learners in the connected learning environment received more opportunities to practise 21st century skills, something that may be attributed to the design of the learning environment. Table 7 (p. 100), on communication and collaboration, makes this observation clear. The connected learning environment gave learners multiple opportunities to communicate and collaborate, both in and out of class. Learners could communicate and collaborate (1) on the Facebook platform (especially outside of class), (2) in the classroom (both in a general and academic sense), (3) during group and self selected team work, (4) at home using the platform, either in a team or alone and (5) through the accessed relationships (e.g. peers, adults), many of which had never been leveraged learning purposes before. Contrast this with the Mathematics class, where learners only collaborated in class and accessed some relationships for learning purposes.

This observation can be seen in the analysis of the other skills, too. Table 8 (p. 103), on the effects on ICT and media literacy skills, shows a similar conduciveness of the connected learning environment. Despite the platform challenges, learners could still practise ICT and media literacy skills through the use of laptops, tablets and smartphones at home and school to access the Facebook social media platform. Learners were engaged on the platform, and they used it to access new sources of information for answering mathematics questions. Compare this to the normal class, where learners had basically no opportunity to practise ICT and media skills, admittedly due to the contextual challenges. Similarly, learners had more opportunities to practise information literacy, productivity and accountability, and critical thinking, problem solving and decision making skills.

In the analysis of the data from the Mathematics class (i.e. before the intervention was introduced), the potential impact of the learning environment on flexibility and adaptability, initiative and self direction, and leadership and responsibility skills, could not be determined. This therefore meant that it was unclear whether or not the learning environment was conducive to these skills. These same skills, however, were distinctly and clearly observed in the Mathematics club (i.e. during the intervention). Table 17 (p. 117) provides a helpful summary of this finding. It therefore isn't as straightforward to say that learners had more opportunities to practise these skills in the Mathematics club, compared to the Mathematics class, because there isn't a simple point of comparison. Despite this, it seems reasonable to assume that the trend of more opportunities to practise 21st century skills would have still applied, had there been a point of comparison. This is because the results showed that learning in the connected learning Mathematics club took place in substantially more contexts than in the Mathematics class. This suggests that, with all things being equal, learners would have also had more opportunities to practise flexibility and adaptability, initiative and self direction, and leadership and responsibility skills in the Mathematics club.

The really curious and odd finding has to do with creativity and innovation skills.

Interestingly, the trend of more opportunities to practise the skill did not apply, at least in this study, when it came to the analysis of the impact on the development of creativity and innovation. Both learning environments had little to no impact on these skills. In fact, it could even be argued that both learning environment setups may have even been detrimental to the development of creativity and innovation skills. This limitation on the development of these particular skills was likely caused by one of two factors; (1) connected learning environment designs alone are not the only requirement for effective development of 21st century skills such as creativity and innovation, and (2) the design of the research and the intervention may have had shortcomings that did not allow for the development or observation of creativity and innovations skills. Both of these possibilities are explored further in Section 9.2.3, where a deeper consideration of the impact on each of the skills is made.

Despite the challenges discussed above, the other results still suggest that connected learning environment designs give learners more opportunities to practise 21st century skills. This finding correlates with what Ito et al. (2013) say about connected learning experiences in their report. Ito et al. (2013) suggest that technology and new media ecologies have the potential to scale the number of connected learning experiences that learners have. This claim would seem to be validated in this study, but what is more interesting is that their suggestion seems not only to apply to connected learning experiences, but also to skills that learners develop while having the connected learning experiences. In the connected learning Mathematics club, learners could remotely connect and collaborate through the Facebook platform, which is a scaling of a connected learning experience that would normally only happen in person and perhaps in class. In this case technology allows it to happen anywhere, and on more occasions.

It also turns out that, because learners are using technology to have these connected learning experiences, they are also simultaneously developing the necessary tools for working in 21st century, such as ICT literacy. The same applies to other skills too. When learners collaborate virtually, they are scaling both connected learn-

ing experiences and the number of opportunities they have to practise the ways of working type of skills, e.g. by having increased opportunities to communicate and collaborate online using the Facebook platform. When learners are engaged with mathematics questions in class, at home, with friends and on the Facebook platform, they are both scaling connected learning experiences and increasing their use of the ways of thinking type of skills, e.g. by having higher levels of engagement in class and at home, they have more opportunities to critically engage with the content. The principle is easily applicable to the life and career type of skills as well, e.g. by working with peers and interacting with caring adults in the community, learners are both scaling connected learning experiences and increasing their citizenship and social responsibility skills.

9.2.2 High learner engagement: insights from learner preferences

A second and key observation that was a general feature in the connected learning Mathematics club is high learner engagement. Learners showed surprisingly high levels of engagement, both in and out of class. In the Mathematics club, learners were fully engaged in the lessons, asking meaningful questions and giving answers. This included learners that did not previously participate in the Mathematics class, as they all changed their attitude and got involved. The trend also continued after school, where learners used the Facebook platform to collaborate virtually and tackle mathematics questions. This was particularly surprising, because it was a well established fact among the group of learners, that not everyone did homework. Among those who did do homework, only a few would submit it on time. The complete reversal of this trend in the Mathematics club was even surprising to the teacher, who was amazed by the learners' behaviour. This is one of the reasons that motivated the teacher to continue using the platform with the learners even after the research was completed (Figure 8, p. 103).

One possible explanation for this positive change in learner behaviour could be the novelty of the classroom setup in the Mathematics club. Indeed, Campbell and

Stanley (1963) do warn about the artificial environment that interventions tend to cause in educational settings. Learners perceive the required behaviour, and thus they can easily emulate it in order to do what is expected. The use of technology and social media, something that had not been done in that context, would also have increased the artificial feel of the experiment, thus skewing the results and making it seem as if the engagement came as a result of the intervention. However, carefully designed steps (see Section 7.3) were followed in this study to limit the effects of such internal validity threats. Furthermore, the technology used in the intervention was sourced from the learners' community, which would have gone a long way in lessening the charm with technology. Facebook itself, although the learners had never used it for educational settings, was familiar to some learners, either through having had some contact with it in the past, or having seen a friend use it. These factors would have reduced the novelty of the intervention, but probably not completely. In the end, it is probably impossible to completely eliminate the artificial nature of interventions.

Despite the novelty of the connected learning Mathematics club, there is one other alternative explanation for the high learner engagement. During the analysis of the data from learners in the Mathematics class, certain codes kept reappearing under the themes *perceptions* and *learning context*. One of the findings of the data from the Mathematics class was that learners preferred doing assignments and other group work at home, signifying a need to bring different contexts for learning closer together. In reality though, the learning that occurred in the Mathematics class was often limited to the classroom context only, as learners reported that they hardly ever received group work for after school. Learners were also generally unhappy with the Mathematics class, citing reasons of difficulty and not following the teacher, amongst others.

In the Mathematics club, however, the same codes appeared, but this time learners were commenting about enjoying doing assignments after school, at any time and with any of their peers, whether they were physically sitting together or collaborat-

ing virtually on Facebook. In fact, when learners were asked when they did their homework, nearly all of them commented that they did it at home, and not during the mandatory study period (a two hour session at the end of the day where learners are expected to study and complete assignments). Learners also expressed a strong preference for the learning format in the Mathematics club, with many citing reasons such as being able to collaborate with peers, being able to see what others are doing and being able to easily ask people for assistance.

The discussion above suggests that there is a fundamental mismatch between the way learners want to learn, and the way the learning environment in the Mathematics class is setup. The learning environment is designed in such a way that learners mostly learn at school and complete most of their assignments and studies at school. However, learners want to learn not only at school, but at home as well. They want to be able to learn after school, with friends and be able to access assistance from peers and other people when they need it. The design of the connected learning Mathematics club seems to fit more closely to the way learners want to learn, by allowing learning to take place in different, and even diverse, contexts. This led to learners being more highly engaged, not just in class, but outside of the classroom as well.

This observation is supported by the literature, such as the work of Taylor and Parsons (2011). They did a thorough literature review of student engagement, and found that one of the key factors that drive learner engagement is interaction. According to them, interaction with relationships in a personal and virtual context drives learner engagement. They also found that multimedia and technology drive learner engagement, too. Learners who use technology and media to learn are more likely to be engaged than learners who do not. The connected learning Mathematics club design encouraged both interaction and use of technology through openly networked media for learning purposes, which explains the high levels of learner engagement.

Looking back at the analysis and results presented in Section 8.2, it can be seen

that engagement was a key driver for the development of the ways of working, ways of thinking, tools of working and life and career skills. On the ways of working skills, high levels of learner engagement meant that students were collaborating around academic content both inside and outside of the platform. It meant that the quality of group work was high, and that all group members participated. On the ways of thinking skills, high engagement meant that learners could critically engage with the content, ask meaningful questions and provide answers to questions. It also meant the contributions on the Facebook platform were meaningful. On the tools for working skills, learners were highly engaged on the platform, meaning they could practise ICT, media and information literacy skills.

On the life and career skills, high engagement meant that learners were committed to completing assignments on time, and they showed a great deal of flexibility and adaptability in answering questions on a new platform that they had never used before. The learners also found ways to source devices that could connect to the internet from within the community in order to participate in the connected learning Mathematics club. The high learner engagement also drove the learning of social and cross-cultural skills, as learners had to communicate and collaborate with peers, as well as access relationships, some of which were new, for assistance with mathematics questions. Based on the evidence, and the discussion in the preceding paragraphs, it would seem that high learner engagement is a prerequisite for 21st century skills development, and connected learning environment designs encourage high levels of learner engagement.

9.2.3 Equal impact on all 21st century skills?

It is already clear that the model of 21st century skills development based on connected learning works by (1) scaling the number of opportunities to learn and practise 21st century skills and (2) increasing learner engagement, which intensifies the learning that takes place in each of the opportunities. The next logical question to ask is, did the intervention have equal impact on all the skills?. The obvious answer is

no, but the reasons why shed light on the causal links between connected learning experiences and 21st century skills development. Table 6 (p. 96) on the distribution of codes grouped under each 21st century skill suggests that the impact on the ways of working and tools for working skills is significantly higher than the impact on the other skills. Specifically, the distribution of codes grouped under communication and collaboration was 27,5%, 25,0% for ICT and media literacy, and 10,0% for information literacy. The rest of the skills had distributions of 5,0% or less. This phenomenon is investigated further, in order to unearth further insights.

Table 7 (p. 100) shows that the number of learners that exhibited the ways of working (communication and collaboration) skills was consistently high no matter which feature of the learning environment the analysis was done from. In each of the features, a positive impact on at least 85% of the learners was achieved, with most having an impact all the learners. Out of all the skills that were observed, communication and collaboration were the ones that were observed the most. Given that this is a goal of connected learning, i.e. to connect learners within a learning ecology, this result is perhaps to be expected. The surprising part, however, was just how much communication and collaboration occurred between the learners. It would seem that, based on this result, the contextual challenges had little to no effect on their ability to learn and practise communication and collaboration.

When it comes to ICT and media literacy, table 8 (p. 103) shows that over 95% of learners exhibited these skills. This result is encouraging because learners had little opportunity to practise these skills in the Mathematics class, due to the contextual challenges. With the use of technology sourced from within the community itself, learners were able to reverse this trend in the Mathematics club, and progressively become better at using ICTs and media for learning purposes. However, threats to learners acquiring these skills still did exist in the Mathematics club, as shown by the technological challenges that some learners experienced. Just over 20% of learners complained about the platform being difficult to navigate, lack of internet access and poor formatting of information on their mobile devices. Despite the overwhelming

impact on ICT and media literacy skills, connected learning designs in rural areas still have the contextual challenges to contend with (see Section 9.3). This shows that a poor consideration of the contextual and technological challenges could actually have a negative impact on learners.

Information literacy skills were exhibited by over 60% of learners, as shown in Table 9 (p. 105). This is a big improvement compared to the previous class where the majority of learners had little opportunity to practise information literacy, especially given the lack of a library, internet and ICT access at the school. It is curious that the learners that exhibited information literacy skills were only 60%, given that as much as 95% showed signs of ICT and media literacy, which is a related skill. One possible answer to this could be that learners were still getting used to finding and discovering online information and navigating the different sources. Given the limited time-scale of this study (just over 2 months) and the fact that the learners were told to collaborate on Facebook, this possibly did not give them enough time and horizon to explore other online sources (e.g. web search, online courses, dedicated mathematics sites, etc.). The researcher would expect this skill to improve over time, and more learners would learn and practise it.

On critical thinking, problem solving and decision making, it is curious that in both the Mathematics class and the club, nearly all learners (90%) could make a decision about the preferred method of solving mathematics questions. It would seem that for this particular aspect of these skills, the intervention had no better an impact than the current environment (Table 10, p. 108). Where the intervention did have a better impact on these skill, though, was due to critical learner engagement in class (Section 9.2.2). This led to learners critically engaging with the content, asking meaningful questions and giving meaningful answers. So, although decision making did not seem to improve in the connected learning Mathematics club, critical thinking and problem solving drastically improved. Over 95% of learners exhibited signs of critical thinking and problem solving in the Mathematics club, compared to over 85% of learners who did not exhibit these skills in the Mathematics class.

On flexibility and adaptability, between 7% and 40% of learners showed signs of these skills (Table 11, p. 109). Learners that did not have mobile devices that could access Facebook joined up with those that did, by forming teams, which led to a hybrid of physical and virtual teams. Others decided to write the answers on their note books (just over 7%), foregoing the use of Facebook due to challenges with internet access. This finding suggests that the contextual challenges in rural areas may actually contribute to learners practising certain 21st century skills, as much as they may be a detriment to practising others. Flexibility and adaptability skills appear to be context specific, and they may look different for learners in an urban school. In this study, the contextual challenges appear to have been the main contributing factor to learners practising flexibility and adaptability.

On leadership and responsibility, up to 88% of the learners exhibited these skills, and this was largely around the self organisation into groups to tackle the mathematics questions. Learners were given no specific mandate to do this, they simply went ahead and formed groups, and appointed people in certain roles (e.g. somebody to write down all the answers or to find extra information). Just over 18% of the learners also took a more proactive approach by helping their peers answer the questions, especially online. Based on this finding, it would seem that connected learning environments are ideal for (rural) learners to practise leadership skills, as they not only get a chance to do it in a physical environment at school or home (group work), but they also get to practise this skill in a virtual environment, which is an important skill for 21st century employment (Dede, 2010). Learners also seemed to respond to rural challenges, such as limited access to ICTs, by banding together and helping those that struggled.

On citizenship and social responsibility, the one key aspect that sufficiently came out from the interviews was the learners' perceptions on the relevance of mathematics in society. In both the Mathematics class and club, learners believed mathematics was very relevant to their community, and to society in general. This perception is quite aligned with one of the goals of connected learning, in that it places learners

within their context, thus connecting them to the social challenges in their community and society. It seems that, the teacher in the mathematics class had already done a great job in in connecting the local community challenges to the mathematical concepts and content in the class. And thus, citizenship and social responsibility skills came out equally strongly in both the Mathematics class and club (100% impact in both cases).

On initiative and self-direction, learners completed assignments on time and drew on past experiences to answer questions in the Mathematics club. This is possibly due to the increased learner engagement, as discussed in Section 9.2.2. It seems that the majority of learners dug deep within themselves to answer questions using a variety of techniques. Some even completed assignments for the first time. This result suggests that connected learning environments also encourage deep personal reflection and growth, and not just an increase in a learner's social skills. It is hard to determine the exact extent to which learners exhibited these skills in the intervention, but it is encouraging to see them regain some sense of purpose and direction for mathematics, especially given that many had given up all hope and aspirations about excelling in the subject. In the Mathematics club, just over 85% of learners showed signs of these skills.

Closely coupled with initiative and self-direction is productivity and accountability, where over 95% of learners (Table 15, p. 112) completed the assignments when it mattered. This is in stark contrast to before, where the majority of learners did not do homework on time, and some, not even at all. Again, the researcher points to the possible explanation of higher learner engagement (see Section 9.2.2) as a cause of this behaviour. However, it appears to be more than just engagement, as learners seem to have rediscovered their passion for learning in the Mathematics club. The research questions and goals of this research do not allow a research design that would give further insight into this, and possibly this insight could only come after such a study. The researcher simply points to one of the individual outcomes of connected learning, i.e. "greater depth and breadth of interest" as a possible phenomenon that

was observed during the intervention (Ito et al., 2013, p 56). The majority of learners appeared to have found a new and deeper appreciation for mathematics, and this could possibly lead to a rejuvenation of learning in other subjects, too.

The last set of skills to consider are creativity and innovation. Table 16 (p. 113) shows that there was little or no impact on these skills during the intervention. This lack of impact is rather curious, especially since there was at least some minimal impact on the other skills. One reason for this may be attributed to the difficulty of assessing creativity and innovation skills (Lai & Viering, 2012; Marilyn et al., 2012). The definition of creativity and innovation skills used in this study (P21.org, 2012) may have been a limiting factor itself, as there is no general consensus on it in the literature (Lai & Viering, 2012). This, including the researcher's perception of what creativity and innovation are, may have influenced the observation and analysis of the data. Perhaps the learners were innovative, even creative, to source old laptops, smartphones and tablets and repurpose them for educational purposes. As Lai and Viering (2012) note, both environmental and cultural factors play a role in an individual's creative potential, as well as the ability to interpret what is creative output. A second reason may be that creativity and innovation, and the ways of thinking skills in general, require an environment where the teacher encourages them, and activities and tools are used to allow learners to develop them, something that was not necessarily part of the connected learning Mathematics club. The combination of the factors above may have led to the lack of observation of creativity and innovation skills.

Based on the extensive discussion above, the intervention did not have an equal impact on the development of all 21st century skills. The main reasons for this in this study can be summarised as follows: (1) Not enough time was spent observing each skill, but clear potential to develop them further existed, e.g. information literacy skills would probably have developed more over time. (2) Technological challenges, where these played a limiting factor in some respects, e.g. these limited the development of ICT and media literacy. (3) Certian skills require more than

just a learning environment design. They require an entirely new teaching approach (Saavedra & Opfer, 2013). In this study, no changes were made in this regard, which may have affected the development of skills such as creativity and innovation. (4) Contextual challenges, which include technological challenges that have already been discussed, but extend wider to cover the socio-economic environment within which the school finds itself. Curiously, the contextual challenges may also provide learners with opportunities to practise skills such as leadership and responsibility, and flexibility and adaptability. The impact on the 21st century skills development in this study may have followed the distribution of codes as suggested in Table 6 (p. 96), but this is due to factors one to four which, had they been addressed, would have seen a different result. This suggests that connected learning alone is only part of the solution to 21st century skills development, and that other measures, both practical and pedagogical, need to be taken into account to design effective 21st century learning environments for rural learners.

9.3 The challenges of implementing a technology supported connected learning environment in a rural school

As can be expected, the introduction of any 21st century learning environment in a rural school context will bring with it a set of challenges. The main challenges experienced during this study are related to teaching, technology and practical design. These three challenges are discussed briefly, and each is related to the broader outcome of 21st century skills development. Firstly, during the intervention, the teacher at the school had an obvious tension between what was expected of him from the school management and dedicating time to support the intervention. It is not that the teacher did not want to support the research, he did and his support was appreciated, but often he had to go out of his way to accommodate the intervention, often sacrificing precious time normally dedicated to other important tasks. Given that teachers in rural contexts are also faced with extraneous conditions that may

affect morale (Hlalele, 2012), the increased time commitment that many 21st century learning environments demand is still a challenge that needs to be addressed. When one also considers that there is still the need to train teachers in the technology and pedagogical design required to teach in such an environment, it becomes obvious that this is a potential point of failure for such interventions in rural contexts.

The challenges could become more pronounced depending on the level of integration of the learning environment into the pedagogical practices of the school. To illustrate, the intervention used in this study was run in the afternoon after formal classes, but within the study period so as not to make it inconvenient for the learners and the teacher. What was taught in the classes was essentially revision of material that learners had already covered (something that the teacher had to facilitate anyway), and assignments would then be posted on Facebook at the end of the day for learners to answer on the platform. However, had the intervention been more deeply integrated, affecting how the normal syllabus was taught and how normal assignments were given, it would have had a far greater impact on the teacher. Other potential issues exist too, as discussed in the literature review, but increased time commitment from the teacher was something that stood out noticeably during the intervention. Somehow, the introduction of 21st century learning environments in rural schools will need to be accompanied by a reordering of the tasks that teachers need to perform, carefully eliminating those that are no longer required, whilst introducing those that support the new pedagogical practices. Without this, interventions in this context may fail over time, and the learners will be the ones who pay the price.

The second set of challenges are technological, and these affected both the learners and the teacher. For the learners, the use of smartphones, tablets and laptops to access the connected learning Mathematics group on Facebook was exciting and attention grabbing, but some did experience issues. For starters, it is difficult to guarantee a consistent formatting of the content on Facebook when learners use different devices, with different form factors to access it. Consequently, some learners

complained that they could not understand how the mathematics questions were written on Facebook, which was a notable negative experience. Others struggled to navigate the platform because trying to find a specific post on Facebook is not as easy as going to a specific page in a text book. The biggest technological challenge, though, was the general lack of internet access at the school and in the community. Some learners complained that they could not participate in the discussions because their data bundle had run out, and they did not have money to buy more. The school has no internet facility, so learners could not use that as a backup plan. To get around this, a mobile Wifi router was set up and left with the teacher so that learners could continue to access the internet. The teacher, too, had some issues with technology, though not as severe. He struggled with internet access, especially when he was away from the school. Eventually, he used his own personal mobile Wifi router to connect to the Facebook group.

Admittedly, these issues were expected, as the challenges with ICT access in this context are well documented in the literature (Dzansi & Amedzo, 2014; Mathevula & Uwizeyimana, 2014; Hlalele, 2014b; Dlodlo, 2010). The lack of access to ICTs in many rural schools is a threat to the learners' 21st century skills development. As Saavedra and Opfer (2013) note, technology is an essential component in learning many 21st century skills, and without it, skills such as ICT, media and information literacy become almost impossible to learn. These challenges partly justify the actions of many organisations that seek to donate ICTs to rural schools. However, as noted multiple times in the literature, the issue is not just lack of access to ICTs. It is also the lack of training of the teaching staff, and an inherent incompatibility between the introduced technology and the established pedagogical practice. Therefore, ICTs that have not been properly integrated into the school often leave more problems than they seek to solve (Dzansi & Amedzo, 2014).

One positive that came out of this study was the use of technological resources acquired from within the community itself. This helped bypass many of the challenges that come with donating technological assets from the outside, such as having

to train the learners and the teachers how to use them. As Hlalele (2014a) suggests about the sustainability of rural learning ecologies, the inherent rural assets need to be leveraged and maximised for educational purposes, and studies like this show that it is certainly possible. Another possible approach may be a hybrid model of using local assets, and only donating those that are absolutely essential, such as a mobile Wifi router. In the end it is about agency, and the more the local people participate in solving the issues in their context, the more agency they will have and the greater the chance that educational interventions will have to succeed (Balfour et al., 2008).

The last set of challenges have to do with the practical design aspects of introducing a connected learning environment. Many questions need to be considered when introducing the intervention, including the role that technology should play in the design. What about the level of integration that the intervention should have into the pedagogical practices of the school? What about privacy? Plagiarism? Technology's role needs to be carefully considered so as to not make the intervention overly dependent on expensive implementations to run effectively. The researcher's experience from this study is that technology is just a support, and that learners participate in connected learning environments for the sake of connection with peers and other caring adults. The technology itself disappears as it were, and only acts as a conduit to allow scaled connections and interactions. The level of integration needs to be considered too, as a deeper integration into pedagogical practices in the school will imply a more expensive setup upfront, including the costs to train the teachers and learners. Perhaps interventions that do not significantly alter how things are done are best in this context, so as to allow for a soft landing for the teachers and the learners. A carefully considered and deeper integration can then be done over time.

As with any internet related activities in the 21st century, privacy becomes a big issue. Regardless of whether we believe Facebook's privacy policies are adequate or not, for instance, the potential of learners giving up bits of their personal information for the sake of advertising is an ethical question that needs to be addressed, or at

least a position needs to be taken early on and communicated to the stakeholders. During this study, one of the most disturbing aspects were the Facebook ads that appeared on the side of the group, some of which the researcher personally felt were inappropriate. We need to be careful not to sacrifice the learners' rights to privacy for education. Better solutions may exist, for instance, that use custom and closed platforms, but those tend to go against the connected learning principle of 'openly networked'. Ryan (2014) suggests helpful tips for designing a classroom environment that uses Facebook, such as only using learners' first names and familiarising learners with the pitfalls of social media. A cautious and professional use of social media may be the key to succesful use in education settings (Ryan, 2014).

To close off the discussion on the practical challenges, the issue of plagiarism is looked at briefly. Although this did not seem to be a big challenge during this intervention, openly networked designs allow for easy plagiarism. For instance, one learner posted an answer on Facebook, and another learner posted the same answer, almost word for word, directly below the original. The original poster called out the contravening learner immediately, which led to an exchange about whose answer it was. This is one pitfall of openly networked designs, although many would argue that the benefits of keeping everything open far outweigh the pitfalls.

Perhaps the trick is to keep the openly networked design, and use such learning environments for revision purposes, as was done in this study. In the case of revision, you would want learners to learn from one another and have critical discussion. If the requirements are for more than just revision, then perhaps practise questions from the active curriculum can be posted onto an openly networked media platform for learners to collaborate and practise. The questions that count for marks could then still be assessed in a more traditional way. Again, closed and networked systems do exist, but such designs tend to minimise the network effects of connected learning. New research by Chu (2014) shows how social media can still be used in a "plagiarism free" manner, whilst still keeping the benefits of 21st century learning environment designs. Whichever method is chosen, plagiarism is an issue that will need to be

addressed in openly networked and media dependent connected learning designs.

Having had a deep and thorough discussion on the impact of the intervention on the learners' 21st century skills (Section 9.2), as well as the discussion above on the challenges of implementing a technology supported connected learning intervention in a rural school, the next step is to discuss the implications of the research in the following section. This will allow the various concepts in the discussion to be pulled together and unified towards the conclusion.

9.4 Implications of the research

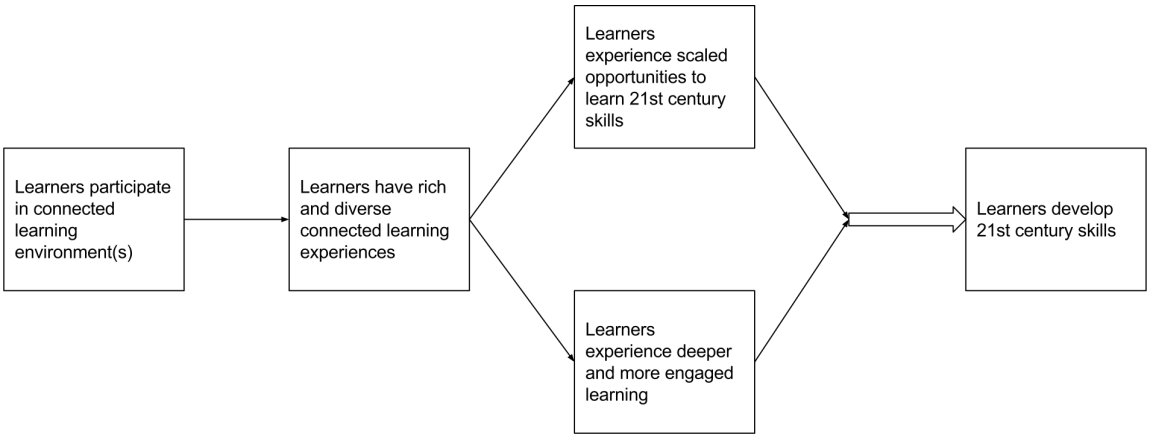

Figure 15: A suggested and revised model for 21st century skills development based on connected learning

The researcher begins this section by revisiting the theoretical framework discussed in Section 5, and the theoretical model in Figure 2 (p. 50). In the framework discussion, questions about how exactly connected learning leads to 21st century skills development were raised. The application of connected learning in a rural context is, as far as the researcher is aware, novel in South Africa, which raised questions about the contextual and technological challenges that this context might bring, and how these might potentially limit the impact of the intervention. The researcher presents a further revised model for 21st century skills development based on connected learning in Figure 15. The technological and contextual challenges are still relevant in a

rural context, however, as this study has shown, they need not be a hindrance to the development of 21st century skills. The brief discussion that follows will be based on this model, and it is a synthesis of the detailed discussion outlined in the preceding sections.

9.4.1 Implications for theory

1. 21st century skills development based on connected learning works by scaling the number of opportunities that learners have to practise 21st century skills. As it turns out, the scaled connected learning experiences that learners have by participating in connected learning environments, often also put learners in situations to learn and practise 21st century skills. This is consistent with the research by Ito et al. (2013), which states that new media ecologies and technologies scale connected learning experiences, which, as shown in this study, have the effect of scaling 21st century skills learning opportunities.

2. 21st century skills development based on connected learning also works by increasing learner engagement, thus intensifying the connected learning experiences that learners have. These intensified connected learning experiences also deepen what the learner learns, including 21st century skills.

3. Despite the contextual challenges that learners face in rural contexts, these same challenges can actually be leveraged to further reinforce certain 21st century skills. The discussion in Section 9.2.3 shows that skills such as flexibility and adaptability, and leadership and responsibility can actually be harnessed using the very challenges that would appear to suppress certain 21st century skills.

4. Connected learning can play a role in creating and sustaining rural learning ecologies, as stipulated by Hlalele (2014a). Evidence from the study shows that when learners have media infused opportunities for learning, it opens and scales up their reach to important resources within the community, which they

can leverage for learning. Clearly, connected learning cannot create an entire learning ecology, many other aspects need to be considered, but it can play an important role in its sustainability.

9.4.2 Implications for research

1. A proper understanding of 'rurality', a context which is often misunderstood due to its multifaceted complexities and dynamic nature, is important for any research in education done in that context. Conceptualisations of 'rurality' such as those given by Hlalele (2014b) and Balfour et al. (2008) provide useful starting points for researchers (and even practitioners) wanting to venture into this area. In this study, the asset based view of 'rurality' (Moletsane, 2012), for instance, forced the researcher to forego potential opportunities to bring in donations in technology into the school, in order to ensure that agency is co-created and left with the research participants.

9.4.3 Implications for practice

1. Maximising rural assets (Hlalele, 2014b). This research has shown that using local assets for learning is not only possible, but also key to the sustainability of interventions in rural contexts. Any practitioner seeking to introduce a connected learning environment in a school, should consider integrating available community assets into their design. As Balfour et al. (2008) note, education is a placed resource, and connected learning connects learners within their own local ecology - the combination of which inherently strengthens the design and reinforces it within the community. In this study, only locally sourced technological assets were used as part of the design, however, broader assets such as community members, families and others could also be integrated to strengthen the design of interventions.

2. Connected learning alone is not sufficient for the development of rural learners'

21st century skills. Besides the integration of rural assets, the way learners are taught, and the activities that they participate in at school, also matter. Even though connected learning environments have the advantage of creating highly engaged and collaborative learners, skills such as creativity and innovation still need to be taught intentionally by teachers in order to see results. Saavedra and Opfer (2013) give helpful insights about some of the required teaching practices.

3. Technology should play a support role in creating connected learning environments (Ito et al., 2013). More than this though, practitioners seeking to introduce a connected learning intervention should find ways to make the technology disappear as it were, so that learners are consumed with the task of learning, not figuring out the technology. This applies equally to teachers, and an intervention that successfully does this is likely to see long-term sustainability and potentially reduced issues (especially training related) in the beginning. In this study, this was achieved by allowing the learners and teacher to use their own mobile devices to participate in the intervention, which nearly eliminated the need for training. Of course, minimal training had to be done on the use of Facebook, but many already had some idea of how it worked, thus lowering the burden of training.

   There are certain pitfalls to using locally sourced technological assets, such as the lack of a guarantee of a consistent experience for every user. Perhaps a useful model is a hybrid one, where only the necessary technology is brought in from the outside in order to guarantee consistent experiences, whilst others could still be sourced from within the community. This will also depend on the specific challenges in the community, as no one rural context is the same as another.

4. Finding ways to ease the burden on teachers is crucial, because many 21st century learning environments bring an extra burden to the teacher, who is

usually already overworked. Practitioners need to find ways of working with the school management to carefully design the tasks that a teacher should perform, so as to eliminate those that are inefficient. This is something that was not done in this study and it proved to be a challenge.

5. In conjunction with the item above, deciding on an appropriate level of integration of the intervention into the pedagogical practices of the school is important. The deeper the level of integration, the more costly the exercise will be, and the more burden will potentially be placed on the teacher. Perhaps starting with a low level of integration is best, such as was done in this research, where the connected learning environment was essentially an after school club which had little impact on the running of the school. Even with this low level of integration, however, the burden on the teacher was still substantial, hence the need for careful planning.

6. With any openly networked 21st century environment design, questions about plagiarism will be raised. This needs to be considered. In this research, only revision questions were posted onto the Facebook platform, which lessened the impact of learners copying. Other designs can consider more closed environments, but the scaled effects of being openly networked can then easily be lost. For this research, where the ultimate goal was 21st century skills development, keeping it openly networked was ultimately the right way to go, as any other design would have minimised the opportunities to learn 21st century skills.

7. Lastly, common pitfalls of open media platforms, and the internet in general, include the possibility of learners being exposed to inappropriate advertising, or even threats to their privacy. Researchers like Ryan (2014) do outline ways to minimise this risk, but it does still exist. Practitioners seeking to introduce 21st century learning environments will need to carefully consider how they will deal with these important issues. They will need to take an ethical stance on privacy, inform all stakeholders, and work together with them to ensure the

safety of the learners online.

9.5 Limitations of the research

As can be expected with any research into a complex phenomenon and framework for learning, (connected learning), in a new context, (rural), many challenges are bound to exist. These are outlined in this section as a way of informing the reader of some of the limitations of the research.

1. *Methodology.* The chosen methodology has been sufficiently justified in Section 6, the crux of which was to explore the causal links between connected learning environments in rural contexts and 21st century skills development. However, a qualitative and experimental design, which puts forward qualitative methods and relegates quantitative methods to the background (also known as mixed methods intepretivism (Howe, 2004)), has its pitfalls. For starters, it is difficult to say that causality has been established between two variables, and to what degree. As a result, only causal descriptions can be given through the chosen methodology. These are useful in understanding more about how the causal mechanisms work, but they are less useful in actually establishing it. At the same time, however, quantitative (summative) assessments of 21st century skills are complex, and riddled with their own issues. In the researcher's experience, these are mostly designed for learners that are already learning and practising 21st century skills, and not necessarily for those that are just beginning their journey. Hence, the researcher chose a more formative approach to the assessment, and depended a lot on definitions given by popular frameworks like P21.org (2012), which were used as a rubric to judge and evaluate the observed skills of the learners.

2. *Degree of impact.* Coupled with the discussion above, the methodology used in this research could therefore not answer the question of degree of impact of 21st century skills development, thus failing to answer the question by Ito et al.

(2013) on the "degree to which connected learning experiences result in these forms of deeper learning".

3. *Data collection and analysis.* The researcher did not have access to the learners for one on one interviews (time constraints imposed so as to not affect the classroom proceedings). This meant that group interviews were done in a round robin manner, allowing each learner to answer each question individually. The researcher still did have interactions with individual learners on an ad-hoc basis during the course of the intervention, but never in a structured way, such as done in the group interviews. This may potentially have influenced learners to answer questions in a particular way, although multiple sources of data were used (Facebook; observation; teacher and learner interviews) so as to reduce the impact that this might have had. As is typical with connected learning studies, triangulating data from Facebook to data captured during the interviews was hard work, especially because not every interaction that learners referred to would be captured on Facebook. Some were in person.

4. *Time.* In hindsight, an ethnographic study over a period of 12 to 24 months, such as done by connected learning studies like the one from Bilandzic (2016), would have allowed for a deeper study and reflection of the learners in their own environment, especially before the intervention was introduced. A similar length of time could then be spent observing learners in the intervention, in order to allow for enough time to observe some of the skills. Due to the intervention used in this study only lasting for a period of two months, certain skills could not be observed properly, and many would likely have been developed further by learners, given the time. In the end, it is as Kumpulainen and Sefton-Green (2014) stipulated, connected learning research is challenging because of trying to track people's experiences in their learning lives, which is practically impossible to do completely, at least at the moment. New techniques to conduct connected learning research, such as the connected learning

analytics toolkit, which pulls data from social media and analyses it automatically (Kitto, Cross, Waters, & Lupton, 2015), are being developed and they may well make this task easier in the future.

5. *Complexity.* This research was arguably complex for two reasons. Firstly, not only did the researcher have to observe learners in a connected learning environment, but the entire environment itself first had to be designed, introduced and piloted with little testing. Although the researcher believes the design adheres closely to connected learning principles, it is hard to determine the impact that this design had on the outcomes. Was it a good design? Was it bad? This is the risk that comes with experimental research. The second complexity had to do with trying to evaluate the impact of the environment on many 21st century skills. Having said this, 21st century skills are increasingly studied as a singular concept, because researchers often need to make generalisations about learning environments that are conducive to all 21st century skills. This does, however, mean that researching all the skills is challenging, especially without well defined and standard tests that are relevant to a rural context.

6. *Practical.* The last set of limitations is practical in nature, and includes aspects of the design that changed during the research itself, and not because of design choice. For example, as soon as the researcher walked into the school, every single learner considered him a teacher, including other teachers. This is less critical in interpretive research, but it can skew the data in interesting ways, especially when trying to establish causality following the Campbell and Stanley (1963) tradition. Another issue that came up from time to time was the teacher having to leave the class to attend to other matters, which meant that the researcher had to step in and give the lessons in the Mathematics club. These sorts of practical challenges are unpredictable and hard to prepare for, although the researcher believes that the due diligence and care taken to ensure validity and reliability (see Section 7.3) is both authentic and to the best of

the researcher's ability given the circumstances.

9.6 Conclusion

21st century learning environments, such as connected learning, have the potential to infuse rural education with a much needed 21st century makeover. Even though connected learning was conceptualised in the global North (Ito et al., 2013) in a largely urban or suburban context, this study has shown that it can plausibly and successfully be introduced in a rural schooling environment in South Africa. Conceptualisations of 'rurality' by local researchers like Hlalele (2014a) have shown that rural education can thrive by employing an ecology and networked approach to learning. This can be done by tapping into and maximising local assets, and allowing learners to interact with them in a fluid, diverse and cross-contextual manner. That networked and ecological approaches to learning are potentially conducive to 21st century skills development (Ito et al., 2013) - is a benefit that this research sought to leverage in order to evaluate a learning environment design that is aligned with the needs of life and career in the 21st century (Dede, 2010). To do this, this study introduced a connected learning environment in a rural school context. This was done in order to explore the causal links between rural learners participating in a connected learning environment, and their development of 21st century skills. The analysis revealed that connected learning is not only applicable to a rural context, but it also suggested that positive causal links existed between the intervention and 21st century skills development. This is despite the contextual challenges that learners were faced with, where, especially when coupled with an asset-based view of 'rurality', they could still effectively learn and practise 21st century skills.

Looking back at the main research question, "what is the impact of introducing a technology supported connected learning environment on rural learners' development of 21st century skills?" - the study has sufficiently answered this question, at least from a qualitative perspective. The impact of the intervention was generally positive, and limitations of this impact in this study can largely be attributed to the

research methodology and the (limited) duration of the study. Looking back at the overall objective for this research, which was to identify a relevant and contextual means of equipping rural learners with 21st century skills - this seems to have been achieved, at least in part. Connected learning employed within the broader context of rural learning ecologies seems to be a winning combination for rural education. This research has, at least in part, shown that this combination has the potential to revitalise rural education in South Africa. It promises to be an effective and sustainable solution for relevant and contextual rural education that is conducive to learners' 21st century skills development.

In closing, this research is significant for its application of a 21st century learning environment in a rural school in South Africa, which had not been applied in this context before. The theoretical insights generated include the mechanisms with which connected learning environments promote and support 21st century skills development. The practical insights include many that can be applied by practitioners in introducing connected learning environments in rural contexts. In fact, many of the practical implications could also be considered for the deployment of any technology supported educational intervention in a rural school. This research generated further questions that need to be explored further in future studies, and these are discussed next.

9.7 Recommendations for future research and implementation

1. The question of degree of impact on 21st century skills remained largely unanswered by this research. New research should focus some attention on answering this question in a rural context, potentially using more quantitative methods, which allow for establishing causality and measuring the degree of impact.

2. It is interesting that connected learning could potentially form part of a rural learning ecology, and actually play a role in sustaining it. Future research

should focus some attention on fullfilling the vision of Hlalele (2014a) on a full blown rural learning ecology, with connected learning as its framework for learning.

3. Future studies can potentially follow a more ethnographic approach, where researchers embed themselves in the learning lives of the research participants in order to track connected learning experiences over time. Such research could potentially shed some light on the way deep and varied connected learning experiences that lead to 21st century skills development, actually occur and change over time.

4. Lastly, connected learning could potentially increase the performance of learners in rural schools, by increasing the learning opportunities and intensifying learner engagement. A study that seeks to show the link between connected learning and improved marks, for instance, would certainly add some value. This could certainly be tested through research ,or even a practical (business) implementation. The possibility of applying this through a business venture is discussed further in Part V (p. 155, after the references) of this dissertation. The researcher believes that a workable business model can be developed by effectively following principles commonly used by entrepreneurs involved in creating startups.

References

Ahn, J., Subramaniam, M., Bonsignore, E., Pellicone, A., Waugh, A., & Yip, J. (2014). "I want to be a game designer or scientist": Connected learning and developing identities with urban, African-American youth. *Proceedings of International Conference of the Learning Sciences, ICLS*, *2*(January), 657–664. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84937715851%7B%5C&%7DpartnerID=tZOtx3y1

Ananiadou, K. & Claro, M. (2009). 21st century skills and competences for new millennium learners in OECD countries. *OECD Education Working Papers*, (41), 33. doi:10.1787/218525261154

Attridge-Stirling, J. (2001). Thematic networks: an analytic tool for qualitative research. *Qualitative Research*, *1*(3), 385–405. doi:10.1177/1468794107085301. arXiv: arXiv:1011.1669v3

Attwell, G. (2007). Personal learning environments - the future of eLearning? *Elearning papers*, *2*(January), 1–8.

Balfour, R. J., Mitchell, C., & Moletsane, R. (2008). Troubling contexts: Toward a generative theory of rurality as education research. *Journal of Rural and Community Development*, *3*(3), 95–107.

Barron, B. (2004). Learning ecologies for technological fluency: Gender and experience differences. *Journal of Educational Computing Research*, *31*(1), 1–36. doi:10.2190/1N20-VV12-4RB5-33VA

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development*, *49*(4), 1–40. doi:10.1159/000094368

Bates, T. (2015). *Teaching in a digital age: Guidelines for designing teaching and learning for a digital age.* Tony Bates Associates Ltd. doi:10.4018/978-1-930708-28-0.ch004. arXiv: arXiv:1011.1669v3

Beetham, H. & Sharpe, R. (2007). *Rethinking pedagogy for a digital age*. New York: Routledge.

Bhengu, T. & Myende, P. E. (2015). Traversing metaphoric boundaries between schools and their communities: An ethnographic study of a rural school. *Journal for Social Sciences*, *43*(3), 227–236.

Bilandzic, M. (2016). Connected learning in the library as a product of hacking, making, social diversity and messiness. *Interactive Learning Environments*, *24*(1), 158–177. doi:10.1080/10494820.2013.825811

Blank, S. (2013). Why the lean start up changes everything. *Harvard Business Review*, *91*(5), 64. doi:10.1109/Agile.2012.18. arXiv: 1111.6189v1

Boix, R., Champollion, P., & Psicologia, F. D. (2015). Teaching and learning in rural contexts. *Sisyphus-Journal of Education*, *3*(2), 28–47.

Botha, A. & Herselman, M. [M]. (2013). Supporting rural teachers 21st century skills development through mobile technology use: A case in Cofimvaba, Eastern Cape, South Africa. *Adaptive Science and Technology*. doi:10.1109/ICASTech.2013.6707490

Botha, A. & Herselman, M. [Marlien]. (2015). *ICTs in rural education : Let the game begin*.

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Sage Publications.

Bransford, J. & Schwartz, D. (1999). Rethinking transfer : A simple proposal with multiple implications. *Review of Research in Education*, *24*(1999), 61–100.

Bransford, J. D., Barron, B., Pea, R., Meltzoff, A., Kuhl, P., Bell, P., ... Sabelli, N. H. (2006). Foundations and opportunities for an interdisciplinary science of learning. *The Cambridge Handbook of the Learning Sciences*, 19–34. doi:10.1207/s15326985ep3904_2

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:http://dx.doi.org/10.1191/1478088706qp063oa. arXiv: arXiv:1011.1669v3

Budge, K. M. (2005). Place as problem or possibility: The influence of rurality and a sense of place on leaders in one rural school district. *Retrieved from Dissertation Abstracts International*, *66*(7), 2448.

Campbell, D. T. & Stanley, J. C. (1963). *Experimental and quasi-experimental design for research*. doi:10.1037/022808

Chingona, A., Chingona, W., Kayongo, P., & Kausa, M. (2010). An empirical survey on domestication of ICT in schools in disadvantaged communities in South Africa. *International Journal of Education and Development using Information and Communication Technology*, *6*(2), 21–32.

Christie, P., Butler, D., & Potterton, M. (2007). *Report of ministerial committee: Schools that work*.

Chu, S. (2014). Developing 21st century skills with plagiarism-free inquiry learning, collaborative teaching, social media, and gamification. *Learning and Teaching Expo*, (2014), 1–16.

Creswell, J. W. (2013). Qualitative Inquiry and Research Design, 472. doi:10.1017/CBO9781107415324.004. arXiv: arXiv:1011.1669v3

Dabbagh, N. & Kitsantas, A. (2011). Internet and Higher Education Personal Learning Environments , social media , and self-regulated learning : A natural formula for connecting formal and informal learning. *The Internet and Higher Education*. doi:10.1016/j.iheduc.2011.06.002

Dalsgaard, C. (2014). Students ' use of Facebook for peer-to-peer learning. *Proceedings of the 9th International Conference on Networked Learning*, 95–102.

Dalvit, L., Kromberg, S., & Miya, M. (2014). The data divide in a South African rural community : A survey of mobile phone use in Keiskammahoek. *Proceedings of the e-Skills for Knowledge Production and Innovation Conference*, 87–100.

Davis, K. & Fullerton, S. (2016). Connected learning in and after school: Exploring technology's role in the diverse learning experiences of high school students. *The Information Society*, *32(2)*(February), 98–116. doi:10.1080/01972243.2016.1130498

De Fruyt, F., Wille, B., & John, O. P. (2015). Employability in the 21st Century: Complex (Interactive) Problem Solving and Other Essential Skills. *Industrial and Organizational Psychology*, *8*(2), 276–281. doi:http://dx.doi.org/10.1017/iop.2015.33

Dede, C. (2007). Transforming education for the 21st century: New pedagogies that help all students attain sophisticated learning outcomes. *Commissioned by the NCSU Friday Institute, February*, (February), 58.

Dede, C. (2009). Comparing frameworks for 21st century skills. *21st Century Skills*, 51–76.

Dede, C. (2010). Technological supports for acquiring 21st century skills. *International encyclopedia of education*, 1–22. Retrieved from http://learningcenter.nsta.org/products/symposia%7B%5C_%7Dseminars/iste/files/Technological%7B%5C_%7DSupport%7B%5C_%7Dfor%7B%5C_%7D21stCentury%7B%5C_%7DEncyclo%7B%5C_%7Ddede.pdf

Department of Basic Education. (2014). *Report on the annual national assessment of 2014*.

Dlodlo, N. (2010). Access to ICT education for girls and women in rural South Africa: A case study. *Council for Scientific and Industrial Research*, *21*(2), 12–56. Retrieved from http://www.sciencedirect.com/science/article/pii/S0160791X09000268

Dzansi, D. Y. & Amedzo, K. (2014). Integrating ICT into Rural South African Schools : Possible Solutions for Challenges. *International Journal of Education and Science*, *6*(2), 341–348.

Ebersöhn, L. & Ferreira, R. (2012). Rurality and resilience in education : place-based partnerships and agency to moderate time and space constraints. *Perspectives in education*, QZ.

Fuchs, C. & Horak, E. (2008). Africa and the digital divide. *Telematics and Informatics*, *25*(2), 99–116. doi:10.1016/j.tele.2006.06.004

García-Peñalvo, F. J. & Conde, M. Á. (2015). The impact of a mobile personal learning environment in different educational contexts. *Universal Access in the Information Society*, *14*(3), 375–387. doi:10.1007/s10209-014-0366-z

Gardiner, M. (2008). *Education in rural areas* (J. Pampallis, Ed.). Johannesburg: Centre for Education Policy Development (CEPD). Retrieved from http://www.cepd.org.za/files/pictures/Education%20in%20Rural%20Areas%202008.pdf

Gee, J. P. (2004). *An Introduction to Discourse Analysis Theory and Method*.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report*, *8*(4), 597–607. doi:citeulike-article-id:6496761

Greiff, S. & Kyllonen, P. (2016). Contemporary assessment challenges: The measurement of 21st century skills. *Applied Measurement in Education*, *29*(4), 243–244. doi:10.1080/08957347.2016.1209209

He, Q., Johnston, J., Zeitlinger, J., City, K., & City, K. (2015). HHS Public Access. *33*(4), 395–401. doi:10.1038/nbt.3121.ChIP-nexus. arXiv: 15334406

Hlalele, D. (2012). Social justice and rural education in South Africa. *Perspectives in Education*, *30*(1), 111–118.

Hlalele, D. (2013). *Sustainable rural learning ecologies- a prolegomenon traversing transcendence of discursive notions of sustainability , social justice , development and food sovereignty*.

Hlalele, D. (2014a). Creating sustainable rural learning ecologies in South Africa : Realities , lessons and prospects. *Journal for Human Ecology*, *45*(2), 101–110.

Hlalele, D. (2014b). Rural education in South Africa: Concepts and practices. *Mediterranean Journal of Social Sciences*, *5*(4), 462–469. doi:10.5901/mjss.2014.v5n4p462

Howe, K. R. (2004). A critique of experimentalism. *Qualitative Inquiry*, *10*(1), 42–61. doi:10.1177/1077800403259491

Howley, A., Rhodes, M., & Beall, J. (2009). Challenges facing rural schools : Implications for gifted students. *Journal for the Education of the Gifted*, *32*(4), 515–536. doi:10.1177/016235320903200404

Huff, A. S. (1999). *Writing for scholarly publication*. Sage.

Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., ... Watkins, C. S. (2013). *Connected learning: an agenda for research and design*. Irvine, CA: Digital Media and Learning Research Hub. Retrieved from http://dmlhub.net/sites/default/%20files/ConnectedLearning%7B%5C_%7Dreport.pd

King, G., Keohane, R. O., Alford, R. R., & Verba, S. (1994). *Designing social inquiry: Scientific inference in qualitative research*. Princeton university press. doi:10.2307/2076556. arXiv: arXiv:1011.1669v3

Kitto, K., Cross, S., Waters, Z., & Lupton, M. (2015). Learning analytics beyond the LMS: The connected learning analytics toolkit. *Proceedings of the Fifth International Conference on Learning Analytics And Knowledge - LAK '15*, 11–15. doi:10.1145/2723576.2723627

Korobkova, K. A. (2014). Schooling the directioners: Connected learning and identity-making in the One Direction fandom. *Digital Media and Learning Research Hub*, 1–39.

Krueger, R. a. & Casey, M. a. (2001). Designing and conducting focus group interviews. *Social Analysis Selected Tools and ...* *36*(October), 4–23. doi:10.1136/bmj.311.7000.299

Kumpulainen, K., Mikkola, A., & Jaatinen, A.-m. (2013). The chronotopes of technology-mediated creative learning practices in an elementary school community. *Learning, Media and Technology*, *39(1)*(1), 53–74. doi:10.1080/17439884.2012.752383

Kumpulainen, K. & Sefton-Green, J. (2014). What is connected learning and how to research It? *International Journal of Learning and Media*, *4*(2), 1–40. doi:10.1162/IJLM

Lai, E. R. & Viering, M. (2012). Assessing 21st century skills: Integrating research findings. *Annual meeting of the National Council on Measurement in Education, Vancouver, BC, Canada*, (April), 66.

Ledward, B. C. & Hirata, D. (2011). An overview of 21 st century skills. *Pacific Policy Research Center*, 2–5. Retrieved from http://www.ksbe.edu/spi/PDFS/21st%20Century%20Skills%20Brief.pdf

Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry* (Vol. 75). Sage.

Malhoit, G. C. (2005). Providing rural students with a high quality education: The rural perspective on the concept of educational adequacy. *Rural School and Community Trust*.

Mapesela, M., Hlalele, D., & Alexander, G. (2012). Overcoming adversity: A holistic response to creating sustainable rural learning ecologies. *Journal of Human Ecology*, *38*(2), 91–103.

Marilyn, B., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In *Assessment and teaching of 21st century skills* (Vol. 1, pp. 17–66). Springer. doi:10.1007/978-94-007-2324-5

Maringe, F., Masinire, a., & Nkambule, T. (2015). Distinctive features of schools in multiple deprived communities in South Africa: Implications for policy and leadership. *Educational Management Administration & Leadership*, *43*(3), 363–385. doi:10.1177/1741143215570303

Masinire, A. (2015). Recruiting and retaining teachers in rural schools in South Africa : Insights from a rural teaching experience programme. *25*, 2–14.

Mathevula, M. D. & Uwizeyimana, D. E. (2014). The challenges facing the integration of ICT in teaching and learning activities in South African rural secondary schools. *Mediterranean Journal of Social Sciences*, *5*(20), 1087–1097. doi:10.5901/mjss.2014.v5n20p1087

Ministerial Committee on Rural Education (MCRE). (2005). *Report of the ministerial committee on rural education*.

Moletsane, R. (2012). Repositioning educational research on rurality and rural education in South Africa : Beyond deficit paradigms. *Perspectives in Education*, *30*, 1–8.

Mtshali, L. (2008). Still a long walk to freedom: Public service delivery in rural South Africa. Retrieved April 15, 2016, from http://www.sacsis.org.za/site/article/128.1

Myende, P. E. (2015). Tapping into the asset-based approach to improve academic performance in rural schools. *Journal for Human Ecology*, *50*(1), 31–42.

Nelson Mandela Foundation. (2005). *Emerging voices. A report on education in South African rural communities*. HSRC Press.

OECD. (2006). *21st century learning environments*. OECD Publishing. doi:http://dx.doi.org/10.1787/9789264006508-en

P21.org. (2012). *21st century skills map - math*. Retrieved from http://www.p21.org/storage/documents/P21%7B%5C_%7DMath%7B%5C_%7DMap.pdf

P21.org. (2016). P21 mission and vision. Retrieved August 8, 2016, from http://www.p21.org/about-us/our-mission

Partnership for 21st century learning. (2015). *P21 framework definitions*. Retrieved from http://www.p21.org/documents/P21%7B%5C_%7DFramework%7B%5C_%7DDefinitions.pdf

Partnership for 21st century skills. (2007). *21st century skills assessment*. Retrieved from http://www.p21.org/storage/documents/21st%7B%5C_%7DCentury%7B%5C_%7DSkills%7B%5C_%7DAssessment%7B%5C_%7De-paper.pdf

Partnership for 21st century skills. (2009). *21st century student outcomes*. Retrieved from http://www.p21.org/documents/P21%7B%5C_%7DFramework%7B%5C_%7DDefinitions.pdf

Pellegrino, J. W., Chudowsky, N., & Glaser, R. (2001). *Knowing what students know : The science and design of educational assessment*. National Academies Press.

Reinders, H. (2012). Online and blended instruction. *The Cambridge Guide to Pedagogy and Practice in Second Language Teaching*, 287–294.

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher*, *16*(9), 13–20. doi:10.3102/0013189X029002004

Ries, E. (2011). *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Crown Business.

Ritchie, J., Lewis, J., Nicholls, C. M., & Ormston, R. (2013). *Qualitative research practice: A guide for social science students and researchers*. Sage. doi:10.4135/9781452230108

Rotherham, A. & Willingham, D. (2010). "21st-Century" skills: Not new, but a worthy challenge. *American Educator*, 17–20. doi:10.1145/1719292.1730970

Ryan, T. G. (2014). Social media use in the classroom: Pedagogy and practice. *ICET 2014*, 308–398.

Saavedra, A. R. & Opfer, V. D. (2012). *Teaching and learning 21st century skills: Lessons from the learning sciences*. RAND Corporation. Retrieved from http://asiasociety.org/files/rand-0512report.pdf

Saavedra, A. R. & Opfer, V. D. (2013). Learning 21st-Century skills requires, 21st-Century teaching. *Phi Delta Kappan*, *94*(2), 8–13.

Scribner, S. & Cole, M. (1973). Cognitive consequences of formal and informal education. *182*(4112), 553–559.

Soland, J., Hamilton, L. S., & Stecher, B. M. (2013). Measuring 21st Century Competencies. *Asia Society Global Cities Education Network*, (November), 68. Retrieved from http://asiasociety.org/files/gcen-measuring21cskills.pdf

Spreen, C. A. & Vally, S. (2006). Education rights, education policies and inequality in South Africa. *International Journal of Educational Development*, *26*(4), 352–362. doi:10.1016/j.ijedudev.2005.09.004

Statistics South Africa. (2014). *Emplyment, unemployment, skills and economic growth*.

Stephens, M. (2016). Connected learning: Evaluating and refining an academic community blogging platform. *Journal of Education for Library and Information Science Online*, *57*(4), 295–310. doi:10.12783/issn.2328-2967/57/4/4

Taylor, L. & Parsons, J. (2011). Improving student engagement. *Current issues in education*, *14*(1).

The Forum for Youth Investment. (2009). *21st century skills : Doomed pedagogical fad or key to the future?* Retrieved from http://forumfyi.org/files/21st%7B%5C_%7DCentury%7B%5C_%7DSkills.pdf

Timæus, I. M., Simelane, S., & Letsoalo, T. (2013). Poverty, race, and children's progress at school in South Africa. *Journal of Development Studies*, *49*(3), 270–284. doi:10.1080/00220388.2012.693168

Tucker, B. & Silva, E. (2009). Assessment: A 21st century skills implementation guide. *Partnership for 21st century skill*, 1–7.

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of Computer Assisted Learning*, *29*(5), 403–413. doi:10.1111/jcal.12029

Voogt, J. & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21 century competences : Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299–321.

Williams, R. (2011). Emergent learning and learning ecologies in web 2.0. *12*(3), 1–20.

Wilson, S., Johnson, M., & Sharples, P. (2007). Personal Learning Environments : challenging the dominant design of educational systems . *Journal of e-Learning and Knowledge Society*, *3*(2), 27–38.

Yilmaz, K. (2013). Comparison of quantitative and qualitative research traditions: Epistemological , theoretical, and methodological differences. *European Journal of Education*, *48*(2), 311–325. doi:doi:10.1111/ejed.12014

Part V

Business model

A Building the business

A.1 A problem that needs solving

On a practical level, the focus of this study was to investigate a solution to some of the challenges identified in the dissertation, by designing, introducing and testing a connected learning environment within a rural school in the Gija-Mhandeni Village of the Limpopo province in South Africa. During the course of the intervention, the research participants, i.e. learners at Madonsi High School, showed signs of 21st century skills development. The results also indicated an organic fit between connected learning theory (Ito et al., 2013) and the conceptualisation of rural education from an ecological perspective that Hlalele (2014a) proposed.

This fit has practical implications for education design in rural areas, and many of these are considered in Section 9.4.3. One practical implication, however, that has not been sufficiently tested in this study, is that of improved learner performance (grades). Will learners improve their grades (measured in the 'marks' they achieve at the end of the year) by participating in academic and curriculum oriented connected learning environments? The literature and findings from this study certainly suggest so, but it is an assumption that remains untested.

The researcher believes that connected learning approaches could go a long way in resolving some of the challenges mentioned above. The goal of this chapter is to sketch out a plan for the practical and business implementation of a prototype, based on part(s) of the research findings, to address some of the challenges. The approach that is needed for the implementation will need to be practical, business oriented and allow for a degree of trial and error. The hypotheses, which forms a large part

of the value proposition is "rural learner participation in academic and curriculum oriented connected learning environments leads to improved grades". Combined with the findings of this study, which showed that connected learning leads to 21st century skills development - it starts to form a basis for building a business entity that supports rural learners' performance at High School, and also prepare them for further education and modern employment. The methodology chosen to build this business is discussed in the upcoming section.

A.2 The Lean startup

A.2.1 What is it?

The methodology chosen to build this business model is called the lean startup. Eric Ries is likely the first serial entrepreneur to start talking about a new methodology for creating startup businesses. In his years of being involved in entrepreneurship, he started noticing patterns that make certain startups to succeed, and others to fail. He famously wrote a book titled, "*The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*" (Ries, 2011), which has become a sort of reference manaul for the methodology. Later works would expound on the methodology and principles, with the most noticeable being Steve Blank's article published on Harvard Business Review, titled "*Why the Lean Start-Up Changes Everything*" (Blank, 2013). In the article, Steve Blank sought to simplify and clarify the methodology, and make it even more accessible for use by traditional organisations and startups alike.

The lean startup is a response to three assumptions about early stage businesses, namely (1) the need to create the perfect business plan, (2) the need to create long term (financial) projections for a (startup) business, and (3) startups are basically smaller versions of large companies. In the both the writing of Ries (2011) and Blank (2013), they go on to systematically show how these assumptions are actually incorrect, and how often times they have been the source of failure for startups. Instead of the above mentioned assumptions, they suggest the following three principles for building a startup. Firstly, rather than build a perfect business plan, focus on the hypothesis of the business, and seek to test its assumptions in an iterative build-test-learn cycle. A popular approach to testing of the assumptions of a business is by using a 'business model canvas', which implies that startups need to focus on finding a *Business Model* that works by iterating through, and even pivoting away from initial "guesses", until finally settling on a viable model. Secondly, the answers that a startup seeks can never be found inside of its own walls. Startups need to focus on

Customer Development, which is about "getting out of the building", talking to customers, understanding their pain points and refining the value proposition. Lastly, *Agile Engineering* is critical to making the whole process work - it seeks to shorten the cycle between building some part of the value proposition, and validation from actual customers, thus enabling the opportunity to improve the offering or product (iteration) or pivot away from bad ones . This can be effectively done by building a minimal viable product (MVP), which can be tested with the customer to see if it fits their needs. If it doesn't, further iterations can be made on the product. If it is completely wrong, then a decision to pivot away from the initial idea can then be easily made.

A.2.2 Is it suitable for social problems?

The lean startup principles have been successfully applied in many technology and services statups, but a question still remains regarding their applicability to social or educational problems. Many of the common catch-phrases that are indicative of startup culture, such as 'fail fast', 'iterate' and 'pivot', are not so easily applicable to social and educational problems. To illustrate, failing fast may be undesirable in educational settings, because real people (the learners and teachers) would be affected by the failure, which might have ramifications for the rest of their lives. One cannot simply go from idea to idea, without due consideration of the impact that this will have on the users and customers.

In order to ensure that the lean startup principles are applied in a consistent, appropriate and ethical manner, the following "rules" will be applied:

1. The notion of 'failing fast' is done away with. Rather, a more appropriate notion of 'discovering issues early' will be applied. This will allow for the early detection of "failing interventions", and allow modification before the point of failure. This will also require a dependence on traditional methods of educational intervention, such as the method of experimentation used in the

research part of this dissertation, as it takes into account issues of agency and ethics.

2. Iterations will only be done on non-critical components of the solution, but not on those that are critical to the delivery of the value proposition. To illustrate, if we use an app to bring online learning to learners, elements of it may change as we get feedback from the users, but the curriculum will not be affected or changed in any way, as that is something that is set at a national level.

3. Pivots will not be allowed. Rather, if interventions are deemed to be unsuccessful, they shall be retired in a careful and systematic way. The schools in which the intervention was introduced must remain able to deliver education to the best of their ability, regardless of the failure of the intervention. In other words, any unhealthy dependency on a failed intervention will need to be corrected before moving on.

A.3 Iterating to the right business model

A.3.1 Social lean canvas

Using the principles described in Section A.2, it's time to describe the process of developing the business and solution. Even though the process is described in a linear manner, it must be noted that the lean startup methodology is non-linear, and a number of iterations occurred in arriving at the (current) business model and solution. A variation of the business model canvas, known as the social lean canvas, which is used to write down all the assumptions about the problem and solution, is depicted in Figure 16. The Social lean canvas has been adapted to be more suitable for businesses that intend to make a social impact.

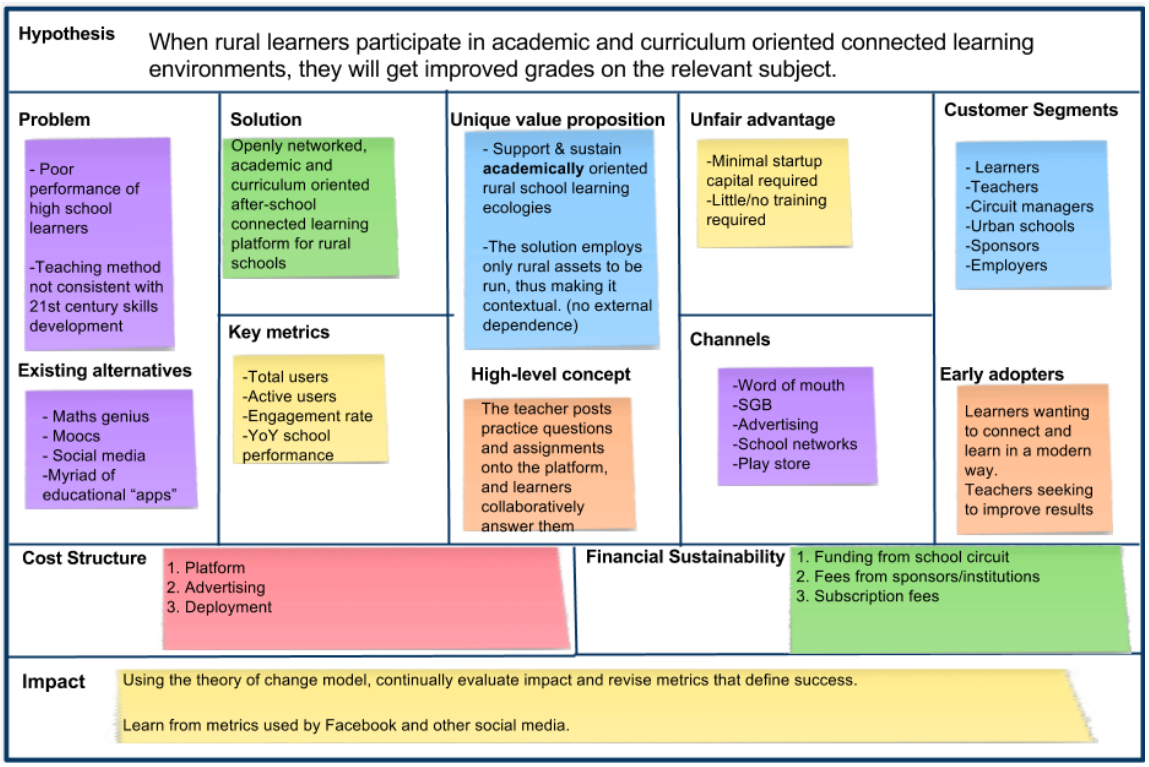

Figure 16: Social lean canvas

The details of the social lean canvas are discussed next:

A.3.2 Concept solution

The solution to the problem was designed in an iterative manner, consistent with the principle of agile engineering. Based on the research findings, it was always clear that the solution would be a connected learning environment design of some kind. What was quite interesting about the experimental method chosen in the research, is that it is actually quite conducive to early stage prototyping. In other words, the after school connected learning Mathematics club that was designed for the research intervention, also became the first MVP for the solution. The learners and the teacher interacted with the MVP during the research intervention, which gave invaluable feedback regarding what needed to be improved, changed or removed altogether. In other words, the intervention provided an opportunity to conduct not only the research, but also perform the critical step of customer development. The MVP essentially had two parts to it; the first was an online platform, in this case Facebook, which would allow for in and out of classroom collaboration between the learners and the teacher (Figure 17). The second part was the Mathematics club element, where the teacher and learners would meet physically to go through revision material on mathematics. The teacher would then post the questions on the platform, and learners would collaboratively answer them.

Key discoveries were made during the research, which necessitated an improvement to the solution. In terms of the platform, key issues regarding it were discussed in detail in Section 9.3 of the research. The main issues included privacy, advertising, formatting and plagiarism. In order to address the issues above, the researcher iterated from the initial concept of using Facebook as the learning platform, and built a custom version that would address the challenges mentioned above. A custom platform allows for the mitigation of privacy and advertising related issues of using Facebook for learning. Formatting issues were also addressed, as the new platform was designed for mobile first, and to scale the user interface according to the type of device that is used. The platform also addresses the issues of plagiarism in a

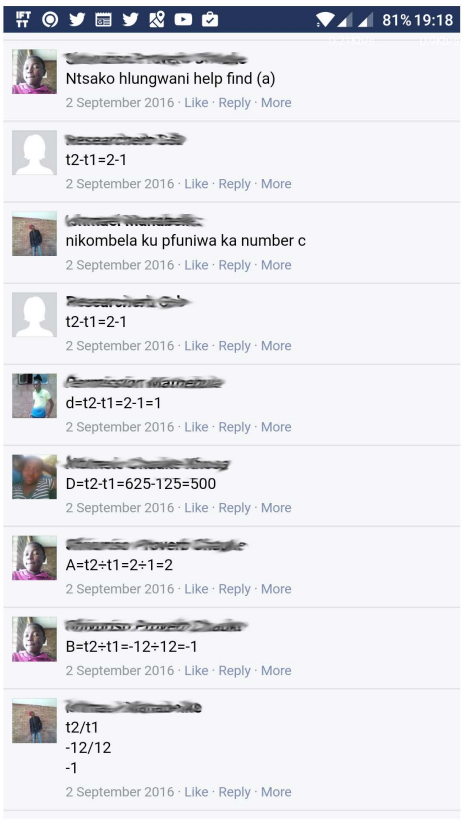

Figure 17: An example of the use of the Facebook platform for learning activities

couple of ways. Firstly, it still allows learners to collaboratively answer questions, and learn from one another. This is useful, especially when looking at practise or revision questions, where no grading of answers will occur. Secondly, it enables the learners to be able to officially submit an answer to the teacher. The new platform, dubbed the connected learning app, is depicted in Figures 18 and 19.

The solution that has been proposed is an updated version of what was used in the main research, based on feedback from the teacher and learners (customer development). Their inputs were essential in creating a solution that would be suitable for them, and allows for further testing to occur. The connected learning app also includes the option to allow other schools to participate in it as well. As Figure 18 shows, when a learner has logged in, they are able to select the school that they belong to, and continue on to see content related to their school. They are also able to

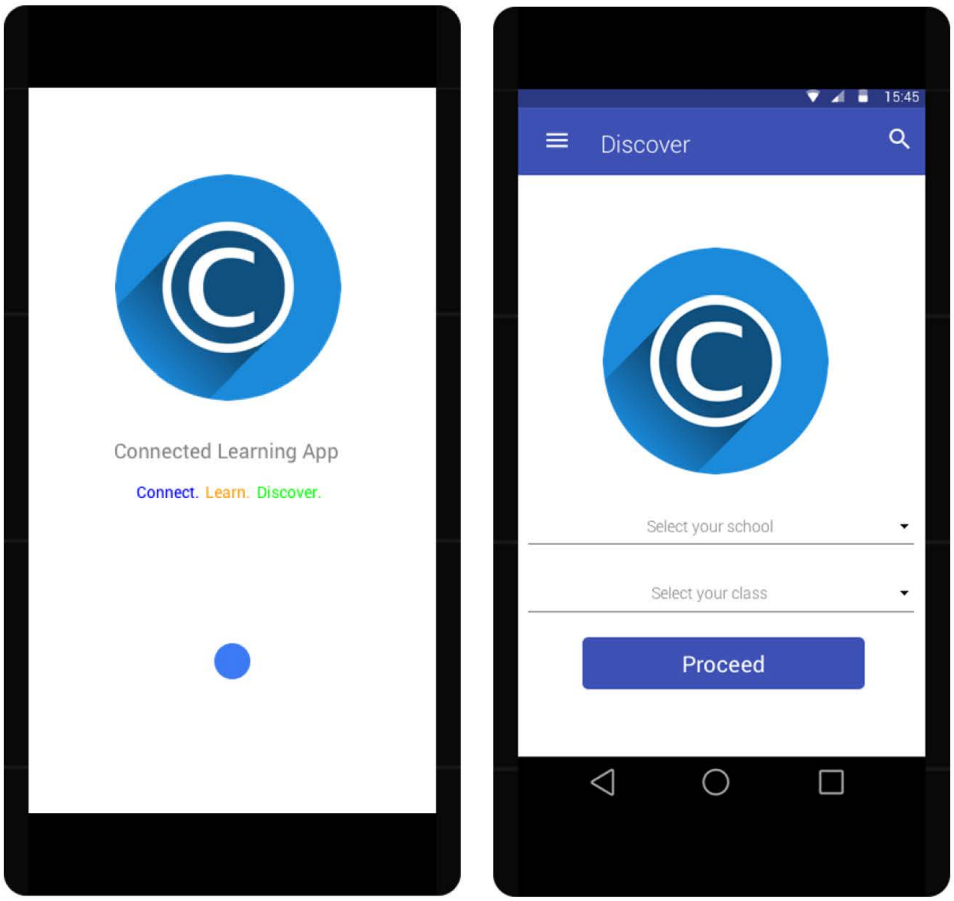

Figure 18: The connected learning app, designed based on real customer and user feedback

select a particular class that they want to participate in, which extends the platform to cover any subject, and not just Mathematics. The ability to add more schools and classes into the platform provides a way to scale the solution to reach more learners, but again, it will need to be tested as it is introduced to new learners in other subjects and schools. For now, the focus of the solution is still on the Mathematics class at Madonsi High School. The app also includes e-badges, which learners can earn based on participation, collaboration and answering questions correctly. The e-badges further reinforce the academic orientation of the solution. The e-badges also give a sort of social recognition amongst the learners, which is important for a peer supported learning approach.

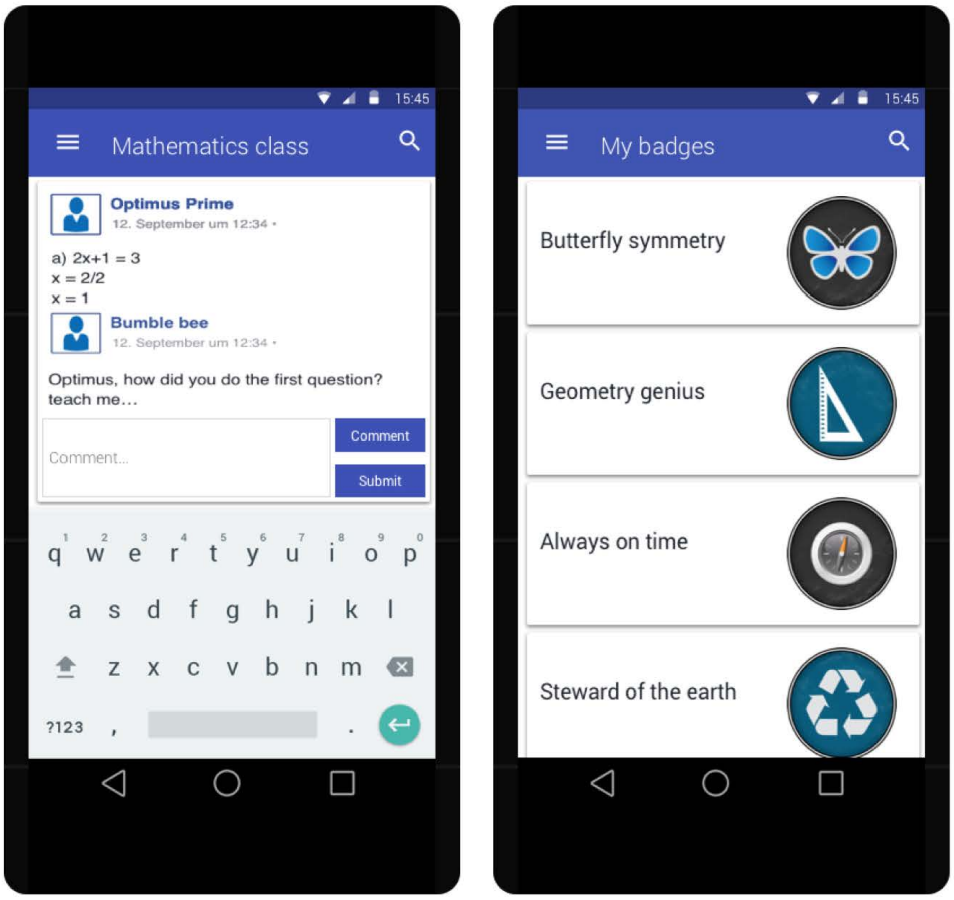

Figure 19: The e-badges element adds a new dimension of social recognition to the learning

NB: A high fidelity mock-up of the connected learning app can be found at (http://tekhut.co). The mock-up is useful to get an idea of the operation of the app. It must be noted that the mock-up is simply for illustration purposes only, and is not meant to reflect the final performance of the app, which is currently under development. The app will also include a 'lite' web version for bandwidth constrained environments and devices with little memory and processing power.

A.3.3 Value proposition

One has to carefully consider the value proposition of the solution, because it will need to be clearly communicated to all stakeholders. This is necessary for the ac-

ceptance of the solution by users and to also secure funding and revenue from the stakeholders who will pay for it. The first value proposition of the solution is that it supports and sustains rural learning ecologies. This might seem abstract and high level at first glance, but consider that there are very few solutions that employ rural resources (i.e. people and assets) to enrich rural education. In this solution, there is minimal dependency on any assets coming from outside of the context. This has the advantage of needing minimal costs to set up and keep the solution running.

The second value proposition is also the hypothesis that the solution goes with, i.e. if rural learners participate in a connected learning environment, they will improve their grades. This is an easy proposition to understand, and it will likely be the one that will cause an investor to contribute money to the cause. It is also the most practical of each, and is less theoretical than the previous one. If this were a presentation, the emphasis would be placed on this tangible value proposition. This still has to be tested in the field, in accordance with the lean startup process, but if it should prove true, it is simple to see how support for the solution can be easily found.

A.3.4 Users and customers

Identifying users and customers is always key for any business. Although users and customers are often the same people in many business, in this case, they are in fact quite different, as shown in Figures 20 and 21. Like many educational interventions, especially in poor contexts, the users are not usually the people that pay for the solution. This is because they would not have the money to do so. Learners are the most important user of the platform, and the focus for this iteration of the solution. The teacher is obviously important, too, because they have to post question onto the platform, and receive and correct answers that learners post. In the future, it is envisaged that the platform will be opened up to parents and mentors, in order to allow for greater collaboration. It is also likely that peers from other schools, either in a rural or urban context, will also be allowed onto the platform. This will allow

the learners to interact with peers in other schools and regions, which is a key feature of connected learning.

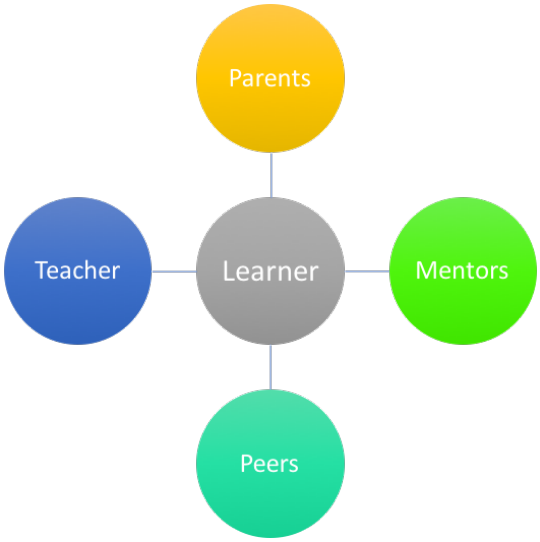

Figure 20: The users of solution

The customers in this case include the DBE, sponsors, donors, corporates and urban schools. The target customer for this iteration is the DBE, through their local Malamulele East Schools circuit office. During the customer development phase, both the teacher and the principal felt that approaching the DBE to fund this would be a good idea, as they receive a yearly budget to ensure that the schools underneath them perform well, amongst other objectives. Since the performance objective is one that is shared by the hypothesis of the solution, it seems natural that DBE should have to pay for it.

A.3.5 Existing alternative solutions

In building any business, it is important to consider what currently exists in the market, so that the positioning of the business can be done appropriately. In theory, the elements needed to replicate a solution like the one presented here are not difficult, and the assumption of higher performance is one that has been made by many (technology based) educational interventions. However, the biggest differentiator for

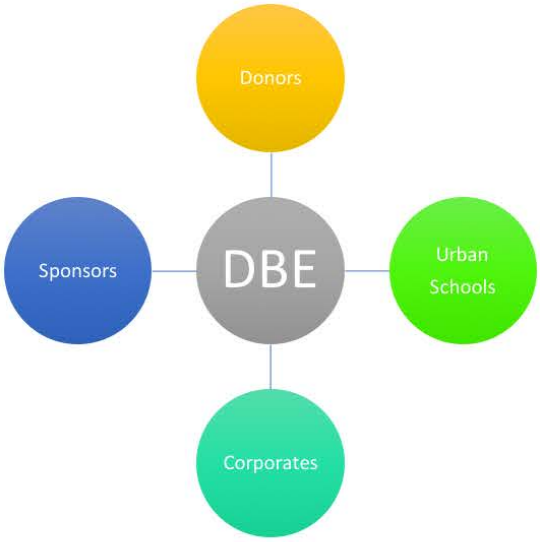

Figure 21: The customers of the solution

this solution is not the technology or the app, but it is the fit for context nature of the design. The connected learning app and general solution proposed here are rooted in real research in a rural context. So, although other technological solutions might exist, hardly any are built with the rural context in mind. No matter how good they are, rural learners just aren't exposed to them, and as a result, are not using them. It takes more than an app or a platform to have sustainable educational interventions for rural learners. Solutions need to be designed with the rural context in mind in order to be effective.

A.3.6 Reaching users in a scalable way

The next aspect to consider is marketing channels for the solution. The solution will get to the users in at least three interdependent ways:

1. *Word of mouth.* During the research intervention, word quickly spread throughout Madonsi High School about the connected learning Mathematics club. It was surprising, but word of mouth is still an effective means of marketing in a rural context.

2. *Publish the connected learning app in popular app stores, social media and the web.* Learners at Madonsi High School used various devices to access the test Facebook group during the connected learning Mathematics club. Some used cellphones, others tablets and even laptops. Publishing in a variety of digital markets will allow as many learners as possible to access it.

3. *Advertise through formal school channels.* The School Governing Body meeting proved extremely useful to get both teacher and parent buy in to the connected learning Mathematics club, and a similar approach would be needed again. Advertising in the school network (e.g. Malamulele East School Circuit) is also a good way of reaching all the schools in the region through the circuit office, especially when the solution is expanded to other schools.

A.3.7 Cost structure and revenue streams

Total recurring costs	**R923.00**	Per school per month. Will gradually decrease with more schools.
Platform costs ($30)	R423.00	Compute (10); $Storage(10)$; Hosting (10); $Testenvironment(5)$.
Advertising costs	R500.00	Per school per month.
Total non-recurring costs	**R2000**	Per school, once off. Mostly consists of training and integration into school.

Table 18: Total recurring and non-recurring costs of the solution

The cost structure is summarised in Table 18. The costs are broken into recurring and non-recurring costs. The recurring costs are roughly R923 per month for a single school, or just over R11 000 per year. The monthly recurring costs consist of platform costs (R423) and advertising costs (R500). The platform costs are comprised of compute, storage, hosting and test environment fees. The app will be hosted on the Firebase mobile backend as a service (MbaaS). The costs indicated here are based on the prototype that is already in development. The computation and storage required

to run the application were calculated to account for the expected level of activity for a single school. The non-recurring costs, which are paid once off during the deployment of the solution to a school, are comprised of training and integration costs, totalling R2 000 per school. Once the training of the teacher(s) and learners has taken place, it is expected that the teacher will post the questions to the platform, and that learners will be able to answer collaboratively without any assistance. This was proven to be true in the connected learning Mathematics club, as the teacher and learners got to a point where they were competent in the platform.

Revenue stream 1		
Funding from DBE	**R3,500.00**	Per month. Validated as a possible funder.
Revenue stream 2		
Subscription fees per Urban school	**R3,000.00**	Per month.
Revenue stream 3		
Fees from Donors (CSI)	**R10,000.00**	Fund a whole circuit/district/cluster of schools per month
Revenue stream 4		
Fees from corporates	**R10,000.00**	Per student sourced from the platform and sent to the corporate for bursary/apprentice programmes. (Not validated)

Table 19: Potential revenue streams

The potential revenue streams are presented in Table 19, and they are derived from the identified customers in Figure 21. The first and primary form of revenue or income that this solution will need is funding from the DBE. During the customer development phase, an assumption that DBE, through its local circuit office, would fund the solution was made . This assumption was in fact validated, and the circuit manager explicitly asked for the results of the main research, for further study and consideration. This was exciting to hear from that office, and a partnership with them could see the solution rolled out to more schools in Malamulele. The anticipated funding from DBE is R3 500 per month, which would be enough to cover the costs indicated in Table 18. At this stage, it is unclear whether DBE would increase the funding for each additional school - the assumption is that they would, but this is

still to be confirmed.

The funding from DBE is the most certain and validated of the revenue streams, but over time others will need to be identified so that the solution can be effectively scaled and remain sustainable. In the (near) future, it is envisaged that the platform will be opened up to other stakeholders. For example: urban schools might pay to join the platform and interact with learners in a rural context; Corporate Social Responsibility (CSI) donations might be acquired from responsible donors; corporates might be interested to join the platform for talent scouting and recruitment purposes. All the above are still assumptions that still need validation as part of the process.

A.3.8 Impact of the solution

Like any measure of impact, important metrics need to be defined and monitored throughout the life of the solution. Looking back at the customers that were defined in Figure 21, the most important of which is the DBE. At this stage of the solution, metrics that would appeal to them need to be identified and prioritised. The DBE will likely want to know about the performance (in terms of grades) of the learners, and how they have improved compared to before. Borrowing insights from popular social media networks like Facebook, the total number of users of the platform (i.e. the learners and teachers), and the total number of engaged users (i.e. learners and teachers that are actively participating in posting questions, answering them, submitting answers, etc.) will need to be also considered. These metrics are important to attract investment in traditional social network platforms, and will likely play a similar role for a connected learning platform. The metrics that will be used are summarised as follows:

1. *Year on year (YoY) performance of learners.* This will be an aggregate indicator of the grade performance of the learners involved in a particular connected learning environment, on say Mathematics, compared to before. It is expected that a performance increase of around 20% would show sufficient value to stakeholders, and that they would continue to invest in the platform. At this stage,

this figure is a "best guess", based on the discussion with the teachers and principal of Madonsi High School. It is possible that a lower performance level increase would still be acceptable, but all this needs further validation.

2. *Total number of users.* This refers to the total numbers of users in the connected learning platform, and also in the connected learning class in general. The higher that this number is, the more learners that the solution will potentially impact.

3. *Engaged users.* This refers to a percentage of the total number of users who are actively involved in posting questions, collaborating with other learners, 'liking' posts and submitting assignments. Social media networks like Facebook use this important metric to sell advertising space, because they can show just how many people will see the advert. In this case, this will show the stakeholders the exact number of learners who are actively extracting benefit from the platform.

As with anything at this stage of the solution development, further work in testing the metrics still needs to happen. They may need further refining, and more may need to be added. What these metrics have shown, however, is that if the solution does indeed work as anticipated, it will be simple enough to show stakeholders value, and to attract further investment.

A.3.9 Time frame

The timeline for execution is also important to discuss, because it give a sense of urgency to the project, and also aligns development requirements with stakeholder expectations. The key mechanism of build-test-learn is crucial for startups, and the timeline is built in such a way to reflect this learning loop. The details around the timeline are shown in Figure 22, and they are briefly discussed next:

1. The timeline starts at 2017, but the research work began in 2016. The connected learning Mathematics club that was used in the research was the first

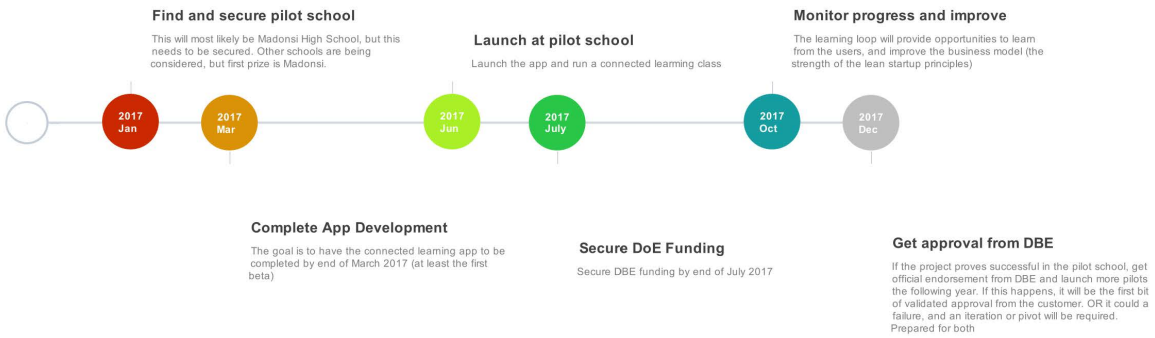

Figure 22: The anticipated timeline for the next year

MVP of the solution. Based on the validated learning, MPV2 is being created and will be tested according to this timeline.

2. By the end of January 2017, work needs to begin on securing a school where MVP2 can be piloted. Naturally, the first prize choice is Madonsi High School. This is a crucial first step in getting a committed "customer".

3. By the end of March 2017, work on developing the first beta of the connected learning app, which is an iteration from using Facebook, needs to be complete. The development is done completely in-house (i.e. done by the researcher), and a little time is needed to complete the work that has already begun.

4. The period between March 2017 and June 2017 will be used for planning purposes with the pilot school. Administrative issues such as the class, learners and teachers that will participate in the pilot will need to be finalised. The DBE, through the local circuit office, will need to also be informed about the pilot.

5. In June 2017, it is hoped that the pilot can be officially launched with the pilot school. This pilot will continue until the end of the school year, which is in December of 2017.

6. Three months after the pilot is launched, a checkpoint in October 2017 is necessary to evaluate progress. This will be an important time to make a

decision on further iterations or a pivot. Regardless of the decision, however, the pilot will continue to run until the end of the school year.

7. The hope is that by the end of the school year, in December 2017, both the school and the DBE will be happy with the pilot, and allow for further pilots in other classes and schools in 2018.

A.4 Conclusion

This section on the Business Model has really been about trying to build a business around the stated hypothesis, which is that rural learner participation in academic and subject oriented connected learning environments will result in them getting improved grades. This hypothesis needs to be tested thoroughly by following the lean startup methodology. Early testing indicates that it is a viable hypothesis, and thus a business can be built around it. The hypothesis driven, and build-test-learn cycle that is a key feature of iterative methodologies, is crucial to ensuring that the right solution is eventually delivered to the users and customers. The researcher believes the solution proposed here is not only achievable, but it can potentially be a sustainable and context specific approach to improving rural education.

Part VI

Research documents

B Consent form

I volunteer to participate in research conducted by Mr. Bongani Mabaso, a Masters student at the University of Cape Town Graduate School of Business. I understand that Mr. Mabaso will run an experimental classroom where I will participate as a learner/teacher. The class is expected to run from June till October 2016, on select Thursdays and Fridays only.

1. My participation in this project is voluntary. I understand that I will not be paid for my participation. I may withdraw and discontinue participation at any time without penalty.

2. I have the right to discontinue participation in the research at any time.

3. I understand that data will be collected during the research experiment by use of interviews, surveys and observation. I understand that all data collected will be anonymised and kept confidential.

4. I understand that recording equipment (e.g. video cameras, voice recorders, etc.) will be used to record proceedings of the experiment.

5. I understand that other persons, e.g. co-researchers, interviewers, observers, etc., may be present with Mr. Mabaso during the experiment.

6. I understand that clearance to conduct this research has been given from the Faculty Ethics in Research Committee in the Commerce Faculty of the University of Cape Town.

7. I have read and understood the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

8. I have been given a copy of this consent form.

Signatures

Participant:

Parent/Guardian:

C Interview schedules

C.1 Learner pre-test questions

The purpose of this focus group is to gain insight into the experiences of learners in the experimental connected learning mathematics class/club. In particular, it is to understand whether students exhibited behaviour and skills consistent with 21st century skills.

The Interview protocol will follow guidelines from Krueger and Casey (2001).

1. [**Introduction; round-robin**]

   What does being part of a mathematics class feel like?

2. [**Transition question; on connected learning experiences**]

   SKIP

3. [**On critical thinking, problem solving and decision making**]

   What do you think of the assignment questions that you get given in this class? How do you go about solving them?

4. [**On creativity and innovation**]

   Has anyone come up with a new way to solve the problem (something different to what the teachers taught you?) Can you explain how you came up with this new way?

5. [**On communication and collaboration**]

   Do you sometimes work in groups? If so, how did you find the experience of working in groups?

6. [**On information and media literacy**]

   How do you go about finding information about something that you did not understand, or if you just had questions in general?

7. [**On citizenship**]

   How do you think Mathematics can be used in your community? In your country?

8. [**Winding down**]

   Do you have other experiences that you would like to share with the group?

THANK THEM FOR THEIR TIME!

C.2 Teacher pre-test questions

The purpose of this interview is to gain insight into whether students are developing 21st century skills at school and class that they teach. This interview will take approximately 1 hour per teacher.

1. [**Context**]

   What Subject do you teach at the school? How long have you been teaching it? What grade(s) do you teach this subject to? What are the age groups of the learners that you teach?

2. [**On creativity and innovation**]

   When you give your students a task/assignment: Do your students come up with interesting and different ways to solve problems?

   Do they critically evaluate their own work against the work of other students, and come up with new ways to solving the problem?

   Do you think your students are learning how to learn (instead of regurgitation of taught concepts) [meta-cognition].

3. [**On critical thinking, problem solving and decision making**]

   To what extent are your students able to construct complex arguments about solving a problem?

   Are they able to defend their reasoning when faced with opposition?

   Do they ask meaningful questions when they are not clear about a concept/problem/solution?

   Are they open to new, innovative or unconventional ways of solving a problem?

   Are they able to make a decision on how to solve a problem, and follow up on the selected method?

4. [**On communication and collaboration**]

   What is the interaction between your students like in class?

Are they able to respect each others views and opinions?

Are they able to work together (in teams) to solve problems?

Are they able to communicate their views verbally or in written form?

5. [**On information and media literacy**]

   Do your students consult different sources of data when they need to understand something about your subject (e.g. new textbooks, library, online sources, social media, etc.)?

   Do they incorporate the information from the various sources into their learning and share it with others?

   Do your students have access to ICTs to conduct research on your subject or access software packages designed to assist them with your subject?

6. [**On citizenship**]

   Do your students understand how your subject can assist them in solving problems for their local community as well as the global community?

   Do your students perceive your subject as relevant to their immediate context?

7. [**On personal and social responsibility**]

   Based on your observation of your students; briefly comment on whether you have observed the following skills and attitudes in them?

   (a) Flexibility and adaptability. (b) Initiative and self-direction. (c) Social and cross-cultural skills. (d) Productivity and Accountability. (e) Leadership.

8. [**Opportunities and Challenges**]

   What challenges do you think prevent students from developing 21st century skills in your school/class/context?

   Are there opportunities to improve the development of 21st century skills in your current environment?

THANK THEM FOR THEIR TIME!

C.3 Learner post-test questions

The purpose of this focus group is to gain insight into the experiences of students in the experimental connected learning mathematics class/club. In particular, it is to understand whether students exhibited behaviour and skills consistent with 21st century skills.

The Interview protocol will follow guidelines from Krueger and Casey (2001).

1. [**Introduction; round-robin**]

   How did it feel being part of the mathematics club(s)?

2. [**Transition question; on connected learning experiences**]

   What do you think was different between learning mathematics in your classroom compared to the club?

3. [**On critical thinking, problem solving and decision making**]

   What did you think about the assignment questions?

   How did you go about solving them?

4. [**On creativity and innovation**]

   Did anyone come up with a new way to solve the problem (something different to what the teachers taught you)?

   Can you explain how you came up with this new way?

5. [**On communication and collaboration**]

   How did you find the experience of working in groups and teams?

6. [**On information and media literacy**]

   How did you go about finding information about something that you did not understand, or if you just had questions in general?

7. [**On citizenship**]

   How do you think Mathematics can be used in your community? In your country?

8. [**Winding down**]

   Do you have other experiences that you would like to share with the group?

THANK THEM FOR THEIR TIME!

NB: The teacher post-test questions were the same as the learner post-test questions, except they were asked from the perspective of the teacher.