Cooperative design of a cross-age tutoring system based on a social networking platform

by

BESTER CHIMBO

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ABSTRACT

In South Africa, many young children from poor social and economic backgrounds are cared for at home by parents or guardians who are themselves illiterate. This leads to poor educational outcomes later in life. Yet there are many privileged teenagers with access to mobile technologies who spend a greater portion of their spare time interacting on ubiquitous social media platforms. This presents an opportunity whereby the poor educational outcomes referred to previously could be addressed by applying a technology solution providing social media-based homework support by privileged teenagers to underprivileged younger children. However, most applications designed for use by children are designed by adults, with little understanding of the user requirements of the target end users. This research explores the following question: *How can a cross-age tutoring system be designed for implementation on a social networking platform to support numeracy and literacy skill acquisition?*

The main contribution of this research was the definition of the *Cooperative design by Children for Children (CD2C) Design Framework*, a blueprint of how a cross-age tutoring system could be co-designed by children of different age groups and life circumstances. The CD2C Design Framework was derived as an abstraction of the second contribution of this research, the TitanTutor, an artifact designed using co-operative inquiry method and the Design Science Research approach. The third novelty of this research was contribution to Design Science Research theory, with the addition of new theory that states that *cooperative design by children from different age groups and life circumstances is tempered by socio-environmental context and power relations between the co-design partners*. This work provided important contributions to researchers in the areas of Cooperative Inquiry (CI), Human Computer Interaction (HCI), and Design Science Research (DSR). Future researchers could extend the CD2C Design Framework to make it even more abstract, thereby making it universally applicable to any co-design scenario.

Key terms: Cooperative Design, Participatory Design, Cooperative Inquiry, Cross-Age Tutoring, Design Science Research, Social Networking Platform, Numeracy, Literacy, Disadvantaged Children, Privileged Environments.

PREFACE

Three papers were published as a result of the research presented in this thesis. The first paper reported on a study to determine what would motivate teenagers to participate as tutors in such a system. We interviewed 28 culturally diverse children attending various affluent urban high schools in Pretoria, South Africa. The research showed that South African teenagers were very aware of socio-economic problems in their environment, and that they saw it as their responsibility to help less fortunate children. They generally felt that tutors should do this for intrinsic benefits, rather than for tangible rewards. The reference to the paper is as follows:

Chimbo, B., & Gelderblom J. H. (2012). Cross-Age Tutoring via Social Media: Motivating Teenage Tutors to Engage in Activities for the Benefit of Younger Children, *Proceedings of the IADIS International Conference on Internet Technologies & Society*, Perth, Australia, 28-30 November 2012, ISBN No: 978-972-8939-77-9.

This second paper described the participatory design of a social media based system aimed at providing after-school learning support to primary school children in South Africa. The paper discussed and compared the design contributions made by the teenagers and the young partners, respectively. We described the difficulties and the positive outcomes when co-designing with children from two different age groups, and we made recommendations in this regard, based on our experience. The reference to the paper is as follows:

Chimbo, **B.,** & Gelderblom J. H. (2014). Comparing Young Children and Teenagers as Partners in Co-design of an Educational Technology Solution, *ESkills and E-summit Conference*, Cape Town, 17-21 November 2014. ISSN No: 2375-0634.

The third paper was on the involvement of children from disadvantaged communities in the design and development of a cross-age tutoring system. The strategy was to let the participants engage in face-to-face tutoring sessions which would be used as supplementary input into the design. The reference to the paper is as follows:

Gelderblom J. H., Yip, J., Bonsignore, E., & **Chimbo**, **B.** (2014**).** Self-recorded Audio Feedback as a Means to Allow Young, Vulnerable Children to Participate in Design, *International Development Informatics Association (IDIA2014) Conference,* Port Elizabeth, South Africa, 3-4 November 2014. ISBN: 978-0-620-63498-4.

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5. Finally, to the Lord Almighty I give Praise and Glory.

STATEMENT OF ORIGINALITY

Student number: 32950063

I, Bester Chimbo, declare that **Cooperative Design of a Cross-Age Tutoring System based on a Social Networking Platform** is my own work, and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

	9 November 2016
SIGNATURE	DATE

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CHAPTER 1: BACKGROUND AND INTRODUCTION

1.1 Background

Numeracy and literacy are key areas of child development and foundation phase education in South Africa (van der Berg, Taylor, Gustafsson, Spall, & Armstrong, 2011). The skills required in these two areas are fundamental requirements for learning. Low levels of numeracy and literacy impact negatively on educational attainment and employment prospects, resulting in economic costs that are borne by the whole community (Baxen & Botha, 2016). The quality of education in South Africa is unsatisfactory (Spaull, 2015; Spaull, 2013b; van der Berg et al., 2011). Various surveys show that the level of cognitive achievement of many South African children is alarmingly low in key learning areas such as reading, mathematics and science (Seekoei, 2010; Spaull, 2013a; Spaull, 2013b; van der Berg et al., 2011).

The low educational achievement has become a national predicament in South Africa (Feza-Piyose, 2012; Fleisch, 2008; Spaull, 2013b; van der Berg et al., 2011; Vally, 2015). The Department of Education (DoE) Annual National Assessment report (ANA) of 2011 attributes this state of affairs to the alarming dropout rate in high schools, and problems in performance at tertiary level to a failure to get the basics right in the first few years of a child's education. Further, the dismal performance of learners at matriculation level in mathematics was evident in the national examinations of 2009, 2010 and 2011, where the mathematics percentage pass rate was 30% (Education Statistics in South Africa, 2012; Feza-Piyose, 2012; Taylor, 2009). There was some improvement in the mathematics performance between 2012 and 2014, with the pass rate rising to 53.5% (DoE, ANA, 2014). The majority of the students clearly had not achieved the competencies specified in the curriculum. An assessment which included numeracy and literacy tests among foundation phase (grades 1 to 3) students attending government schools, showed that only 17% of the Grade 3 students scored 50% and above in their numeracy assessment, and 31% in their literacy assessment (Fry, 2012).

Several socio-economic factors lead to poor performance in literacy and numeracy. To start with, many young South African children are cared for at home by family members with low literacy levels, who cannot provide the necessary support with homework and preparation for tests. Poverty also contributes to poor performance in schools, as it has a devastating effect on children's life chances, and nowhere is this more strongly felt than in schooling (Mji & Makgato, 2006; Spaull, van der Berg, Wills, Gustafsson, & Kotzé, 2016; Taylor, 2008, 2011).

The huge shortage of teachers, capable of providing mother-tongue education to children who have English as a second or even third language is yet another factor.

It is generally accepted that addressing literacy and numeracy problems during early years of education will reduce the problem of high levels of failure and dropout in later grades (Organization for Economic Cooperation and Development (OECD), 2012; Pandor, 2008; Spaull et al., 2016; van der Berg et al., 2011). South Africa, therefore, needs to improve literacy and numeracy skills in the elementary phase of childhood development by developing relevant tools and programs. Given that primary schooling forms the foundation for all further education and training, the overwhelming challenge for the entire system is to improve the quality of basic education provided to children (van der Berg et al., 2011; van der Berg, 2015). Homework support is one way of assisting students to gain valuable literacy and numeracy skills. Research findings greatly strengthen the case for homework support (Carr, 2013; Cooper, Robinson, & Patall, 2006; Costley, 2013; Milbourne & Haury, 2003). Many teachers and parents agree that homework develops students' initiative, discipline, study habits and responsibility (Hoover-Dempsey, Bassler & Burow, 1995; Haley, 2006; Hoover-Dempsey & Sandler, 1995, 1997; Paulu, Lehr & Walne, 2005).

Research has shown a rising use of social networking sites (SNSs) such as Facebook, MySpace, Twitter, Blogs, MXit, and WhatsApp by youths (Akpan, Akwaowo & Senam, 2013; Boyd & Ellison, 2008; Correa, Hinsley & de Zuniga, 2010; Yeboah & Ewur, 2014). This has resulted in social network addiction in some instances (La Barbera, La Paglia, & Valsavoia, 2009; Pantic, 2014). “The overall usage of SNSs increased by two hours per month to 5.5 hours, and active participation increased by 30% from 2009 to 2010” (Kuss & Griffiths, 2011, p. 3531). The 12- to 17-year-old youths from around the United States, determined that on a typical day, about 70% used SNSs (Madden, Lenhart, Cortesi, Gasser, et al., 2013). The accessibility that youths have to social networking platforms results in them spending large amounts of their time socialising.

Social media applications are widely used by children for social interaction, and sometimes for learning-related interaction. These media provide a potential platform where children can provide each other with learning support. This is already happening informally and formally. Dr Math is one successful example of a tutoring system where university students help high-school children with homework through MXit (Berge & Muilenburg, 2013; Butgereit, 2007; Butgereit & Botha, 2011). Working from the assumption that children's problems with reading and mathematics should be addressed as early as possible, a social media based tutoring system was developed. It was suitable for children in the very early phases of their schooling careers, and receiving homework assistance from teenagers.

According to Hussein and Nassuora (2011), the potential of mobile technology is huge and it has broken ground for enhancing knowledge-sharing activities among learners in schools. There are increasing numbers of institutions of higher education in South Africa, offering courses using mobile technologies as an alternative teaching and learning tool (Bagarukayo, & Kalema, 2015; Msomi, 2016). Regardless of such interests in mobile technologies in education, however, there is a lack of academic research on the use of these technologies as a tool to support young children with their work, in or out of their school setting, using social networking platforms (Hussein & Nassuora, 2011). It is important to establish how these technologies can be incorporated into school and home settings for educational purposes.

The fact that the social networking environment is a comfort zone for young people forms part of the motivation for this research. Teenagers, especially those who are socially advantaged, are already patronising these networks. Instead of discouraging this, researchers can find ways to turn this "problem" into a solution. The constant presence of teenagers on social networks can be seen as an opportunity to gain access to their learning support capacity (Chimbo & Gelderblom, 2012). For this research study, teenagers from privileged environments in Pretoria, South Africa, were chosen to provide social media based after-school support to children in grades 3 and 4, who come from disadvantaged communities.

This research investigated best practices and recommendations for the design of a user interface for a tutoring system. The system was based on social networking platforms that enabled teenagers in grades 9 and 10, with established social networks skills, to provide literacy and numeracy homework support to younger children in grades 3 and 4. Grades 9 and 10 teenagers were the chosen group, based on the assumption that they had settled in well at high school. They were not in the critical stage of high school, such as grades 11 and 12, where they would have to prepare to write final year examinations, or in Grade 8, where they would still be adjusting to high school life.

If older children from privileged communities could be motivated to provide after-school learning support to younger children who do not have academic support at home, this could, in a small way, make up for the problems mentioned previously. Previous research has established that it is possible to find South African teenagers who are willing to act as tutors, using social networking platforms (Chimbo & Gelderblom, 2012), to assist lower-grade learners with homework and test preparation. Some of the older learners with access to mobile or computer technology spend much of their time socialising with tools such as Facebook, Twitter and YouTube. An opportunity exists whereby the pervasiveness of mobile technology could be exploited to help with solving some of the problems in foundation-phase education in a developing-world learning context.

In the social media based, cross-age tutoring system, teenagers would provide homework support to young children from disadvantaged communities. Young children who come from well-to-do homes usually have parents assisting them with their homework. In South Africa, many young children are cared for at home by siblings or family members with low literacy levels, who cannot provide the necessary support with homework and preparation for tests. Having able children in higher grades helping those in lower grades, would go a long way in bridging the homework/learning support gap.

The strategy of cooperative inquiry (CI), in which children were partners in the design process, was used to design the tutoring system. Druin (2002) strongly believes in the involvement of end users in the design of any interactive system. As both the teenagers and the younger children were end users, both groups were involved in the design. Further motivation for using cooperative design (CD) was the fact that it contributes positively to problem-solving capacity, as well as social and communication skills, of participants (Guha, 2010).

1.2 Objectives of the Study

1.2.1 Aim of the Study

The aim of this study was to design a cross-age tutoring system based on social media platforms, whereby teenagers would provide learning support to younger children whose access to such support was hampered by unfavourable socio-economic circumstances. The intention was to involve the young children and teenagers as design partners to design an artifact, which would later be abstracted into a design framework.

1.2.2 Rationale of the Study

The intended study aimed at contributing to South Africa's socio-economic well-being through explicit promotion of child rights and responsible citizenship. Thousands of young children in South Africa lack proper educational resources, and researchers have the responsibility to explore every possible opportunity to provide these children with the education they deserve. In this study, teenagers from privileged communities were invited to provide after-school support to young children who did not have access to such support. This was done so that the researcher and children received the opportunity to display responsible citizenship, and the participating teenagers were able to develop social responsibility and learn to "give back" to those who were less privileged. Through the use of cooperative design, the children (also the young tutees) were given "a voice" in the design and development of the system. It is believed that any technology to be used by children should be designed in close collaboration with children. The children's involvement in the design of the system was most likely to contribute to a long-term interest in science and technology. The children would also develop technological, intellectual and social skills that go far beyond specific numeracy and literacy skills development.

1.2.3 Problem Statement

There are teaching and learning problems associated with lower-grade mathematics and literacy in South Africa, which have a ripple effect that can be seen in the low Grade 12 mathematics throughput. The poor achievement of learning outcomes in the higher grades can be caused by challenges faced in the foundation phases, such as lack of tutoring support at home, inappropriate pedagogical approaches, teacher absenteeism, large class sizes, limited infrastructure, etc. There is a great need to improve the quality of basic education provided to children from disadvantaged backgrounds by involving the children in solving the problem.

An opportunity exists whereby the pervasiveness of mobile technology could be exploited to help with solving some of the challenges in foundation phase education in a developing-world learning context. One way of solving this bigger problem can be by developing a cross-age tutoring system, similar to existing social networking platforms such as Facebook, YouTube, and Skype to support numeracy and literacy skills acquisition. Software applications intended for use by children are often designed by adults, often resulting in poor acceptance of the end product due to insufficient understanding by adults of the end user needs of children. Applications targeting children from different age groups and life circumstances can be designed through cooperative design by children of the relevant age groups and life circumstances. The motivations of the co-design partners, together with the power relations that exist between them, influence the co-design process. An abstraction of the outcome of this co-design process would then define a design framework for how co-design by children of different age groups and life circumstances should be conducted.

The research questions that exist to address the research problem are considered next.

1.2.4 Research Questions

This research focused on the following question:

How can a cross-age tutoring system be designed for implementation on a social networking platform to support numeracy and literacy skills acquisition?

SQ1 To what extent are teenage tutors willing and able to provide learning support to foundation phase learners who do not have access to such support?

SQ2 What are the best practices in providing after-school numeracy and literacy tutoring to grades 3 and 4 learners?

SQ3 Which elements of face-to-face tutoring can be incorporated into a tutoring system with similar characteristics to a social networking platform?

SQ4 What considerations should be taken into account when tutoring children from socio-economically disadvantaged contexts?

SQ5 What are the current practices, experiences and limitations of using social networking tools to support tutoring?

SQ6 How does CI contribute to the success of designing an online tutoring system?

To respond to these questions, this thesis addresses the following objectives:

1. To find out the extent to which teenage tutors are willing and able to provide learning support to foundation phase learners who do not have access to such support.

2. To identify and specify the best practices in providing after-school numeracy and literacy tutoring to learners.
3. To investigate the elements of face-to-face tutoring that can be incorporated into a tutoring system with similar characteristics to a social networking platform.
4. To explore the current practices, experiences and limitations of using social networking tools to support tutoring.
5. To gain an in depth understanding of co-design.
6. To develop a framework of the critical factors of the practice of co-design by children with children that affect co-design sessions.

1.3 Research Methodology

All research is based on some underlying philosophical assumptions about what constitutes 'valid' research, and which research methods are appropriate for the development of knowledge in a given study. The interpretive paradigm was identified for the framework of this study, because it is a paradigm concerned with understanding the world as it is from subjective experiences of individuals. The reason for choosing this paradigm was because it uses meaning-oriented methodologies such as interviewing or participant observation, that rely on a subjective relationship between the researcher and the subjects. Design Science Research (DSR) was selected as the design approach, as it contributes to design theory building through the construction of a purposeful artifact for a specific problem domain.

The research approach used in this study was an inductive qualitative approach, which enables researchers to condense raw textual data into brief summaries (Thomas, 2006). It helps researchers in establishing clear links between the research question(s) and the findings. In this study, the inductive approach provided an easily used and systematic set of procedures for analysing qualitative data, which produces reliable valid findings (Thomas, 2006). The outcome of the inductive analysis we used was the development of themes. Therefore, the questions in section 1.2.4 were answered using a qualitative inductive approach conducted through the application of the following research methods:

a) Literature Reviews

The purpose of using literature reviews as a methodology has been to identify and make explicit the issues, concepts and evidence associated with particular areas of significance in the study, that is, cross-age tutoring, social networking platforms and cooperative inquiry. These reviews provided awareness of the gaps and new ideas in these areas of study.

b) Interviews

Semi-structured interviews were employed to gather information from tutor participants on their interaction, assessment strategies, motivations and concerns regarding tutees, and to encourage them to raise other issues they felt to be relevant to the study.

c) Observations and Video Recordings

Observations and video recordings were carried out throughout the study, where the researcher observed tutors having face-to face tutoring encounters with the tutees. Recordings were also done while the tutors and the researchers were doing cooperative inquiry.

d) Cooperative inquiry

Cooperative inquiry, which is a method of involving users, especially children, very early in the design process, was used (Fails et al., 2012; Yip et al., 2013). The goal was to 'give the end users a voice' in the design and development of a cross-age tutoring system for after-school support for children in grades 3 and 4 (Druin, 1999; 2002). Prototyping, which refers to the users building a simple model of a cross-age tutoring application and experiment on its usefulness, was used by the tutors, tutees and researchers.

Chapter 4 discusses, in detail, the research methodologies and research design used in the study, including strategies, instruments, and data collection and analysis methods, while explaining the phases and processes involved in the study.

1.4 The Theoretical Framework

The current study falls within a mix of disciplines: education, social sciences and Human-Computer Interaction (HCI). The main theoretical concepts that guided this research were the following: social learning, motivation, cooperative design/inquiry and cyber safety. Figure 1.1 illustrates the theoretical framework of the study:

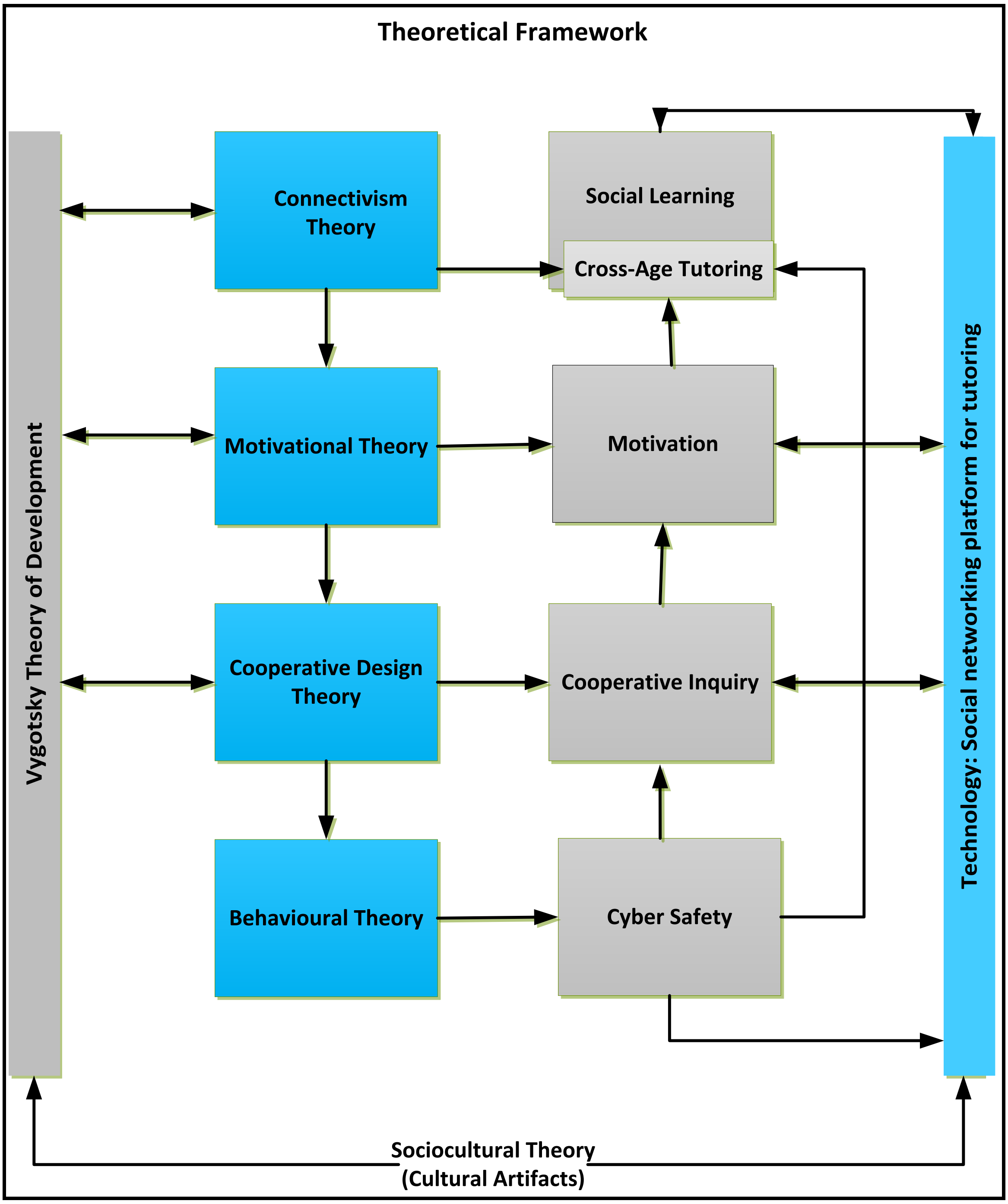


Figure 1.1: Theoretical framework of social networking platforms for tutoring

It shows Social Learning (and particularly cross-age tutoring), Motivation, Cooperative Inquiry and Cyber Safety as central concepts in the design of the social networking platform based tutoring system. It also shows that the concepts were founded on well-established bodies of knowledge in the form of foundational theories. The relationship between the main concepts, their associated theories and what has been done in this study is given below.

a) Social Learning

Social learning means participating with others to make sense of new ideas (Conner, 2010). It can create more powerful and enduring learning experiences through the use of online communities and networks, where learners are encouraged to co-create, collaborate and share knowledge, and fully participate in their learning. Social learning theory, especially connectivism, provided the theoretical context for social learning that is integrated with social media technologies (Siemens, 2004, 2005, 2008). It provided insights into the roles of researchers, educators and learners in the social networked environment. In this study, cross-age tutoring was categorised as a social learning intervention, because it involved learning through modelling and observation (tutee observation of tutor modelling), as well as reciprocal interaction between the participants. This reciprocal interaction is a defining characteristic of social learning, which is of importance to this study; the detailed discussion is given in Chapter 2.

b) Motivation

Motivation can be broadly defined as the forces acting on or within a person, which cause the arousal, direction and persistence of goal-directed, voluntary effort. According to Cherry (2010), motivation is the force that initiates, guides and maintains goal-oriented behaviours. The forces that lie beneath motivation can be biological, social, emotional or cognitive in nature. Motivation theory is thus concerned with the processes that explain why and how human behaviour is activated. Children who are motivated to engage in playful learning activities learn better than those who focus solely on serious and structured learning activities. Vygotsky (1978, p. 100) claims that "a child's greatest achievements are possible in play". The fact that, in this study, teenaged participants provided tutoring support to young children, helped in turning the learning experience of the young children into a less formal one. Added to that, the use of a social networking platform provided an exciting environment that was perceived by the learners as more playful and exciting than the learning environments they are used to. Hence, the young children were motivated to do better, and the teenagers, who were the tutors offering the support, were also motivated by this.

c) Cooperative Inquiry (CI)

CI is a method of designing technology for a group of end users, by working with the end users during the process (Druin, 1999; 2002). It is a method which has its roots in participatory design and contextual design (Guha, 2010). Theories of cooperative design, participatory design and contextual inquiry, provide the grounding for CI. These are all theories that fall within the broader theory of interaction design – which deals with the shaping of interactive products and services, with a specific focus on their use. CI was used in this study, and detailed discussion of it is presented in Chapter 3. Low-fidelity prototyping was used, in which young children and teenagers were supplied with big bags filled with an assortment of art supplies such as glue, clay, string, markers, cork and scissors, to build their models. Some insights were obtained from this cooperative inquiry study, and these are discussed in Chapter 6.

d) Cyber Safety

Cyber safety refers to the protection of individuals when they are online. Cyber safety addresses online dangers such as exposure to illegal or inappropriate material, stranger danger, identity theft, invasion of privacy, harassment and cyber bullying (ACMA, 2010). For this study, the researcher discussed cyber safety from the perspective of behavioural theory. The study investigated cyber safety issues in a social networking system aimed at young children. The researcher investigated types of behaviours of teenagers and young children, especially behaviours that can make them victims and/or perpetrators. Researchers needed to understand the behaviours of children, in order to identify what could make them vulnerable. Children require protection from unsuitable content, paedophiles and cyber bullies. By identifying behavioural traits of cyber criminals, researchers ensured that the designed system would be able to exclude them. The design therefore, took into account behavioural theory, in order to deal with design for safety. Cyber safety is discussed in detail in Chapter 2.

All these theories and concepts were examined through the lenses of Vygotsky's theory of development. Vygotsky's theory relates to each of the identified theories (and their related concepts) as follows:

a) Connectivism

Behaviourism, cognitivism and constructivism were the three broad learning theories most often utilised in the creation of instructional environments. These theories were developed at a time when learning was not impacted by technology. Connectivism is a learning theory which is contextualised in a digital era, and characterised by the influence of technology in the field of education (Bell, 2010, 2011; Calvani, 2008; Downes, 2012; Kop & Hill, 2008; Siemens, 2004, 2005). It is a theory of learning based on the premise that knowledge exists in the world, rather than in the head of an individual (Duke, Harper & Johnston, 2013). Connectivism presents a model of learning that acknowledges the tectonic shifts in society, where learning is no longer an internal, individualistic activity (Siemens, 2004). The way people work and function is altered when new tools are utilised. The field of education has been slow to recognise both the impact of new learning tools, and the environmental changes in what it means to learn (Downes, 2012; Siemens, 2008). Connectivism provides insight into learning skills and tasks needed for learners to flourish in a digital era. Connectivism proposes a perspective similar to Vygotsky's activity theory, in that it regards knowledge as existing within systems which are accessed through people participating in activities (Calvani, 2008; Siemens, 2005). The above relates to this study, as the researcher looked at the participation of both teenagers and young children engaging in design activities of a tutoring application based on social networking platforms.

b) Motivational Theory

Motivation can be divided into two different types: intrinsic (internal) motivation and extrinsic (external) motivation. Intrinsic motivation is the self-desire to seek out new things and new challenges, to analyse one's capacity, to observe, and to gain knowledge (Ryan & Deci, 2000). Intrinsic motivation is a natural motivational tendency, and is a critical element in cognitive, social and physical development. Learners who are intrinsically motivated are more likely to engage in a task willingly, as well as work to improve their skills, thereby increasing their capabilities. Intrinsic motivation can be long-lasting and self-sustaining. Extrinsic motivation, on the other hand, refers to the performance of an activity, in order to attain a desired outcome. This type of motivation comes from influences outside of the individual. Usually, extrinsic motivation is used to attain outcomes that a person would not obtain from intrinsic motivation (Ryan & Deci, 2000). Common extrinsic motivations are rewards (money or grades, for example) for showing the desired behaviour, and the threat of punishment following misbehaviour.

Motivational theory was relevant for this study, given that an investigation was done to determine what motivated teenagers to participate as tutors in a cross-age tutoring system in order to achieve success. Insights obtained from this investigation were that teenagers are motivated by both intrinsic and extrinsic factors. Intrinsic factors mentioned by the teenagers were that it was an opportunity to make a difference in someone's life, doing good, and feeling comfortable doing it. Extrinsic factors mentioned were recognition, awards, money, and other concrete benefits, discussed in detail in Chapter 5.

c) Cooperative Design Theory

Vygotskian theory has been used in reference to children and technology in the field of Interaction Design and Children (Gelderblom, 2008; Guha, 2010). Vygotsky believed that children could learn more if they were actively working together with a more experienced person (Vygotsky, 1978). Cooperative inquiry (the cooperative design techniques used in this study) gave young children the opportunity to design with the support of more experienced designers. As a result it offered many cognitive and social experiences to all participants in the study.

d) Sociocultural Theory

Vygotsky (1978) advocates a sociocultural theory whereby we learn how to think through our interactions with those around us. Vygotsky acknowledges the importance of the external world in child development. The author positions the child within a web of culture, and suggests that cognition is the product of that culture. Sociocultural theory supports the fact that human social and mental activity is organised through culturally constructed artefacts. For Vygotsky, cultural symbols and artefacts are fundamental in determining both what children learn and how they learn it. According to Turuk (2008), these artefacts are created by humans under specific social and historical conditions; for example, social media can operate as Vygotskian scaffolds, prodding and inspiring children to accomplish tasks beyond their usual performance levels (Weigel & Heikkinen, 2007). Based on the sociocultural lens, this study weaved the

Vygotskian web of culture further by adding social media as a cultural artefact that facilitated learning. The sociocultural theory is further discussed in Chapter 2.

1.5 Research Contributions

The main contribution of this study was the definition of the *Co-Design by Children for Children (CD2C)* Design Framework. The design framework provides a guideline of how co-design by children from different age groups and life circumstances should be conducted. Another novel aspect of this study was the design and development of an artifact, the TitanTutor, by teenagers and young children as equal partners in the co-design process. The design and development of the TitanTutor artifact contributed to Design Science Research theory-building through construction. There is an undoubted push for children's involvement in cooperative design research in the developing world. Underprivileged children participated in the co-design of an application which would help them with homework support, giving a voice to those who frequently cannot participate in the technology design process. The results could potentially be used to encourage children in developing countries to be involved in design and can also be used to encourage more youths to participate in tutoring, for the benefit of young, under-privileged children.

1.6 Specific Relevance

There is a need to solve the education problems in South Africa. The South African government has invited researchers to find sustainable and practical solutions to the challenges of improving numeracy and literacy in schools (Modisaotsile, 2012; Ramdass, 2009). It is generally accepted that there is an urgent need to improve the quality of mathematics education and the number of students with access to it. Poor grounding in numeracy and literacy in primary school is one of the fundamental causes of poor learning outcomes. The objective of the research was to address the challenges of numeracy and literacy education in South Africa, with a special focus on tutoring enabled by ubiquitous social networking platforms. Thus, the study has contributed to this body of knowledge.

1.7 Definition of Terms

The concepts and terms central to this study are defined in the following table:

Table 1.1: Definitions of concepts and terms central to the study

Term	Definition
1. Mobile technology	Mobile technology is a collective term used to describe the various types of cellular communication technology.
2. Cross-age tutoring	Cross-age tutoring refers to a system of instruction where the tutor teaches people who are older than the tutee, or vice versa.
3. Socioeconomic status	Socio-economic status is commonly conceptualised as the social standing or class of an individual or group.
4. Numeracy	Numeracy is defined as the ability to reason and to apply simple numerical concepts.
5. Literacy	Literacy refers to the ability to read for knowledge, write coherently, and think critically about the written word.
6. Developing country	A developing country is a nation with a low living standard, undeveloped industrial base, and low human development index, relative to other countries.
7. Cultural barrier	A cultural barrier is a wall between two people because of identity differences.
8. Disadvantaged children	Disadvantaged children have been considered as those whose home background does not prepare them as well as other children, for an education.
9. Privileged environments	A right or immunity or benefit granted to a particular individual or class.
10. Cooperative inquiry	It is an approach that involves creating new technologies for children, with children.
11. Cooperative design	Cooperative design is a method in which children are partners in the design process.
12. Participatory design	Participatory design is an approach to design that actively involves all stakeholders (e.g. employees, partners, customers, citizens, end users) in the design process to help ensure the result meets their needs and is usable.
13. Contextual design	Contextual design is an approach to designing user-centred ICT systems, with forms on being integrated in existing work contexts and practices.

1.8 Limitations and Delimitations

1.8.1 Limitations of the Study

Due to the unique sample for the study, results were not generalised beyond the specific population from which the sample was drawn. Due to the length of the study, a significant number of participants available at the beginning of the study were, however, unavailable, or unwilling to participate, in the final stage of the research. Nevertheless, some willingly agreed to help with the testing of the system, although they were now in upper grades – that is, grades 11 and 12.

1.8.2 Delimitation of the Study

Due to the large number of potential participants in the study population, the test population that was involved in the current study focused only on the foundation phase, grades 3 and 4 primary school learners, and teenagers in grades 9 and 10, from different cultural backgrounds. The primary school children were from disadvantaged environments, and the teenagers were from privileged home and school environments in Gauteng.

The structure of the thesis is given in the next section where Figure 1.2 summarises the chapter interrelationships of the study.

1.9 Structure of the Thesis

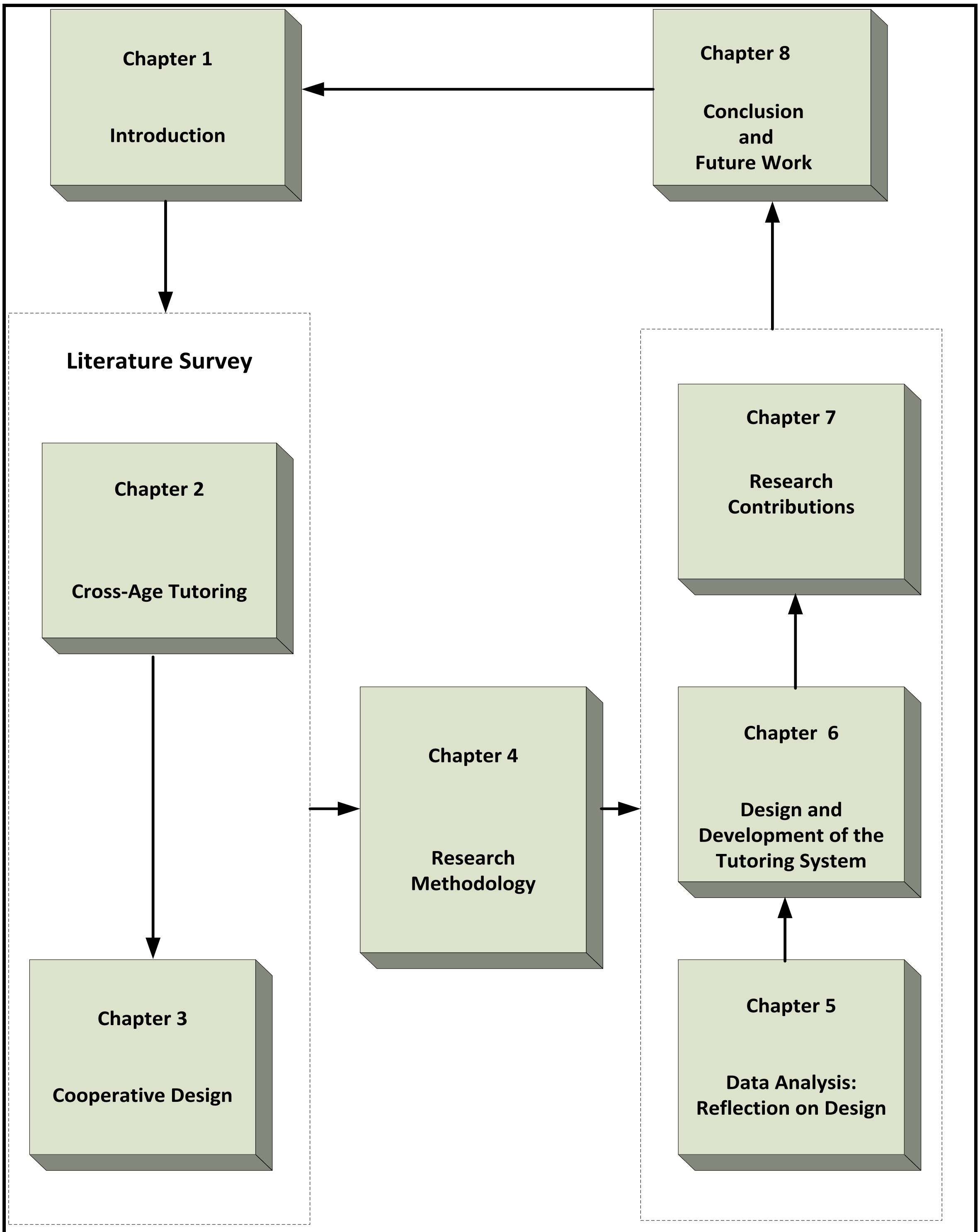


Figure 1.2: Structure and chapter interrelationships of the study

Chapter 1: Introduction

The introduction and overview of the study was presented in this chapter. The chapter established the purpose of the research, the statement of the problem, the significance of the research, its delimitations, the theoretical framework of the study, and an overview of the rest of the thesis chapters.

Chapter 2: Literature Review on Cross-Age Tutoring

This chapter discusses what cross-age tutoring is, on which particular areas of the topic previous research concentrated, and whether there have been developments over time. The chapter also discusses the investigation of social networking as a platform for a cross-age tutoring system, what has been done in this area to date, and what the significant discoveries, key concepts, arguments, and/or theories are, that scholars have put forward.

Chapter 3: Literature Review on Cooperative Design

This chapter discusses the approaches to design, cooperative design and cooperative inquiry. The discussion focuses on the significant discoveries, key concepts, arguments, and/or the theoretical framework cooperative design and cooperative inquiry.

Chapter 4: Research Methodology

In Chapter 4, the methods used to conduct the research are discussed, and the research design is described. The process for consolidating the data extracted from semi-structured and unstructured interviews, observations, and audio and video recordings, is described.

Chapter 5: Data Analysis: Reflection on the Design Process

Chapter 5 covers the data analysis, with reflections on the design process. The chapter focuses on the interpretation of the data that was translated to design. It discusses the research results, with respect to the research questions.

Chapter 6: Design and Development of the Tutoring System

Chapter 6 discusses the design and development of the tutoring system, TitanTutor.

Chapter 7: Research Contributions

In Chapter 7, knowledge contributions, practical and theoretical implications and artifact contributions of the study are given. The design framework contribution is explained.

Chapter 8: Conclusions and Future Work

In Chapter 8, the findings from the research are summarised and conclusions are drawn. Future work is also discussed in this chapter. In this section, I discuss my findings and how they interoperate with each other to answer my research questions.

Appendices

The appendices section contains information that is peripheral to the thesis report, and, if included, would disorganise the flow of its content. However, the inclusion of this section may complete an argument or aspect to be discussed in the report.

Summary

Chapter 1 described the severe problems encountered in lower-grade numeracy and literacy levels in South Africa, which have a ripple effect that is seen in the low Grade 12 mathematics throughput. A brief discussion followed, on social networking as a platform for a cross-age tutoring system that could be designed and implemented and tested in a restricted environment before preparing it for more general deployment. This chapter, additionally, provided an overview of the study, including positing some potential contributions and limitations of the study.

CHAPTER 2: LITERATURE REVIEW ON CROSS-AGE TUTORING

2.1 Introduction

Chapters 2 and 3 comprise a literature study of the two main components of this study: cross-age tutoring and cooperative inquiry. Chapter 2 provides an overview of previous research on cross-age tutoring, by tracing the cross-age tutoring evolution within the scholarship of HCI. The purpose of the literature review is threefold: firstly, it places the research study in a historical context; secondly, the review shows familiarity with state-of-the-art developments and identification of likely directions for future research in this area; and, finally, it reveals the impact of peer and cross-age tutoring worldwide. The literature review investigates the relatively new and developing topics on cross-age tutoring. In addition, the chapter provides a review of social media platforms and their potential contribution to cross-age tutoring. Section 2.1.1 and Figure 2.1 provide a conceptual framework of cross-age tutoring, based on social networking platforms, as a starting point.

2.1.1 Conceptual Framework

The conceptual framework of the study is outlined in Figure 2.1, below. It covers the following main concepts: cross-age tutoring via social media platforms, context, technology, and cooperative inquiry.

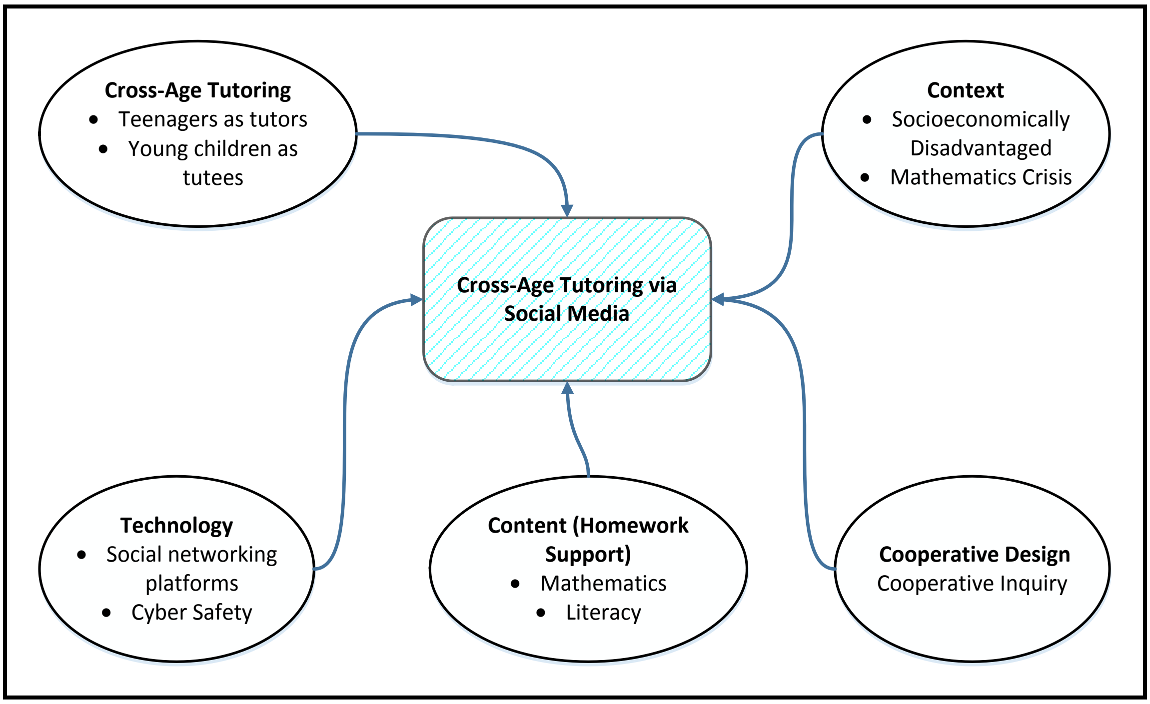


Figure 2 1: Conceptual framework of the study

Each of the components of the conceptual framework is explained below.

a) Context

The context of the study was the socioeconomic factors such as poverty, teacher shortages, poor after-school support, and the general lack of resources for underprivileged children, on the one hand, and, on the other hand, exactly the opposite for privileged children. This has led to the poor performance in lower grade literacy and numeracy in South Africa, and has resulted in a ripple effect that can be seen in the low Grade 12 mathematics throughput. The socioeconomic inequality in South Africa is very well reflected in the inequality between urban and rural schools. In general, urban schools draw the best teachers, can generate funds through parent involvement, and rely on parents having skills to support their children with their schoolwork. In underdeveloped rural areas there are very few qualified teachers, children are cared for by family members with low levels of literacy, and educational resources are scarce. This study involves teenagers from privileged educational settings, supporting younger children who receive little or no academic support at home.

b) Cross-age tutoring

One way to improve low literacy is to help young children with their homework and test preparations. Many young children are cared for at home by family members with low literacy levels, who cannot provide the necessary support with homework and preparation for tests. In this study, cross-age tutoring involved teenagers from advantaged communities, who helped the young children from disadvantaged backgrounds with their homework support and test preparation, using social media platforms.

c) Technology

A survey of available technologies that could potentially be used in the designing of cross-age tutoring platform was discussed. Social networking platforms such as WhatsApp, MXit, Facebook, Skype, YouTube and the Internet, were explored as potential academic networking platforms. Learners need to be made aware of the powerful ways networking can change the way they look at education, not just their social lives. In South Africa, however, young children, including those who have thus far had limited access to technology, were naturally drawn to technology, and keen to use a system that allows them to communicate with older children about their schoolwork.

d) Content

In this study, mathematics and literacy were targeted, as they are among the most important life skills that children should be taught. No child should leave school without having mastered these skills to the best of their ability. Literacy and numeracy skills are crucial to a person's ability to develop fully as an individual, to live a satisfying and rewarding life, and to participate fully in society, but we know that some children are not developing these skills as they should. Therefore, ensuring that all young people acquire these skills is one of the greatest contributions that we can make towards achieving social justice and equity in our country.

e) Cooperative Design

The aim of this study was to develop a social media based, cross-age tutoring system whereby teenagers could provide online homework support to younger children from less advantaged communities. The approach was to have children design an application, similar to social networking platforms that would enable other children to do their homework and test preparations online. This application was designed using cooperative inquiry – a methodology that evolved through the participatory design process, and involves children in the design.

The literature review chapters give a more elaborate discussion of the concepts used in the study. It is therefore important to set the context of the literature review work by first providing the following:

- a brief description of the objectives of the literature study, and
- an organisational outline of the work presented in these two chapters.

2.1.2 Objectives of the Literature Review on Cross-Age Tutoring

The main objective of the literature study was to review previous literature on tutoring, with a view of ascertaining the state of the art of cross-age tutoring intervention designs. Another objective was to learn about the dominant theoretical frameworks, if any, that have guided studies in peer and cross-age tutoring. Yet another objective was to review definitions of cross-age tutoring, in order to inform the operational definition of key terms in my thesis.

2.1.3 Organisation of the Chapter

The remainder of this chapter is divided into ten sections that deal with the following aspects, respectively: different types of tutoring models, peer and cross-age tutoring, the benefits of cross-age tutoring (in particular, tutor and tutee benefits), cross-age tutoring research studies in non-South African settings; cross-age tutoring in the South African context, research gaps and attempts to fill the gaps, and lastly, social networking platforms and their potential contribution to cross-age tutoring.

2.2 Tutoring Models

Tutoring is a kind of individualised instructional delivery mode, with one-on-one human interaction, in order to help students improve their learning strategies, facilitate active learning, and promote independence and empowerment (Frey & Reigeluth, 1986; Gier & Hancock, 1996; Goodyear, 1991; Grant & Spencer, 2003; Wenger, 1987). Studies have shown that one-on-one tutoring is one of the most effective educational delivery methods (Elbaum, Vaughn, Hughes, & Moody, 2000; Leyzberg, 2014). Bloom (1984) argues that students involved in one-on-one tutoring seem to perform at about the 98th percentile, compared with students who are traditionally trained via the group instruction method. Implemented and supervised carefully, tutoring is a method of instruction that can improve and supplement traditional teaching, while assisting students with specific learning needs (Center for Prevention Research and Development [CPRD], 2009).

Tutoring can be done either by an expert, often called professional tutoring, or by an amateur, usually referred to as peer tutoring (Gier & Hancock, 1996). Amateurs differ from professionals in that amateur tutors are usually untrained, and therefore need to be under the supervision of a more experienced person while tutoring. Another kind of tutoring is school tutoring, which often has parents, teacher-aids or other paraprofessionals, paid or unpaid, acting as tutors (Chopra et al., 2004). Tutoring can also be used for first-time, or non-remedial, instruction. It can be used in conjunction with other modes of instruction. Frey and Reigeluth (1986) described the most prominent tutoring models introduced in the early 19^{th} century. They identified the domain for which each model was designed, that included the kind of tutees and tutors, the skill area, the type of tutoring (for example, first-time vs. remedial, and adjunct vs. mainline), and the level of learning.

2.2.1 Historical Perspectives of Tutoring

The origins of tutoring can be traced to the developing needs of societies to educate the young in the tasks necessary to ensure the continuation of the group (Campbell, 1999). The practice of tutoring has a rich history, dating back to the ancient Greeks, as noted by Topping (1988; 1998). The first pedagogy among primitive societies, mentioned by Jenkins and Jenkins (1987, p. 64), was that of “parents teaching their offspring how to make a fire and to hunt, and adolescents instructing younger siblings about edible berries and roots”. The main objective here was to educate the young children in necessary tasks. Frey and Reigeluth (1986) discuss some of the early tutoring models and their characteristics. The earliest one was the Laubach Literacy International, which was originally developed in 1930. It was an organisation founded by Frank C. Laubach, which enlisted volunteer tutors to organise and administer local community-based literacy programmes for teaching reading and writing skills to adults – both native speakers of English, and speakers of other languages.

Douglas Ellison developed the Programmed Tutoring model in the 1960s at Indiana University. The lesson content in Programmed Tutoring was highly structured, and designed to lead the learner in small steps, much like programmed instruction. The instructional materials were described in enough detail for nonprofessional adults or students to use them quickly. Ellison advocated the use of his tutoring programme as an adjunct to academic classroom teaching, rather than as a substitute for it (Frey & Reigeluth, 1986).

Literacy Volunteers of America, Inc., developed in 1962 in Syracuse, New York, was a national literacy tutoring programme. Its primary emphasis was on the tutoring of adults in reading and learning English as a second language, through community-based, volunteer tutoring. Fred Keller advocated the Personalised System of Instruction (PSI) in 1968. It was an instructional management system in which students worked on individualised materials in a classroom setting at their own pace. Advanced students, or proctors, provided one-to-one tutoring assistance to help students master the sequentially arranged materials. PSI originated at college level, but has been used at all grade levels and for most subject areas (Frey & Reigeluth, 1986).

The Audio-Tutorial System, developed by Postlethwait, Novak and Murray in 1972, was an individually-paced, independent-study method using audio tapes. These tapes were tutorial conversations with the instructor. A live instructor was always available to give students needed tutorial assistance. Besides one-to-one instruction, the Audio-Tutoring System also utilises large and small group instruction. The Audio-Tutoring system was used primarily in science education, but has been successfully applied in many other subject areas, at many age levels, and in both institutional and non-institutional settings (Frey & Reigeluth, 1986).

The instructional model, known as structured tutoring, was developed by Grant Von Harrison between 1972 and 1975 (Frey & Reigeluth, 1986). In this model, tutors worked with learners in a one-to-one situation. Harrison's model has been used in elementary schools for intergrade peer tutoring, and for parent and paraprofessional tutoring in both reading and mathematics, often for remedial purposes.

Peter Rosenbaum developed a peer tutoring model in 1973, based on the instructional program processes of computer-assisted instruction, known as the Peer-Mediated Instruction (PMI). In the PMI system, students worked in pairs, with one student designated as the "teacher" and the other designated as the "student". Peer-Mediated Instruction has been proved effective in teaching spelling at an elementary level (Frey & Reigeluth, 1986).

Other academics trace tutoring back to the "Monitorial System" of the early nineteenth century, which was proposed by Joseph Lancaster (Bland & Harris, 1989, p. 142). In this system, children were found to be very successful in teaching other children within his schools. However, the system was dictated by economic rather than educational factors. A limited number of trained teachers were available to teach the greater numbers of children, so other older or more competent students were utilised (Campbell, 1999). Early tutorial programmes were based on several assumptions or predictions that learners are often likely to relate to and trust others in their own circumstances, more than professionals whose experience might be entirely different from theirs. In the mid-1900s there was a rebirth of tutoring in society and researchers began looking seriously at tutoring as an alternative to teacher-led group instruction (Osguthorpe et al., 1985). Initiatives of tutoring were developed with the aim of improving the student's experience and student progression and retention (National Audit Office [NAO], 2002). The NAO has recommended investment to support students through the early period of their studies.

Another reason for introducing tutoring was that researchers discovered that children were, in some respects, better teachers than adults were (Dash, Baral, & Jena, 2015; Fox, Vos, & Geldenhuys, 2007; Rodriguez, 2013; Topping, 1996). The child tutors and tutees seemed considerate and respectful of each other's feelings. Tutoring was also introduced to reduce the workload on teachers, as they were faced with large numbers of children in a class, and to reduce the financial burden on schools in hiring more teachers.

Tutoring can help to enhance learners' understanding of their subject matter, and also help to develop their problem-solving skills. In addition to improving academic competence, tutoring transforms learning from a private to a social activity, thereby increasing social interaction and making the process of learning and its end product more rewarding (Colvin, 2007; Karolia, 2008). Peer and cross-age tutoring are discussed in sections 2.3 and 2.4. The model of tutoring we concentrated on in this study, however, was cross-age tutoring.

Table 2.1 is a comparative summary of the models discussed above. The models present conceptual developments, over the years, shown in tutoring. There has been some transformation from tutoring mainly catering for adult literacy to catering for all ages at any level. Nevertheless, much still needs to be done on tutoring of young children by teenagers.

Table 2.1: Comparative summary of the tutoring models

	Based on individualised material	One-on-one instruction	Based on age level	Reading and mathematics tutoring	Based on college level	For remedial purposes	Based on structured tutoring	Parent and paraprofessional tutoring	Programmed instruction	Community based
Personalised System of Instruction (1968)	√	√	√	√	√					
Audio-Tutoring System (1972)	√	√	√				√		√	
Peer-Assisted Instruction (1973)		√	√	√		√	√		√	
Structured Tutoring (1972; 1975)		√		√		√	√	√		
Programmed Tutoring (1976)				√	√	√	√		√	
Literacy Volunteers of America (1981)				√		√	√	√		√
Laubach Literacy International (1981)	√			√		√				√
System	**Category**									

Tutoring models vary, and can focus exclusively on homework assistance, skill-building, or some combination of both. Depending on the type of tutoring programme, specific outcomes can also range from acquiring new skills to increasing homework assignment completion

(Hock et al., 2001; Nguyen, 2013). Tutoring programmes also vary in the type of tutors they employ: community volunteers, same-age or older cross-age.

2.3 Peer Tutoring

According to Karcher (2005), peer tutoring has been the most thoroughly researched tutoring method, with both outcome and process studies reported in the literature since the 1970s. Goodlad (1979, p. 13) defined peer tutoring as, "a system of instructions in which learners teach each other and learn by teaching". It is characterised by "specific role-taking where at any point someone has the job of tutor or helper, and the other (or others) are in a role as tutee(s)" (Topping et al., 2003, p. 292). According to Gartner and Riessman (1993, p. 1), peer tutoring is an "unutilised resource" with minimal cost and high effectiveness. Wagner (1990) traces the historical origins of peer tutoring in Western civilization back to Greece in the first century A.D. through Rome, Germany, other European locales, and finally America. Peer tutoring is a flexible, peer-mediated strategy that involves students serving as academic tutors and tutees. Typically, a higher performing student is paired with a lower performing student to review critical academic or behavioural concepts (Hott, Walker, & Sanhi, 2012).

Peer tutoring has received much attention in educational research, and tutoring programmes have been found to have drastically increased achievement scores in subjects such as mathematics, literacy and science, among tutees (Ozgen, 2013). Within peer tutoring there are variations such as fellows (i.e. social status issue), same age, same class level, same school, and etc. Cross-age tutoring may mean learners of different ages, different class levels, different schools, and etc. These variables are important for PEER tutoring.

There are several well-known peer tutoring programmes, such as the Coca-Cola Valued Youth Program, which claims to have worked with more than 129,000 children, families and educators (Coca-Cola Youth Partnership, 2002). The Coca-Cola Valued Youth Program identifies students who are considered to be at risk of dropping out, and places them in a designated class where they become engaged in learning by tutoring younger children. The "tutees" develop a strong affection for their tutors. An added benefit is that tutors recapture academic skills they may have forgotten or missed during their earlier school years. In the Coca-Cola Valued Youth Program, tutors improve and contribute to their own education as well as to others. Most importantly, however, they find caring adults, as well as young children who look forward to seeing them at school.

The Chicago-based Time Dollar Tutoring programme reportedly had provided 480,000 hours of instructional time in the Chicago schools through their programme (Boyle, n.d.), and is now operated in seven other states and in Washington, DC. In 1995, the Chicago mayor, Richard Daley, decided to reform the city's public education (Boyle, n.d). Chicago ranked as one of the worst cities in the nation with respect to education. Based on the city's dire situation, the Time Dollar Institute was able to persuade the school system and city officials to experiment with a tutoring programme using Time Dollars[1], in the south side of Chicago. In the first year, five elementary schools in Englewood took part, and in the next year that number jumped to ten, because of the success of the first year.

There are also large-scale peer helping organisations, such as Peer Assistance and Leadership (PAL), which reflected variants of peer tutoring (Topping & Ehly, 1998). PAL is a peer helping programme that seeks to build resiliency in youth by pairing youth with peer helpers who receive training and support from teachers participating in the programme. The programme is designed to help youth avoid risk factors for substance use as well as other problems, such as low achievement in school, dropout, absenteeism, violence, teen pregnancy, and suicide. PAL peer helpers act as guides, tutors, mentors and mediators to peers or younger students (PAL mentees), by utilising skills learned through PAL, including cultural competency, effective communication, decision-making, higher order thinking, and resiliency building (Topping & Ehly, 1998). Learning Helpers (National Helpers Network, 1998) was a similar peer helping programme that had 37 state organisations and 14 international affiliates (National Peer Helpers Association, 2004). These peer tutoring programmes had short-term relationships, however, and their primary emphasis was on problem or academic remediation, and involved only same age peers.

Hott et al. (2012) describe a number of peer tutoring models, namely class-wide peer tutoring (CWPT) that involves dividing the entire class into groups of two to five students with differing ability levels. Students then act as tutors, tutees, or both tutors and tutees. This type of tutoring

[1] **Time Dollars** are a tax-exempt complementary currency used as a means of providing mutual credit in **Time** Banking.

involves highly structured procedures such as direct rehearsal, competitive teams, and posting of score (Fulk & King, 2001; Hott et al., 2012). The entire class participates in structured peer tutoring activities two or more times per week, for approximately 30 minutes (Harper & Maheady, 2007). While the procedures and routines in CWPT remain the same, student pairings or groups may change weekly or biweekly. In CWPT, student pairings are fluid, and may be based on achievement levels or student compatibility. Students may also be grouped to promote social development or opportunities to work with students from a variety of backgrounds (Hott et al., 2012). CWPT has been used extensively in elementary schools with many different children and content areas, but it has not been used as much for middle and high school level students, nor has it been used in outside-school environments.

Peer-Assisted Learning Strategies (PALS) is a version of the CWPT model. It involves a teacher pairing students who need additional instruction or help, with a peer who can assist (Fuchs, Fuchs, & Burish, 2000). Groups are flexible and change often across a variety of subject areas or skills. Cue cards – small pieces of cardstock upon which are printed a list of tutoring steps, may be provided to help students remember the PALS steps (Spencer, Scruggs & Mastropieri, 2003). All students have the opportunity to function as a tutor or tutee at differing times. Students are typically paired with other students who are at the same skill level, without a large discrepancy between abilities (Hott et al., 2012).

Reciprocal Peer Tutoring (RPT) is another model where two or more students alternate between acting as tutor and tutee during each session, with equitable time in role (Fantuzzo, King, & Heller, 1992; Hott et al., 2012). Often, higher performing students are paired with lower performing students. RPT utilises a structured format that encourages teaching material, monitoring answers, and evaluating and encouraging peers. Both group and individual rewards may be earned to motivate and maximise learning. Students in RPT may prepare the instructional materials, and are responsible for monitoring and evaluating their peers once they have selected a goal and reward as outlined by their teacher.

Same-age peer tutoring, where peers are paired to review key concepts of areas of study, is another model. Students may have similar ability levels, or a more advanced student can be paired with a less advanced student. Students who have similar abilities should have an equal understanding of the content material and concepts. When pairing students with differing levels, the roles of tutor and tutee may be alternated, allowing the lower performing student to quiz the higher performing student. Answers should be provided to the student who is lower achieving, when acting as a tutor, in order to assist with any deficits in content knowledge. Same-age peer tutoring, such as class-wide peer tutoring, can be completed within the students' classroom, or tutoring can be completed across differing classes (Hott et al., 2012). Procedures are more flexible than traditional class-wide peer tutoring configurations.

The last model, as given by Hott et al. (2012) is cross-age peer tutoring, where older students are paired with younger students to teach or review a skill. This study concentrated on the cross-age tutoring model. Table 2.2 and Figure 2.1, below, illustrate a comparative summary of the peer tutoring programmes discussed above, according to their maturity:

Table 2.2: Illustration of the differences of the peer tutoring programmes discussed above according to their maturity

Name of Programme	**Unique features of the Programmes**
Chicago-based times dollar tutoring programme	First coined by economists in the late 1970's to explain why development programmes seemed so difficult to sustain, and why they so often had exactly the opposite result than what was intended.
Learning helper	Learning helper is a comprehensive computer teaching system for children (students) with learning difficulties such as autism.
Coca-Cola valued youth program	A programme which provided connectedness among students.
Assistance and Leadership (PAL)	PAL peer helpers help in so many ways as guides, tutors, mentors and mediators, to peers or younger students (PAL mentees) by utilising skills learned through PAL, including cultural competency, effective communication, decision-making, higher order thinking, and resiliency building.
Class-wide (CWPT)	CWPT has been effective in teaching spelling to both students in general education and students with Attention Deficit Hyperactivity

	Disorder (ADHD), mild intellectual disabilities, and learning disabilities.
Peer Assisted Learning Strategies (PALS)	PALS are a 25-to-35-minute math or reading activity designed to complement, not replace, existing reading and math curricula.
Reciprocal Peer Tutorial (RPT)	Students are assembled in groups of two or more, and are trained to work together on a specific academic task. The students work together to prompt, monitor and evaluate each other, while working toward group goals.
Cross-age tutoring	Older students assisting younger students through tutoring

Similarities of the Programmes

Besides the uniqueness in each programme there were some which had similar features. The similarities in the following programmes – Learning helper (1998), Chicago-based times dollar tutoring (late 70s), PAL (2004), and Coca-Cola valued youth (2002), are that they all had the following:

- short term relationships;
- their primary emphasis was on problem or academic remediation; and
- they involved only same-age peers.

Similarly, Peer-assisted learning strategies (PALS), Cross-age tutoring, Reciprocal peer tutoring (RPT) and Class-wide are all versions of CPWT.

2.4 Cross-Age Tutoring

Cross-age tutoring is a type of peer tutoring that has gained increased attention over the years. Whereas in peer tutoring the tutor and tutee are from the same age group, the process of cross-age peer tutoring involves an older student, under a teacher's guidance, helping a younger student to learn or practice a skill or concept (Daniels, 2004). Students' pairing may include a variety of combinations of primary students as tutees with high school students as tutors, or those who are one or three grades older, or advanced students (Cairo & Craig, 2005; De Wever et al., 2010; Miller & Miller, 1995). Cross-age tutoring actively engages both tutors and tutees in their education, and gives students a feeling of control over academic outcomes (Kalkowski, 1995). Students can practice appropriate social skills while being academically engaged (Barbetta & Miller, 1991).

2.4.1 Vygotsky's related Theoretical Framework of Cross-Age Tutoring

In this study, theories were introduced, as they illuminated the effects, both positive and potentially negative, of cross-age peer tutoring programmes on tutors and tutees. Vygotsky's work provides insights that contribute to an understanding of cross-age tutoring. He stressed the importance of collaborating with a more competent partner (Vygotsky, 1978). For Vygotsky, age is not as important as the relative skills of the individuals. In a tutoring relationship, a more competent tutor can offer instruction at a level just beyond the tutee's individual capability – that is, within the tutee's zone of proximal development (Vygotsky, 1978). 'Zone of proximal development' (ZPD) is defined as the "distance between the actual development as determined by individual problem solving, and the level of potential development as determined through problem solving under adult guidance or collaboration with more capable peers" (Vygostky, 1978, p. 86). The concept was developed by Vygotsky, and referred to the difference between a learner's ability to perform a task independently versus with guidance.

Vygotsky's sociocultural theory can be used to elucidate the process of a cross-age tutoring programme. The theory suggests that all human activities are socially, culturally and historically constructed (Vygotsky, 1978). Vygotsky argued that in order to determine the nature and path of development in children, it is essential to examine the social environment where the development occurs (Tudge, 1992). Social interaction and cooperative dialogues between children and more knowledgeable members of society, are necessary for children to acquire ways of thinking and behaviour. Adults and more expert peers help children master culturally meaningful activities (Berk, 2003; Jaramillo, 1996; Vygotsky, 1978). Vygotsky further offered new visions of teaching and learning that emphasised the importance of social context and collaboration. Collaboration helps children to reflect on their own thought processes and shift to a higher level of cognitive functioning, and it is these higher cognitive processes that develop out of social interaction (Karolia, 2008).

Vygotsky (1978) maintained that there are two types of concepts, namely spontaneous and scientific concepts. Children develop spontaneous concepts contextually and unconsciously from their everyday life and have little control over them. Scientific concepts learnt through mediated experience between children and adults or more competent peers. Vygotsky proposed a general theory of cognitive development. The principle of Vygotsky's theory is that, at any given age, full cognitive development requires social interaction. Vygotsky argued that the range of skills that can be developed with adult guidance or peer collaboration exceeds that which a child/learner can attain alone.

The theory's emphasis is on how social context interacts with cognitive development, and how important social perspective-taking capabilities may shape and be shaped by social interaction. Vygotsky's theory stresses the importance of the social context and the presence of expert scaffolding (Vygotsky, 1978). The concept of ZPD refers to a range of tasks that the child cannot yet handle alone, but can accomplish with the help of adults and more skilled peers. The ZPD defines those functions that have not yet matured, but are in the process of maturation (Vygotsky, 1978). For Vygotsky, it is the mediation of more expert peers or tutors that can spur children's actual development to their potential performance, as long as they adjust the help to fit the less mature child's ZPD. Furthermore, Vygotsky's theory states that mental functions which are beyond an individual's current level must be performed in collaboration with other people before they are achieved independently.

Supported exploration, through social and cognitive interaction with a more experienced peer in relation to a task of a level of difficulty within the tutee's ZPD, remains a theoretical cornerstone of peer-assisted learning (Goodlad, 1998). The theory enables us to make predictions, frames and test hypotheses, to conduct high-quality research, with good experimental design, to evaluate educational initiatives. The notion of the ZPD assumes even more significance for understanding students' development, when extended to the conceptualisation of students' personal development among learners. During tutoring, the tutee acquires the skills or knowledge to progress from the ZPD to the zone of actual development (ZAD). This refers to the skills and tasks that a student is able to perform independently. The acquisition of such competence is generally not a feature of the traditional classroom.

According to Hetherington and Parke (1993, p. 332), "Vygotsky focused on the social nature of cognitive development and emphasised the critical role that the social world plays in facilitating children's development". Cross-age tutoring provides this social setting, whereby the tutors and tutees can interact and engage in a meaningful way. The social benefits include learning of academic skills, development of social behaviours, classroom discipline and the enhancement of peer relationships (Greenwood et al., 1988; Gumpel & Frank, 1999; Samway & Syvanen, 1999; Utley & Mortweet, 1997). Tutors become models of appropriate behaviour, organising work, asking questions, demonstrating self-management, encouraging social interaction and facilitating better study habits (Barbetta & Miller, 1991; Cohen, 1986; Gaustad, 1993; Kalkowski, 1995; Miller & Miller, 1995). Therefore, cross-age tutoring actively engages both tutors and tutees in their education, and gives them a feeling of control over academic outcomes. One of the arguments against using teenagers as tutors is that they may not be emotionally or cognitively mature enough to provide empathy and understanding to younger children (Karcher, 2005). However, research suggests that these teenagers and other older siblings regularly serve as natural tutors. By doing so, they make a considerable contribution to their younger siblings' social and cognitive development, by providing supportive contexts for their younger siblings to discuss family and extra-familial issues (Brody, Kim, Murry & Brown, 2003; Tucker, McHale & Crouter, 2001).

2.4.2 Cross-Age Tutoring Characteristics

Cross-age tutoring involves the use of one learner as an expert or more knowledgeable student of the content area, providing a focus of control to other learners, who are novices (Almassaad & Alotaibi, 2012; Gaustad, 1993; Giesecke, 1993; Gautry, 1990; Gillies, 2012; Gumpel & Frank, 1999; Rodriguez, 2013). Research indicates that cross-age tutoring is often delivered in non-reciprocal formats (Gumpel & Frank, 1999; Samway & Syvanen, 1999; Utley & Mortweet, 1997). Specific procedures for interaction might be outlined, in which participants are likely to have had training which might be either specific or generic or both (Fuchs & Fuchs, 1994; Mendez Gonzalez, 2014; Topping et al., 2003, 2011). The positions of tutor and tutee do not change. The older student serves as the tutor and the younger student is the tutee. The older student and younger student can have similar or differing skill levels, with the relationship being one of a cooperative or expert interaction. Tutors serve to model appropriate behaviour, ask questions, and encourage better study habits. This arrangement is also beneficial for a variety of students, including students with disabilities, as they may serve as tutors for younger students (Basister, 2013; Gillies, 2012; Hott et al., 2012; Miller & Miller, 1995; Utley & Mortweet, 1997).

Cross-age tutoring can be done in various disciplines, which include mathematics, science, languages, and many others where attention is required. This practice improves reading attitudes, fluency and comprehension. Cross-age tutoring projects can foster student responsibility, empowerment, and new-found interest in reading and writing activities. Politically, cross-age peer tutoring delegates the management of learning to learners in a democratic way, and seeks to empower students, rather than de-skill them by dependency on imitation of a master culture, and might reduce student dissatisfaction and unrest (Goodlad, 1998).

2.4.3 Cross-Age Tutoring Benefits

Cross-age tutoring has emotional as well as cognitive, attitudinal, self-confidence and self-efficacy gains (Robinson et al., 2005; Spencer, 2006; Topping & Ehly, 1998; Topping, 2000, 2001). It can provide opportunities to practise and improve communication skills and work habits (Gaustad, 1993). More importantly, cross-age tutoring could serve to improve a child's motivation, confidence and self-image (Topping et al., 2004). Improved attitudes might have enduring effects later in the educational system and, possibly, in career choices made later in life. Cross-age tutoring can also foster student responsibility and empowerment in writing activities (Daggett & Pedinotti, 2011; Schneider & Barone, 1997). Tutors' self-esteem rises as they see their tutees improve, and as knowing that they are making a meaningful contribution is a powerful experience (Gaustad, 1993). Child tutors have an advantage over adult tutors in that they are cognitively closer (Gaustad, 1993). This may help tutors present subject matter in ways which their tutees understand.

A reason for introducing tutoring is to assist students who may be finding difficulties in studying a certain subject. This tutoring might facilitate better understanding of the tutors' roles to students, acclimatise students to the demands of the work, and enhance their confidence and skills in dealing with role conflict. The commonly cited benefits of cross-age tutoring are the learning of academic skills, the development of social behaviours, classroom discipline, and the enhancement of peer relations (Barbetta & Miller, 1991; Greenwood, Carta, & Hall, 1998, p. 264; Kalkowski, 1992). Effective cross-age tutoring requires careful planning and children need to be motivated to do it (Kamps et al., 1999). Tutoring procedures are most effective when carefully structured and involving clearly articulated scaffolding procedures (Cohen, Kulik, & Kulik, 1982; Sharpley & Sharpley, 1981). Cross-age tutoring is said to help to "develop the social skills of listening, understanding, soliciting and delivering help, and communicating clearly" (Cohen 1986, p. 176). According to Barbetta et al. (1991), some of the advantages of cross-age tutoring are that:

- Tutors may require less time or no time for tutor training because they are older;
- Both tutor and tutee may benefit from positive interactions with students of different ages and abilities;
- Students, including those with disabilities or social skills deficits, may benefit from the structured opportunities to practice academic and social behaviours in the role of the tutor; and
- A personal-social connection is established between the younger tutee and the older tutor.

In conclusion, cross-age tutoring simultaneously addresses the teaching of both academic and social skills, and it is an acceptable means of establishing social relationships between and among diverse groups of students. Because it addresses issues such as heterogeneity, inclusion of students with mild disabilities, non-categorical special education, and performance-based formative assessment, it offers a research-based solution to issues raised by school reformers. Cross-age tutoring is an excellent demonstration of how applied research in an educational practice can be used to improve academic outcomes in local schools, in terms of achievement, which will be shown by children, and will be of major importance to parents, schools, and policy-makers.

2.4.3.1 Tutor benefits

Research over the past decades has shown that students can successfully tutor other students (Basister, 2013; Gaustad, 1993; Thurston et al., 2009). Tutors are said to generally exhibit a small but significant improvement in academic performance (Cohen et al., 1982). In the process of tutoring, tutors reinforce their own knowledge base and skills (Cairo & Craig, 2005). Tutors become models of appropriate behaviour, organising work, asking questions, demonstrating self-management, encouraging social interaction, and facilitating better study habits (Almassaad & Alotaibi, 2012; Barbetta & Miller, 1991; Cohen, 1986; Gaustad, 1993; Miller & Miller, 1995). Benefits are predicted for the tutor, as they improve their own attitudes towards learning, and for the tutee, by promoting a positive relationship with an older child.

Tutors' self-esteem rises as they see their tutees improve (Gaustad, 1993; Kalkowski, 1992; Topping, 2004). Children have certain advantages over adults in teaching peers. They may more easily understand tutees' problems because they are cognitively closer (Gaustad, 1993). Cohen (1986) believes that this is due to the fact that their "cognitive framework" is similar, and this may help tutors present subject matter in ways which their tutees understand. Knowing that they are making a meaningful contribution is a powerful experience. Children gain the value of independence and cooperation through cross-age tutoring. It also fosters student responsibility, empowerment and interest in reading and writing. It also likewise enhances the older students' capacity for learning in a cooperative context even as it strengthens the younger students' literacy knowledge (Rodriguez, 2013; Schneider & Barone, 1997). Falchikov (2001) lists multiple benefits, such as generic skills development, reinforced subject knowledge, and personal satisfaction amongst tutors. Additionally, Vincent and Ley (1999) note that many tutors function as cognitive role models for their tutees, implying that peer tutors can effectively model study skills such as concentrating on the material, organizing work habits, and asking questions.

Theoretical advantages of cross-age tutoring are often promoted on the grounds that, for tutors it is 'learning by teaching'. In addition to the tutees benefiting both cognitively and socially, just preparing to be a peer tutor reportedly enhances cognitive processing in the tutor by increasing attention to and motivation for the task, and necessitating review of existing knowledge and skills. Consequently, existing knowledge is transformed by reorganization, involving new associations and a new integration, simplification, clarification and exemplification (Goodlad, 1998). Some studies have found that tutors help themselves increase their own understanding of the subject matter they tutor students in. This boosts confidence and can carry over to their desire to learn other subjects (Ehly & Larsen, 1980).

2.4.3.2 Tutee benefits

Tutees can benefit from learning of academic skills, and from individualised instruction, in which tutors scaffold information and adapt the strategies they use to the younger learner's pace, learning style, and level of understanding (Almassaad & Alotaibi, 2012; Basister, 2013; Dzubak, 2008; Rodriguez, 2013). Dzubak (2008) acknowledges that it is the effective use of scaffolding during a tutoring session that makes it to be conducted during a personalized, face-to-face, “social” interaction. Immediacy of feedback is provided that is seldom possible in a classroom situation.

Tutoring also has emotional as well as cognitive benefits to the tutees (Gaustad, 1993). It can foster student responsibility, empowerment and newfound interest in reading and writing activities (Schneider & Barone, 1997). It also helps by promoting a positive relationship with an older child. Tutees feel more at ease, and concentrate well, on the subject matter, with a peer tutor, rather than with a professional teacher or consultant (Ehly & Larsen, 1980). These are the characteristics researchers are looking for, to help children from disadvantaged backgrounds. It also helps tutees with development of their social behaviours and classroom discipline, and the enhancement of peer relationships.

Pedagogical advantages for the tutee include more active, interactive and participative learning, immediate feedback, swift prompting, lowered anxiety – with corresponding higher self-disclosure, and greater ownership of the learning process. In addition to immediate cognitive gains, improved retention, greater meta-cognitive awareness and better application of knowledge and skills to new situations, have been claimed (Goodlad, 1998). Studies have been done to support the claim that many students may feel more at ease, and can thus concentrate better on the subject matter, with a tutor, rather than with a professional teacher or consultant (Ehly & Larsen, 1980).

The main benefits for tutees are receiving individualised instruction and more teaching, tutees may respond better to their peers than to their teachers, and they can obtain companionship from the students who tutor them (Kalkowski, 1992; Robinson et al., 2005). The first case, in which they receive individual instruction, gives students a fairly obvious advantage. According to Goodlad and Hirst (1989) the benefit is rooted in Behaviourist theory, which itself is based on an assertion that learning will be effective if every correct response to a question by a student is rewarded – the reward working as an incentive for the student to take another step in learning (Goodlad & Hirst, 1989). Also, giving each learner their own personal tutor can spark dialogue between student and tutor, and the student may ask the tutor questions they would not dare to ask in class, or spend time on things that could be crucial to a student’s understanding of the subject matter.

Spending time working with just one person may discount outside perspectives, but if the tutor is familiar enough with the subject matter, the one-to-one experience can help a student immensely, and the student can learn in a low-pressure situation. The second case, in which tutees receive more teaching, also gives students, being tutored a pretty obvious advantage. In this study tutoring was conducted outside of normal class time, so spending more time on their work with someone who is familiar with what they are doing, outside of class, obviously means that the students receive more teaching time.

The fact that tutors, as well as tutees, benefit from the tutoring experience has important implications such as promoting participation among students, and tutees gain one-on-one attention. Both tutors and tutees gain self-confidence (Howard et al., 1986; Rodriguez, 2013) – the tutor by seeing self-competence in their ability to help someone, and the tutee by receiving positive reinforcement from peers. Most tutoring research has shown that both tutors and tutees can benefit socially, emotionally and academically. It is evident that cross-age peer tutoring is mutually beneficial, as both tutee and tutor stand to gain something. It is also beneficial to teachers, who may not have the time to spend with each of their students, one-on-one. Cross-age tutoring makes both tutors and tutees become more independent, cooperative and responsible for their own learning, by interacting in an authentic teaching and learning situation. This would result in tutor and tutees having a change in attitude about learning. Tutors reinforce their own learning by reviewing and updating their knowledge.

2.4.4 Cross-Age Tutoring Research Studies in Non-South African Settings

There are a variety of cross-age tutoring studies that have been conducted at all levels of education, from kindergarten to higher education (De Smet et al., 2008; Gillies, 2012). Most studies involved university students helping high-school students with homework, studying, and in-class projects. This section discusses some of the cross-age tutoring studies done outside South Africa. Table 2.1 summarises what each project or study entailed.

Chavez and Arreaga-Mayer (1987) analysed the effects of class-wide peer tutoring on science vocabulary achievement for three language groups: Spanish-dominated and limited English proficient (LEP) students, a Spanish- and English-proficient group, and monolingual English speakers. Findings revealed that the peer tutoring procedures resulted in gains for the three language groups, with the Spanish-dominant LEP group making greater gains than the non-

LEP group. These findings, although limited in scope and in need of replication, strongly suggested that class-wide peer tutoring results in greater academic gains for students. Specifically, the study validated that the effects of intervention changes in instructional contexts and student responding, as in the English condition vs. the language preference condition in peer tutoring, co-vary with achievement gains, and support the validity of both approaches.

Topping et al., (2004) initiated a number of peer and cross-age tutoring projects which involved helping children to develop literacy and numeracy skills. The projects stressed the importance of providing tutors with some basic training and less monitoring. The following are some of the projects Topping initiated:

- He introduced a project of tutoring that involved the use of mathematical games and scaffolding of mathematical discourse. The aim of the project was to investigate whether a structured cross-age peer tutoring programme, using the mathematical games, would have a positive impact on attitudes towards mathematics, mathematics skills and knowledge, and social and emotional factors and tutors (Topping et al., 2003; 2005).

- Cross-age tutoring of science in primary school, with the aim of evaluating cognitive and effective gains of both tutees and tutors in science, using the "paired science" programme (Topping et al., 2004). On pre-post assessments of understanding of scientific concepts and keywords, the experimental group made significant gains, while the control group made no gains, yielding effect sizes greater than one. Tutees made greater gains than tutors. The study concluded that cross-age peer tutoring of science using the paired science programme, offers an effective pedagogical strategy, with both cognitive and effective benefits for both tutors and tutees.

- Cross-age tutoring of reading and thinking, where the authors described and evaluated methods of peer tutoring in thinking skills, was also conducted. Findings showed that tutees who used thinking skills performed significantly better than tutees who used reading skills.

Fitz-Gibbon (1990) published extensively on cross-age tutoring between the 1970s and the 1990s. In his studies, students from four low-achieving ninth-grade general math classes and students from three fourth-grade classes were randomly assigned to experimental and control groups (Fitz-Gibbon, 1990). In the experimental groups, 40 ninth-grade students tutored 68 fourth-grade tutees, one-on-one, in fractions. The tutees were randomly assigned to tutors, with no preference given to gender or ability. Achievement was measured by an objective test developed by the researcher to assess students' abilities to conduct fraction operations (to add fractions, for example). By comparing pre-test scores gathered before tutoring began, to post-test scores collected after the tutoring had been completed, Fitz-Gibbon (1990) found that both tutors and tutees registered larger gains from pre-test to post-test, in comparison to the control group that remained in the regular classroom setting. Fitz-Gibbon also found that the tutors had higher retention rates, as indicated by scores on a second post-test of fraction operations, in relation to the first post-test (Fitz-Gibbon, 1990).

Leland and Fitzpatrick (1994) implemented a cross-age reading programme, to find a way to increase students' enthusiasm for reading and writing. The 6th-grade students they studied performed below grade level in reading, and were unenthusiastic about reading and writing. At the end of the project, in which the 6th-graders tutored kindergartners in literacy activities, the older students' attitudes improved. The authors credited this newfound enthusiasm to the students' sense of empowerment they achieved in their tutoring sessions.

Peters (1998) reported the findings of two studies done, which were part of the Early Mathematics Improvement Project (EMI-5s). This project was started to investigate ways to improve the understanding of numbers among five-year-olds and seven year olds. The two studies described by Peters are follow-up interventions designed to explore how the ideas from EMI-5s can be implemented on a wider scale. The first study measured the impact of parents playing games with small groups of children in the classroom. The progress of eighteen five-year-old children was measured over their first eight months of school. Data was collected through private task-based interviews at the start of school, two months into the school year, and at the end of eight months of school. The data collected for 14 of these children was compared to a control group of 37 children starting school at the same time.

The second study measured the same impact among seven-year-old-children. There were 128 participating students. Thirty-nine students received a similar treatment to the first study, for six months. Parents were invited into the classroom to play games with small groups of students once a week. Fifty-eight (58) children played identical games in small groups without parent involvement, and 31 students only received the normal mathematical instruction, without games. Private task-based interviews were conducted before and after the interventions were implemented. Both studies also used observations and interviews to capture the experiences of participants as they played the mathematical games, and during their normal instruction.

The results showed that games appeared to be most effective as a way of enhancing children's learning when a sensitive adult was available to support and extend the children's learning as they played. The largest gains in the first study were in tasks that involved enumeration, rote counting, and understanding of the number sequence and recognition of number patterns. However, the results of the task-based interviews in the second study indicated that the 7-year-old children involved in the two intervention programmes (games with parents and games without adults) made similar progress to the contrast children who followed their normal mathematics programme (Peters, 1998).

De Smet et al. (2008) focused on studies on the nature of cross-age peer tutor support within an online context. Their context was based on the definition of "learning" as "knowing and helping others to know" (Bereiter, 2002: 68). The argument was based on Vygotsky's social constructivist theory, which emphasises that at any given age, full cognitive development requires social interaction through problem solving under adult supervision or in collaboration with more capable peers (Falchikov (as cited in De Smet et al., 2008). This argument supports this study's line of thought – namely that capable teenagers can help young children with their homework via social networking platforms.

Cross-age tutoring has been applied to students with varying disabilities (Utley & Mortweet, 1997). It is believed that by involving students living with disabilities in their education, and giving them self-management tools, these students can generalise motivation into other areas, thereby taking an active role shaping their future.

Coats (as cited in Karolia, 2008) focused on cross-age tutoring at North Central University, Arizona, America. He examined the effects on reading achievement of tutors and tutees in an after-school programme. It involved the cross-age tutoring of learning-disabled sixth-grade students and non-disabled first and second-grade students in reading recognition, and determined the effects that cross-age tutoring had on reading achievement. Statistical analysis of the data collected in this study implied that both tutors and tutees could increase reading recognition, improve attitudes regarding their own reading abilities, and enjoy the activities and relationships within such an after-school tutor programme.

Very few projects have been conducted on online tutoring. These projects introduced a peer allocation model, which allowed a learner who has asked for assistance to get the most appropriate peer tutor from the population (Westera, 2007). The peer allocation model was supposed to meet criteria in two separate dimensions: quality – that is, selecting of a competent tutor, and economy – that is, achieving a fair workload distribution among the tutors. A software prototype was also developed to investigate the feasibility of the model (Westera, De Bakker & Wagemans, 2009). The system architecture comprised a client server solution which was based on Transmission Control Protocol (TCP) connection, a central database for user data, and a management module for the arrangement and monitoring of course runs (Westera et al., 2009). The important motives for the TCP-based client-server solution, rather than a web application or peer-to-peer solution, were (a) reducing user-side firewall problems, to make it easy to check whether students were online or not, and (b) easy and complete user logging for system dynamics analysis. The two pilot studies conducted both involved university students (Westera et al., 2009). The evaluation showed that the use of a self-organising, synchronous, peer-allocation system is not self-evident. It may be successful, but context variables have a great impact on its functioning (Westera et al., 2009). Although the system technically functioned appropriately, students often appeared to use alternative ways for asking for help. In view of its potential for the efficient arrangement of distributed online support, recommendations were given for successful application of the approach. The approach was, again, designed for university students, and not for school-going children.

Studies by De Wever et al. (2010) examined cross-age tutors' contributions in asynchronous discussion groups which concentrated on the analysis of peer tutors, and also focused on evolution in the tutors' interventions, in order to explore variety in the nature of tutor support. The aim of their studies was to explore the types of support characterising peer tutors' interventions in asynchronous discussion groups. A content analysis coding scheme was developed to explore activities, over time, during tutees' discussions on group assignments (De Smet et al., 2010). Tutors received training, in order for them to adopt a rich mix of tutoring behaviours. The results of the study yielded design guidelines for improving training activities for online peer tutors, and these design guidelines helped us in the design of a cross-age tutorial system with social media features.

Holecek (2012) gave a report on the study done in Finland, where he used cross-age and cross-disability tutoring. Three students were chosen as tutors from an Emotional Behavior Disorder (EBD) level II special education programme in an upper Midwestern middle school/high school programme. The tutors chosen were all older than the tutees by at least one grade, and were considered to have higher basic-level math skills. Three tutees were chosen from a group of students in a programme for students with cognitive disabilities, located directly across the hall. Students showed a slight improvement in basic math skills in post-test results. Students were found to increase total math time involvement when actively tutoring, compared with the traditional daily math lesson sessions.

Basister (2013) conducted a study that aimed at determining the effects of cross-age tutoring on high-performing students and students 'at-risk with learning disabilities' in mathematics. This study used both the experimental method and the descriptive-correlation method, involving two groups of students – the control and experimental group. The experimental and control group were composed of both fourth-year high-performing students and Grade 7 students who were at-risk with learning disabilities in mathematics. The cross-age tutoring programme was implemented in the experimental group wherein fourth-year high-performing students tutored Grade 7 students who were at-risk with learning disabilities in mathematics. The control group, however, went through their lessons without any involvement in the cross-age tutoring programme or any other similar programme.

The study revealed that, compared to students in the control group, students in the experimental group showed a higher increase both in cognitive and non-cognitive factors (Basister, 2013). The significant differences posted between the control and experimental groups of both high-performing students and at-risk students, were sufficient evidence to show that cross-age tutoring is an effective intervention to improve the cognitive and non-cognitive aspects of involved students (Basister, 2013). Table 2.3, below, provides a summary of some the different studies done in non-South African settings.

Table 2.3: Summary of the different projects discussed in this section

Study	**Authors**	**Description**
Class-wide peer tutoring on science vocabulary	Chavez and Arreaga-Mayer (1987)	Analysis of the effects of class-wide peer tutoring on science vocabulary achievement for three language groups: Spanish-dominated and limited English proficient (LEP) students, a Spanish and English proficient group, and monolingual English speakers.
Peer and cross-age tutoring projects	Topping (1988; 2005)	Project of tutoring that involved the use of mathematical games and scaffolding of mathematical discourse. Cross-age tutoring of science in primary school, with the aim of evaluating cognitive and effective gains of both tutees and tutors in science. Cross-age tutoring of reading and thinking.
Cross-age tutoring	Fitz-Gibbon (1990)	Students from four low-achieving ninth-grade general math classes and students from three fourth-grade classes were randomly assigned to experimental and control groups.
Cross-age reading programme	Leland and Fitzpatrick (1994)	Implemented a cross-age reading programme to find a way to increase students' enthusiasm for reading and writing.
Cross-age peer tutor support	De Smet et al. (2008)	Studies on the nature of cross-age peer tutor support within an online context.
Cross-age reading programme	Karolia (2008)	A study from North Central University conducted in 2007 which focused on cross-age tutoring and examined effects on reading achievement of tutors and tutees in an after-school programme.
Online tutoring	Westera, De Bakker & Wagemans (2009)	Projects involving online tutoring which allowed a learner who has asked for assistance to get the most appropriate peer tutor from the population.

Cross-age tutors' contributions in asynchronous discussion	De Wever et al. (2010)	Studies examined cross-age tutors' contributions in an asynchronous discussion group which concentrated on the analysis of peer tutors.
Cross-age and cross-disability tutoring	Holecek (2012)	The study where researcher used cross-age and cross-disability tutoring.
Cross-age tutoring with children with learning disabilities	Basister (2013)	A study conducted aimed at determining the effects of cross-age tutoring on high-performing students and students at-risk with learning disabilities in mathematics.

From the above discussion, we can conclude that studies, to date, of cross-age tutoring, have been found to be very beneficial to both tutor and tutee. Participants improved in the academic disciplines tutored, as well as in self-judgment, behaviour and social interactions. Areas that have been included in cross-age tutoring are reading, spelling, mathematics and social skills. The next section discusses cross-age tutoring studies that have been conducted in South Africa, to date.

2.4.5 Cross-Age Tutoring: The South African Context

In South Africa, cross-age tutoring in primary schools has not been sufficiently validated. According to Sorenson and Gregory (1998), peer tutoring in South African schools has neither been widely accepted nor developed. A few peer-tutoring procedures have been compared to alternative teacher- or materials-mediated procedures, and there are no commercially available peer-mediated curricula. Virtually all schooling in South Africa is structured around the traditional belief that knowledge is best transmitted from adult to child in linear fashion. However, some grass-roots studies – for example, the study which was undertaken by the Academic Development Programme (ADP) of Rhodes University, Grahamstown, South Africa, and hosted by the iKhonco ('Chain') project, have been conducted on the feasibility and potential of using student tutors in South African schools. This study was conducted as a contribution to the reconstruction and development of the nation's education system, and the practice was mainly conducted in high schools and universities (Goodlad, 1998; Sorenson & Gregory, 1998).

These studies concluded that the success of future South African tutoring in schools programme was likely to hinge on the awareness and handling of a number of critical issues such as teacher involvement, training and logistics. The fact that tutoring was done through practice, that it fulfilled specific needs in the schools, and that feedback from students and teachers was positive, argues a strong case for the further development of student tutoring in the South African environment (Sorenson & Gregory, 1998).

In response to the policy goals of the National Commission on Higher Education (NCHE, 1996), the University of the Witwatersrand (Wits) undertook case studies in the two faculties of Arts and Science to investigate tutor roles for students. Goodlad (1998) examined these two case studies, and found that in both cases, student tutors were an invaluable resource as tutor educators at Wits. This was both in terms of person power and as reservoir of intellectual knowledge and skills that can be effectively utilised in the goal of national capacity building. The tutors drew attention to the need for developing the skills of under-prepared students in higher education, and, while helping others, they themselves gained in intellectual development, and received training and skills – which are important in their own career goals (Goodlad, 1998).

Fox et al. (2007) did a study which involved the experiences of learners who were involved in a cross-cultural peer teaching initiative between a privileged private school and a township school in Port Elizabeth, South Africa. The aim of the project was to explore the possible advantages of cross-cultural peer tutoring of certain sections of the new mathematics curriculum for both tutors and tutees, and, especially, to see whether the township learners' understanding of the learning content could be improved (Fox et al., 2007). Every year the learners of a privileged private school in Port Elizabeth engaged in a community service programme. These learners initiated a peer teaching programme at a township school. The learners felt that they could use assets such as a good knowledge of their school subjects, supportive parents and teachers, financial means and transport, to help their less-privileged counterparts. The results showed that the township learners' understanding of the mathematics dealt with during the peer teaching sessions was enhanced, and that both groups gained from the cross-cultural peer teaching interaction. Most of the studies on cross-age peer tutoring conducted in South Africa focused on a one-on-one tutoring basis.

Few projects, such as Dr. Math (Botha & Butgereit, 2012) that runs on the MXit social networking platform, have been successfully introduced in South Africa. Dr Math allows high school learners to get help with mathematics homework from university students, via their mobile phones (Butgereit, 2007). None of the projects reported on in the literature referred to online tutoring support provided by older children to children in the early primary school years (Chimbo & Gelderblom, 2012). Many cross-age peer tutoring programmes are coordinated by school counsellors or teachers in a school environment setting. None of the programmes thus far reported were coordinated outside the school environment, and used for homework purposes via social media. Exploring this will be of great benefit for younger children in South Africa. The practice should be encouraged, as it provides the children with opportunities to relate to one another, and work together in a cooperative and/or collaborative way from early childhood onwards. There is, therefore, a need to explore this avenue of cross-age tutoring using social media, which will be discussed in the next chapter.

2.5 Social Learning in the Digital Age

Behaviourism, cognitivism, and constructivism were the three broad learning theories which were most often utilised in the creation of instructional environments (Siemens, 2005; Carreno, 2014). These theories, however, were developed in a time when learning was not impacted through technology. In recent years, technology has reorganised how people live, communicate and learn (Duță & Martínez-Rivera, 2015). Learning needs and theories that describe learning principles and processes should be reflective of underlying social environments. This has led researchers in the new digital age to propose the connectivism theory, where social learning is integrated with social media technologies (Downes, 2005; Siemens, 2005; Tschofen & Mackness, 2012). Though the connectivism theory has initiated debate over whether it is a learning theory, instructional theory or pedagogical view (Kerr, 2007; Kop & Hill, 2008; Verhagen, 2006), it is undoubtedly an important school of thought directly applicable to the use of technology in the classroom today (Duke, Harper & Johnston, 2013). Connectivism is a new theory of learning that takes into account the way in which learning is influenced by the new learning technologies (Kargiban, 2012). This study views connectivism as social learning that is networked.

2.5.1 Connectivism Theory

Researchers are positioning connectivism, or distributed learning, as a new and important theory of teaching and learning which is more adequate to the digital age (Downes, 2005; Kargiban, 2012; Mattar, 2010; Siemens, 2005). Connectivism is defined as actionable knowledge, where an understanding of where to find knowledge may be more important than answering how or what that knowledge encompasses (Duke et al., 2013). According to Siemens, (2004, p. 6) connectivism presents "a model of learning that acknowledges the tectonic shifts in society where learning is no longer an internal, individualistic activity". Learners are using existing and new network tools to supplement and enhance their learning experiences.

As a theoretical framework for understanding learning, the starting point for learning occurs when knowledge is actuated through the process of a learner connecting to, and feeding information into, a learning community (Kop & Hill, 2008). In a world 'where social media is on the increase', learning is not an internal, individualistic activity; learners gather information from connecting to others' knowledge using Wikipedia, Twitter, WhatsApp and other similar platforms (Chen & Bryer, 2012).

Social learning theories, especially connectivism, provide insights into the roles of educators and learners in this social networked environment. Some of the principles of connectivism, especially "learning is a process of connecting" principle, seem to relate closely to that of the cognitive information processing theory, which focuses on relating (or connecting) concepts to information stored in long-term memory (Ormrod, Schunk & Gredler, 2009). This theory is suggesting that it is not knowledge that we need to retain, but rather that our ability to seek and find knowledge is the most important factor in learning. Connectivism stresses two important skills that contribute to learning: the ability to seek out current information, and the ability to filter secondary and extraneous information (Kop & Hill, 2008). How people work and function is altered when new tools are utilised. The field of education has been slow to recognize both the impact of new learning tools and the environmental changes in what it means to learn. Connectivism provides insight into learning skills and tasks needed for learners to flourish in a digital era (Siemens, 2008).

Connectivism is associated with, and proposes, a perspective similar to Vygotsky's (ZPD). It supports the ZPD by offering specific technological opportunities for the learner to be actively involved in the presentation of the body of knowledge. Vygotsky views peer interaction as an essential part of the learning process (Vygotsky, 1978). There is limited research on how social media influences learners' learning experience, and how learners can use social media to support learning through peer tutoring. There is, therefore, a need to explore this avenue. This has led this study to focus on teenagers providing after-school support to young children, using social networking platforms.

2.5.2 Social Networking Platforms

Boyd and Ellison (2008) define social network platforms as Web-based services that allow individuals to construct profiles, display user connections, and search and traverse within that list of connections. A social networking tool represents "a virtual community in which people with shared interests can communicate by posting and exchanging information about themselves" (Shin, 2010, p. 428). The phrase "SNSs" is commonly used as an umbrella term for all social media and computer-mediated communication, including, but not limited to, Facebook, Twitter, IDroo, Skype, YouTube, Ning, Scribblar, wikispaces, blogs and Myspace, as well as the inaugural SNSs of Cyworld, Bebo and Friendster (Davis et al., 2011). The network tools are used for various things that include communication, collaboration and educational purpose.

The tools discussed in the above section could be mixed and matched for many instructional purposes. Technology is changing the way we think about education. The present generation of primary and secondary school learners is growing up with social network tools, and many of them are already spending many hours per day interacting with peers on these networks. Studies have been conducted which regard social media, such as Facebook, MySpace and others as distracting learners from their studies (Kamnoetsin, 2014). Distractions have always been a part of our everyday life, be it in the classroom, where learners daydreamed or passed notes to each other, or at home, doing homework and watching television at the same time. As most of these interactions with social media are not learning-related, there is some evidence that learners do sometimes use these platforms to communicate about schoolwork (Ahn, 2011, 2012). Attention is drawn to Facebook, which is regarded as the most distracting medium and finding ways to make it less distracting (Kamnoetsin, 2014). Facebook and other media can be used by learners and teachers to realise their roles in learning and teaching, and this can change behaviour in the classroom significantly. Social media can be used to engage learners in interactive and independent learning.

Social networking sites (SNS) are virtual communities where users can create individual public profiles, interact with real-life friends, and meet other people, based on shared interests. Social networks reflect the relationships traditionally shared in a learning situation, between a learner and the teacher, between one another, and between the learner and the material itself. According to Ahn (2011), SNSs such as Myspace and Facebook are now popular online communities with large teenage user populations. There is no doubt that young people today are often more eager about embracing new technologies, increasingly learn with digital media tools, and become highly skilled more quickly than adults. Teens use these technologies to interact, play, explore and learn in significant ways, which is much more conducive to social exchange and interaction. This paradigm is familiar to the users and becomes less daunting when applied to a learning situation. The “real world” relationships reflect into the online social network, and allow users to support each other without the teacher’s help. Using social networking platforms for learning can allow for exchange of media to accommodate learners of all types. A great deal of learning happens between learners in these online communities, as they desire to incorporate social and digital media into their education (Ahn, Bivonia, & Discala, 2011).

Ning is a social networking tool that can be used for making announcements. Users submit voice thread assignments here; they can carry on chats and discussions with tutors; users can get to know each other, and also helps in downloading pictures; Ning is similar to other social networking media, which most users are already familiar with.

Skype is a VoIP tool which can be used for communication and tutoring purposes. Skype free service for calls and chat has become ubiquitous. People around the world communicate with each other and also use skype to collaborate with other classrooms. Skype can be a way of connecting students from different places and backgrounds to each other and so becomes an interesting way for them to learn about the world beyond their own community than reading a chapter in a textbook. Skype makes it possible to make the conversations more direct. Teachers can connect with classes around the world, or even at different schools in the same area, as a way to give students a glimpse into cultures and lifestyles other than their own. Or you can come up with creative collaborative projects that students from different classes can work on together, like writing songs together or having a debate with students from different backgrounds, all over Skype. Skype can also be used for tutoring. This idea can extend to enabling an after-school tutoring program by peers. There can be probably peer volunteers willing to give their time to be available to other students for tutoring and questions if they can do so from the comfort of their own home. Students having trouble can send a chat or make a call at any point during the assigned hours to work through their difficulties.

IDroo is a collaborative teaching, learning and brainstorming whiteboard that works with Skype, which enables tutors and tutees to talk to one another. Tutors and teachers around the world are using IDroo for one-on-one collaboration. You can draw and write ideas, add images, insert mathematical times tables and more. iDroo is a real-time whiteboard that is useful anytime when one is giving a presentation over the internet or for presentations in a class, especially any time when there are students outside the classroom tuning in.

Scribblar is another online, tutoring tool. It supports multiple users, live audio, text chat and images. Like IDroo, Scribblar is great for online tutoring, brainstorming, and interviews and tests. Many high schools, colleges, and universities already use this tool for their long-distance education programs. This tool enables users to write, draw, or attach documents, and what makes it great is that it is LIVE, i.e., the tutee sees everything in real time just as the tutor is writing, drawing, or sending documents. It is a whiteboard application and it’s the same as writing on a chalk board in a physical classroom. Scribblar has features such as audio, video, and chat.

YouTube can greatly assist with video presentations and upload of homework done by young children. Many lessons can be enhanced with the right video. Something visual and entertaining that speaks to the subject you’re teaching breaks up the monotony of a lecture, brings some fun into the lesson, and keeps your students more engaged and interested in the subject. Showing videos in the classroom doesn’t have to mean much work for you. All it takes is some searching and browsing on the website to see what videos are already out there on the subject you’re teaching, along with a little time spent watching to find videos that are a good fit. Although if you choose, you can write some questions or create activities that relate to the video to help students get more out of them.

Some people learn better by watching than reading, so providing video alternatives to the reading homework you assign could really pay off for some students. You can create playlists, either to supplement the other work you assign or as an alternative, and simply send the link to your students for viewing. A playlist puts it all into an easy, well-organized format for their consumption.

Google docs are used to create a channel of communication between tutor and tutee through written work and feedback of submitted work. Google Docs are well-suited for online, collaborative brainstorming sessions that provides students with opportunities to work together to develop ideas. Students are provided with immediate feedback and one can increase motivation by creating a simple self-grading quiz with a Google Form.

2.5.3 Potential Contribution of Social Networking Platforms' to Cross-Age Tutoring

According to Vygotsky (1978), students learn most effectively by engaging in carefully selected, collaborative problem-solving activities, under the close supervision of educators or more experienced peers. However, collaboration is the most important characteristic of social learning. Collaborative learning has proved to be more effective than individualistic learning in contributing to motivation, raising achievement, and producing positive social outcomes (Chen & Bryer, 2012).

Previous studies focused on understanding the use of social media tools among higher education faculties, strategies used to integrate social media in formal learning, concerns they had, and their strategies to mitigate those concerns. Clearly there are enormous potential educational benefits from harnessing new technologies, but to date this potential has not been realised (Chimbo & Gelderblom, 2011, 2012). SNSs such as YouTube and Facebook now shape how young people connect, socialise and learn (Ahn, 2011, 2012). Therefore, we need to find ways to incorporate these technologies into our general education practices.

Research shows that learners can negotiate identity, learn social skills, and become subject matter experts, through peer teaching in topics that pique their interests (Boyd & Ellison, 2008;

Horst, Herr-Stephenson, & Robinson, 2009). For social networking to be successfully implemented in learning, it must appeal to the users. To keep users motivated to participate, the platforms should have rich content which is dynamic and interactive. Social networks for learning must provide a certain level of autonomy to the users, and users should be allowed to express themselves creatively.

Research shows, however, that social networking platforms have little or no integration into formal learning environments, as conventional environments provide limited opportunities for learners to participate in online interactions (Chen & Bryer, 2012). The common use of social media by the young is for personal use, and rarely for educational or learning purposes (Hew, 2011). Research conducted shows some concern around ethical issues in using social media in educational environments, as the primary concern is with learners' privacy and security issues (Chen & Bryer, 2012). This study also investigated, further, the issue of security, as social networking platforms must ensure a secure environment to give users a sense of identity protection.

2.5.4 Cyber Safety

Internet use by children and teenagers has increased, and so have concerns about their online safety. The Internet has transformed society by enabling a variety of positive activities, involving communication, entertainment and knowledge acquisition (Sozio, Ponte, Sampaio, Senne, Ólafsson, Alves & Garroux, 2015). Human behaviour on the Internet and related technologies, such as mobile phones, tablets, iPads and computers, have also been found to have negative consequences such as the encouragement of antisocial behaviour and increased loneliness (Donchi & Moore, 2004; Lee & Leets, 2002). Cyber bullying, in the form of a new medium used by bullies, presents a dark side of the use of the technology, which is surfacing.

Cyber bullying or bullying using technology via email, text, chat rooms, mobile phones, mobile phone cameras and web sites, has become prevalent. The communication often involves repetition of actions, and a power imbalance between the victim and the perpetrator (Campbell, 2005; Farrukh, Sadwick, & Villasenor, 2014). Cyber bullying can also be carried out in chat rooms, with the cyberbullies posting whatever they want about someone, without being recognised. Campbell (2005) believes cyber bullying to be an increasing problem for young people, with possibly more dire consequences than face-to-face school bullying. Numerous incidents of cyber bullying have been reported worldwide (Bargh & McKenna, 2004; Byrne & Lee, 2011; Bryce & Fraser, 2013; DeHue, Bolman & Vollink, 2008; Finkelhor, Turner, Hamby, 2012; Snider & Borel, 2004). In South Africa, cyber bullying has become a true safety risk (Odora & Matoti, 2015).

Providing a safe environment requires an in-depth understanding of the types and prevalence of online risks young Internet users face, as well as of the solutions most effective in mitigating these risks (Farrukh et al., 2014). Research has shown a number of cyber safety measures that have been suggested or implemented in order to prevent cyber bullying. Internet users have a variety of ways to make available, or limit, access to their personal information online. They can choose to use default privacy settings, or finely tune the privacy controls to limit who can see certain parts of their profile, as well as restrict who can view individual posts (Madden et al., 2013). Also, preventative strategies being implemented are the encouragement of schools to develop "cyber bullying policies" to reduce and address cyber bullying among peers (Campbell, 2005; Farrukh et al., 2014). The youth can also be made aware of the consequences of disclosing information about themselves online.

Parents, and the community, can also become involved in safeguarding youth against online risks, by monitoring them through online technologies, or personal supervision, or teaching them the appropriate online behaviours (Farrukh et al., 2014; Rode, 2009). They could encourage children not to disclose any personal information online. Parents and guardians could also utilise IP addresses to track and block problematic visitors on the children's sites, and to switch online user accounts, if misused. Besides cyber bullying, children can endanger themselves by using the internet inappropriately through visiting sites which result in them meeting strangers and making their devices targets of viruses or spyware. Monitoring and supervision of children by parents or guardians and blocking access to sites that could potentially be harmful are some of the ways to protect children. The application that was designed in this thesis adopted the strategies that were mentioned in the literature study (Campbell, 2005; Rode, 2009).

2.6 Research Gaps Revealed by the Literature Review

2.6.1 Gaps Related to Cross-Age Tutoring

There is empirical evidence which shows that cross-age tutoring has positive academic, attitudinal and socio-emotional outcomes to students who participate as tutors, or tutees, or both (Basister, 2013; Robinson et al., 2005). However, from the research and studies done in South Africa, it is evident that cross-age tutoring in South African schools has not been widely researched, accepted and practised. After much effort by the South African government to find ways to improve the pass rate of students, a much slower improvement has been shown in mathematics and science subjects. There is a public outcry over the low matriculation marks and poor pass rates of South African secondary school learners countrywide (Hlalethwa, 2013; Nkanzela, 2015). As mentioned in Chapter 1, the teaching and learning problems associated with lower grade numeracy and literacy in South Africa still exist, and this results in a ripple effect that can be seen in the low Grade 12 mathematics throughput.

There is a general lack of research on the use of online technologies in the area of cross-age tutoring. Contemporary cross-age tutoring mostly happens in face-to-face settings. Cross-age tutoring should not be limited to students who are able to meet face to face, but should also be practised online. There are many technological tools which can be adopted, but the education system in South Africa has been slow in adopting these potentially useful technology tools (Andoh, 2012; Schneckenberg, 2009). Although there are a number of studies on cross-age tutoring in various areas, as mentioned above, studies on cross-age tutoring using social media platforms are few, and those that are underway have not been systematically evaluated. This justifies the need to explore this area of study.

South African children coming from disadvantaged backgrounds find it more difficult to pass than children from advantaged, middle class backgrounds. This is due to the fact that growing up in an illiterate environment affects children's exposure to resources and literate behaviours. Some parents frequently feel they have nothing to give their children that will be of educational value, and, as a result, do not participate in their children's formal education (Machet, 2002). A large proportion of learners in South Africa, especially those living in rural areas, are from poor families who rely on government social grants (Department of Rural Development and Land Reform [DRDLR], 2010), pensions, subsistence farming, part-time work, and money sent from relatives who work in urban areas.

HIV/AIDS compounds the problem, since many children orphaned by Aids often head their households (Mogotlane et al., 2010). The education of these children, and that of the siblings for whom they are responsible, is severely compromised. On top of that, many disadvantaged children without any academic support at home, attend schools with severe inadequacies. Children who attend better schools usually have the further advantage that they are supported in their academic development by parents or after-care services at their schools. These are the children with access to mobile or computer technology, who spend much of their time socialising with tools such as MXit, Facebook, Skype and YouTube.

In South Africa, interventions have focused around policy making, and there is very little evidence to suggest the use of cross-age peer tutoring as a possible intervention programme. A paradigm shift should perhaps be considered from policy making to innovative and cost-effective programmes such as cross-age tutoring via social media. Vygotsky's theory (1978) on sociocultural theory and research findings on cross-age peer tutoring, offer new visions for teaching and learning that emphasise the importance of social contact and collaboration. It is hoped that the implementation of cross-age peer tutoring via social media in this research study, will significantly improve the performance of disadvantaged children in their work in South Africa and Africa at large.

2.6.2 Attempts to Address Academic Performance Gaps

Currently, there is much interest in developing effective ways to intervene early in the education of young children who are at risk in learning especially those with low-socioeconomic status (Cooper, 2008; Cooper et al., 2006; Ehri et al., 2007). The South African education system is adopting ways to try and bridge the low throughput gap, and homework is one of the ways. The importance of homework is increasingly being recognised. Homework can play a valuable part in learners' education. If properly designed, it can help in strengthening the liaison between the home and the school (Milbourne & Haury, 2003; Center for Prevention Research and Development [CPRD], 2009). Homework can help address learners' individual problems and varied amount of time needed for comprehension, allowing learners to learn at their own pace (Villas-Baas, 1998).

The gap that lies within homework is associated with the social context, as many young children do not have adequate learning support at home as they are cared for by family members with low literacy levels who cannot provide the necessary support with homework and preparation for tests. When family members, especially parents, help their children with homework, they model the children's belief that educational pursuits are worthy of their time and effort (Balli, 1998). There is a great need to improve the quality of basic education provided to children from disadvantaged backgrounds. Homework does not have to be supported only through home environments by parents or family members; it can also be achieved through cross-age homework tutoring.

The gap would be filled by the development of a cross-age tutoring system based on a social networking platform. The primary aim of this study was to establish technology-enriched learning support for young, underprivileged children, with the emphasis on providing after-school mathematics and reading support. The technology investment in schools, worldwide, has increased more than a hundredfold in the last two decades. An opportunity exists whereby the pervasiveness of mobile technology can be exploited to help with solving some of the problems in foundation phase education in a developing world learning context. Teenagers have tremendous potential for helping young children with their homework, and this has social and personal benefits. The children helped design the system they wanted to use, themselves. Reports in the literature of children as information technology designers are still very limited. Involving child users in the design processes can work effectively, as children are creative designers, continually watching, assessing, learning, rethinking, retooling, and improving their strategies to provide the best possible learning experiences for themselves and others (Karolia, 2008). Children working as designers are not yet fully widely accepted in the professional design community, especially in Africa (Gelderblom, 2014).

2.7 Summary

Lessons from the Literature Review

Lessons learnt from the literature review on tutoring, were that early tutorial programmes were based on several assumptions and predictions. The concepts of tutoring, where children help other children, remain unchanged, What has changed, however, is that the emphasis has shifted to training students to meet the cognitive and affective demands of a larger society through the formal education system.

Most cross-age peer tutoring studies to date have been conducted within face-to-face contexts (for example, Carroll, 1996; Duran & Monereo, 2005; Topping, 1996). Research focus is especially scarce on online learning contexts, therefore the most innovative aspects of this study were (1) to provide a safe enough environment within the social networking context, so that children as young as those in grades 3 and 4 can experience advanced technology as a collaborative learning tool, and that (2) social network tools have been developed for use by younger children for purposes other than being tutored. An example of the latter is DisCo, a computer-based design tool that enables intergenerational co-designers to collaborate online while in geographically distributed locations (Walsh, 2010; Walsh et al., 2012). The goal of this thesis was to design a cross-age tutoring system with social media features, using cooperative design. Special attention was paid to literacy and numeracy support to children in grades 3 and 4 in South African schools.

Research and studies done in South Africa show that peer and cross-age tutoring in South African schools has not been widely researched, accepted and practised. There is, therefore, a great need to improve and maximise research and practices of cross-age tutoring in all educational avenues. Another learning point is that there have been many “success stories” to show that, when used properly, technology tools do lead to enhanced teaching and learning outcomes (Lim et al., 2013). Social network platforms have led to the development of new laws and new areas of research. Google, Microsoft, Apple, eBay, Amazon, World of Warcraft and Facebook are only a few examples of the magnitude and importance of these technologies.

A goal of this thesis was to investigate social media as a platform for cross-age tutoring, that could be used to design a system whereby teenagers would provide learning support, through tutoring, to younger children whose access to learning support is hampered by unfavourable socio-economic circumstances. Vygotsky’s theories, which emphasised that children learn more when actively working together, guided this study.

CHAPTER 3: LITERATURE REVIEW ON COOPERATIVE DESIGN

3.1 Introduction

Cooperative design is a maturing field of research, and an evolving practice among design professionals. Also known as participatory design (PD), Greenbaum and King (1991) describe cooperative design as involving designers and users on an equal footing. It is an approach where users are regarded as the best qualified to determine how to improve their work and life. This chapter discusses cooperative design and cooperative inquiry as distinct sets of design approaches used in the study.

3.1.1 Operational Definitions of Cooperative Design, Participatory Design and Cooperative Inquiry

"Cooperative design" and "participatory design" are used by some researchers interchangeably (Guha et al., 2010; Melonio & Gennari, 2013; Nesset & Large, 2004). Participatory design originated in Scandinavia, and was known as cooperative design. It is rooted in a Scandinavian cooperative design tradition, with a strong emphasis on the political aspects of technology design (Gregory, 2003). In the Swedish discourse, the term 'cooperative' was favoured over 'participatory' (Holmlid, 2009). In this thesis, 'cooperative design' refers to both cooperative design and participatory design, and 'cooperative inquiry' is used when referring to designing with children. The term 'cooperative design' will be maintained, even though we recognise that the term 'participatory design' has gained greater international use (Iversen & Dindler, 2014). From now on, this thesis will use 'cooperative design' to also refer to participatory design.

3.1.2 Objectives of the Literature Review on Cooperative design

The main objective in this chapter is to review definitions of 'cooperative design' and 'cooperative inquiry', in order to establish the operational definition of key terms in the thesis. The other objective is to learn about the dominant theoretical frameworks of cooperative inquiry that have guided studies in HCI. The study that this thesis reports on focused on the design of a cross-age tutoring system, based on a social networking platform, using the mentioned design approaches.

3.1.3 Organisation of the Chapter

This chapter is organised into nine sections, of which section 3.1 is the introduction to cooperative design. Sections 3.2 and 3.3 are about the conceptual definitions of the important terms used in the study – that is, cooperative design (CD) and cooperative inquiry (CI). These sections are followed by section 3.4, which concentrates on the theoretical framework of cooperative design in the context of the intended study. Section 3.5 explores what has been done in this area of design, to date. Section 3.6 identifies the gaps in the research. Section 3.7 and 3.8 explore what contribution this intended study will make to the field of HCI. Section 3.9 summarises the chapter.

3.2 Cooperative Design (CD)

"Cooperative Design (CD)", or "co-design", is an approach that can be described as actively involving the stakeholders, most probably the users, in the design process, where expert designers work with the target audience to solve a problem or improve the quality of working life (Guha et al., 2010; Halskov & Hansen, 2015; Sanders et al., 2010; Walsh, 2012;). Co-design emphasises a more in-depth and often equal partnership between designer and end user, and enlists user participation at earlier stages in the design process (Bodker et al., 1993, 2000; Walsh et al., 2013). CD is widely accepted and applied in research and commercial design projects. It has gained growing acceptance in the world of research, particularly from academic professionals in Europe and North America, who focused on developing new technologies for children (for example, Druin, 1999, 2002; Jones et al., 2003; Kam et al., 2006; Large et al., 2007; Mazzone et al., 2008; Robertson, 2002).

CD has enjoyed successful application in many socio-political contexts in which adults were the target population of study, using CD approaches such as contextual inquiry (Beyer & Holtzblatt, 1998). Contextual inquiry was first articulated in response to the workplace needs of adults (Beyer & Holtzblatt, 1998). Contextual inquiry calls for researchers to collect data in the users' own environment, by observing them performing typical activities. In the final stages, low-tech prototype mock-ups of the system are developed and tested with users (Large et al., 2007). The use of low-tech paper prototypes, pictorial diagramming, and concrete techniques, is suitable when working with children. Large et al. (2007) argue that contextual inquiry's emphasis on a team approach and concrete methods of pictorial flowchart data analysis, make it applicable and appropriate in a child-centred context. Currently, CD is being used in a large variety of fields, such as user-centred design, graphic design, software engineering, architecture, public policy, psychology, anthropology and sociology (Muller & Druin, 2012). According to Druin (1999), in contextual inquiry a team of researchers observe and analyse the users' environment for patterns of activity, communication, artifacts and cultural relationships (Druin, 1999; Good & Robertson, 2006). Over time, these successes have been replicated in many other research contexts, with diverse target populations such as children, individuals with disabilities, and older adults (Benton et al., 2012; Druin, 1999, 2002; Druin et al., 1997; Ellis & Kurniawam, 2000; Frauenberger, Good & Keay-Bright, 2011).

The methodologies of CD have evolved to find application in contexts outside the workplace, such as education (Barab et al., 2005), urban planning and policy (Friedman et al., 2008) and social media (Hagen & Robertson, 2010). Common to all CD endeavours is the central goal of facilitating dialogue among members of design teams (DiSalvo & DiSalvo, 2014).

3.2.1 Historical Perspectives of Cooperative Design

The historical perspective of cooperative design is relevant, as it allows researchers to uncover how this approach has evolved over time. The cooperative design methodology was used in the Utopia project[2] (1981-1985), involving users very early in the design process. They had an early development and application in the use of computers (Bodker et al., 1987, 2000; Ehn, 1988). This was to 'give the end users a voice' in the design and development of computer support in workplaces, thus enhancing the quality of the resulting system (Druin et al., 2008). Low-tech prototyping, and early design sessions with users, had great impact on IT design in general (Bodker et al., 2000). Scaife et al. (1999) provide suggestions of design methods which can be employed by different stakeholder groups, such as storyboarding, interviews, high-tech prototyping in multimedia environments, and cognitive and interactivity analysis.

CD has roots in the Scandinavian Cooperative Design tradition (Bjerknes, Ehn & Kyng, 1987; Bodker et al., 1993; Greenbaum & Kyng, 1991; Muller, Wildman & White, 1993; Schuler & Namioka, 1993). It was primarily a political, and idealistic, approach to promote democracy,

[2] The project Utopia was started in 1981 at the initiative of NGU (the Nordic labour unions for graphic workers). From a research perspective the Utopia project may be seen as an ambitious continuation and follow-up of a number of projects in Norway, Sweden, and Denmark in the 1970s, in which researchers followed and supported the attempts of local trade unions to influence the use of technology at work (Bodker et al., 1987).

skilfulness and emancipation, through the design of new technology (Hussain, Sanders, & Steinert, 2012; Nesset & Large, 2004). In the CD traditions, the involvement of users, and building on their activity and participation, is a well-developed technique. In the Scandinavian approaches, during the 1970s and 1980s, the rationale for user participation was partly based on the fact that system developers rarely, if ever, met the real users – or the end users, as they were called (Bjerknes, Ehn & Kyng, 1987; Greenbaum & Kyng, 1991; Holmlid, 2009; Kyng & Matthiassen, 1997; Schuler & Namioka, 1993). There was a movement by academics and trade unionists to involve users in the design of the applications that were being designed, to assist their work. It aimed to prevent workers from being disempowered by the tools and computer technologies imposed on them by their employers. CD provided a way to collaboratively develop technology, engaging people in the designs that affected them. Several projects in Scandinavia were aimed at finding effective ways for computer system designers to collaborate with labour organisations to develop systems that most effectively promoted the quality of work and life of workers.

HCI literature reflects on political issues of design, where CD ensures that the users of technological artifacts are involved in their design, as informants or co-designers (Greenbaum, & Kyng, 1991; Kensing & Blomberg, 1998). There is a belief that users have a democratic right to be included in the design process of what affects them, and will benefit as a result. This belief can be seen in work on cooperative design done in Scandinavia (Bjerknes et al., 1987; Greenbaum, & Kyng, 1991; Druin, 1999; Bodker et al., 2000), and participatory design done in the United States (Greenbaum, 1993; Muller, 1991; Muller et al., 1994; Schuler & Namioka, 1993). The inclusion of users in design activities yields more efficient, usable, profitable products and systems.

There have been numerous debates in HCI about different ways to involve users during the design process, and thereby providing successful products that actually meet users' needs. Works by Gould and Lewis (1985), Nesset and Large (2004) and Good and Robertson (2006) suggest that good design results came from an early focus on the users. This can be done by working closely with the users, asking their preferences, and modelling the users and their tasks. More recent approaches require active user involvement, where designers give to users the more responsible role of including them in the design phase, as valued, or in some instances equal, partners (Bonsignore et al., 2013; Druin, 2011; Guha et al., 2013). The history of CD clearly shows that it advocates and values the perspective, knowledge, skills and involvement of the end user in designing a system that creates progressive opportunities for employers, employees and system designers.

3.2.2 Overview of Roles Played by Children in Cooperative Design

As given in the taxonomy proposed by Druin (2002), the roles that children play in cooperative design of technology, from minimum involvement to full partners, are user, tester, informant and design partner. Figure 3.1 shows the increasing involvement that children have had in the design process. Historically, children have been involved firstly as *users*, where children are given technology to use once it had been fully designed, developed, and generally deployed by adults (Guha et al., 2011). In this role, very little input is given by children in the design process. This is followed by the *tester's* role, in which children are asked to test the technology earlier in the design process. This affords designers the opportunity to gather input from the children earlier in the design and developmental cycle, and real changes can be made to the technology before it is deployed (Guha et al., 2011).

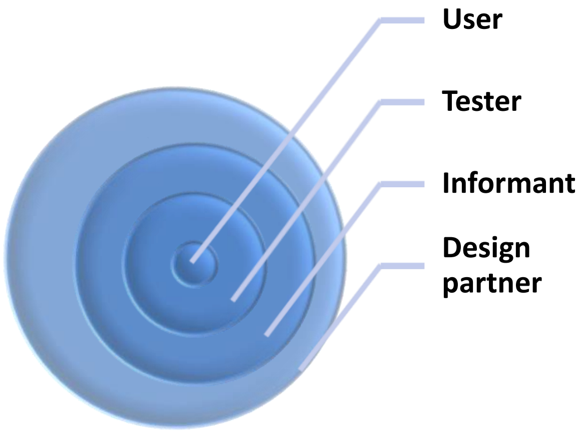


Figure 3.1: Design roles assumed by children, adapted from Druin (2002)

Informant is the role where children are seen as potential problem solvers in the technology design process. As *informants*, children were called on at any time during the design process, to brainstorm. Finally, children who were 'design partners' were considered to be equal participants in the design process with adult designers. The children would attend design sessions regularly, and participate in all aspects of design from initial brainstorming to interface design, to aiding in testing with users (Guha et al., 2011). The advantage of involving children in the design process is that this may lead to fewer revisions before reaching a final product which means children's voices are heard and respected throughout the design process. While there are many possible methods of working with children in the technology design process, this study employed cooperative design. Table 3.1 gives the summary of the roles of children in the design process:

Table 3.1: Summary of the roles of children in the design process; adapted from Druin (1999)

Role of child	Began	Strengths	Challenges	In use by
User	Late '60s/ Early '70s	• Easy to include children • Researcher in control • Can suggest future directions in HCI and education areas	• Less direct impact on changes in technology • Children have less say in changes • Educators need time to accomplish	Primarily academic researchers
Tester	A few examples in the 1970s—Began primarily in the late '80s/ early '90s	• Begins to empower children • Quicker input for changing technology • Methods can be done in and out of schools	• Children don't have input until later in the design process • Can offer surprises to adults • Adults decide what can be done, given limits of schedule	Academic researchers and industry professionals

Informant	Mid-1990s	• Empowers children • Brings children's input into the start of the development process • Flexible when children and adults work together	• Adults still decide when to bring children into the design process • More time is needed to work with children	Academic researchers and industry professionals
Design Partner	Mid-1990s	• Empowers children throughout development experience • Children and adults can change and learn from the experience • Instant feedback from children throughout the design process	• Team decisions must be negotiated between adults and children • More time is needed to work as partners • School environment is difficult to work within • Difficult finding researchers that can work with children	Primarily academic researchers with industry professionals

It is from the roles above that Druin's research championed the role that children could play in the design of new technologies for children, by introducing the notion that, with the appropriate amount of guidance, a child can assume the role of design partner, and thus provide valuable input in decision making (Druin, 2002; Druin et al., 2014). Druin introduced methods of cooperative inquiry – which involve brainstorming, sketching, interviewing and other 'low-tech' development activities, into the research process, from roles discussed above. All these methods are performed by children, with adult involvement where deemed necessary. However, the assumption is that young children can partner with older children (teenagers, for example), and perform design with little intervention from adults. Cooperative inquiry is discussed in detail in the next section.

3.3 Cooperative Inquiry (CI)

Cooperative inquiry (CI) is a method of designing with children for children (Druin et al., 2014). CI was developed by Druin et al. (1999) most extensively at the University of Maryland in the U.S. The CI process involves the use of, for example, brainstorming and low-tech prototyping tools to capture and demonstrate the ideas of the participants (Druin et al., 2014; Kano & Read, 2005). It is a method where end users are invited to be partners in the design of new technologies for them (Bodker et al., 1987; Druin, 1999, 2002; Walsh, 2012). This method builds on informant design by having adults and children work together as design partners to create low-tech prototypes (Druin, 1999, 2002; Druin et al., 2014).

According to Walsh (2012), co-design means that the end user is part of the design process. Most of the software that is intended for children is designed with very little input from children themselves. It is typically designed and built by adults who often have very little ideas about what children want and need from interactive products. There is a growing body of research on developing interactive products for children, and on examining the different levels of involvement that they can have during the system lifecycle. CI is a type of co-design that has been used in the design of children's technologies for over a decade (Druin, 1999; Guha et al., 2013; Walsh, 2012). Prototypes then receive feedback from the design team, and the iterative cycle continues. In this method, the intergenerational design team participates in the design of the technology throughout its lifecycle as partners (Walsh, 2012).

In CI, ‘design’ includes all the steps necessary to conceive, develop and produce a technology. Essentially, it involves all the work, including brainstorming, coding, building, iterating and testing, in the creation of technology (Fails et al., 2009; Guha et al., 2013). In CI, no one party is considered to be more important than another, as they all acknowledge one another. Besides the obvious advantage of CI that end user input is available throughout the design process, children involved in CI can have positive experiences in the social and cognitive developmental areas (Guha, 2010). CI activities build children’s abilities to collaborate, communicate and be confident, and, at the same time, enjoy what they do. These qualities would lead to a society with more effective and productive problem solvers (Druin, 2002).

Cooperative inquiry is unique, as it gives children a voice in the design process, along the lines of user-centred design (Druin, 1999, 2002). Many children's technologies designed by adults are not as good as they could be, because children have not systematically been included in the design team. Druin (2002) wrote that there is a need to understand how designers can create new technologies that offer children control of a world where they are so often not in control. According to Fails et al. (2009, p. 2), "Children's voices are so important because regardless of the fact that adult designers have been children, and that some may understand the literature describing the development of children, adults have never been children in the context of the current social, economic, societal, and technological world". It is therefore essential that children have a voice in the design of their technologies.

Guha (2010) carried out a qualitative case study that explored the social and cognitive experiences of children involved in co-design with adults. The children who participated in the study were members of an intergenerational team of adult researchers and child designers, known collectively as Kidsteam, from the Human-Computer Interaction Lab (HCIL) (Guha, 2010). In a case study, Guha followed eight child design partners over a period of a year, collecting data such as observational notes and artifacts, as well as interviews with the children and their parents (Guha, 2010). Results from this study showed that the children developed in the following domains: the cognitive domain, in skills and content, in the social domain in relationships, enjoyment, and confidence, and in the overlapping social and cognitive domains of communication and collaboration (Guha, 2010). What we learnt from Guha's case study is that children across a range of ages, not just 7-11 year olds, can be included successfully in the co-design process.

Naronjo-Bock (2011) indicates that one of the biggest challenges of designing interactive experiences for children is creating age-appropriate experiences in terms of content, functionality, interactions and visual design. It is often difficult for user-experience designers to step out of their adult point of view and really immerse themselves in a child's world, while avoiding being either condescending or too tough (Naronjo-Bock, 2011). New techniques need to be developed, in order to adapt to changing technologies and design spaces.

CI can support designing with and for today's international, independent, interactive, and information-active children in the context of the developing world, mobile computing, social computing, and the ubiquity of search (Guha et al., 2013). It is a commonly held belief that children are more creative than adults, and that formal schooling suppresses natural creativity (Sawyer, 2003). Children have now become one of the frequent and experienced user groups of technology. As more and more children are using computers, there is a growing market for children's computing products and packages (Burton, 2006; Plowman et al., 2010). This compels designers to involve children in CD in order to better understand their issues and needs (Druin, 2005).

Burton (2006, p. 13) states that "the world through the eyes of a child is a vastly different place to that of an adult and the only way to obtain this view is through the involvement of the children". Children and adults have a different perspective of the world, resulting in a difference in mental models. Burton believes that a good user interface helps the user develop the correct mental model that matches the conceptual model developed by the designers. To create a successful interface for children, an understanding of children's mental models and thinking must first be established. This can only be done through the involvement of children in the design.

Research has shown that children involved in the designing of children's technology, range between the ages of 4 to 6 years (Farber et al., 2002), the ages of 7 to 11 years (Druin, 1999; Guha et al., 2013), and ages of 10 to 13 years (Fails et al., 2012; Knudtzon, 2003). Although CI has been primarily implemented with children aged 7 to 13, there have been forays into using it with children whose ages span from 5 to 18 (Fails et al., 2012). CI has continued to change and grow, so a set of methods has been created to suit a specific context. Designing with teenagers is an area which researchers such as Read et al. (2013) consider as a rich new area to investigate.

In many situations, and given the right tools, teenagers may be the best evaluators of technologies, and, with their imaginative risk-taking minds, the best designers of products (Read et al., 2013). Teenagers have their own environments that, just as for children, result in certain behaviours being supported. The collaborative nature of teenagers, and their social infrastructures, all create a landscape of chatter, a language of socialisation and a "crowd sourced" platform where the opinions of many come together to form the opinion of the mass (Read et al., 2013). In this study, cooperative inquiry is the method used involving young children and teenagers as design partners.

This current study used the cooperative design approach, where young children and teenagers were design partners of a cross-age tutoring system to be used for homework and test preparation support. According to Fitton et al. (2013, p. 207), children's participation in the design process brings out the following traits:

- desire for independence and autonomy;
- desire to develop and maintain individual identity;
- desire for association with peers;
- high susceptibility to peer influence; and
- willingness to take risks.

These traits were relevant to the current study, as the teenagers had the capacity to decide for themselves, and pursue a course of action, during design sessions. Below are some of the techniques and theoretical framework of cooperative inquiry discussed in the literature.

3.3.1 Theoretical Framework of Cooperative Inquiry

CI is a combination of techniques from different design methods, and it is "grounded in HCI research and theories of cooperative design, involving a multi-disciplinary partnership with children, field research, and iterative low- and high-tech prototyping" (Nesset & Large, 2004, p. 144). A theoretical framework given by Druin (1999), positions these aspects in the HCI literature as follows:

a) Multidisciplinary Partnership with Children

The first key aspect is multidisciplinary partnership with children, which emphasises the partnership between users and researchers from different disciplines for example, HCI, linguistics, psychology, education, computer science, information systems or information technology.

b) Field Research

The second key aspect of cooperative inquiry is field research. Under field research, adult researchers collect field data from the children's operating environment. This data is then used to build patterns of action from which user requirements can be deduced (Druin, 1999). Field research emphasises understanding the needs of users from the activities and the artifacts that are a part of a user's context.

c) Low-Tech and High-Tech Prototyping

Low-tech and high-tech prototyping form the third key aspect of cooperative inquiry. It is having intergenerational design teams visualising their ideas through prototyping techniques. Children iteratively refine low-tech prototypes to produce improved versions of high-tech prototypes (Druin, 1999). The use of easily available low-tech resources such as paper, crayon, clay, etc., to produce low-tech prototypes, makes this activity easily accessible to design partners of all ages (Walsh, 2012).

Guha et al. (2013) found that being smart or tech-savvy does not necessarily equate to being able to collaborate well, and that it may be more difficult for academically smart children to collaborate, since they may have less of a need to do so on a regular basis. The specific characteristic looked for in our design partners were a rough balance of gender, age and ethnicity. Part of the motivation of working with children as design partners was to have creative, thoughtful teenagers who are able to hear what children are saying and pull out the 'big ideas' that are workable for the technology all as a part of the elaboration process. The issues discussed above form a framework for research and design with children.

3.3.2 Characteristic Cooperative Inquiry Techniques

The techniques of CI enable design partners to work together to create innovative technology. These methods include ideas adapted from cooperative design and contextual inquiry, but are tailored to meet the unique challenges of working with children (Druin et al., 2014). Good and Robertson (2006) provide a detailed breakdown of the cooperative inquiry process with children, as a three-step process involving contextual inquiry, participatory design and technology immersion. Contextual inquiry involves collection of data from the end user's typical operating environment by unobtrusive researchers who observe the end user at work, in search for patterns of activity that could reveal user requirements. The output of the contextual inquiry phase serves as input to the participatory design phase that follows. Here, children engage in low-tech prototyping (Good & Robertson, 2006). Technology immersion is the third step, in which children iteratively produce high-tech prototypes from successive revisions of low-tech prototypes.

The design techniques included in CI are the use of bags of stuff and large sheets of paper to prototype; sticky notes to critique; journals, videos, and white-board discussions to reflect; role playing to problem solve, mixing ideas, layered elaboration and many others (Druin, 1999; Guha, 2011, 2013; Nesset & Large, 2004; Walsh, 2012). These techniques are used mainly for brainstorming, iteration and evaluation. Bags of stuff is a low-tech prototyping technique in which children and adults use big bags filled with art supplies such as glue, clay, string, markers, socks, and scissors to create low-tech prototypes of technology. This is a brainstorming activity where large sheets of paper are used by the participants to sketch or model their thoughts. In this technique, the created artifact is not just an end, but a means to a discussion about a topic of interest (Fails et al., 2009). This is based on one of the oldest cooperative design methods used in Scandinavian countries (Bjerknes et al., 1987), namely the Scandinavian low-tech prototyping technique. The technique involves different groups sitting either on the floor, or on tables, or anywhere they feel comfortable, and engaging in low-tech prototyping. However, the contents in the bags of stuff are tailored to suit a specific context or environment (Guha et al., 2013; Yip et al., 2013).

Sticky noting is another CI technique used to critique a new prototype or an existing technology, where the participants write down on sticky notes (Guha et al., 2013) what they like or dislike about the technology, and if they have anything to add or subtract from that technology. Usually, the outcome is a kind of informal frequency analysis which shows possible trends that can inform directions for the next iteration of a technology.

According to Guha et al. (2013), layered elaboration is another technique where design partners either create, or are provided with, a base design on which to elaborate and iterate. As each small group elaborates on the original design, a sheet of clear acetate is laid over the original design. Sheets of acetate can be added upon each other, so that each group can add their ideas without “destroying” the original, or the work of other groups. Between iterations, there were meetings held, in which design partners quickly explained their ideas before the design was passed on to another group for further elaboration.

The Mixing Ideas technique grew out of Cooperative Inquiry work with young children (Guha et al., 2004). In this technique, younger design partners (aged 4 to 6) may need more support, in order to combine their ideas during the ideation or brainstorming phase of the design process. They are relatively good at coming up with individual ideas; however, they are often reticent to combine their ideas with those of others. The primary design goals in Mixing Ideas are to create and refine multiple solutions. In order to do Mixing Ideas, teams need paper, drawing and writing implements such as crayons and/or markers, and tape and scissors. According to Guha et al. (2004), Mixing Ideas works best when each activity is done during a different design session. Thus, designers considering this technique need to consider if multiple sessions are a possibility for their design team.

From the above discussion, it is noted that CI enriches CD research with techniques that enable young children and teenagers to work together and share ideas in ways that maximise collaboration and yet minimise differences in age, ability and communication styles (Bell et al., 2013; Fitton et al., 2013; Read et al., 2013). While all these techniques offer a good starting point for design, they need to be adapted to suit design teams in their different environments and contexts. CI aims to provide insights into that world, in order to design the best products for users – especially children.

3.3.3 How Cooperative Inquiry relates to Vygotsky's Theory

Cooperative inquiry is a technology design process that adapts the techniques of cooperative design and contextual inquiry in the HCI literature, for use with children in design. Cooperative inquiry (CI) is unique in that it promotes child involvement (Druin, 1999). CI is based upon the belief that partnering with users is an important way to understand what is needed in developing new technologies (Druin, 1999). HCI research is performed to provide and promote a scientific understanding of the interaction between humans and the computer technology and tools that we use (Giacoppo, 2001). The methodologies of many non-scientific disciplines have also been adapted for use in HCI research and practice. Cooperative inquiry encourages an interdependent and collaborative relationship between children and adults.

One way to understand the cooperative inquiry process is to look at it through the lens of Vygotsky's ZPD. It accomplishes goals with the help of more knowledgeable others, such as a peer or adult or teacher. The ZPD is the "distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). At the periphery of the zone are tasks that children can accomplish independently, while the upper limit is the space where complex tasks can be realised by children only through interaction with knowledgeable others (Large et al., 2007). Communication and social interaction are key features of ZPD. Vygotsky believed that development occurs most rapidly when children collaborate with others within their ZPD.

Aspects of the CI process that relates to Vygotsky's work bring together designers and end users as equal partners in a design project (Guha, 2010). In our current study, teenagers and young children are brought together as equal partners in a design process. An interdependent and collaborate relationship between young children and teenagers is to be realised. Both teams are to work as equal partners in designing a cross-age tutoring system. The relationship between young children and teenagers as equal partners in a design project can be organised into a theoretical framework. Engaging children in the design of digital technology is one of the core strands in child-computer interaction literature (Iversen et al., 2013). In the next section, we discuss lessons learnt from studying projects in which children have been involved in technology design processes.

3.4 Specific Design Projects that Involved Children

The literature on previous design projects that involved children as design partners serves to enrich the current study with the wisdom of hindsight. The tools used by previous designers show the extent of progress in tool use, providing a useful predictor of what could be possible with the current study. Benford et al. (2000) demonstrate with KidPad how rich the toolbox for creating stories and pictures could be. The 3-D modelling-based Klump (Benford et al., 2000), with its unique, sound-based status indication, demonstrates how working in all three dimensions could assist in demystifying the unique characteristics of a design. Three-dimensional modelling can also assist design partners in contributing more in the specific dimensional area where they feel to be strongest.

The PETS project by researchers from the University of Maryland (Druin, 1999) showed that cooperative inquiry could lead to exciting results in the development of new technologies and design-centred learning. The study in Cambodia for the International Committee of the Red Cross (Hussain, Sanders, & Steinert, 2012) showed that it could be rewarding to do participatory design projects with marginalised children. The work of Hourcade, Bullock-Rest and Hansen (2012), with autistic children as design partners, suggested that novel self-expression activities could be designed to improve communication. Lindberg, Thomsen and Akesson (2014) suggest that ethical considerations should be considered seriously when doing participatory design activities with vulnerable user groups.

The research projects discussed above show the efforts made by previous researchers in advancing the science of cooperative inquiry with children as design partners. New researchers entering this field can learn from such previous works. The current study benefits from such previous knowledge; the design partners in the cooperative inquiry of this study involved vulnerable children, similar to the design partners used in previous research as discussed above. The next section discusses the research gaps that were found in the literature.

3.5 Research Gaps in the Literature

As previously mentioned, CI is a widely adopted method for involving children as full partners in technology design. There is, however, a notable absence of reports on the use of cooperative inquiry in developing countries. The cooperative inquiry design process has been used extensively by researchers in Europe, Canada and the United States (Bekker, Beusmans, Keyson, & Lloyd, 2003; Chipman et al., 2006; Druin et al., 2001; Fails et al., 2005; Guha et al., 2004; Guha, Druin & Fails, 2011; Guha et al., 2013; Hussain, Sanders, & Steinert, 2012; Lindberg, Thomsen & Akesson, 2014; Robertson, 2002; Yip et al., 2012), but not in South Africa. No examples of participatory interaction design with children in South Africa could be identified in the literature.

One explanation is that issues relating to the context of the developing world (for example, cultural aspects and socio-economic circumstances) have made it difficult to initiate and implement cooperative design efforts (Gelderblom et al., 2014). Also, the institutionalised ethical clearance processes aimed at protecting vulnerable children during the research process could potentially hinder children’s participation in the creation of knowledge that directly relates to them (Coppock, 2011). Designers should involve children from disadvantaged communities in the design, but one has to devise mechanisms for participation that overcome the more pronounced vulnerability of children in developing countries (Gelderblom et al., 2014).

There is a gap in the literature, in that there have been little or no research reports where CI has been used with teenagers and younger children as partners in co-designing, in developed and developing countries. As mentioned above, the research community has focused on adults involved in design with children between the ages of 4 to 13 years (Druin, 1999; Farber et al., 2002; Guha et al., 2013; Knudtzon et al., 2003), and older child participants from 14 to 19 years have received far less attention (Fitton et al., 2013; Danielsson & Wiberg, 2006; Isomursu, Isomursu & Still, 2003; Inversen et al., 2013; Mazzone et al., 2008; Mazzone, 2012) in this regard. In the very few studies done in developed countries on research and design, teenagers have been involved as users or testers, rather than as informants or design partners (Batson & Feinberg, 2006; Danielsson & Wiberg, 2006).

Reasons for fewer studies done with teenagers is that teenagers are considered more demanding and more challenging, due to their particular developmental stage of being adolescents (Mazzone, 2012). Adolescence is considered a difficult stage to exercise acceptable tactics of power, as it borders between childhood and adulthood (Holt, 2013). At this stage, teenagers strive for their own identity, and have a stronger self-consciousness which often results in conflictive relationships with adults, where the power relationship starts to be questioned (Mazzone, 2012). Since, in the developing countries, technology is generally being introduced as a vehicle for solutions to problems, such as inadequate education, children are often affected by the introduction of technology in these contexts (Roy et al., 2014). Teenagers and younger children should therefore be involved in the design of such solutions.

3.6 Closing the Gap

The approach used in this study to bridge the above gaps, was to use cooperative inquiry, in which young children and teenagers worked together as design partners with little interference from adult researchers. The guiding belief was that any technology aimed at children should include children of different age groups in the design team, as this would lead to solutions that would appeal to the users it is aimed at (Chimbo & Gelderblom, 2012). Teenagers are an interesting and challenging age group to work with, but this requires additional attention to the choice of design methods and communication tools. Instead of adults working with teenagers as design partners, in this study it was the teenagers who partnered with young children as co-designers. The reason to involve teenagers and younger children was that they would be the end users of the system, and all team members would be valued for their ideas and contributions (Steinberg, 2004).

Children under the age of 14 experience the world differently from adults (Nardini, Bedford, & Mareschal, 2010). Children between the ages of 6 and 13 are considered pre-operational, by Piaget, and construct their reasoning through those experiences and perceptions (Gelman, Lee & Gattis, 1995). This means that these children reason in a way which adults cannot. They have insights into designing technology for children that adults would not. CI can be an empowering process that results in empowering outcomes such as gaining more confidence in their own abilities by taking part in developing solutions that can help both themselves and others. The solutions developed can also be viewed as empowering outcomes, since they can contribute towards giving participants better lives. Help with homework and text preparation, for example, can enable young children to do well, be more independent and work on their own.

In conclusion, the crucial contributions made in this study is that of involving teenagers and young children as design partners, since the literature has shown that teenagers' input is crucial. Similarly, younger children are another user group receiving growing attention (Yarosh et al., 2011). These two groups would complement each other well when working together.

3.7 Summary

The field of CI, according to existing literature, has revealed that cooperative inquiry research is quite sparse, if not non-existent, in the developing world, especially using social networks platforms. Researchers have shown that it is necessary to work with children when designing new technology for children (Druin, 1999, 2002; Fails et al., 2012; Guha, 2011; Nesset, 2004). An important advantage of using cooperative design with children in developing countries is the opportunity to develop empowering outcomes. The children's involvement in the design of the system most likely contributes to a long-term interest in science and technology. This results in technological development, as well as intellectual and social skills that go far beyond the specific mathematics and literacy skill development, and this forms the core motivation for the current study.

As argued by Guha et al. (2011), we value children's abilities to collaborate, communicate and be confident. These qualities produce stronger, more effective, more productive adults in society, later in life. As children are tomorrow's workers, they need to be able to communicate, collaborate and problem-solve with partners across the globe; therefore, to prepare them, new ways of learning must be employed. The belief is that cooperative design is one of these methods.

The goal of this study was to explore better ways to meet the needs and interests of children in schools today. Cooperative inquiry proved to be an effective method for our purposes. The long-term partnership of teenagers and younger children as co-designers allowed our exploration of 'big ideas' and, consequently, to condense the most salient ones into a set of guidelines.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

The theoretical overview, and literature review, of chapters 2 and 3, dealt with the importance of cross-age tutoring and cooperative design, giving a theory base for the cooperative inquiry (CI) of a cross-age tutoring system based on a social networking platform. These chapters showed gaps in the research on tutoring and design that is, little information given in the literature relating to the use of CI in developing countries, and no research reports where CI has been used with teenagers and young children as partners in co-design. Lastly, the chapters also discussed the contribution this study makes to the fields of education and cooperative design. The previous chapters, therefore, constitute a conceptual and theoretical framework for this research study, while this chapter presents the methodology.

Research methodology encompasses the complete research process, namely the research approaches, procedures and data collection or sampling methods used (Collis & Hussey, 2009; McMillan & Schumacher, 2001; Remenyi, Williams, Money, & Swartz, 2003). The outline of the chapter is as follows: Section 4.2 discusses the methodological framework of the study, using the ‘research onion’ of Saunders et al. (2009). This section discusses the following components: research philosophy, research approach, research strategy, and, lastly, the data collection methods used. Section 4.3 presents the research question and research process. Section 4.4 discusses the context of the study and the sampling methods used. A narrative description of the research process and the analysis of data collected are presented in sections 4.5 and 4.6, respectively. Section 4.7 describes how the design data was translated into a design prototype, while section 4.8 discusses validation of the study. Lastly, section 4.9 presents the mechanisms used to establish the ethical aspects of the research, followed by section 4.10, a summary of the chapter.

4.2 The Research Process

This study used the ‘research onion’ developed by Saunders et al. (2009). Each layer of the onion describes a more detailed stage of the research process. The research onion provides an effective progression through which a research methodology can be designed (Saunders et al., 2009). It is adaptable for most types of research methodologies and contexts. Saunders et al. (2009) developed the research onion in order to describe the stages through which the researcher must go through when formulating an effective research methodology. Identifying the research philosophy is the first step in the process. This is followed by the second step that defines the research approach. The research strategy, time horizon and data collection methodology are the other considerations that the research onion represents as individual rings. Figure 4.1 depicts the adaptation of the research onion layers relevant for this study, with the discussion of the layers given below:

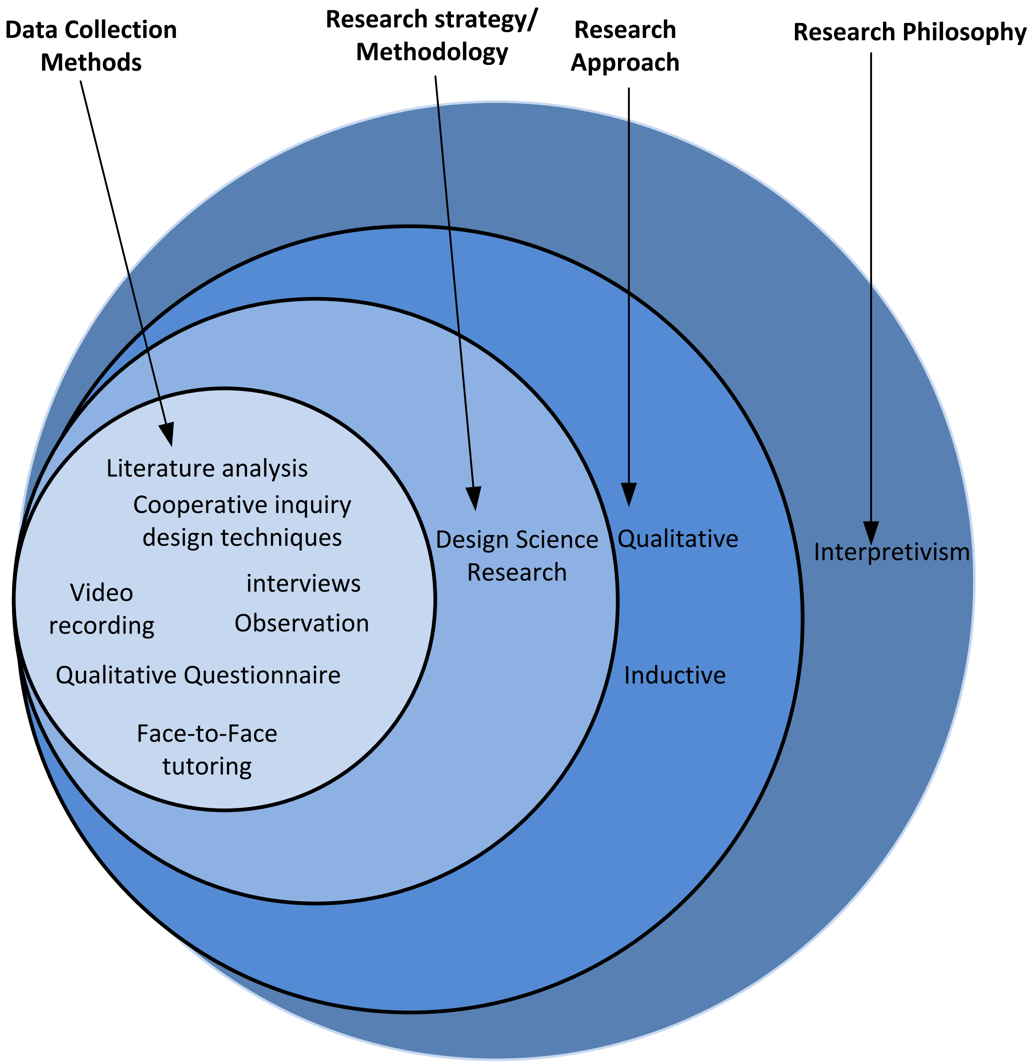


Figure 4.1: The research 'onion' has been adapted from Saunders et al. (2009)

4.2.1 Research Philosophy

The research philosophy provides a way in which data of a phenomenon should be gathered, analysed and used, and, hence, helps in the formulation of a research methodology. The research paradigms (for example, positivism, realism and interpretivism) which are relevant to a particular study differ with regard to the goals of the research and the best approaches to achieve those goals (Goddard & Melville, 2004). The current research followed the interpretivist paradigm. This paradigm is characterised by a belief in a socially constructed, subjectively conceived reality one that is prone to the influences of the environment (Walsham, 2006). People try to make sense of the world they live in. Through interaction with other people and the specific social, political, cultural and historical context in which they find themselves, they develop subjective understandings and meanings of their existential experience.

Interpretivists believe that there is not one reality, but rather varied and multiple realities (Ritchie & Lewis, 2003). The interpretivist researcher enters the field with some sort of prior insight into the research context, but assumes that this is insufficient in developing a fixed research design, due to the complex, multiple and unpredictable nature of what is perceived as reality (Hudson & Ozanne, 1988). The researcher remains open to new knowledge throughout the study. The use of such an emergent and collaborative approach is consistent with the interpretivist belief that humans have the ability to adapt, and that no one can gain prior knowledge of time- and context-bound social realities (Hudson & Ozanne, 1988). Knowledge of reality is gained through social constructions such as language, documents, tools and shared meanings (Klein & Myers, 1999).

Interpretivism rejects the positivist view of pure observations, but, rather, recognises the inevitability and desirability of environmental impacts on observation. An underlying assumption of interpretivism is that the whole needs to be examined, in order to understand a phenomenon. As a consequence of this, qualitative methods of analysis are well suited to interpretivist investigations. Howe (1988) proposes that interpretivist investigations must employ broad-based understandings of phenomena, as opposed to the narrower aims of explanation, prediction and control that characterise the positivistic viewpoint.

The position of interpretivism in relation to ontology, epistemology and methodology, is that interpretivists believe that reality is multiple and relative (Hudson & Ozanne, 1988). The interpretivist paradigm assists in making sense of the multiple realities about the world (ontology), where people's subjective experiences are real and should be taken seriously (Terre Blanche & Durrheim, 1999). The reality is constructed through interaction with the researched (epistemology), thereby reducing the distance between the researcher and the researched

(Carson et al., 2001). Multiple realities also depend on other systems for meanings, which make it even more difficult to interpret in terms of fixed realities (Neuman, 2003). According to Terre Blanche and Durrheim (1999), research is done through interactional, interpretive and qualitative techniques (methodology).

However, interpretive research has a place in more scientifically oriented fields such as information systems (Mårtensson et al., 2016). In their discussion of interpretivist research in Information Systems, Klein and Myers (1999) acknowledge that there are different views of interpretive research, but classify their view as interpretive research from a hermeneutic perspective. The hermeneutics research approach was used in this study. Hermeneutics is the science of interpretation (Crotty, 1998), and is situated in the interpretivist paradigm. According to Vaishnavi and Kuechler (2015), hermeneutics is the interpretation and understanding of social events by analysing their meanings to the human participants and their culture. Hermeneutics can be treated as both an underlying philosophy and a specific mode of analysis (Bleicher, 1980). As a mode of analysis, it suggests a way of understanding the meaning, or trying to make sense, of textual data which may be unclear in one way or another. As a philosophical methodology to human understanding, hermeneutics provides the philosophical grounding for interpretivism.

The most fundamental principle of hermeneutics is that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form. Modern hermeneutics encompasses not only issues involving the written text, but everything in the interpretive process. This includes verbal and nonverbal forms of communication, as well as prior aspects that affect communication – such as pre-suppositions and pre-understandings. According to Gadamer (1976, p. 117), “a circular relationship exists in the movement of understanding from the whole to the part, and back to the whole” (*cf.* Figure 4.2). This principle is foundational to all interpretive work that is hermeneutic in nature.

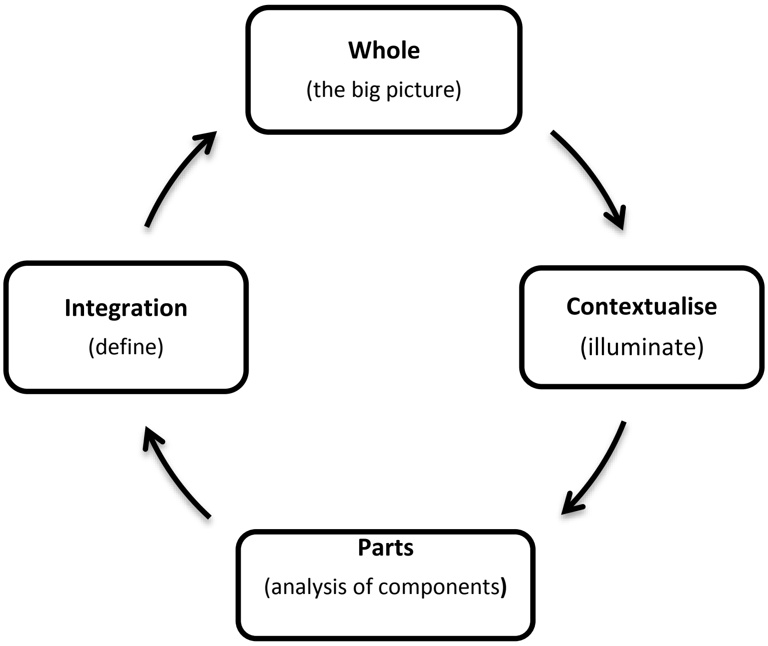


Figure 4.2: The Hermeneutics Circle, adapted from Bontekoe (1996)

HCI is a subfield of Information System, and therefore Klein and Myers' view is relevant to my study. According to Klein and Myers's view of interpretive research, knowledge of reality can be gained through social constructions such as language, documents, tools and shared meanings. In the field of Information Systems, interpretive research aims to understand the relationship between systems – that is, some form of technology, and the context within which the systems are used. Interpretive research aims to understand the purpose of the information system, the intention of the person using it, the effect of the system on those who use it and the environment within which it is used.

For my research, Klein and Myers's description of interpretive research provided a suitable lens through which to investigate how a cross-age tutoring system could be designed for implementation on a social networking platform, to support mathematics and literacy skill acquisition in grades 3 and 4. I am particularly interested in giving children of different generations support and encouragement in their quest to do cooperative inquiry design.

4.2.2 Research Approach

Creswell (2009) describes research approaches as plans and procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis and interpretation. Qualitative, quantitative and mixed methods are some of the research approaches that one can use. A qualitative research approach was used in this study, as the research outcomes were influenced by the interaction between the researchers and the participants. Burns and Grove (2003, p. 19) describe a qualitative approach as “a systematic subjective approach used to describe life experiences and situations to give them meaning”. Qualitative researchers study things which are in their natural settings, attempting to make sense of, or interpret, phenomena, in terms of the meanings people bring to them (Denzin & Lincoln, 2011). The strength of qualitative research is its ability to provide textual descriptions of how people experience a given issue. It involves an interpretive, naturalistic approach to its subject matter, and gives priority to what the data contributes to important research questions.

The approach adopted by qualitative researchers tends to be inductive, which means that they develop a theory, or look for a pattern of meaning, on the basis of the data that they have collected (*see* Figure 4.3). This involves a move from the specific to the general, and is sometimes called a bottom-up approach. The inductive approach starts with research questions, aims and objectives, which need to be achieved during the research process.

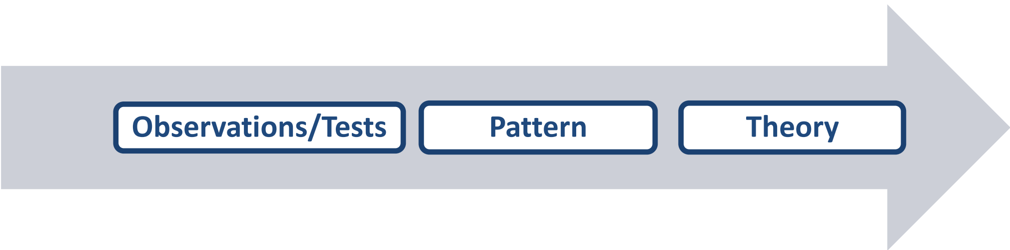


Figure 4.3: Route followed by inductive studies

My research was qualitative, because the data collected was in the form of written language, which was analysed by identifying themes and patterns that played a part in solving the research problem. A qualitative approach was used in this study, to investigate how a cross-age tutoring system could be designed for implementation on a social networking platform, to support numeracy and literacy skill acquisition in grades 3 and 4. To investigate the research issue mentioned above, the researcher used a Design Science Research strategy.

4.2.3 Research Strategy

The central research thrust for this study was based on the Design Science Research strategy. The research strategy involves the design of novel or innovative artifacts (human-computer interfaces, systems designs, and systems design methodologies, for example), and the analysis of the use and/or performance of such artifacts to improve and understand the behaviour of aspects of Information Systems (Vaishnavi & Kuechler, 2015). The reason for adopting this strategy was the apparent match between the requirements of the problem statement in terms of “how to design ….” and the focus of Design Science Research on building knowledge through the construction of artifacts. Before discussing Design Science Research, a brief explanation is given on the general concept of design research.

4.2.3.1 Design research (DR)

In the Design Research (DR) paradigm, knowledge and understanding of a problem domain are gained by building an artifact and applying the artifact to solve problems in the domain. Hence, DR can be called ‘exploring by building’, and it is inherently a problem-solving process (Hevner et al., 2004; Vaishnavi & Kuechler, 2015). Such research may be conducted by designers as part of their work, or it may be led by academic institutions aiming at expanding knowledge of ‘what’ can be designed and ‘how’ designing can be done (Binder & Redstrom, 2006).

Design research was originally constituted primarily as research into the process of design, developing from work on design methods. The concept has since been expanded to include research embedded within the process of design, including work concerned with the context of designing and research-based design practice. The concept retains a sense of generality, aimed at understanding and improving design processes and practices quite broadly, rather than developing domain-specific knowledge within any professional field of design.

DR is research specifically undertaken to support the strategic design and development of products, services, and programmes (Lee, 2012). According to Sein et al. (2011), DR positions information technology artifacts at the centre of the Information Systems discipline. However, dominant DR thinking takes a technological view of the IT artifact, paying little attention to its shaping by the organisational context (Sein et al., 2011). Consequently, existing DR methods focus on building the artifact, and relegate evaluation to a subsequent and separate phase. They value technological rigour at the expense of organisational relevance, and fail to recognise that the artifact emerges from interaction with the organisational context. DR consists of activities concerned with the construction and evaluation of technology artifacts to meet organisational needs, as well as the development of their associated theories.

Different terms have been used to describe DR, namely D*esign Science Research* (Hevner et al., 2004; Peffers et al., 2008) and *design science* (Gregg et al., 2001; March & Smith, 1995; Nunamaker et al., 1991; Peffers et al., 2008; Reeves, Herrington & Oliver, 2005; Vaishnavi & Kuechler, 2015;). DR has also been used to describe *design-based research* (Anderson & Shattuck, 2012; Baskerville & Myers, 2015) as a practical methodology designed by and for educators who seek to increase the impact, transfer and translation of education research into improved practice, by stressing the need for theory building and the development of design principles that guide, inform and improve both practice and research in educational contexts (Anderson & Shattuck, 2012).

In my study, I concentrated on the method of designing a framework for cooperative design of a cross-age tutoring system. Vaishnavi and Kuechler (2015) present the Design Science Research model as one that builds knowledge through the construction of an artifact and the evaluation of its perfomance. Their design cycle promotes the inclusion of multiple methods to inspire, generate and evaluate an artifact through the Design Science Research approach. Design Science Research, which is the research approach adopted for this study, is discussed in detail in the following section.

4.2.3.2 Design Science Research (DSR)

DSR can be considered a methodical design process whose aim is to bridge research and practice by embracing both a rigour cycle and relevance cycle (Ardakan & Mohajeri, 2009; Baskerville & Myers, 2015). It revolves around a build-and-evaluate cycle that exchanges inputs and outputs with a knowledge base (the rigour cycle) and with a real-world application of the artifact (the relevance cycle) (Hevner, 2007; Hevner et al., 2004). DSR requires the creation of an innovative, purposeful artifact for a specific problem domain. In developing and constructing an artifact, the researcher draws upon theoretical knowledge and personal creativity (Hevner et al., 2004; March & Smith, 1995; Vaishnavi & Kuechler, 2015). Construction and evaluation of the artifact must be done rigorously. Evaluation of the artifact will be an attempt to assess the value in usefulness of the artifact (Petter, Khazanchi & Murphy, 2010). DSR artifacts could be constructs, models, methods or instantiations (Gregor & Jones, 2007; March & Smith, 1995; Vaishnavi & Kuechler, 2015). A summary of the outputs of a DSR project is given in Table 4.1, below:

Table 4.1: Outputs of Design Science Research (DSR) (March & Smith, 1995; Vaishnavi & Kuechler, 2015).

Output	**Description**
1. Constructs	Constructs constitutes a conceptualisation used to describe problems within the domain and to specify their solution.
2. Models	A set of propositions or statements expressing relationships between constructs.
3. Methods	A set of steps used to perform a task.
4. Instantiations	The realisation of an artifact in its environment which operationalises constructs models and methods.

The past few decades have witnessed considerable developments in the nature of design artifacts and design science methodologies (March & Smith, 1995; Orlikowski & Iacono, 2001; Peffers et al., 2008; Vaishnavi & Kuechler, 2015). Gregor and Jones (2007) introduced theorising as an important output in DSR research, which has spurred the use of design theory.

The DSR knowledge contribution from this thesis was in the form of an artifact, method and a design theory. Figure 4.4 depicts the reasoning behind the methodology of Design Science Research, according to Vaishnavi and Kuechler (2015):

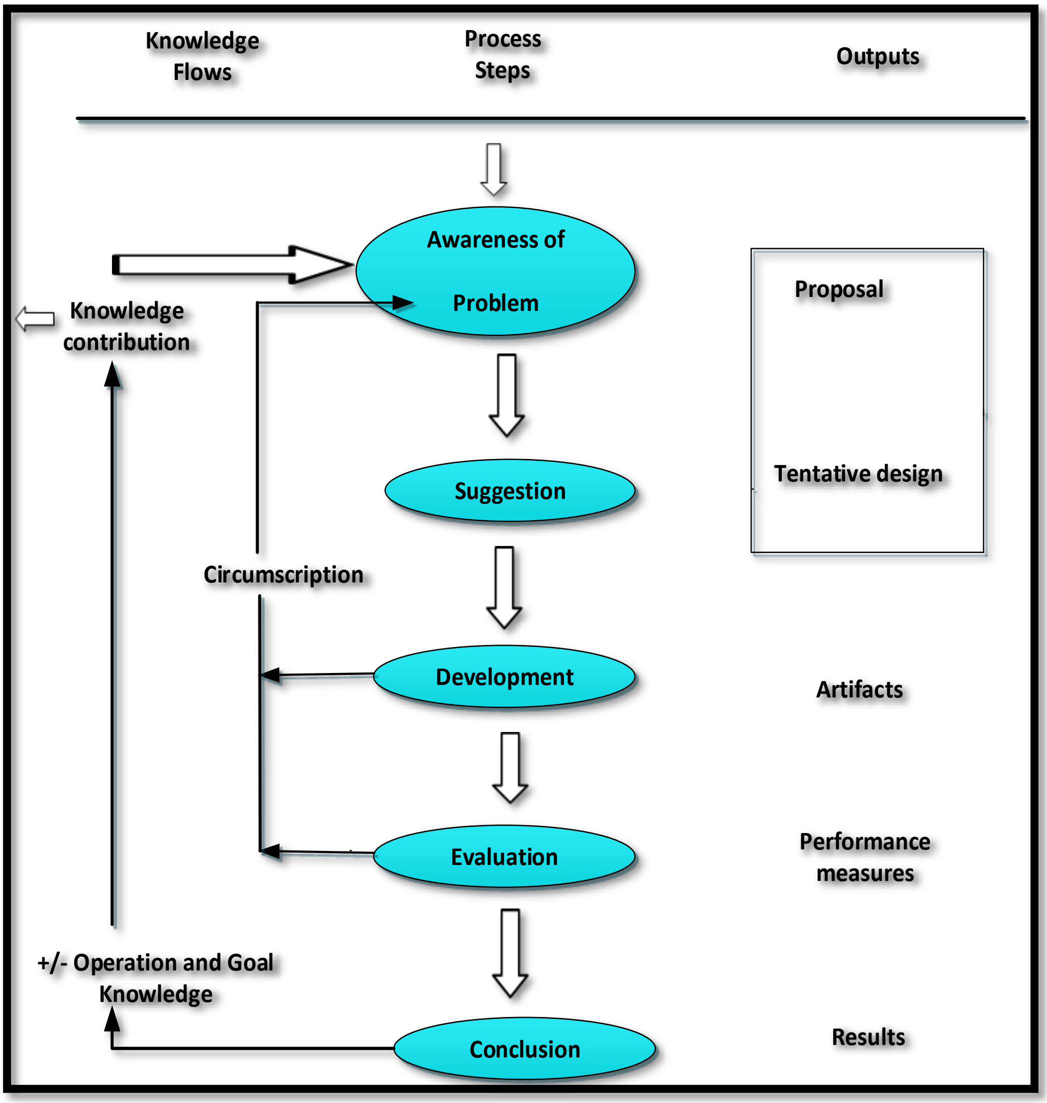


Figure 4.4: The general methodology of Design Science Research (Vaishnavi & Kuechler, 2015)

All design begins with *Awareness of a problem*. The *Awareness of the problem* phase determines what resources are available to designers and software project managers for reusing knowledge, and what gaps remain. *Suggestions* for a problem solution are drawn from existing knowledge, or the theory base for the problem area, or developed using an appropriate research methodology. The exploratory study in the *Suggestion* phase provides a useful foundation for the creation of an artifact to encourage the reuse of the experiences of designers. Next, implementing an artifact according to the suggested solution is attempted, and is shown in Figure 4.4 as *Development*. This is the phase where most of the actual design takes place, which, according to Vaishnavi and Kuechler (2015), is the creative effort, required in synthesising existing knowledge and well-defined problem definition into an artifact for solving the problem. This phase is where creativity plays a major role.

After the development of an artifact, it is necessary to evaluate the artifact in order to determine how well the artifact works. *Development*, *Evaluation* and further *Suggestion* are frequently performed iteratively in the course of the research design effort. The Circumscription arrow, or basis of the iteration, represents the flow from partial completion of the cycle back to *Awareness of the problem*. Circumscription is a formal logical method that assumes that every part of knowledge is valid only in certain situations (McCarthy, 1980). The knowledge has to be used as part of the working design, in order to clarify the implications of a theory. The circumscription process is especially important towards understanding Design Science Research, because it generates understanding that could only be gained from the specific act of construction (Kuechler & Vaishnavi, 2011).

The *Conclusion* indicates termination of a specific Design Science Research project. Therefore, the conclusion phase leads to the knowledge contribution (Gregor & Hevner, 2013). The outputs and the expectations on the nature and depth of knowledge can vary, depending on the type of knowledge contribution and the state of knowledge in the area of research (Vaishnavi & Kuechler, 2015).

Each DSR step is described according to the patterns that are used in that step. According to Vaishnavi and Kuechler (2015, p. 128), patterns are defined as “a solution to a problem in a recurring context”. Patterns are typically goal based, and they demonstrate a way of, or general technique for, approaching a type of problem that is abstractly similar to other problems, even though it has never occurred before in exactly the same way (Vaishnavi & Kuechler, 2015). DSR methods and patterns present innovative research methods that help break new ground by applying patterns, reuse, and design science to research. Patterns have also been developed for conducting Design Science Research, to aid researchers in understanding approaches for finding relevant problems to address, stimulating creativity, and publishing research (Vaishnavi & Kuechler, 2015). Within DSR, researchers develop artifacts to solve a problem, and evaluate their value (Hevner et al., 2004; March & Smith, 1995; Vaishnavi & Kuechler, 2015).

The patterns used in this study were, for example: *Redefine the Research Problem* and *Literature Search* patterns (Vaishnavi & Kuechler, 2015). They provide solid fundamentals of various research techniques that demonstrate how to innovate research methods. Petter, Khazanchi and Murphy (2010) believe that the development of patterns is a design science activity in which an artifact is created, to communicate about and improve upon the current state of practice. Patterns can provide researchers with a method to synthesise and capture knowledge in a given domain, as well as highlight areas for future research. Patterns have the potential to represent the properties ascribed to the best practices and experiences that are incorporated in the ‘good’ solution to a problem, within a given context (Petter et al., 2010).

Researchers have come up with a number of models of the DSR process. Hevner et al. (2004) presents DSR as a two-stage process *building* and *evaluation* of an innovative artifact. Artifact building involves understanding the problem and conceptualising the new design on the basis of the so-called *kernel theories*, drawn from the natural and social sciences through a creative translation process (Beck, Weber & Gregory, 2013). A follow-up iteration of building and evaluation leads to the maturity of the artifact (practical goal) and the answering of a research question associated with the artifact or its value (theoretical goal). According to Gregor and Hevner (2013), the output of a DSR project should be a design science knowledge framework, as depicted in Figure 4.5. This framework includes *invention* (that is, inventing new knowledge or solutions for new problems), *improvement* (developing new knowledge or solutions for known problems), *adaptation* (non-trivial or innovative adaptation or known knowledge or solutions for new problems) and *routine design* (applying known knowledge or solutions to known problems).

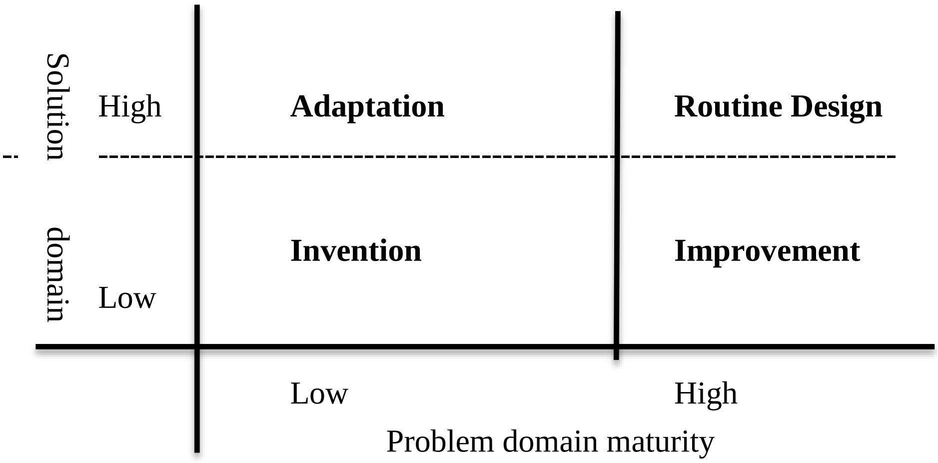


Figure 4.5: Design Science Research knowledge contribution framework (adapted from Gregor & Hevner, 2013)

Invention, improvement and adaptation are considered types of knowledge contribution in DSR, and routine design by itself is rarely considered as a research contribution (Vaishnavi & Kuechler, 2015).

Peffers et al. (2008) developed a DSR model that attempts to synthesize selected prior literature on the topic. The model breaks the *Awareness of Problem* phase into two phases: *Identify Problem* and *Motivate and Define Objectives* of a solution, the *Suggestion* and *Development* phases are merged into a single phase – *Design and Development*. The model breaks the *Evaluation* phase into two phases: *Demonstration* and *Evaluation*, and renames the *Conclusion* phase as *Communication*. A distinguishing feature of this model is the fact that the research can be initiated from a variety of contexts: Problem-Centred, Objective-Centred, Design and Development, and Client/Context Initiations (Peffers et al., 2008). Before relating the DSR phases, the current study discusses the philosophical grounding of DSR.

4.2.3.3 Philosophical grounding of Design Science Research

Research is often grounded in certain philosophical underpinnings from which the underlying assumptions of the research are derived. Very frequently, these assumptions are explicitly stated, providing delimitations for the research. However, researchers sometimes do not explicate the research assumptions, making it difficult to evaluate the research outcome. It is therefore important to explain the philosophical grounding of the research. The orthogonal dimensions of philosophical grounding are Ontology, Epistemology, Methodology and Axiology.

Ontology describes the worldview(s) of the research participants. It is the study of the nature of reality for the research. Each research stakeholder holds a different worldview in terms of the research. As a result, multiple realities exist, and each research participant is interested in a viewpoint of the research that is defined by their own reality. Qualitative researchers embrace the idea of multiple realities, and are thus subjective in their outlook. They conduct their research with the intent of unearthing and reporting these multiple realities.

Research is also based on assumptions about how research participants know that they know something. Epistemology is the study of the nature of knowledge. Knowledge is established through the meanings attached to the phenomena studied. Research participants need a way of knowing what knowledge depends on, and how to be certain about what they know. The main outcome of a DSR activity is an artifact with some functionality. To the extent that the artifact behaves predictably, the information content of the artifact is true. What the artifact does defines its meaning. Therefore, for DSR, the artifact is central in the development of knowledge, meaning and truth, which influence how the worldviews of the research participants evolve.

Axiology is the study of values. It is how 'certain cultures' promote and hold other ways of being. Values are slow-changing, strong beliefs that shape how research participants respond to their environment. Values provide the basis for predicting and interpreting behaviour. Thus, interpretivist methods yield insight and understanding of behaviour, explain actions from the research participant's perspective, and do not dominate the participants (Scotland, 2012). Examples include open-ended interviews, focus groups, open-ended questionnaires, open-ended observations, think-aloud protocol, and role-playing. These methods usually generate qualitative data. Analyses represent the researchers' interpretations, which are often influenced by the researchers' value systems; consequently, researchers need to make their agenda and value system explicit from the outset.

Methodology is defined as the theoretical framework or lens by which we view the data, after it has been collected using methods available to us. In DSR, the philosophical assumption is that data is analysed in a manner that seeks to develop an increasingly detailed knowledge of the topic being studied. Qualitative researchers are characteristically inductive and emergent; the research outcome is shaped by the researcher's experience in collecting and analysing the data.

This thesis employed DSR to develop a novel artifact as the main research output to address the research problem statement. Such a research approach is relevant to the research question, the research methodology and the research framework, as set out in Chapter 1.

4.2.3.4 The relationship of the DSR process to the study

We discuss, below, how the DSR phases described in section 4.2.3.2, relate to our study.

a) Awareness of a problem

As noted above, the first step of the DSR process is an *Awareness of a problem* through problem identification and definition. The study was directed at addressing severe problems with lower-grade mathematics and literacy levels in South Africa. The problems have a ripple effect that can be seen in the low Grade 12 mathematics throughput. It is generally accepted that addressing mathematics and literacy problems during the early years of education will reduce the problem of high levels of failure and dropout in later grades.

Many young children in South Africa do not have access to learning support outside of school. Where such support exists, it is limited. For example, children who grow up in care facilities, or those whose family members have low literacy levels, cannot receive adequate support with homework and preparation for tests. Teenagers with access to mobile or computer technology spend large amounts of their time socialising, using tools such as Blackberry Messenger (BBM), Facebook and YouTube. For such teens, the social networking environment is a comfort zone, whereas for many adults it holds more threats than advantages. It would therefore be much easier for teenagers to adjust to a tutoring system based on a social networking platform, than it would be for many adults. Young children, including those who have thus far had limited access to technology, are naturally drawn to technology, and would be keen to use a system that allows them to communicate with older children about their schoolwork.

The problem identified for this DSR step was how to design and develop a cross-age tutoring system based on a social networking platform as a DSR artifact, and then to implement and evaluate such an artifact in a restricted environment, before preparing it for more general deployment. The artifact would allow teenage tutors to provide after-school learning support to lower-grade learners who do not have access to such support. The support focused on mathematics and reading skills. The output of *Awareness of the problem* was a draft proposal of our intended plan.

b) *Suggestions*

Having identified the problem, it was necessary to conduct research on how to derive *Suggestions* to address the research problem. Elements of Cooperative Inquiry were used to derive solution suggestions on how a cross-age tutoring system could be designed for implementation on a social networking platform, to support numeracy and literacy skill acquisition in grades 3 and 4. Cooperative Inquiry was selected as a solution suggestion method, as it was expected to encourage both tutors and tutees to fully participate in suggesting possible solutions to the design of an artifact that would eventually benefit them as end users.

During solution suggestion sessions, a couple of use case scenarios were sketched, to enable the co-design participants to contextualise solution suggestion ideas. A typical use case of the artifact was as follows: a Grade 3 tutee needs to read aloud from a book, and needs someone to listen and help her through it. She goes online at the pre-arranged time (or maybe ‘pokes’ the tutor to come online if no specific time has been set). She takes a picture of the text that she needs to read and sends it to the tutor using her mobile phone. The tutor and tutee will ideally be on a video call, or at least a voice call, and when the tutor has opened the picture on her tablet computer, she prompts the tutee to start reading, while she checks, corrects and encourages as the tutee reads through.

Another use case would be a Grade 4 tutee who needs to be guided through his mathematics homework for the day. He takes a picture of his homework book and sends it to the tutor. The tutor sees that the tutee’s homework for the day is to practise the 3x and 4x tables. The tutor explains to him what this means, and starts helping him to memorise the tables.

A third scenario could be a situation whereby a tutee does his/her work, and sends the work to the available tutor who then checks the work and provides feedback to the tutee. All communication that took place through the tutoring system was recorded and monitored, to make sure that the tutoring was done properly, and also as a method of data collection for research purposes. This process played a crucial role in the subsequent design and implementation of the planned cross-age tutoring system.

c) Development phase

Most of the actual design took place in this phase, synthesising existing knowledge and producing a well-defined problem definition of an artifact for solving the problem. Conceptual modelling, an approach used to better obtain and communicate requirements with the users and designers, was applied. Creating a conceptual model ensured that the requirements of such a process were understood in terms of a set of integrated ideas and concepts about what the system should do, how it should behave, and what it should look like. Various design alternatives were considered, going through several iterations of prototyping for early evaluation.

A tentative design of the cross-age tutoring system was developed and implemented according to the suggested design. The researchers designed the system by producing hand-drawn wireframes, and a programmer was employed and given the design information for implementation. The system was implemented on a web-based platform. Since a cooperative design approach was used, this determined how the system was implemented. The researchers worked closely with the children in choosing the tools that would be used to implement the cross-age tutoring system, in line with the method of cooperative inquiry. With the help of the children involved in the study, researchers selected, designed, implemented and refined the technology tools until they were ready for wider deployment.

d) Evaluation

After the development of the artifact, it was necessary to evaluate it using empirical methods. Usability evaluation was used to evaluate the artifact. Such an evaluation method was selected because of the rigour of its theoretical basis, and its relevance to the evaluation of the usefulness and other design outcomes of the DSR artifact. Through a process of step-wise refinement, *Development, Evaluation* and further *Suggestion* were frequently iteratively performed in the course of design (Vaishnavi & Kuechler, 2015). The basis of the iteration, the flow from partial completion of the cycle back to *Awareness of the problem*, is indicated by the *Circumscription* arrow in Figure 4.4. As a result of this evaluation, future research would refine the artifact until a final product was developed and evaluated.

e) Conclusion phase

It marks the completion of a specific design project. The phase shows the results of the DSR project, which are consolidated and documented. According to Vaishnavi and Kuechler (2015), new knowledge production is shown by *Circumscription* and *Operation* and *Goal Knowledge*. The Circumscription process generates understanding that can be gained from the specific act of construction.

4.2.4 Data Collection Methods

Data collection is dependent on the methodological approach used (Bryman, 2012). This study had three phases of data collection, organised as follows:

Phase 1 was concerned with collecting data on the willingness of teenagers to participate in tutoring. The researchers prepared an open-ended questionnaire, which was used to carry out interviews to determine what would motivate grades 8, 9 and 10 teenagers to provide homework and test preparation support to young children in grades 3 and 4 *(cf. Appendix 2)*, with special attention to literacy and numeracy support. The interviews sessions were recorded on video.

Phase 2 involved collecting data through face-to-face tutoring, where homework and test preparation support sessions were conducted by tutors and tutees. The face-to-face sessions were conducted to obtain feedback on the tutees' experience of the face-to-face tutoring, and to immerse them in the tutoring context, so that they would know exactly what was expected of them when they eventually had to design the application.

Phase 3 was the design sessions carried out using cooperative inquiry. During this phase, a system was designed, in order for the tutors to assist tutees with their homework and test preparation.

In order to improve the accuracy and credibility of our work, we used methodological triangulation, which involved using more than one data collection method. The multiple methods, such as observations, interviews, and video and audio recordings that we used in the study, led to more valid, reliable and diverse construction of realities. Triangulation facilitates validation of data through cross-verification from more than two sources. It tests the consistency of findings obtained through different instruments, and increases the chance to control, or at least assess, some of the threats or multiple causes influencing our results. The next section discusses, in detail, the primary data collection methods that were used in the study, for achieving our goals and objectives.

4.2.4.1 Semi-structured interviews and unstructured interviews

Phase 1: Determining what would motivate teenagers to participate

Semi-structured interviews were used in this phase, to collect data from teenagers in groups, pairs and individually, as shown in Table 4.3. These interviews were used, as researchers had only one chance to meet with the participants, and, according to Bernard (1988), such interviews are best used when one is unable to get more than one chance to interview someone. The researchers preferred semi-structured interviews, as they allowed the participants to be prepared for the interview. This would allow participants to easily share their explicit knowledge in interviews or questionnaires, just by saying what they thought. Researchers used the semi-structured interviews, as the latter allowed interviewees the freedom to express their views in their own terms which contributed to providing reliable and comparable qualitative data.

The researchers conducted interviews in either English or Afrikaans. A list of guiding questions was used, but the interviewers allowed some discussion not directly related to the prepared questions, when they regarded the discussion as relevant and informative. Interviews were video or audio recorded with the signed consent of the parents.

Phase 3: Feedback on design sessions

Unstructured interviews were carried out after the design sessions, with both tutors and tutees. The interviews were used to elicit information from tutor and tutee participants on their experience with the design. Unstructured interviews can be very useful for studies attempting to find patterns, generate models, and inform information system design and implementation

(Zhang & Wildermuth, 2009). In this phase, unstructured interviewing was particularly useful for exploring the design sessions' ideas. The decision to use unstructured interviews as a data collection method was governed by both the researcher's epistemology and the study's objectives. Researchers making use of unstructured interviews often hold a constructivist point of view of social reality, and, correspondingly, design studies within an interpretive research paradigm (Zhang & Wildermuth, 2009). It is believed that to make sense of a study participant's world, researchers must approach it through the participant's own perspective and in the participant's own terms (Denzin, 1989; Robertson & Boyle, 1984). The structure of our interviews was guided by a list of open-ended questions called an *aide memoire* or agenda (Briggs, 2000; MacCann & Clark, 2005). Using an *aide memoire* in an unstructured interview encourages a certain degree of consistency across interview sessions; thus, a balance can be achieved between flexibility and consistency. The unstructured interviews were appropriate, as we were working within an interpretive research paradigm in which we assumed that reality was socially constructed by the participants in the setting of interest.

4.2.4.2 Observations, audio and video recording

Observing people gives researchers insight into what people do and how they use things. Direct observation was done, where the researchers were watching rather than taking part. The researchers, as direct observers, strove to be as unobtrusive as possible, so as not to bias the observations. At the end of each tutoring session, each tutee audio recorded their experiences of being tutored by teenagers. They used languages of their choice either Afrikaans or English. Teenagers also audio recorded their experiences with the face-to-face tutoring encounters they had with young children. Direct observation, and the use of technology to audio- and videotape the data-gathering activities, suggested a more detached perspective for the researchers. This made direct observation a relevant data-gathering method for this research, as deeper knowledge could be obtained by means of unobtrusive direct observations of the research participants.

In *phase 1*, the semi-structured interviews were video recorded. The researchers recorded these interviews as they wanted to capture every answer and all comments made by the participants, and to avoid distracting them. *Appendix 6* contains transcriptions of some of the video recordings.

In *phase 2*, the researchers observed teenagers having a face-to-face tutoring encounter with the young children. For four weeks, in September 2013, the researchers took turns to take tutors to the children's home once or twice a week, depending on the availability of the teenagers. The number of teenagers who attended these sessions varied from only 1 to 5. During the sessions, the tutors would help the young children with their homework and test preparation. From the outset, the researchers interfered as little as possible, and allowed the teenagers to decide who to tutor, how many tutees to work with at a time, what to cover in a session, and how to go about it. At the end of each session, both the tutors and the tutees shared their experiences for the day through individual audio recordings, made either on digital audio recorders (provided by the researchers) or on mobile phones. These recordings were collected, and later transcribed to form part of the dataset to be used as input into the design. The transcriptions were systematically reviewed and the data and information was organised into categories (Creswell, 2012).

During design, in *phase 3*, teenagers were video recorded presenting what they had designed. Capturing much of the data on video allowed what Edwards and Westgate (1987) refer to as "retrospective analyses at leisure", and in much greater depth than would have been possible using techniques involving live coding. The other advantage of using this approach is that it is not dependent on respondents' personal views, but seeks explicit evidence through the eyes of the observer (Jacob, 1998; Patton, 1980). This allowed the researchers to gain some insight into the design sessions that were taking place.

4.2.4.3 Cooperative inquiry

The cooperative inquiry method (discussed in Chapter 3, section 3.3), which involves users very early in the design process, was used in *phase 3*, the design phase. The goal was to 'give the end users a voice' (Druin, 1999) in the design and development of the cross-age tutoring system. Prototyping, which refers to the users building a simple model of an application design artifact, and experimenting with its usefulness, was used by tutors, tutees and researchers. Prototyping in cooperative inquiry involves visualising ideas through low-fidelity prototyping techniques (Druin, 2002). It helps children to communicate what they are imagining. The nature of the activity, and the environment within which it is done, should support the children and allow them to participate effectively. Low-fidelity paper prototyping (Snyder, 2003) is highly visual, and uses basic, familiar tools with which to design. Children would be comfortable with this, because most of them would have had exposure to using basic art supplies. Low-fidelity prototyping in cooperative inquiry is sometimes referred to as ‘bags of stuff’, a technique in which children and adults are supplied with big bags filled with an assortment of art supplies such as glue, clay, string, markers, cork and scissors, from which to build their models (Guha, Druin & Fails, 2013).

4.3 Matching Research Methods with the Research Question

The research problem and research question were outlined in Chapter 1. The main research question was, “*How can a cross-age tutoring system be designed for implementation on a social networking platform to support numeracy and literacy skills acquisition?*

Table 4.2 shows how the methods and techniques stated above were used to address the research question and sub-questions:

Table 4.2: Methods and techniques to address the research question

No:	**Sub-Question**	**Methodology**
1.	To what extent are teenage tutors willing and able to provide learning support to foundation phase learners who do not have access to such support?	i) Semi-structured interviews were used pre- and post-project for both primary and high-school participants.
2.	What are the best practices in providing after-school numeracy and literacy tutoring to grades 3 and 4 learners?	i) Observations of teenage tutors assisting the young children with their after-school mathematics. ii) Audio recordings of both tutors’ and tutees’ experiences.
3.	Which elements of face-to-face tutoring can be incorporated into a tutoring system based on a social networking platform?	i) Analysis of the answers to sub-questions 2 and 3 to identify the elements that can be transferred to a social networking system. ii) Cooperative inquiry sessions with tutors and tutees on how to incorporate face-to-face elements into social media.

		iii) Literature study to establish good elements of face-to-face tutoring.
4.	What considerations should be taken into account when tutoring children from socio-economically disadvantaged contexts?	i) Literature study to establish best practices when working with vulnerable children.
5.	What are the current practices, experiences and limitations of using social networking tools to support tutoring?	i) Literature study on social networking platforms and existing online tutoring systems. ii) Review of existing systems in use which provide similar functionality, to see the relevance and their applicability to the South African education context.
6.	How does CI contribute to the success of designing an online tutoring system?	i) Observation of the effects of this design method on the resulting system. ii) Unstructured interviews to gather information from the participants about the role CI played in the success (or not) of the system. iii) Observations of teenage tutors assisting the young children, and the responses given by these young children. iv) Cooperative inquiry to find out which tools appealed to children. v) Two expert contractor programmers were paid to program the designed artifact. iii) Usability evaluation through observation.

4.4 Context, Sampling and Participants

In this section, elements of the research methodology that were important for this study namely context, sampling and participants, will be discussed.

4.4.1 Context (Setting)

Researchers must be aware of their own context and what that brings to the research process. An implication of conducting research from an interpretivist point of view is that context is assumed to have an important impact on the research process. According to Holloway and Wheeler (2002, p. 34), context includes the "environment and conditions in which the study takes place as well as the culture of the participants and location". The broader social context within which this specific research was undertaken, as well as the specific context of the environments of the participants, was taken into account. When analysing the results, the effect of these contexts on research results needs to be taken into account.

This research was conducted in South Africa, a country that is still regarded as a developing country with widespread socio-economic inequality. In terms of education, this means that there are affluent schools where learners receive high-quality teaching, and have access to libraries, computer laboratories and after-school support. Alongside such institutions, are schools with too few and inadequately qualified teachers, sometimes no electricity, and very little in terms of books and educational material. Not only do disadvantaged children attend schools with severe inadequacies, but they also do not have any academic support at home. Children who attend better schools usually have the further advantage that they are supported in their academic development by parents or after-care services at their schools.

In this study, the focus was specifically on providing homework and test preparation support for grades 3 and 4 children, with special attention to literacy and numeracy support. The young children who were provided this support were from a care facility, a centre that looked after underprivileged children. The study aimed at contributing directly to South Africa's social and economic well-being through explicit promotion of child rights and responsible citizenship. Many of the young children in South Africa lack proper educational resources, and researchers have a responsibility to explore every opportunity available to provide these children with the education they deserve.

4.4.2 Sampling

A sample is a selected subset of elements from a defined larger set (Puttergill, 2000). The type of sampling used in this study was convenience sampling sometimes known as 'grab' or 'opportunity' sampling. Leedy and Ormrod (2010) describe it as a type of non-probability sampling (subjects chosen in a non-random manner) which involves the sample being drawn from that part of the population which is close to hand. Convenience sampling, with a purposive selection criterion, was applied in the selection of participants, as we chose easily available participants who were appropriate for the study. This type of sampling was used, as it was useful, because we required a relatively small number of participants (Neuman, 2003). The sample became purposive, because the researchers used judgment to select participants that best enabled the researchers to answer the research question. The participants required were young children and teenagers. This sample was not intended to be statistically representative, but rather to be theoretically representative and suitable for small-scale, in-depth studies (Ritchie & Lewis, 2003).

4.4.3 Participants

Two groups of participants were chosen to participate in the three phases.

Phase 1:

Teenage participants were recruited by word of mouth from the church, social groups and schools attended by daughters of the researchers and children of colleagues of the researchers. The aim of this phase was to identify factors that would motivate teenagers to participate in a cross-age peer tutoring system. Qualitative data collection and analysis methods, with the main data-collection tool being semi-structured group and individual interviews with teenagers, were used. Ten (10) interviews were conducted with a total of 28 children – 15 girls and 13 boys, in grades 8 to 12. Table 4.3 provides demographic details of the interviewees:

Table 4.3: Demographic details (names have not been used to ensure confidentiality)

Group/ Individual	**Grade**	**Gender**	**Home language**		**School type**
Group 1	9	F	Afrikaans		Public (girls)
	9	F	Afrikaans		Public (girls)
	9	F	Afrikaans		Public (girls)
Group 2	8	M	English		Public (Mixed)
	8	F	English		Public (girls)
	10	F	English		Public (girls)
	10	M	Setswana		Public (Mixed)
	10	M	English		Public (boys)
Individual	9	M	English		Private (boys)
Individual	9	F	Afrikaans		Public (girls)
Group 3	9	F	English		Public (girls)
	9	F	Afrikaans		Public (Mixed)
Individual	12	M	English		Public (boys
Group 4	12	M	Tsonga		Public (boys)
	12	M	Setswana		Private (Mixed)
	12	M	Swati		Private (Mixed)
	11	M	Tshivenda		Public (boys)
Group 5	12	M	Setswana		Private (Mixed)
	10	F	Setswana		Private (Mixed)
	10	F	Afrikaans/Xhosa		Private (Mixed)
	8	F	Setswana		Private (Mixed)
	12	M	Xhosa		Private (Mixed)
	9	F	Sesotho		Public (Mixed)
	9	F	Setswana		Private (Mixed)
	10	M	Setswana		Public (Mixed)
	9	M	Xhosa		Public (Mixed)
Group 6	10	F	Setswana		Public (Mixed)
	8	F	Zulu		Public (girls)

The participants were culturally diverse, with 21 being black and 7 white; there were 7 English-speaking teenagers, 5 Afrikaans, 7 Setswana, 2 Xhosa, 1 Swati, 1 Tshivenda, 1 Sesotho and 1

Zulu. The teenagers attended a variety of Gauteng high schools that included both private and public schools, as well as boys-only, girls-only and co-educational schools. The 7 girls were learning at a public school for girls only, 4 boys were attending a public school for boys only, 8 teenagers were from public mixed schools, and 8 from private mixed schools. There were two researchers. The participants reflected the cultural diversity in South Africa, speaking 9 different languages. Some of the participants from this group volunteered and continued into the design phase. Tables 4.4 and 4.5 illustrate some of the demographic distributions:

Table 4.4: Grade and gender distribution

Grade	Female	Male
8	3	1
9	8	2
10	4	3
11	0	1
12	0	6

Table 4.5: Language Distribution

Language	No of participants
Setswana	8
English	7
Afrikaans	6
Xhosa	2
Tshivenda	1
Swati	1
Tsonga	1
Zulu	1
Sesotho	1

All non-Afrikaans speaking participants attended English schools, and were fluent in English.

Phases 2 and 3

The second group of participants was involved in both phase 2 and phase 3. The participants were 2 adults, 9 teenagers, who were girls only, and 6 Grade 3 and 4 children (3 boys, 3 girls). One boy and one girl were nine years old at the time of the research and the rest were ten years old. These six young children lived in a children's home, where they had been placed by a court of law due to lack of proper care by their parents or families. No information on the young children's backgrounds for example, the real reasons for being in the home, who or where their parents were, or where they were before they came to the home, was released to us. The children attended mainstream public schools in an urban environment. These children represented a population of children in South Africa, who are disadvantaged by their social or socio-economic circumstances to the extent that they do not have access to sufficient after-school learning support. All the young children were Afrikaans speaking, and two could also communicate well in English. The researchers deliberately did not investigate the tutees' backgrounds, so as not to be influenced by feelings of sympathy unrelated to the research project. None of the children displayed learning or intellectual challenges.

The teenagers ranged in age from 14 to 17 (except for one who was 12 at the time but did not participate in the tutoring sessions). Two teenagers attended English schools, and regarded English as their first language although their parents spoke Shona and Zulu, respectively. The rest attended Afrikaans schools, although two of those spoke English at home. All the teenagers were fluent in English. This reflected the multilingual, multicultural character of the community. The underprivileged children's community that was identified as appropriate for the design phase of this project, was a privately run children's home that had a branch in Pretoria, South Africa. The underprivileged children attend public schools in Pretoria, and although they received excellent care in the home, there was a need for individual, after-school homework support. With the help of the staff, we selected 6 children in grades 3 and 4 (that is, aged 9 or 10) as part of our design team of 3 boys and 3 girls. All these children had Afrikaans as their home language. They all understood English well, but only two were willing to communicate in English.

Both researchers had children in public high schools in privileged areas of Pretoria, so nine teenage participants were recruited by word of mouth. Two of the teenagers had also been interviewed in the first phase. The selected teenage participants were between the ages of 14 and 17 (in Grade 9 or 10) and were all female. The language barriers were overcome by the correct pairing of the tutors and the tutees. Since one of the researchers did not understand

Afrikaans, the second researcher acted as interpreter when necessary. Table 4.6 shows the individual characteristics of each of the participants:

Table 4.6: Child participants' demographic information

	Name	Gender	Age	Grade	School
1.	Tutee 1	Female	9	3	GPS[3]
2.	Tutee 2	Male	9	3	GPS
3.	Tutee 3	Male	10	4	GPS
4.	Tutee 4	Female	10	4	GPS
5.	Tutee 5	Male	10	4	GPS
6.	Tutee 6	Female	10	4	GPS
7.	Teen 1	Female	16	10	GHS[4]
8.	Teen 2	Female	15	9	GHS
9.	Teen 3	Female	16	10	GHS
10.	Teen 4	Female	16	10	GHS
11.	Teen 5	Female	16	10	GHS
12.	Teen 6	Female	15	9	GHS
13.	Teen 7	Female	16	10	GHS
14.	Teen 8	Female	15	9	GHS
15.	Teen 9	Female	15	9	GHS

These state schools follow the national curriculum, and are run by a governing body.

4.5 A Narrative Description of the Research Process

This section discusses a narrative description of the research process.

(i) Identification of a community of underprivileged children

The community of underprivileged children identified as appropriate for the design phase of this project, was a privately run children's home that had a branch in Pretoria, South Africa. Before we finally decided on identifying a home, we had tried primary schools in the surrounding Pretoria area, but our efforts were in vain, as school principals gave the excuse that there was no time to fit the project into their busy schedules. For this reason, we decided to find a centre that looked after underprivileged children. As this study was a pilot study, the

[3] GPS stands for Government Primary School
[4] GHS stands for Government High School

researchers agreed to identify an underprivileged community in Pretoria, in the form of a home. A Google search was conducted to find the homes which were in Pretoria. The three homes near the area where the researchers worked were identified. Two of the homes identified were not comfortable allowing us to conduct the research with children in these homes, citing the fact that they were vulnerable children. The third one agreed that we meet them first to discuss further what our intentions were. We scheduled a meeting with the principal and two other members of staff. After explaining our intentions, the principal explained the situation in the school to us, and gave us guidelines on how to handle the children.

(ii) Recruitment of teenage volunteers

Recruitment of teenagers was done by the two researchers through word of mouth. The challenge encountered was to obtain male participants. All the teenage participants were girls. The researchers obtained consent from the parents of these teen participants. The teen participants also filled in a questionnaire to find out their knowledge of computers and social media. With the help of a psychologist, the researchers prepared the teenage research participants for their interaction with the children in the home, so that they would be equipped to correctly handle potentially difficult or emotional situations. The psychologist was on standby throughout the project, to deal with any issues, but was never called upon to assist.

(iii) Face-to-face homework and test preparation support sessions

Only two of the fifteen children in our design team had previously participated in the design of a technology solution to a real-world problem. This meant that starting right away with cooperative inquiry sessions would not likely be the best approach. Constraints, such as their limited access to technology, and limited content and design knowledge relating to the educational problem under investigation, would make it difficult for them to participate optimally. Instead, we opted to start with face-to-face tutoring sessions at the children's home, at least twice a week for four weeks.

After each tutoring session, the young children in the home were asked to describe their experiences during the session. This was done by recording their impressions, using a simple digital audio recorder. Two teenagers explained to the young participants how to use the recorders and what we wanted them to do with it (that is, to tell us what they did during the session, what they liked about it, what they did not like, and anything else they wanted to tell us). They gave the children a chance to play with the recorders and practise recording themselves. The audio recorders were left with a caregiver at the home. The children could then ask for a recorder whenever they felt ready to record their stories, and return it for safekeeping. At the end of the series of face-to-face sessions, we would collect the recorders with all their stories. These recordings were later transcribed to form part of the dataset to be used as input into the design (*cf. Appendix 6).*

(iv) Design sessions with the young children and teenagers

The third part of the data collection process involved participatory design sessions with the children. These took place in October 2013 at the University of South Africa and at the children's home, respectively. We decided to conduct separate sessions with the two groups. The tutors had one 3-hour design session, while tutees had two 90-minute sessions on separate days. In the tutors' session, the researchers acted as facilitators, while the tutee design sessions were facilitated by some of the teenagers. The groups gave presentations on the activities of design sessions. Data collected was the 'big ideas' that emerged from the presentations of the paper prototypes produced. 'Big ideas' in the form of written notes were recorded by the researchers, while the groups of teenagers and young children presented their designs, respectively (those presented in Afrikaans were translated into English by one of the researchers). After the presentations came discussion about the name to give to the tutoring system. Various suggestions were made, and the full discussion is given in Chapter 6.

4.6 Data Analysis

All data was analysed qualitatively. Data collection was through unstructured interviews, observations, and audio and video recordings. The mass of data collected in this study was ordered and structured in such a way that meaning was extracted from it, allowing patterns to emerge from the data. The data analysis was divided into the following parts:

- Analysis of data from semi-structured interviews (Phase 1) and unstructured interviews (Phase 3)
- Analysis of data from audio and video recordings (Phases 2 and 3)
- Analysis of data from observations of the design sessions and prototypes (Phase 3)

4.6.1 Analysis of Data from Semi-Structured and Unstructured Interviews

In *Phase 1*, the semi-structured interview data was analysed through repeated viewing of (or listening to) the recordings, and finding instances of data relating to the following categories:

- interest in participating as tutor;
- reasons for wanting to participate (intrinsic/extrinsic factors);
- reasons for not wanting to participate;
- interest to participate in designing the technology for the system;
- opinions about the use of a social networking platform;
- comments/opinions about gender and other relevant data. *(The results of the analysis will be discussed in section 5.2 of Chapter 5).*

In *phases 2* and *3*, after the observations and interviews, analysis of the data was done by way of thematic analysis. Using thematic analysis is a way of seeing, as well as processing, coded qualitative information. The researchers took many decisions on the process of identifying themes or patterns, and they stated why specific categories were chosen. It involved reading and re-reading the text, and identifying coherent categories. The researchers assigned abbreviated codes of a few letters, words or symbols, and placed them next to the themes and ideas they found. This helped with the organisation of the data into categories. Descriptive names for each category were created. As researchers categorised the data, other themes that served as sub-categories were also identified. The themes were organised into coherent categories that summarised and brought meaning to the text. Table 4.7 shows the thematic analysis which was used in the study to generate themes from the observations and interview data:

Table 4.7: Phases of thematic analysis by Braun and Clarke (2006)

No:	**Phase**	**Description of the process**
1.	Familiarising yourself	Transcribing data, reading and re-reading the data, with your data: noting down initial ideas.
2.	Generating initial codes	Coding interesting features of the data in a systemic fashion across the entire data set, collating data relevant to each code.
3.	Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
4.	Reviewing themes	Checking if themes work in relation to the coded extracts (Level 1), and the entire data set (Level 2), generates a thematic ‘map’ of the analysis.
5.	Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6.	Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts relating back of the analysis to the search question and literature, producing a scholarly report of the analysis.

4.6.2 Analysis of Data from Audio and Video Recordings

In this study, audio recordings were done during *Phase 2* of the face-to-face sessions and video recording in some parts of *Phase 3*. The analysis of the data was done through the transcription of the audio data. Transcribing data into written form was done for closer study, as representation of audible and visual data into written form is an interpretive process which is therefore the first step in analysing data. Recordings were transcribed into written form so that they could be studied in detail.

Researchers used transcription, as it involved close observation of data gathered through repeated careful listening and/or watching of the audio tapes – an important first step in data analysis. This familiarity with data, and attention to what is actually there, rather than what is expected, can facilitate realisations or ideas which emerge during analysis (Bailey, 2008), as transcribing is an interpretive act, rather than simply a technical procedure, and the close observation that transcribing entails leads researchers to notice unanticipated phenomena.

Transcriptions formed part of the data set to be used as input into the design. The coding mechanisms associated with grounded theory (open, axial and selective coding) were used to analyse the transcripts, with the aim of understanding the nature of the narrative contributions made by the participants (Baskerville & Pries-Heje, 1999; Corbin & Strauss, 1990). In open coding, concepts emerging from the data were identified, and then grouped at a more abstract level, into categories. Through axial coding, relationships between the various categories were searched for, and finally (through selective coding) developed a core category (or story) that represented the central phenomenon in the data. The research questions and the literature were used to guide the development of the study. The research approach was suitable for this study, due to the following strategies used:

- C*oding* – a process for both categorising qualitative data and describing the implications and details of these categories; and
- *Open coding* – was used initially, considering the data in minute detail while developing some initial categories.

Later, the researchers moved to more *selective coding*, where one systematically codes with respect to a core concept.

4.6.3 Analysis of Data from Observations of the Design Sessions

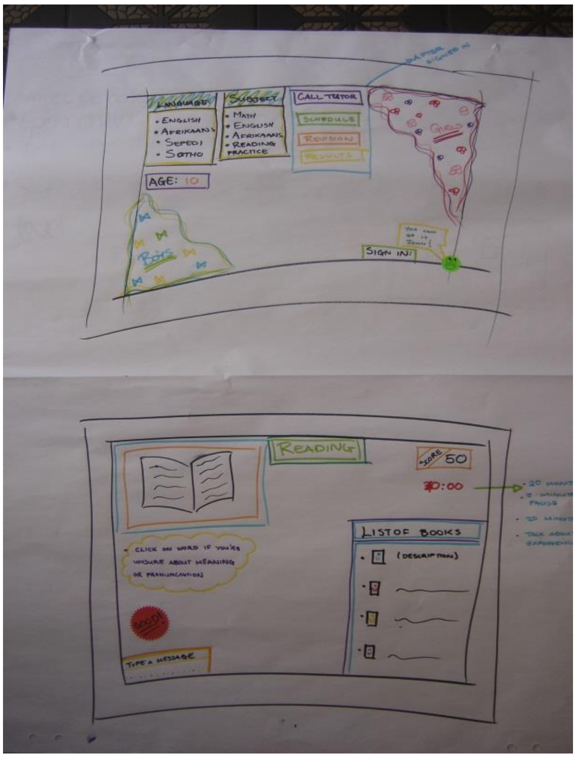
During *Phase 3,* the design sessions, the researchers used direct observation as one of the methods of collecting research data. Direct observation is particularly important, because it has the potential to give insight into what people actually do, rather than what they say they do, or think they do. The researchers recorded the observational data using two methods of written notes and video/audio recordings. Video recordings of presentations of the designs produced by teenagers were done in English. Presentations of the designs by the younger children were audio-recorded. In analysing data collected through direct observation, the researchers were essentially looking for patterns, in order to build up a design data store of all the ‘big ideas’ presented. The researchers used content analysis to categorise the verbal and behavioural data, for the purposes of classification, summarisation and tabulation. The aim of this type of analysis was to make sense of the data collected, and to highlight the important messages, features or findings.

4.6.4 Analysis of the Outcomes of the Design Sessions

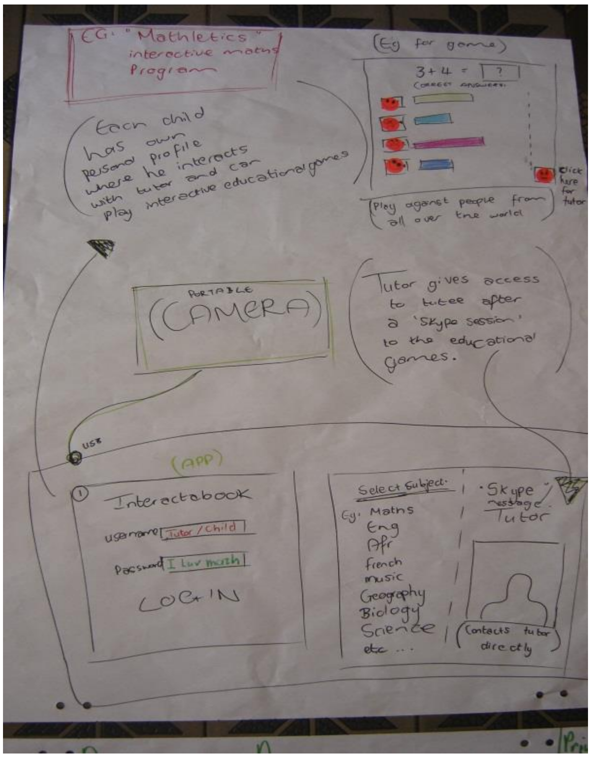
The results of the design sessions were posters representing the designs, the demonstrations done by the participants, and the ‘big ideas’ recorded by the researchers:

The Posters

The participants created posters that showed how they envisaged the system. As they were working in groups, they prepared at least two posters per group, one showing the tutor profile page and another tutee profile page. The groups that had more than two posters went on to give a breakdown on each unit found on the profile page. Figure 4.6 shows two of the many posters prepared by the participants:



Poster 1



Poster 2

Figure 4.6: Two of the posters showing the profile pages

The Demonstrations

Demonstrations were done by members of each group, illustrating how the system which the participants created, would work. Figure 4.7 shows one group demonstrating how a section of the profile page would work:

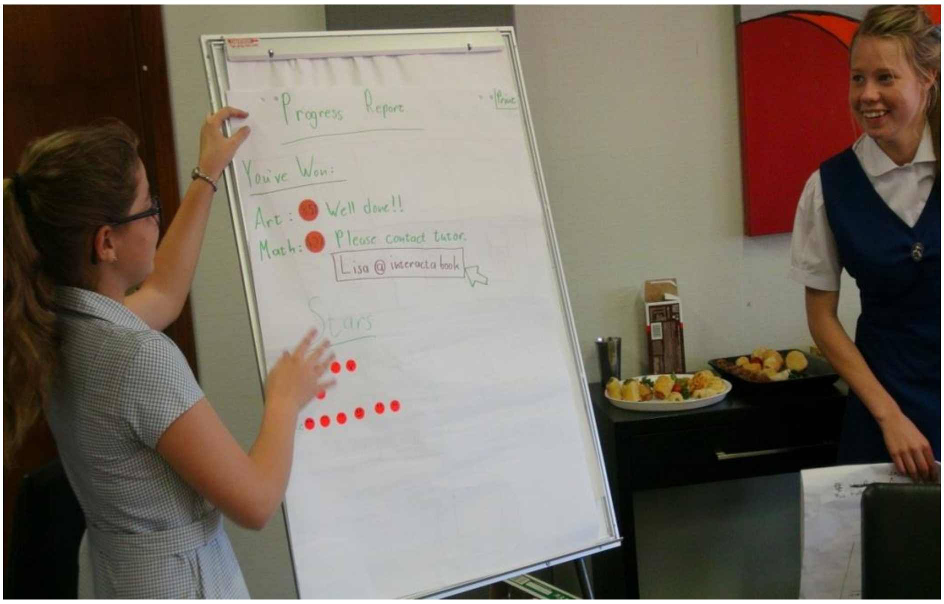


Figure 4.7: Demonstrating how part of the system would work

The 'Big Ideas'

The researchers then extracted 'big ideas' from demonstrations presented by both the tutors and tutees (*cf Figure 4.8 and Figure 6.1*). A substantial number of ideas were similar, and only a few were different. These 'big ideas' were later translated to wireframes to be included in the design. Figure 4.8 is an example of the 'big ideas' from the tutees. They were written in Afrikaans, but were later translated into English. More discussion on the 'big ideas' is given in chapters 5 and 6.

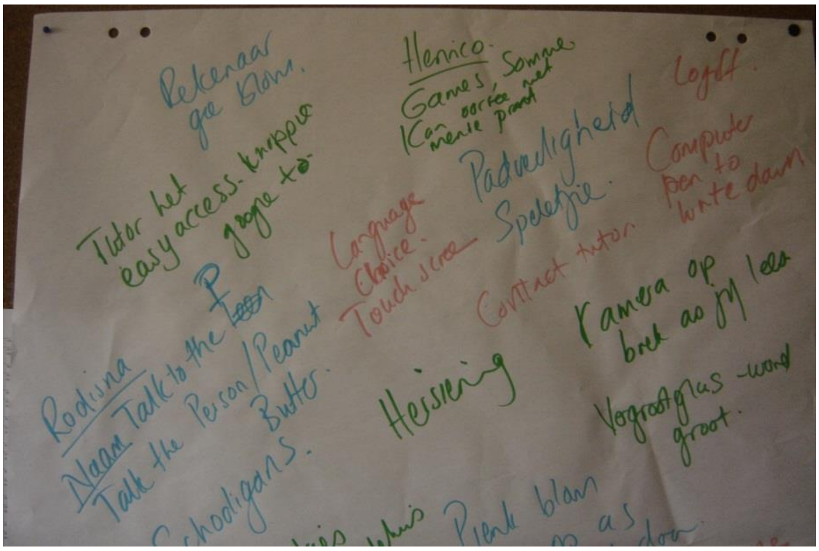


Figure 4.8: Tutees' 'big ideas' in Afrikaans

4.7 Translation of Design Data into Design Prototype

The researcher created the first draft of the design by putting together sketches of what was recorded in the first and second phases of the study. These sketches, described fully in Chapter 5, were then translated into the actual design. The design artifacts were then converted to a working prototype. The artifact was then subjected to a thorough testing process. First, the artifact was extensively tested for debugging purposes within a closed user group. Next, the application was shared with the entire group via a web portal, where users were able to download the software after providing some personal information. The information provided was automatically linked to the middleware directory. For this study, only the participants and researchers had access to the directory, as children downloaded the software artifact. Lastly, the software was tested for performance, usefulness and usability.

Usability testing was one of the methods used for testing the usability of the artifact. According to Dumas and Redish (1993), usability testing aims to achieve the following goals:

- Evaluate the product's usability;
- Involve real users in the testing; and
- Give the users real tasks to accomplish.

Usability testing focuses on user needs; it uses empirical measurement and iterative design (Nielsen, 1993, 1994). It gives direct input on how real users use the system. Involving users in design, one way or another, has been shown to lead to the development of more usable, satisfying designs (Abras, Maloney-Krichmar & Preece, 2005). If usability testing uncovers difficulties, such as children having difficulty understanding instructions, manipulating parts, or interpreting feedback, then developers should improve the design and test it again. The evaluation method used for evaluating the usability of the artifact through sticky noting is discussed in detail in Chapter 6.

4.8 Validation and Reliability of Study

Validity and reliability are two factors that any qualitative researcher should be concerned about while designing a study, analysing results, and judging the quality of the study (Golafshani, 2003; Patton, 2001). These factors can be approached through careful attention to the research's conceptualisation and the manner in which the data is collected, analysed and interpreted, as well as the way in which the findings are presented (Merriam, 1998). Reliability and validity are important in all research, and address issues about the quality of data and appropriateness of the methods used.

Cohen et al. (2000) point out that discussion about reliability and validity should be framed by the paradigm and methodological approach taken. Thus, reliability, when using a qualitative methodological approach, involves trying to ensure that different researchers are consistent in the way that they interpret or categorise observations or interviews, or that the same researcher would show consistency over time (Grossoehme, 2014; Lincoln & Guba, 1985; Silverman, 2011). Validity in qualitative research tends to relate to the extent to which the research provides an authentic account of the participants' voices (Hughes, 2001), as well as a reflexive account of the researcher's own role in the production of the data (Coffey, 1999).

4.8.1 Validity

A brief discussion is given below on the five issues mentioned by Miles and Huberman (1994) on validation. For each, Miles and Huberman (1994) provide sets of questions that researchers can answer, in order to assess their research. The questions mentioned in this discussion are only those that were related to this study.

4.8.1.1 Credibility

The question asked here is whether the findings are credible to those who read them and how they match reality. According to Miles and Huberman (1994), credibility requires context-rich and meaningful descriptions that make the findings convincing. The credibility criterion involves establishing that the results of a study are credible or believable from the perspective of the participant in the research. The use of triangulation in this thesis was to facilitate data validation, theoretical fit, saturation, and confirmation of artifact evaluation (O'Donoghue & Punch, 2003). It was used to ensure that data gathered from the semi-structured and unstructured interviews, audio and video recording, and observation with teenagers and young children on the design and development of the system, was reliable. In order to increase the reliability of this study, each step followed was described in sufficient detail to enable another researcher to repeat the research and, if using the same procedures and criteria, to obtain similar results.

4.8.1.2 Confirmability

Confirmability is the degree to which the research findings can be confirmed or corroborated by others. The question here is whether a different researcher would have come up with the same results. It is analogous to objectivity – that is, the extent to which a researcher is aware of, or accounts for, individual subjectivity or bias. In this research, the researchers intend archiving all collected data in a well-organised, retrievable form, so as to make it available to those who might want to challenge the findings. Miles and Huberman (1994) suggest that the data collection and analysis methods should be described in sufficient detail so as to give a complete picture.

4.8.1.3 Transferability

Research findings are transferable or generalizable only if they fit into new contexts outside the actual study context. Transferability is analogous to external validity – that is, the extent to which findings can be applied to other contexts, or generalised (Miles & Huberman, 1994). Generalisability involves linking findings to situations or aspects that did not form part of a specific study. Seale (1999) advocates that transferability is achieved by providing a detailed, rich description of the settings studied, to provide the reader with sufficient information to be able to judge the applicability of the findings to other settings that they know. According to Ritchie and Lewis (2003, p. 268), "It is a matter of judgement of the context and phenomena found which allows others to assess the transferability of the findings to another setting". Therefore, the generalisability issue has to be resolved by the reader of the research report, based on how close the researcher's and the reader's contexts are.

4.8.2 Reliability

Reliability for qualitative research lies with consistency. According to Joppe (2000), reliability is the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable. A margin of variability for results is tolerated in qualitative research provided the methodology and epistemological logistics consistently yield data that are ontologically similar but may differ in richness and ambience within similar dimensions (Leung, 2015).

4.8.2.1 Dependability

A study is dependable if it is consistent over time, and across researches and methods. According to Seale (1999), dependability can be achieved through auditing – which consists of the researcher’s documentation of data, methods and decisions made during the study, as well as its end products. Auditing for dependability requires that the data and descriptions of the research should be elaborate and rich. It may also be enhanced by altering the research design as new findings emerge during data collection. In order to increase the reliability of this study, each step followed was described in sufficient detail to enable another researcher to repeat the research and, if using the same procedures and criteria, to obtain similar results. This “audit trail” (Lincoln & Guba, 1985, p. 316) allows the reader to assess the extent to which proper research practices were followed in order to establish the credibility (internal validity) of the research. If the researcher does not maintain any kind of audit trail, the dependability cannot be assessed and dependability and trustworthiness of the study are diminished.

4.9 Ethical Aspects

Research ethics refers to the moral principles guiding research. The principal aim of ethics is, as far as possible, to protect all groups involved in research, including participants, institutions, funders and researchers, throughout the lifetime of the research and into the dissemination process (Unisa’s Policy # 89). In order to protect human research participants, the University of South Africa seeks to ensure that research is conducted in accordance with the highest ethical standards of the university. This research involved children from a care facility and teenagers who were still under the age of 18 years. Accordingly, Unisa’s Policy # 89 mandates that all research involving human participants, that is conducted under the auspices of the University, must be approved and overseen by a sanctioned Research Ethics Board. The Research Ethics

Board at Unisa, and affiliated institutions, ensures that research is designed and conducted to protect the rights, welfare and privacy of research participants. It was therefore imperative to go through the review process.

The researcher dealt with ethical issues in the following manner:

i). Informed consent

Informed consent was obtained from the Head and caregivers of the centre where the young children stayed. Three meetings between the centre management and researchers were held. The purpose of the meetings was to discuss how children were going to be involved, and how the privacy and confidentiality of research participants was to be maintained. The Head also explained what the researchers were allowed and not allowed to do. A signed written consent form was then submitted to the centre. In respect of the teenage participants, the researchers informed both the parents and participants of the purpose, nature, data collection methods, and extent of the research, prior to the commencement of the study. Further, the researchers explained to them the typical roles to be played by the teens. In line with this, the researchers obtained their informed consent in writing (*cf. Appendices 2).*

ii). Harm and risk

In this research study, the researcher guaranteed that no participants would be put in a situation where they could be harmed physically or psychologically as a result of their participation (Trochim, 2006). The participants' identity information was not made available to anyone who was not directly involved in the study.

iii). Honesty and trust

The researchers adhered strictly to all the ethical guidelines, as this served as quality assurance for the honesty and trustworthiness of the data collected and the accompanying data analysis. It is of great importance for researchers to develop a greater awareness of how to avoid being irresponsible and untrustworthy. The researchers demonstrated the ability to develop and maintain ethical standards for the study, and worked out the ethical implications of diverse research practices.

iv). Privacy, confidentiality and anonymity

In this study, the researcher ensured that the confidentiality and anonymity of the young children would be maintained, through the removal of any identifying characteristics before widespread dissemination of information. Permission was granted by parents of teenagers to show their pictures in the study. The researcher made it clear that the names of the participants would not be used for any other purposes, nor would information be shared that revealed their identity in any way.

v). Voluntary participation

Despite all the above mentioned precautions, it was made clear to the participants that the research was only for academic purposes, and their participation in it was absolutely voluntary. No one was forced to participate.

vi). Recruitment of a psychologist

One of the researchers approached and interviewed a psychologist, specialising in teenager development, to discuss the study and how to prepare the teenagers for working with the younger children from the children's home. Since the schedules of the teenagers barely made it possible for them to do more than one tutoring session per week, it was practically impossible to get all seven of them together for a session with the psychologist. A video recording of the psychologist talking to the teenagers was prepared, and each teenager was issued with one which they had to watch before their first visit to the care centre. The psychologist was available throughout the study period.

vii). Ethical clearance

Ethical clearance was obtained from the University of South Africa, School of Computing Ethics Committee:

Number: 065/BC/2013;

Approval date: 2013/05/31 *(cf. Appendix 1)*

4.10 Summary

This chapter presented the research paradigm and research methods for this study. A qualitative approach was adopted to investigate the key issues in relation to this study, followed by a detailed description of the implementation of research methods. This description included information about the aims of the study, participant selection, data collection, and data analysis procedures for the study. The primary focus of this chapter was to provide a description of the research process used, and its applicability to the research questions at hand.

The following two chapters use a structured narrative format to report in detail on how the design was done. Chapter 5 describes the data that was collected through the three phases which later fed into the actual design and answered some of the research questions. Chapter 6 discusses the process of creating the wireframes from the data collected, and the technical specifications of the design which would aid the conversion of detailed design into executable computer codes.

CHAPTER 5: DATA ANALYSIS: REFLECTION ON THE DESIGN PROCESS

5.1 Introduction

The context of this study was a design project with the aim of developing a social media based, cross-age tutoring system, whereby teenagers from more privileged communities in South Africa provide online homework support to young children from disadvantaged communities. The primary aim was to establish technology-enriched learning support for young, underprivileged children, and the emphasis was on providing after-school mathematics and reading support. From the outset, the approach was to design the system in collaboration with children from both of the intended user groups – teenagers who acted as tutors and young children who received homework support as tutees. Initially, the system would be deployed within a restricted environment, with a small group of tutors and tutees, to ensure that it was safe for children to use, especially on the tutee side, before deploying it more widely. Chapter 5 is a reflection on the design process described in detail in Chapter 4. This chapter describes the data that was collected through the phases, which later fed into the design. Some of the research sub-questions in Chapter 1 are answered through the activities that took place in the three phases. The rest of the sub-questions will be answered in Chapter 8.

In this study, different phases, as described in Chapter 4, were used, and they all contributed to the designing of the application. The data collection methods included the following:

- interviews that were carried out at the beginning of the study, to determine if teenagers were willing to participate in tutoring, and what would motivate them to do so;
- audio recordings of individual feedback on face-to-face tutoring sessions were transcribed and translated into English;
- physical paper prototypes created by the teenage, and grades 3 and 4, designers in groups;
- video recordings of the presentation of the designs produced by the teenagers (all these presentations were done in English) and audio recordings of the presentations by the younger designers;
- ‘big ideas’ recorded by the researchers, while the groups of teenagers and young children, respectively, presented their designs. Those presented in Afrikaans were translated into English by one of the researchers.

The analysis of data collected, and the results, are discussed phase by phase in this chapter; in the process, a subset of the research questions given in Chapter 1, are answered. The outline of the chapter is as follows: 5.1 is the introduction of the chapter, followed by a discussion of the three phases in sections 5.2 to 5.4. Section 5.5 is on the difficulties encountered during the activities of the phases, and section 5.6 gives a summary of the chapter.

5.2 Phase 1: Willingness of teenagers to participate in tutoring

Interviews carried out during Phase 1 were to determine if the project was viable. The main aims of the interviews were to gather information on whether teenagers would be willing to participate in tutoring, and in the design of the system, and what would motivate them to do so. The following sub-question relates to this phase:

What would motivate teenagers to participate in tutoring activities via social media, for the benefit of younger learners?

To answer the above question, the following sub-questions were investigated (Chimbo & Gelderblom, 2012):

1. Are privileged South African teenagers at all willing to participate in cross-age tutoring activities?
2. Which specific internal and external factors would motivate participation?
3. Would the use of cooperative inquiry to design the tutoring tool, motivate teenagers to become involved?
4. The above questions were answered through semi-structured interviews carried out with 28 teenagers.

5.2.1 Are Privileged South African Teenagers Willing to Participate in Cross-Age Tutoring Activities?

A total of ten interview sessions carried out with groups of teenagers, showed that teenagers from privileged backgrounds were interested in participating in the role of tutor (Chimbo & Gelderblom, 2012). The main intrinsic reasons for wanting to participate were as follows:

- to do something good;
- having been involved in tutoring before (either as tutor or tutee), and feeling

comfortable doing it;

- that it would give them the opportunity to make a difference in someone’s life; and
- that it would be an opportunity to learn something.

Extrinsic factors mentioned were the following:

- being paid (or receiving something tangible in return); and
- receiving recognition.

Table 5.1 gives examples of how teenagers expressed the above reasons.

Table 5.1: Expressions of reasons to participate (Chimbo & Gelderblom, 2012)

Reason	**Examples of how respondents expressed their opinions**
1. To do something good	“There is a benefit of helping the less privileged, or helping people who will benefit from our knowledge in future.”
2. Have been involved in tutoring before	“I was tutored at a young age and that is the reason I am excelling at school right now. So, I want to give back what I was given to by others.” “We already help our own brothers and sisters so it will be easy to help
3. The possibility of making a difference	“This generation which is coming after us is the future of the country. We want our future leaders to be educated. If we educate the future now then the future is bright, that is why I want to participate.” “To see that you have made the children understand something that you have taught them.”
4. Tangible rewards	“Money, if we are paid for instance R5000 for 5 people.” “Give them an iPad if they have helped for a certain number of hours.” “Like a competition – the one who did the most hours gets something
5. Receiving recognition	“Anything that will make you stands out, like blazers.” “Getting hours for community engagement that will lead to a president’s
6. Self-improvement	“It makes you to learn to become a leader.” “It will make you to believe in yourself.”

Interviewees had different opinions on tangible rewards and recognition. Some were clearly against receiving tangible rewards, as they felt that this would draw teenagers that are not suitable for the task. They said things such as the following: “If you do it to get something you will want to get it over with to get the thing” and “People who want iPads to do that are not the right people to do it – they will not do it well”.

With regard to recognition, there were similar sentiments – for example: “When one participates in this project one should not do it because you want to be recognised, but do it for the sake of helping other people.” Most of the respondents said they would prefer to tutor the same children over time. The reason for this also emerged as a motivational factor, namely seeing how the child improves over time. The nurturing disposition of girls also surfaced as a motivational factor: “Like having a little brother or sister that you can be responsible for.”

Although most of the interviewees indicated that they would participate, there were some who were very certain that they did not want to. The reasons they gave were lack of time, lack of tutoring skills, and that they would just not enjoy doing it. Table 5.2 lists some specific responses from teenagers who were sure about not participating:

Table 5.2: Specific responses from teenagers (Chimbo & Gelderblom, 2012)

Reason	**Examples of how respondents expressed their opinions**
1. Time constraints	“We won’t find time if we are doing it for free.” “Religious issues, family business, own lives, sports and schoolwork may not leave time to do this.”
2. Not having the skills	“Difficult to teach people.” “Teenagers may not know how to do it. They aren’t necessarily correct.”
3. Will not enjoy tutoring	“Not everybody enjoys just doing good. I just want to do what I enjoy doing.”

Some interviewees, who were interested in participating, expressed doubt about their peers’ capacity for community service, mentioning teenagers who no longer like school, let alone helping other children. There are teenagers who are self-absorbed and more concerned about themselves than other people. There was also mention of teenage girls tending to be moodier than boys, leading to the creation of tension between the tutor and the tutee, and making the latter suffer as a result.

There was agreement between male and female respondents, that girls would be more willing and/or suitable for the tutoring role than boys, as boys were seen to be lazy and to have too much pride. There was a belief that girls loved children, were patient, had a soft heart and got along well. There were, however, some comments in favour of male tutors: “It depends with individuals; there are boys who would like to help and are better than girls.”

5.2.2 Which Specific Intrinsic and Extrinsic Factors would Motivate Participation?

The intrinsic factors that emerged from the interviews were the following:

- the mere satisfaction of doing something good;
- gaining self-confidence; pride in doing well;
- reciprocating;
- making a difference; and
- the need to nurture younger children.

The extrinsic factors can be divided into tangible rewards and less tangible ones. The most mentioned tangible rewards were the following:

- money;
- food/free lunch;
- cell phones;
- tablet computers (Samsung Galaxy tablets and iPads, specifically);
- laptops and desktop computers; and
- music “gadgets”.

Other factors mentioned were being acknowledged as someone doing good, and publicly visible recognition (blazers, or an award, for example).

The teenagers who were in favour of receiving tangible rewards gave some good reasons for their preference. Three examples are as follows:

“Yes, as most people do things in order to be rewarded and gain the benefit of doing something.”

“It would be a good idea because it will bring people in and make the world a better place.”
“Yes, it might be an initiative (meaning incentive) if it is put at the end and it’s given as a prize for helping a kid to score high marks.”

5.2 3 Would the Use of Cooperative Inquiry Play a Motivating Role?

Only one of the 28 interviewees, a girl, had ever been involved in the design of technology and understood the idea of cooperative inquiry. After one of the researchers explained to the participants what cooperative inquiry entailed, the interviewees expressed their interest in participating in the design. The majority of the remaining interviewees thought, however, that boys would be more interested in the design part. The male interviewees themselves also seemed more interested than the female interviewees. Some thought that only teenagers who took computer courses, or who attended after-school computer classes, would be interested, saying, for example:
“Although they did not necessarily want to participate in the design, a number of interviewees saw the advantages of participating in the design.”
“To be involved in the design is a good idea ... if you are using applications which you did not design, you might not understand how the application works and this might scare you all.”
“It is possible for adults to design for kids, but they must collaborate with the children.”
“We come from different perspectives and would gladly share ideas.”

5.2.4 Phase 1 Conclusion

Interviewing teenagers about possible participation in a cross-age tutoring system based on a social networking platform, revealed interesting insights into motivational factors. Teenagers from privileged backgrounds were clearly willing to participate in cross-age tutoring, for reasons ranging from intrinsic gains to purely external rewards. The majority focused on internal motivational aspects such as helping for the sake of doing well, reciprocating what had been done for them, and making a difference in someone’s life. Although a third of the respondents felt strongly that tangible rewards would draw the wrong kind of tutor, at least seven of the 28 teenagers thought extrinsic rewards such as money, tangible goods, or receiving public recognition, would provide good motivation.

On the issue of designing the tutoring system, responses indicated that girls would be more interested in participating in the tutoring, while boys would be more interested in the design aspects. From our point of view this is not an ideal solution, because the children who will use the system should be the ones to design it. If the tutors are girls, they should be the ones who participate in cooperative inquiry. From our experience with cooperative inquiry, the researchers are convinced that girls will be able to make a significant contribution to the design, and that their reluctance stems from their lack of knowledge about the design method. It was clear that all the respondents linked the design aspects with computer and programming skills, while cooperative inquiry requires none of these.

The findings of the study done during Phase 1 played a crucial role in the subsequent design and implementation of a cross-age tutoring system. Researchers learnt that it would not be difficult to find South African teenagers willing to act as tutors, and they expect most of these volunteers to be girls. The system needed was to be flexible, and allow for different preferences with regard to the tutoring situation; and tutors are likely to participate without tangible compensation. The few who thought some form of reward or recognition was necessary, had good arguments – if done correctly, such rewards could thus draw more tutors. However, the findings did not indicate cooperative inquiry as a clear motivational factor, but this needs to be investigated further with teenagers who have had the opportunity to participate in such design activities. The findings discussed here are also discussed in detail in Chimbo and Gelderblom (2012).

5.3 Phase 2: Face-to-face tutoring sessions

5.3.1 How the Face-to-Face Sessions were conducted

The face-to-face sessions, also discussed in Chapter 4, were the first part of the data collection for the design. For a period of four weeks, the researchers took turns to take tutors to the children's home once or twice a week, depending on the availability of the teenagers to conduct face-to-face tutoring. The number of teenagers who attended these sessions varied from 1 to 5. During the sessions, the tutors helped the young children with their homework and test preparation. From the outset, the researchers interfered as little as possible and allowed the teenagers to decide who to tutor, how many tutees to work with at a time, what to cover in a session and how to go about it. At the end of each session, both the tutors and the tutees shared their experiences for the day through individual audio recordings made either on digital audio recorders (provided by the researchers) or on mobile phones. These recordings were collected and later transcribed to form part of the data set to be used as input into the design (*cf. Transcriptions Appendix 6*).

The face-to-face sessions were conducted to obtain feedback on the children's experience of the face-to-face tutoring sessions. Another reason was to immerse them in the tutoring context, so that they knew exactly what it entailed when they had to design the application. The initial reaction was to focus only on the tutor recordings for design input, but after some reflection and discussion among the researchers, it was realised that there may be hidden value in the tutee recordings. These stories were then used as supplementary input into the design. Individually recorded audio-only stories formed part of the children's contribution to the design. Researchers followed with an analysis approach that was based on grounded theory research, to see if anything useful emerged from the audio recordings.

5.3.2 Results from the Audio Recordings

Audio recordings were one of the mechanisms used in collecting design data. The teenagers were much more comfortable making the recordings, than the younger children. Audio recordings extracted from the teenage participants' audio feedback, yielded results that could be translated into design suggestions such as the following:

- tutoring should be one-on-one, rather than one tutor working with more than one child at the same time;
- one should have other activities ready, in case the tutees do not have specific homework or test preparation to do (for example, teaching them French words or letting them read out loud); and
- if the tutees need to be paired up, they need to be friends, because it is difficult to work with two or more who do not get along.

The tutees, however, conveyed the notion that they felt comfortable engaging with teenagers during the face-to-face tutoring. The level of comfort observed during Phase 2, and the face-to face tutoring, is revealed in the recordings which the young children gave after every session – for example:

Recording 1: Hello I am Cynthia[5]. It was very nice to do Mathematics with Mabel[5]. She is very nice and I would like to learn more with her.

[5] Names used in this study are not the real names of participants

Recording 2: It was very enjoyable. I would like to do Mathematics again, more Mathematics. It was nice to be with Marjorie and to talk and everything.
Recording 3: The girl with glasses. She's cool; she's pretty. We are naughty in her class – we laugh a lot.
Recording 4: And I want to say thank you for You (now addressing God) who made the world … that there are people with good hearts … and who can prepare themselves. And I just want to say that we could have another wonderful day Lord. (*cf: Appendix 6).*
Making the recordings was clearly a novelty for the tutees, and they were reluctant to express opinions about the tutoring situation; however, they were very grateful, and enjoyed the visits from the teenagers and the researchers very much. The teenagers were more aware that their feedback served a purpose, and that they needed to express specific opinions and make suggestions. The tutees' recordings demonstrated overwhelming appreciation for the visits and the tutoring that they received. Their stories provided clear evidence that there was a great need for homework support, and that getting this from teenagers would be very well received.

There were, however, a few problems which were experienced during this phase, which could be attributed to methodological issues. No examples of similar studies to inform our procedures with regard to the use of audio recordings were found. Through this experience, valuable lessons have been learned that can inform future studies that use individual audio recordings to collect data from vulnerable children. In conclusion, with regard to the design of technology for development, the researchers recommend the use of audio recordings as a supplement to the accepted CI methods, especially when vulnerable children are involved as co-designers. The sub-question on face-to-face tutoring, which relates to Phase 2, was answered as follows:

SQ4 Which elements of face-to-face tutoring can be incorporated into a tutoring system based on a social networking platform?

The audio recordings by the participants were transcribed by the researchers, who used the coding mechanisms associated with grounded theory (open, axial and selective coding) to analyse the transcripts with the aim of understanding the nature of the narrative contributions (Baskerville & Pries-Heje, 1999; Corbin & Strauss, 1990). In open coding, concepts emerging from the data were identified, then grouped at a more abstract level into categories (Gelderblom et al., 2014). Researchers then searched for relationships between the various categories through axial coding, and, finally (through selective coding), developed a core category (or story) that represents the central phenomenon in the data. The elements of face-to-face tutoring which were identified, that could be transferred to designs were the following:

a) Identity

With reference to self and identification of self, most of the tutees introduced themselves, because this is what they were instructed to do. Only two of the teenagers did this. It was very important for one tutee that researchers knew it was him speaking, often repeating his name and grade (for example, “I am X in Grade 3. Please just remember my name”). In the design, researchers incorporated a section on the interface where both tutees and tutors put in their profile information. Researchers included an 'edit my profile' button, where the users would be allowed to change the colours and style. They were also allowed to change their avatar identities. The interfaces also included a photo strip where users could have a photo album where they could add or delete photos.

b) Expression of emotion

During face-to-face tutoring, expression of emotion through gratitude, love, care, sadness and enjoyment, was shown. Tutee contribution counts were as follows: Enjoyment/Gladness=17; Love=5; Gratitude=18; Care=5; Sadness/Unhappiness=3. The children came across as extremely thankful, caring and concerned for the safety of tutors, making statements such as “my heart is very sore that you are going away because you do all the things you can for us”; “can you please look after your body well”; “You must go very carefully home. And don’t make accidents”. In the tutor data, researchers found two expressions of enjoyment, one of sadness and one referral to emotional attachment to the tutees. To cater for emotions in the design, the researcher included a flower and ‘smiley face’ images.

c) Gaining content-related support

During the sessions, some mention was made of school subjects that could be of interest for homework support. The tutees mentioned doing mathematics 16 times, and reading only once. The tutors mentioned mathematics 8 times, reading 4 times, and language and spelling 5 times. This meant that both the tutees and tutors saw the need for homework support in the subject areas mentioned. An inbox was therefore included in the design, to enable tutors and tutees to communicate asynchronously on the homework support preferences. Tutees could contact tutors for homework support either by, for example, sending voice or text messages, or Skype-like voice or video calls. A ‘play and learn’ store was also incorporated in the design. This would take tutees to an “app store”-like page where they could choose between available games, books, exercises and videos. The tools a tutor uses to communicate during sessions are crucial for a successful learning experience. A whiteboard was also created, as it is one of the most important tools that could be used when tutoring. It is virtual space where tutors and tutees interact, to work on mathematics and literacy problems in real time.

d) Enjoyment of the nurturing aspect

The tutees gave individual descriptions of tutors and researchers and tutors did the same for tutees. Tutees used the following words to describe the tutors: “nice, pretty, cool, great, sweet, kind (they do it out of their hearts), good people”. With regard to references to specific staff members and to the home in general, the tutees again expressed gratitude – for example, “And I also want to say thank you very, very, very much that we have a roof over our heads and that we have people that can teach us …”. Tutors described tutees as “cute, resistant to work, an angel, good reader, adorable, nice, clever, focused on work”. Therefore, when designing, researchers need to cater for such nurturing aspects by including a “message” link on the tutee page, which can be a voice, text, picture or award. The tutees can also have their own tutor evaluation section where they show appreciation to the tutors.

The tutors’ expressions were informative, providing a clear indication of problems of getting too attached – for example, “It is different from what I expected; It is very emotional; I didn’t expect to become emotionally attached to the kids, but yes”. The tutees, however, just provided positive feedback and requests for more tutoring – for example, “And I just want that they will come and help us forever, but if they can’t it is OK”.

Emotional attachment should be avoided, as it might later cause problems such as mistrust, jealousy and irrational behaviour. Both parties should preserve and develop as much emotional self-reliance as they can. In the design, ways must be found of avoiding possible unacceptable behaviour between tutee and tutor, by encouraging and allowing them to work with different tutors and tutees from time to time.

e) Learning management

The other aspect discussed, with respect to how the tutoring sessions were to be set up or managed was learning management. During face-to-face tutoring, tutors in some cases had tutees coming without homework, or in other cases there were more tutees than tutors at a time. Tutors solved this problem themselves, by coming prepared with extra work in later sessions. They discussed things outside the school curriculum that they found useful to the tutees, showing that they saw potential for tutoring to provide more than just homework support. So, when designing, researchers incorporated a 'play and learn' store that will cater for extra activities that tutees could work on. These will help enhance tutee learning with easy and open ways to communicate, making learning easier. In the design, the researchers were included as administrators who would manage and maintain the system and provide technical support to people using the site.

f) Dealing with contextual issues

Previous research has found that environmental context can affect children's physical, intellectual and socio-emotional development (Huston, 2002). It is also recognised that children often play a role in both selecting and responding to available contexts, and they, in turn, are influenced by their experiences. Thus, most current child development theories maintain that effects on children and context are bidirectional – that is, they are mutual and intertwined (Huston, 2002). As discussed in Chapter 4, the young children in the current study were from a centre that cares for children who have been through traumatic experiences, and provides a home with a stable environment in which they can grow to their full potential. The children are placed through a court order, of which 90% come from a background of molestation, abuse and poverty. Because of their backgrounds, the children live in a highly religious environment, where thanksgiving and praise in prayer is an important ritual.

For this reason, eight of the tutee recordings (made between two tutees) ended up as prayers or just expressions of thanks and hope that God would look after the tutors and others involved (for example, "I just please want you Lord to be with us tonight and with the people that taught us today"). When one of the tutees turned to prayer, it was clear that they spoke more fluently, following an internal script that they were comfortable with – for example, "I want to say thank you for You who made the world … that there are people with good hearts … and who can prepare themselves. And I just want to say thank you that we could have another wonderful day Lord. And I want to ask You if You can please help that the people who are not as fortunate as us, that they …. The people who do bad things, that they will be forgiven. I ask please. Lord, can I just ask that we have another nice day today." Their prayers can thus be a ritualised form of expression based on conventions and rituals of religious talk from the adults under whose care they were. According to Moore et al. (2012), the words and thoughts that children use in prayer can help them to articulate their feelings. Besides being a source of support and comfort, it helps children with self-expression. It is a "comfortable aspect of family life or membership of a religious community" (Mountain, 2005, p. 297). Mountain (2005) also found that praise and thanksgiving in prayer can merely be the result of personal happiness or it can follow from the religious community's prayer rituals.

In Gelderblom et al. (2014), researchers report that it was very clear that the context within which children lived had a great influence on their contributions. For example, placing children in a new situation where they interacted with people whom they saw as higher on the social ladder, might lead the children to revert back to narratives that they are comfortable with; in this case it was 'prayer'. What this means for design, using cooperative inquiry, is that if private audio recordings are used as a mechanism to remove power relations when obtaining children's input, researchers need to be very aware of the possible "voices" that are created and triggered by contextual factors. The unfamiliarity of this activity triggered familiar communication patterns that ironically reflected clear power structures implicit in the rules of a care facility or the rituals of the religious community that the children were part of.

The views above can explain why it is important to deal with contextual issues directly. The emergence of religious expression is viewed as a prominent category. There are clear signs of the important role religion played in the narratives recorded by the tutees. It led to a deeper investigation of the role of religion as an important contextual factor in this research. Therefore, during design, researchers dealt with contextual issues directly. Researchers took into account the broader social context within which the study was undertaken, as well as the specific context of the design conducted, as the system was meant to best serve the kind of tutees available and the context of their environment.

5.3.3 Phase 2 Conclusion

In this phase, the face-to-face tutoring and the use of audio recordings provided us with tangible data that could be transcribed and translated, so that it was accessible to all the researchers involved. The method was successful, in terms of providing the children with a mechanism to give input into the technology design. Even though we as researchers had problems attributed to methodological issues, we had no examples of similar studies to inform our procedures with regard to the use of individual audio recordings, but valuable lessons were learnt that can inform future studies which use individual audio recordings to collect data from vulnerable children. Contextual factors must be studied carefully, and researchers must be clear, beforehand, on how these might influence the children's input (Gelderblom et al., 2014). The children must be given more opportunity to practise, by letting them listen to other recordings of this kind. One could provide them with the kind of script that they could use in their feedback. One could also experiment with recording private conversations between two or more children, rather than individuals. However, with regard to the design of technology for development, researchers can recommend the use of audio recordings as a supplement to the accepted CI methods, especially when vulnerable children are involved as co-designers, as it is believed that the children were able to make useful contributions to the design.

5.4 Phase 3: Design Sessions

In this phase, cooperative design sessions were conducted with the participants, and a full discussion of the procedure was given in Chapter 4. Separate sessions were conducted with the two groups of tutors and the tutees. The tutors had one 3-hour design session, while tutees had two 90-minute sessions on separate days. In the tutors' session, the researchers acted as facilitators, while the tutee design sessions were facilitated by some of the teenagers. Tutors were divided into groups of three, and asked to design and build/draw paper prototypes. Researchers had prepared "bags of stuff" that included large sheets of paper, glue, sticky notes, stickers, colour pens, and more. Tutors were to reflect on their face-to-face tutoring experiences, and then translate those ideas into designing a system that could incorporate features of familiar social media (for example, Skype, FaceBook, Scribblar, IDroo, Ning and Twitter), but also completely new and innovative ideas.

Typical examples of scenarios were discussed in section 4.2.3.4. From these scenarios the researchers identified actors, entities and their relationships. The scenarios were used to develop the required capability of the system – for example:

- Presence: The capability of the system to indicate which actor is online;
- Messaging: The capability of the system to enable the tutee to synchronously/asynchronously send or receive messages; and
- Audio/Video calling: The capability of the system to enable audio or video calling as a way for the tutee and tutor to interact with each other.

In Chapter 6, a discussion on how the scenarios were translated into the design is given.

A combination of Muller's PICTIVE approach (Muller, 1991) and paper prototyping (Snyder, 2003) was used. The groups worked for about 45 minutes on their designs. The tutors, though in groups, decided to each put their own personal ideas down first, and then collate their ideas within the group. Past participatory design research confirms this approach to be successful, as long as the participants believe their ideas are important (Burton, 2006). Figure 5.1 shows the three groups at work.

Figure 5.1: The three groups of teenagers during a design session

In design, there is always the need to calibrate the different inputs coming from each design participant, according to their specific skills and expertise. When it comes to children as design partners, this difference is even more evident, especially because the domain is often something they know little about and with which they have little experience. In this respect, research has shown that for children to participate in the design process more effectively, they need to have information about usability issues, and what constitutes good interface design (Kafai et al., 1997). This leads to perceived benefits for design and participants through cooperative design, such as giving children a voice in the design of new technologies (Guha et al., 2010).

After combining their ideas, each group presented their design. Following Guha et al. (2013), throughout these presentations one of the researchers wrote down all the ‘big ideas’ that emerged from the three groups of teenagers (*cf. Table 5.3, Figure 6.1*). These became part of the data set. As there was no restriction in the ethical clearance letter prohibiting the use of video recordings of the teenage participants, they were video recorded while doing their presentations. Figure 5.2 shows some of the ideas later tabled in Table 5.3.

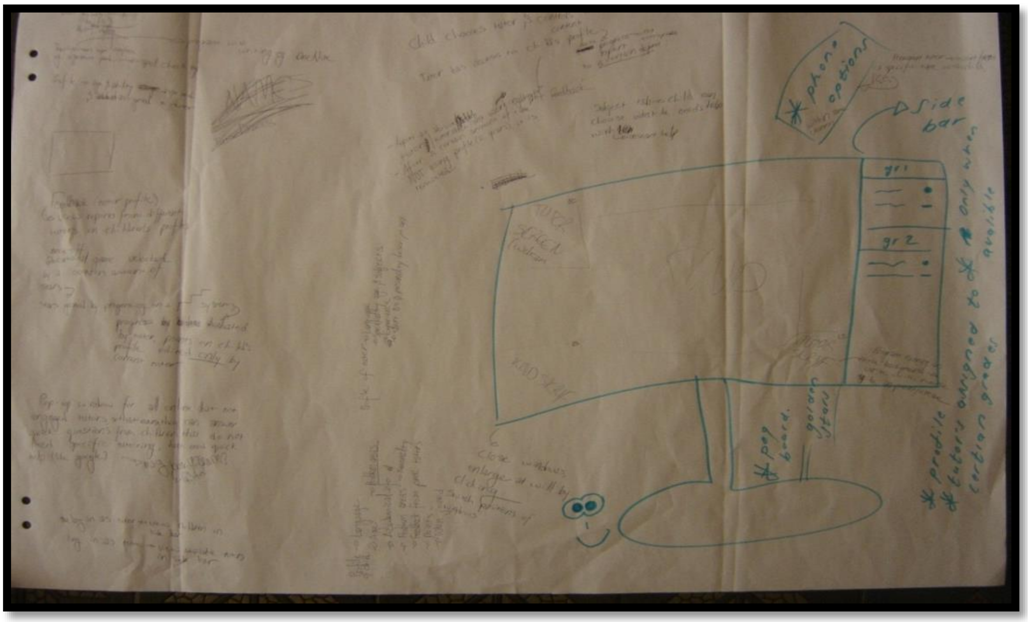


Figure 5.2: Ideas from one of the teenage design groups

After the presentations came discussion on the name to give to the tutoring system. Various suggestions were given, and the name that was selected for the artifact was TitanTutor. Details of this selection process will be discussed in Chapter 6.

The tutees had their first session two weeks after the teenagers’ presentations, so that some of the teenagers could help with facilitation. Four teenagers participated in the design sessions with the tutees, which took place at the children’s home. The tutees had limited exposure to technology; therefore, the first session of 90 minutes was spent on familiarising them with the design content (that is, mobile technology, tutoring and social media), as well as with the general concept of design. The children ‘Skyped’ individually with a research partner in the United States. This was done to convey the idea that distance is not a problem in communication, and that one can have face-to-face interaction with someone who lives far away.

Researchers then let them build an obstacle course using the adult researchers and the teenagers as the building blocks (or obstacles). They had to guide a blindfolded partner through the obstacle course (*cf. Figure 5.3 and 5.4*). The obstacle course activity was borrowed from the University of Maryland’s Kidsteam (1998) design team. The objective was to give the children exposure to the design process, while simultaneously breaking down the power relations between the different generations in the team. It was successful on both counts. Afterwards, reflection as a group was conducted on the overall design idea, in preparation for the actual design session.

Figure 5.3: Obstacle course activity 1

Figure 5.4: Obstacle course activity 2

The second 90-minute design session began at the home, with a “question-of-the-day” (also borrowed from Kidsteam practice), where each participant received a chance to answer the question, “What is meant by thinking out-of-the-box?” Their answers demonstrated that they understood the concept well, with one tutee giving the definition, “it is when you think of things that you never even knew you knew about”. In the design exercise that followed, the tutees were teamed up, either one teenager with one child, or one teenager with two children. They were provided with the same ‘bags of stuff’ (*cf. Figure 5.5*) that we used in the teenage session before, and created paper prototypes.

The teenage facilitators were briefed beforehand, to allow as many of the design ideas as possible to come from the younger partners. Through the activities of the first tutee design session, it was made clear to the tutees that the process was informal and safe, and that they should feel free to air their views. Figure 5.6 is one of the sessions where a tutor helped the tutee with his design. After the session, the tutees reported back on their designs and their ‘big ideas’ were collected on paper by the researchers. The presentations were audio recorded only, since our ethical clearance did not allow us to video record the young tutees.

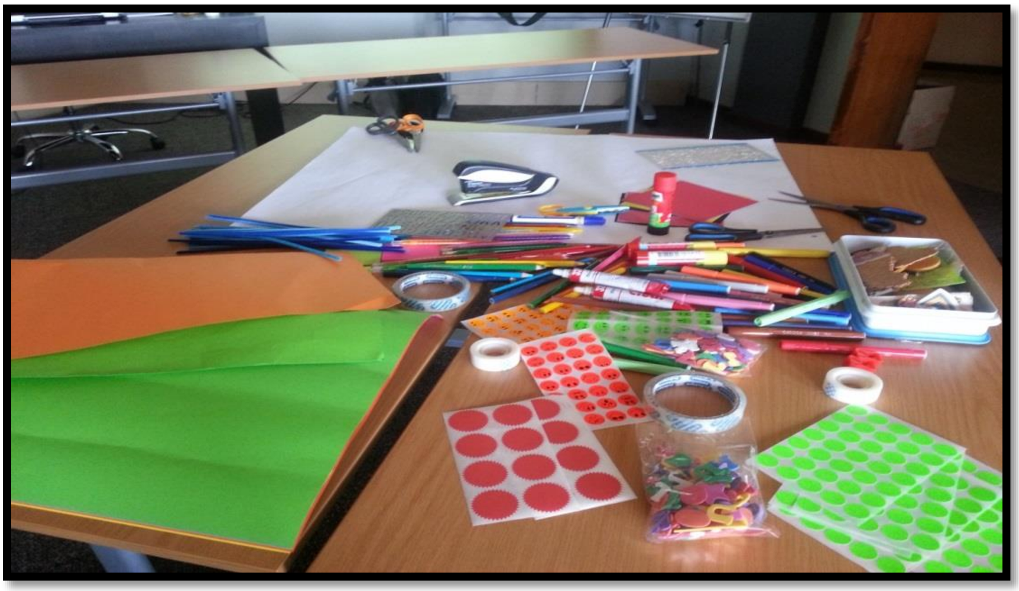


Figure 5.5: Stuff used by the young children and the teenagers in this study

Figure 5.6: Tutor helping a tutee with his design

All participants recorded their reflections after each session: young children used the audio recorders, while teenagers used either voice recorders or their mobile phones. The activities of Phase 3 provide part of the answer to the research sub-question, *How does cooperative inquiry contribute to the success of tutoring?*

5.4.1 Low-Fidelity Paper Prototypes

During the design sessions, the two groups produced some paper prototypes. Figures 5.7 and 5.8 show some of the prototypes produced by the two groups. *The rest of the prototypes are presented in Appendix 3.*

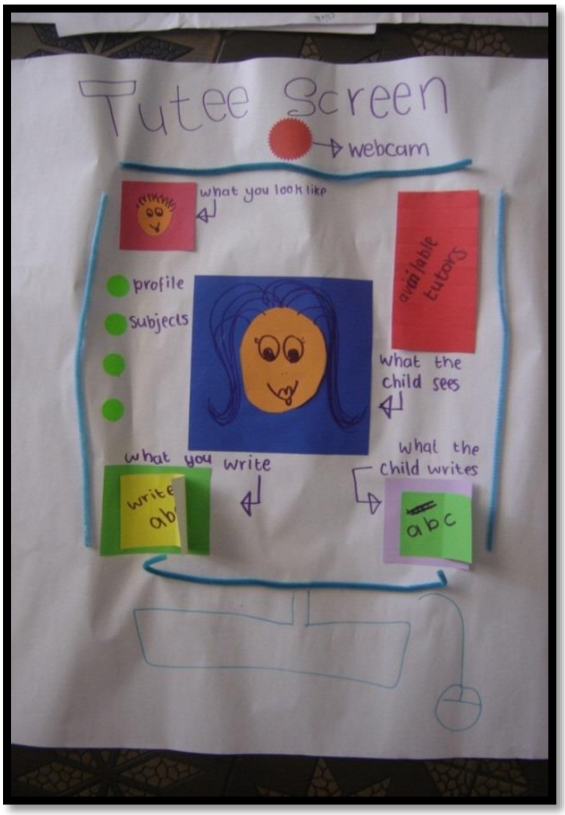


Figure 5.7: Paper prototypes of the design by the tutor group

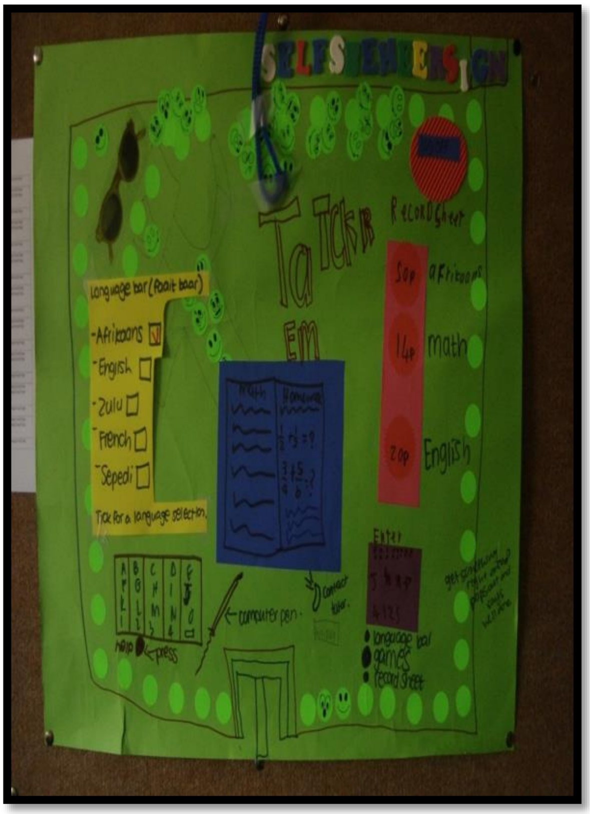


Figure 5.8: Paper prototype of the design by the tutee group

A comparative summary of the design ideas generated by the teenagers and young children is given in Table 5.3.

Table 5.3: Comparative summary of design ideas generated by the design partners during design sessions

TEENAGERS	**YOUNG CHILDREN**
Design ideas relating to high level interface design	
User profiles: ● Users should have a user profile and from their profile page they should be able to access all functionality. ● Tutee profiles should include indication of which tutors are available for assistance. ● Tutor profiles should include indication of which tutees need help. Other: ● Tutor schedules should appear somewhere visible to all. ● Must log in to the system with a password. ● Automatically logs out if child forgets to log out. ● The screen includes a designated section where the tutee can write, and a designated section where the tutor can write.	● The tablet or phone must be plugged in to a TV so that the tutor appears on the TV screen and more than one tutee can see her. ● Tutor can choose which children he/she wants to help. ● Must allow you to put your own pictures on the interface. ● There must be a cartoon-like login screen where you must enter a password. ● There must be an “easy access” button that takes you directly to Google. ● Homepage must give access to: tutor session; math homework exercises; games; progress report. ● Almost all of them placed their names very clearly on the screen design.
Communication mechanisms	
● Tutee profile should have a button that they can use if they need help immediately (i.e. emergency button). ● Tutors must be linked to subjects. For example, if the tutee needs help with Mathematics she can click on a button that will take her straight to a Mathematics tutor. Tutees must be free to choose the tutor who knows the subject. ● There must be a designated button for cases when the tutee wants to talk to the tutor. ● There should be an “inbox” for questions that tutors can answer asynchronously. Tutee can send message to tutor – e.g. “I need help with English adverbs”. The tutee can then place a pre-made explanation video on a YouTube channel where the tutee can access a whole lesson on adverbs. ● The “inbox” can be seen by all tutors, and anyone who knows the answer can provide one.	● Should be able to pick your language from the home screen. ● Users must have a “computer pen” so that they can write on the screen. ● When the tutor goes on holiday there must be holiday games that the tutee can play. ● There must be a camera on the book that a tutee is reading from, so that the tutor can see what they are reading.

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- Tutors who are unavailable at times can access a location with "pop-up questions" and respond at any time.
- If tutors are unavailable, there must be a link called "Revision" to take tutees to a database with material on everything from English to Mathematics done previously, so they can review it for test preparation.
- There should be predetermined time slots when tutees know that tutors will be available to provide immediate help.
- So the process will be that computer/phone buzzes when there is a request for tutoring. Tutor then connects to the system to respond.
- Session should be restricted to 20 minutes, followed by a break of 5 minutes – timing should happen automatically.
- Tutee can choose subject he/she wants help with.
- Can also speak to a friend (fellow tutee registered on the system) not necessarily tutor.
- Tutors should be able to write with the mouse on a whiteboard-like space to give feedback immediately.
- Each tutor should be assigned two tutees.

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<tr><td colspan="2">Additional functionality: Educational games</td></tr>
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- Mix fun and education – learn while playing games.
- Tutees must get rewards for answering correctly – e.g. allow them to make their own drawing on the interface.
- After a face-time session the tutor can give the tutee access to educational games, based on what they think the tutee need to improve on.
- To motivate the tutees to visit the site when doing test preparation, the tutors can give the tutees access to game pages – e.g. art games; mathematics games; no pressure, fun games; games for accumulating points; games that allow tutees to compete.

</td><td>

- There should be a game to teach tutees about road safety.
- Also a paint game, where tutees are given an object which you then have to draw or paint in its correct environment.

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Ideas related to rewards and motivation	
● If the tutee is making progress, the tutor should reward the tutee by allowing the tutee to access some interesting games on the site. ● Messages of praise should pop up to reward the tutee: e.g. “You can do it”, “Oh my, you are a genius”.	● Also a chocolate appears on screen as a reward. ● When the tutee gets a Mathematics problem right, there should appear a pink flower that smiles.
Monitoring tutee progress	
● For each tutee there should be a “Progress report” link that looks different from the tutor and tutee perspectives. ● The tutor view of the progress report will have information on the parts the tutees are struggling with. ● The tutee view of the report will show a link to incentives for those doing well, or a prompt to contact tutors for those struggling. ● The tutor should have access to the work done by a tutee, so that the tutor can set up a progress report (e.g. if the tutee is making progress the tutor will reward the tutee by increasing the tutee’s steps on the ladder or giving them access to interesting games.) ● The system should pick up when a tutee gets something wrong and notify the tutee to contact a tutor. ● Tutors can post feedback on the tutee’s profile so that other tutors will be able to view and see the problems tutees encounter and how they can help. ● The work must sometimes be above the level of the tutees to help them aim higher. ● There can be a general progress site where tutors can log in to look at the tutees’ progress. The progress is “calculated” through letting the tutees play games.	● One group had a “Record sheet” on their homepage that shows how the tutee progresses in the different subjects.
Social media related elements	
● Create own YouTube channel with pre-made lessons that tutees can watch. ● Overall description of the system as “Skype and Facebook collide”.	● Quick access to Google when one is stuck.

● Tutors make live YouTube recordings. ● The system interface can include its own YouTube-like function (called "MeTube") where tutor videos can be posted.	
Additional features	
● Click on words to get meaning or pronunciation. ● There should be a list of electronic books that the tutee can choose from to read (this section they named "Interact-a-Book").	● Magnifying glass that will enlarge parts of the screen.
Psychological design issues	
● Tutors should have time to tutor, and should not feel "pushed" to do it.	

5.4.2 Results from the Design Sessions carried out by Young Children and Teenagers

All data was analysed qualitatively. Through cycles of comparative analysis of transcripts of audio recordings, video recordings of presentations; recorded 'big ideas'; and the physical attributes of the prototypes, researchers searched for elements that could potentially provide input into the design of the intended tutoring application.

The similarities and differences in Table 5.3 led to the comparison of design behaviour among teenagers and the young children, and the identification of themes. The design behaviours and the themes are analysed and discussed in the sections that follow.

5.4.2.1 Comparing the design behaviour of teenagers and young children

i) Aesthetics vs. functionality

Young children placed more emphasis on decorative design – i.e. they were more focused on decorative elements that users could add themselves, while teenagers preferred detailed designs that emphasised textual content. The young designers were interested to see how they could use the materials provided on their design prototype, without necessarily connecting it to the specific functionality of the tutoring system. The teenagers showed a combination of focus on aesthetics and functionality, with some taking it upon themselves to determine which features should be included, and others putting this together using the materials given. In general, the teenage designs were more functional, and the young designs more decorative.

ii) Creativity

Although both groups wanted a way for tutors and tutees to write on screen, the young designers were more creative in this, by suggesting a "computer pen" as opposed to the teenagers' suggestion that writing could happen with standard input devices (e.g. a mouse). Again, the younger designers were thinking out of the box, and were not afraid to try out new ideas which would contribute to the innovativeness of the resulting designs. Further evidence that young designers found it easier to stray from what was practical was their suggestion for rewards in the form of symbolic gifts (e.g. an image of a flower or a chocolate that appears on screen). The young designers asked for an interface that could be tailored according to their likes (e.g. placing their own pictures on it).

iii) Attitude towards incentives

The research shows that ideas for reward systems differ according to age group. This finding will help designers to include appropriate incentive schemes based on the target age group for their designs. Related to incentive schemes, is an understanding of what motivates different age groups to apply themselves at the highest level in any endeavour. While the teenagers suggested tangible rewards, such as the chance to play a game, the young children's ideas showed that they expected much simpler rewards (e.g. a symbolic chocolate).

iv) Participation in groups

There were clear differences in the children's ability to work well in their small design groups. The teenagers were assigned to their groups by the researchers, and accepted this readily. All three teenage groups worked together effectively, and it was clear from their presentations that they all played equal parts in their respective designs. All group members of each of the groups contributed in the presentation.

The young groups struggled more, and, from reflections with the teenage facilitators afterwards, it became clear that there was conflict between the young designers in both the groups that had more than one young member. These two groups did, however, produce more elaborate and useful designs than the group which consisted only of one young designer and one teenager. The boy in the latter group was very adamant that he did not want to work with any children, and only with one specific teenager – which we conceded to. The presentations made by the young designers were also not as successful as those of the teenagers. In one group, the two children competed for speaking turns. The boy who designed alone with the teenager, refused to present his design. The third group was successful in explaining their ideas, with some help from the teenage facilitator.

Teaming up young children with teenagers had clear positive outcomes, especially in terms of motivating the young partners to participate fully in design tasks. When teenagers were given the responsibility to design and facilitate, it instilled confidence in them, and they gained trust from the young children they were assisting. Young children brought to the design table an unrestricted imagination that did not necessarily provide crucial information about functional aspects of an application, but their ideas shed light on what they would require in terms of interaction.

5.4.2.2 Themes emerging from the presentations on prototypes and design ideas

Seven themes emerged from the comparisons given, as a result of the presentations on the paper prototypes and design ideas produced by the two groups during design in Table 5.3. The themes were as follows:

1. High-level interface design;
2. Communication mechanisms;
3. Additional features and functionality;
4. Rewards and motivation;
5. Monitoring and evaluating tutee progress;
6. Social media elements; and
7. Psychological design issues.

Theme 1: High-level interface design

There was general agreement between the two groups that some way of indicating either tutor or tutee presence information on the user interface was important. Ease of navigation from the user profile page to all other accessible content, was highlighted by both groups. The main differences between the two groups seemed to emerge from age difference. For example, in the case of a tutor being absent for any reason whatsoever, the younger children brought out their playful nature, advocating computer game play time over revision for test preparation – which the teenagers proposed. The young children showed a clear need for their own identity to be visible on their designs. Teenagers distinguished between a tutor view and a tutee view, while the young partners only designed a single view.

Theme 2: Communication mechanisms

Both groups agreed on the need for secure access, using password protection. Both groups also agreed on the need for on-screen writing tools. Both thought of synchronous as well as asynchronous uses of the system, and they all regarded access to games as essential. Two of the three groups of young partners mentioned the need to choose which language they wanted to communicate in, while this did not come up in the teenage designs. However, the design partners differed on the detail of the writing tools. For example, the teenage designers proposed using a mouse for on-screen writing, whereas the younger children were more creative, proposing a stylus instead.

Theme 3: Additional features and functionality

The teenagers had many ideas, and could describe the full functionality of their design. The young children had few ideas, and none of them could give a coherent description of how the interaction would proceed. The design partners were in agreement on the need to use computer games as learning tools; however, both groups considered computer games not as a primary feature of the application under design, but as an additional feature or functionality that could be used to motivate the desired learning behaviour.

Theme 4: Rewards and motivation

The design partners agreed on the need to reward the desired learning behaviour. The teenage designers proposed providing access to computer games as a just reward for making good progress. The younger designers ran with their imagination to propose more virtual rewards such as smiley faces, smiling on-screen flowers, on-screen gifts, etc. Rewards suggested by teenagers were tangible, in the sense that they would give the tutee access to some actual fun activities.

Theme 5: Monitoring and evaluating tutee progress

The design partners were in agreement on the need to monitor and evaluate tutee progress, and to provide feedback to both tutee and tutor. Teenagers put a great deal of emphasis on recording the tutees' progress, and tailoring the interaction according to that. Teenagers thought about practical issues such as their own time constraints.

Theme 6: Social media elements

The design partners were influenced, in some of their design choices, by existing social media elements to which they had exposure. The teenage designers proposed certain design features similar to what is available on YouTube, Facebook or Twitter, while the younger designers proposed certain features that are available in certain Google applications. Neither group, however, wanted merely a Skype-like interface where they could talk synchronously; both groups requested much more – access to games, progress reports, fun rewards, and more.

Theme 7: Psychological design issues

On psychological design issues, the teenagers suggested that tutors should have time to tutor, and should not feel "pushed" to do it. While the research project provided an exciting opportunity for children to help develop a novel system that could greatly impact on children in less privileged communities, it also raised some difficulties regarding co-design. They also agreed that there should be some choice, with respect to whom the tutor and tutee would work with.

5.4.2.3 Difficulties encountered during the phase activities

The various extra-mural activities of the teenagers, and their different schedules at school, made it difficult to find suitable times to bring all of them together. Therefore, during the preparation for design phases (that is, the face-to-face tutoring sessions), researchers relied on their availability to determine who went to the children's home. Sometimes only one tutor was available, and had to split her tutoring time among the tutees, working with groups of three, and sometimes there were five tutors – allowing for one-on-one tutoring. This logistical difficulty in getting teenagers to the tutees, provides direct justification for developing an application that makes after-school support available online. Both the tutors and tutees had limited design experience. It takes time to become truly comfortable with the design process (Yip et al., 2013), and the younger children especially, found it difficult to complete their prototypes in the available time. Ideally, children must be given more opportunity to become comfortable with the methods and techniques of a design process. This applies to both age groups involved.

Some of the difficulties, however, could be overcome by including both teenagers and young children in the design process. A wide range of design ideas were generated from the purely functional to the purely decorative. Young partners are better motivated to participate in design by the presence of teenagers. The young designers can learn from the teenagers about design. The adult designers can use the teenagers as a communication channel to engage with the young partners, avoiding the inhibiting effect that adult-child power relations may have on the young children.

Another major problem was the language barrier, where the designers spoke different languages. In this study, researchers overcame this barrier by correct pairing of the tutors and the tutees. With regard to one of the researchers not understanding Afrikaans (the first language of all the tutees involved), the second researcher acted as translator. This added to the overall research time and effort, but in a country where there are eleven official languages, this is not a rare situation in research.

5.4.3 Phase 3 Conclusion

Creativity inherent in young children's thinking yielded designs of user interfaces that were rich in decorative elements and graphical content, as also noted by Nesset and Large (2004). Teenagers emphasised textual content elements in their designs, as opposed to decorative ones. Working with both groups showed that "children" cannot be regarded as a homogenous user group, and that when a system is to be used by children from different age groups, both groups must be accommodated in the design. If designing was only done with teenagers, the researchers might have ended up with a system that looks good in terms of functionality, but lacked the decorative aspects that would attract younger users. On the other hand, if design was done only with young children, it might have ended up with a decorative, aesthetically adaptable interface, but with (possibly unsuitable) functionality determined by adult designers.

Teenagers displayed different attitudes towards incentives, from what was observed with younger children, which means that the reward system used in an application aimed at more than one age group should be considered very carefully, and evaluated with the various user groups. In this design case, they might have designed an intricate reward scheme that involved scoring and access to games, where a mere electronic flower could have sufficed. In agreement with Little et al. (2013), it was found that co-designing with designers from different age groups has its challenges – the respective age groups will emphasise their own design preferences. However, if managed well, the diversity of preferences from the different age groups should result in designs that are richer, on account of the diversity of design preferences of the different age groups.

Involving teenagers as facilitators in the design sessions with the young designers, proved very successful. This was a key motivating factor in getting the young partners committed to the design task. Important in the success here was the fact the teenagers had their own design session prior to their facilitation role, and thus had a clear idea of how to proceed during the sessions with the young children. The system was implemented on a social networking platform. As the development process moved from planning to implementation, the tutors and tutees continued to play a role in operating and evaluating the system. The teenagers and the young children had interfaces especially selected (or designed and developed) according to their respective needs. For example, the teenagers used Facebook as their interface, and a Facebook App was implemented to facilitate communication with the tutee side of the system. The design and implementation of the application are given in the next chapter.

5.5 The Link between the Findings and the Theoretical Framework of this Study

This section links the discussions of the findings, given in the phases described above, to the theoretical framework of this study given in Chapter 1. Table 5.4 is a summary of the phases from the activities, or data, of that phase and the theory linked to it:

Table 5.4: Summary of the links between the phases, activities/data and the theoretical framework

Phase	**Activity/Data**	**Theory**
Phase 1: Willingness to participate in tutoring	• Interviewing teenagers • Video recording the activities	Motivation Theory
Phase 2: Face-to-face tutoring	• Cross-age tutoring • Social networking platforms	• Social Learning Theory • Sociocultural Theory
Phase 3: Designing an application	• Cooperative inquiry • Cyber safety	• Connectivism Theory • Cooperative Design • Behavioural Theory

The findings that emerged from the data gathered in Phase 1 played a crucial role in the preceding design and implementation of a cross-age tutoring system. The theory of motivation, given in the theoretical framework of this study in Chapter 1, relates to the activities of Phase 1, in that upon investigating what would motivate teenagers to participate as tutors in a cross-age tutoring system in order to achieve success, insights emerged. The insights obtained from this investigation were that teenagers are willing to participate in tutoring of young children, and that they are motivated to do so by both intrinsic and extrinsic factors, as discussed in section 5.2. The other general insight obtained in the study was that young children, who are motivated to engage in playful learning activities, learn better than those who focus solely on serious and structured learning activities.

Vygotsky (1978, p. 100) claims that “a child’s greatest achievements are possible in play”. The fact that teenager participants in this study provided tutoring support to young children, helped in turning the learning experience of the young children into a less formal one. Added to that, the use of a social networking platform provided an exciting environment that was perceived by the learners as more playful and exciting than the classroom learning environments they are used to. Hence, the young children were motivated to do better, and the teenagers, who were the tutors offering the support, were also motivated to continue tutoring.

Social learning means participating with others to make sense of new ideas (Conner, 2010). Findings from Phase 2 reveal that social learning can create more powerful and enduring learning experiences through the use of online communities and networks**,** where learners are encouraged to co-create, collaborate, share knowledge and fully participate in their learning. Social learning theory, especially connectivism, provided the theoretical context for social learning that is integrated with social media technologies. It provided insights into the roles of researchers, educators and learners in the social networked environment. Cross-age tutoring, in this study, was categorised as a social learning intervention, because it involved learning through modelling and observation (tutee observation of tutor modelling), as well as reciprocal interaction between the participants. This reciprocal interaction is a defining characteristic of social learning, which was important to this study.

In Phase 3, there were aspects of cooperative inquiry design that were related to Vygotsky's theory of social interaction. In the design sessions, teenagers and young children worked in teams, and in those teams they were equals. This was accomplished through the use of the same techniques such as being at the same level, and participating in almost the same activities in the groups. This enabled a better flow of ideas, and better elaboration between the design partners, resulting in good designs being produced. Ensuring that the young children and teenagers were equal partners contributed to the social processes involved in cooperative inquiry, and this linked with Vygotsky's focus on social interaction. Cooperative inquiry tools such as "bags of stuff" used during design can be attributed as cultural tools, as they were specific to the culture of cooperative inquiry and in line with Vygotsky's sociocultural theory.

Phase 3 involved collaborative activities that included working in pairs or small groups. The design sessions held by young children involved both a teenager and young children in a group –the intergenerational nature of collaboration (*cf. Figure 5.6*). Design partners are frequently asked to collaborate with both peers and adults (Guha, 2010), where the benefit is tied to the Vygotskian view of collaboration as a social process which would lead to cognitive outcomes. Cooperative inquiry is the kind of technology design process that might lead to interesting cognitive and social experiences for both teenagers and young children. The findings in the area of relationships concerning young children and teenagers within a cooperative inquiry design process support and extend the work of Vygotsky.

The other level of enabling young children, teenagers and adults (researchers) to become equals, was revealed during Phase 3, the design session, when they were doing the human obstacle course (*cf: Figures 5.3 and 5.4*). The aim was to break down the power relations between the different generations in the team.

5.6 Summary

In this chapter, the findings that emerged from the data gathered from the 3 phases were presented, along with a discussion of how these findings were connected to the framework given in Chapter 1. Phase 1 showed that there are South African teenagers, mainly girls, who are willing to act as tutors. The teenagers are likely to focus mainly on internal motivational aspects, rather than the external ones. Recording teenagers' explanations and answers during the interview sessions was useful for a clearer understanding and interpretation of the sessions output. Audio recordings from phase 2, provided researchers with tangible data that was transcribed and translated, so that it was accessible to all the researchers involved, for use later in the design. By first involving both the teenagers and young children in face-to-face tutoring, it would benefit both teenagers and young children in that it boosted their confidence and willingness to participate in tutoring, and also helped to immerse them in the tutoring context, so that they knew exactly what it entailed when they had to design the application.

The activities of phase 3 gave researchers an understanding of the outcomes. The cultural and social backgrounds of participants affected the suitability of the design activities, more than age. Researchers having an open mind towards the outcomes of the design sessions, allowed them to embrace novel and unexpected results. The phases served to reinforce researchers' knowledge on the different elements of design, and thus contributed towards answering some of the research questions.

Chapter 6 describes the design and development of the software application and Chapter 7 presents the contributions this work brings to the body of knowledge. Chapter 8 discusses detailed descriptions of both the answers to the research questions, and the lessons learnt from the literature reviews given in chapters 2 and 3.

CHAPTER 6: DESIGN AND DEVELOPMENT OF THE TUTORING SYSTEM

6.1 Introduction

In keeping with the Design Science Research (DSR) approach described in Chapter 4, section 4.2.3.2, this chapter focuses on the design and development of the tutoring system, as well as an evaluation of the effectiveness of the design in addressing the problem statement. This chapter is structured according to the five process steps of the DSR model. DSR Step 1, *Awareness of the Problem,* is discussed in section 6.2; Step 2, *Solution Suggestion,* is discussed in section 6.3, while Step 3, *Development,* is discussed in section 6.4. The functionality of the tutoring system is then evaluated (Step 4) in section 6.5, followed by section 6.6, on the adapted design, and concluding remarks in section 6.7, which represents Step 5 of the DSR model. The chapter is then summarised in section 6.8. Each DSR step is described according to the patterns that are used in that step (*cf. Chapter 4, section 4.2.3.2*). Patterns provide researchers with well-proven methods to tackle research in a given domain.

The following section discusses awareness of the problem phase.

6.2 Awareness of the Problem

The *Awareness of the problem* was highlighted in Chapter 4 through problem identification and definition. The focus in this study was on designing and developing a cross-age tutoring system based on a social networking platform, and then to implement and test such a tutoring system in a restricted environment, before preparing it for more general deployment. The outcome for *Awareness of the problem* phase was a draft proposal of our intended plan.

The problem selection DSR patterns that were selected for this study were the *Redefine the Research Problem* and *Literature Search* patterns (Vaishnavi & Kuechler, 2015). The *Redefine the Research Problem* DSR pattern is suited for problems which appear to be a restatement of a problem that has been researched before, but which is now being restated for greater focus, or a different context. Cooperative inquiry and co-design have been studied before, but not in the context applicable to this research. The *Literature Search* DSR pattern is suited to problems that seem to display a knowledge gap in the literature.

The intent was to redefine the research problem after reviewing the proposed research and its scope. The area we redefine in our research is that of cooperative design. Cooperative inquiry is not a new area of study. Previous research has studied cooperative design where the design partners were adults, or a combination of adults and children, the latter of which is referred to as cooperative inquiry. This research breaks new ground by studying cooperative design where the design partners are children of different age groups – young children and teenagers. The context in which it was applied, namely to develop a tutoring system for use in a developing country – is also novel. The tutoring system will be used by young tutees and teenage tutors, and therefore it made sense to include both groups in the design team. There have been few or no research reports where cooperative inquiry has been used with teenagers and younger children as partners in co-design.

Using the *Redefine the Research Problem* pattern more than once during the study has led to a refined and well-scoped research problem that promises an interesting knowledge contribution. Having identified the problem, it was necessary to conduct research on how to derive solution s*uggestions* to address the research problem, which is the subject of the next section.

6.3 Solution Suggestion

As mentioned by Vaishnavi and Kuechler (2015), *Solution Suggestion* is essentially a creative step, wherein new functionality is envisioned, based on a novel configuration of either existing or new elements. For inspiration on finding solution suggestion strategies for the design of the tutoring system, researchers turned to many solution suggestion patterns of the DSR approach. The DSR pattern that was found to be relevant to this study was the Hermeneutical/Inductive (H/I) approach described in Chapter 4, section 4.2.1. While the Iterative Prototyping pattern could also apply to this research, this study provides only the first iteration of many circumscriptions that may follow in future research. It was for that reason that Iterative Prototyping, as a DSR theory building pattern, was not considered much further in this study. The H/I approach provides systematic guidance to DSR theory building. A detailed explanation of how the approach is used is given in section 6.3.1.

After explaining the details of the H/I theory development pattern in section 6.3.1, sections 6.3.2 to 6.3.4 discuss the actual solution suggestion process. Young children and teenagers were involved in every step of the solution suggestion process, in accordance with the requirements of cooperative inquiry. Before designing the solution, researchers came up with scenarios (*cf. Chapter 4, section 4.2.3.4*) that would help focus design efforts on the users' requirements. The scenarios created a family of techniques in which the use of a future system is concretely described at an early point in the development process (Rosson & Carroll, 2002). The scenarios helped in describing how users interact with the system. Unlike use cases, scenarios can be understood by people who do not have any technical background. Narrative descriptions of envisioned usage episodes were then employed in a variety of ways to guide the development of the system that enabled these user experiences. The design scenarios discussed that would lead to the actual design were translated into low-fidelity prototypes, then 'big ideas' and wireframes, as discussed in sections 6.3.2, 6.3.3 and 6.3.4, respectively.

*6.3.1 Hermeneutical/Inductive (*H/I*) Solution Suggestion*

This study used prototyping in the design of the tutoring system. Proper application of the H/I approach in building or analysing a prototype often leads to DSR theory development (Vaishnavi & Kuechler, 2015).

The operation of the tutoring system can best be understood through observation of typical use cases and their unbiased evaluation, using the proven methods of usability evaluation. Observation itself is an H/I approach (Vaishnavi & Kuechler, 2015). The body of knowledge about the system under study incrementally grew through circumscriptive cycles of observation and learning. The key features of this approach to DSR theory building include detailed planning of the design process, documentation of design decisions, data collection on prototype behaviour, and theory induction. According to Vaishnavi and Kuechler (2015), in order to induce a theory, it is necessary to write a narrative case study describing the prototyping and the data obtained on prototype behaviour (*cf. section 6.3.2*). Relationships between prototype design features and the observed prototype behaviour are then generalised into 'big ideas' (*cf. section 6.3.4*) to form the theory. This is the basis for constructing prescriptive propositions, as found in section 6.3.5. Theory verification then follows, by considering alternative theories that could explain the observed data and behaviour, and explaining away any contradictory evidence to the theory.

The H/I approach provides systematic guidance to DSR theory building. However, the approach takes considerable effort and time in order to be effective. The completion of a single circumscription of a research project may provide only an initial set of prescriptive propositions, as set out in section 6.3.5. Theory building, with the supporting theory validation and verification activities, may require the completion of many projects, using different approaches to theory building. This study, therefore, represented one of many similar studies that may follow in the future, with all studies aiming to build DSR theory based on the tutoring system artifact.

The next section describes an example of a typical use case scenario of the tutoring system that will provide a starting point for the description of the design outcomes.

6.3.2 Use Case Scenario

Based on the outcomes of the design process described in Chapter 5, the following is a typical use case scenario for the tutoring system:

Penny lives in a centre for abandoned children where schoolchildren have limited, supervised access to the Internet from the care centre's mobile devices for short periods of the day. Penny is in Grade 3, and her homework for today is to read two pages from her English reading book and they are writing a times 6 multiplication table test in mathematics. Penny logs into the tutoring system and sees that Mary, her favourite tutor, is online. She clicks on *Send a Message* and selects *Photo Message*. With the tablet's camera she takes a photograph of the two pages she has to read and sends them to Mary. She then activates the *Voice/Face Talk* function and selects Mary from the contacts. She knows the care centre has limited Internet access, so she requests a voice call. Mary answers and after saying their hellos she asks Penny what she can help with. Penny says that Mary should open the reading material in her Inbox so that Penny can read to her. Mary listens while Penny reads and corrects and helps her as she goes along. She makes sure to comment with "Well done" every now and then. Penny then asks Mary to ask her the x6 tables to practice for the test. When they are done with that they say goodbye and end the call. Mary then goes to the *Tutee progress* function and updates Penny's information to indicate that she knows the x6 tables and changes the progress icon to a big smiley face. She also sends Penny a *Flower award* to show her appreciation for Penny's hard work.

Embedding this scenario into the outcomes of the cooperative inquiry process guided the formulation of a set of wireframes. Detailed discussion of the wireframes can be found in sections 6.4.1 and 6.4.2. The next section discusses the low-fidelity paper prototypes that were produced by the research participants during the design sessions.

6.3.3 Low-Fidelity Paper Prototypes

The paper prototypes discussed in section 5.4 were the result of design session activities of the two groups of research participants. These were later translated into 'big ideas'. Figures 5.7 and 5.8 show some of the paper prototypes produced by the two groups. The rest of the low-fidelity paper prototypes are presented in Appendix 3. The low-fidelity paper prototypes helped in enabling early visualisation of alternative design choices, which in turn would help in provoking innovation and improvement. Teenagers and young children enjoyed this stage, as this approach made them feel more comfortable suggesting changes. The process helped the groups to gather feedback early in the design process, making changes quickly, and improving the initial designs. The paper prototypes provided insights into cognitive processes such as creativity, brainstorming and problem solving. The low-fidelity paper prototypes conveyed how the teenagers and young children would perform tasks. It also helped in informing requirements that were translated into decision-making tools, such as scenarios.

Discussion of the paper prototypes yielded many ideas. In order to analyse these ideas, the main points put forward by the two groups of designers were translated into 'big ideas'.

6.3.4 'Big Ideas'

The research participants produced 'big ideas' from the design sessions in which they participated in groups. This activity enabled every group to share ideas. The ideas emerged from the paper prototypes that each group had prepared and presented. These ideas were recorded by one of the researchers on a whiteboard (*cf. Figure 6.1*), as each group presented their work after a design session. The ideas appear in different colours, representing ideas from three different groups. The 'big ideas' were then translated into prescriptive propositions of the *Solution Suggestion* step of DSR, which forms the subject of the next section.

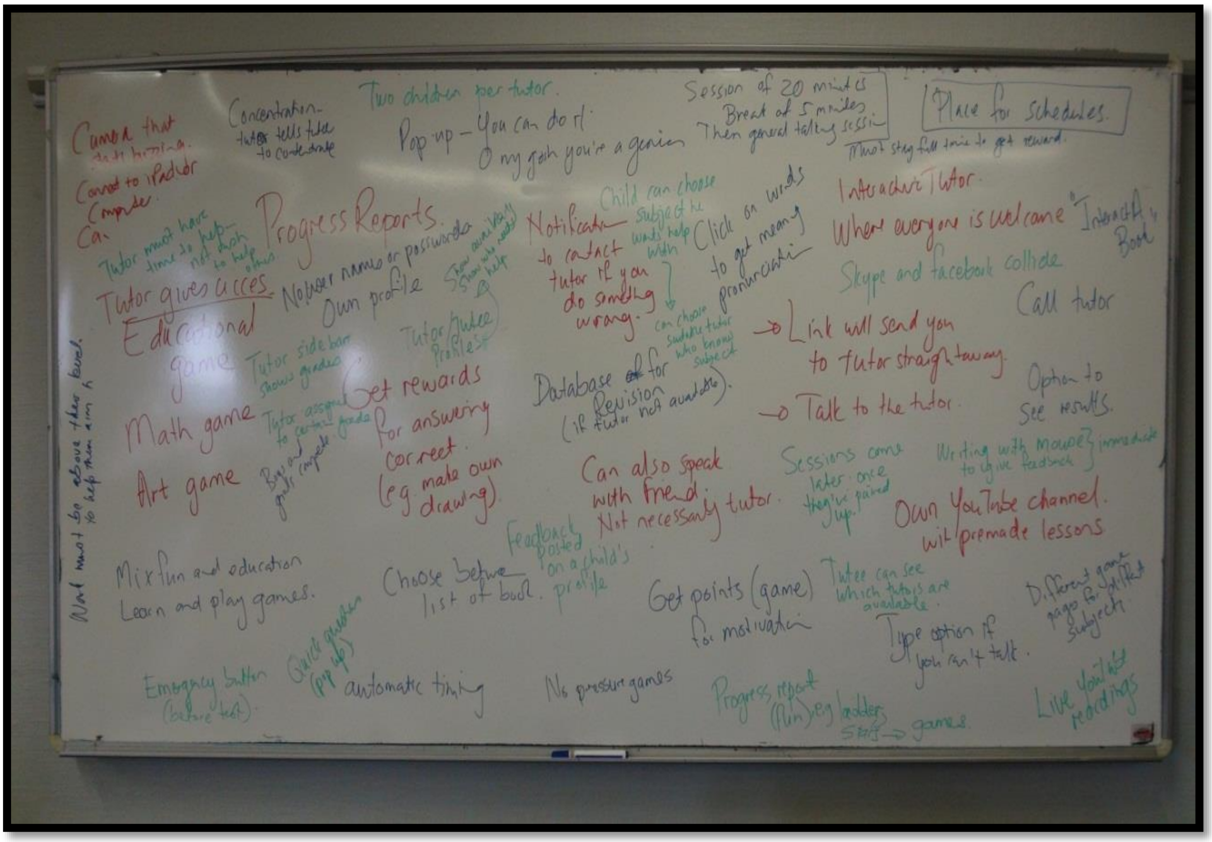

Figure 6.1: The 'big ideas' captured on a whiteboard

6.3.5 Prescriptive Propositions (PPs) of Solution Suggestion

Similar and related 'big ideas' were combined and then translated into themes, which were discussed in detail in section 5.4.2. These themes were then synthesised into prescriptive propositions (PPs) of the solution suggestion step of the DSR approach. The PPs form the basis for DSR theory building and, subsequently, DSR evaluation. The PPs identified here are the following:

PP1: For users to know who is online at any time, the tutoring system must show user presence.

PP2: For users to easily navigate the system, the tutoring system must be designed with context awareness capability.

PP3: For users to feel safe while using the system, the tutoring system must provide secure access through password protection.

PP4: For users to use free-hand writing as user input method, the tutoring system must support on-screen writing.

PP5: For users to communicate synchronously, the tutoring system must support chat functionality.

PP6: For users to communicate asynchronously, the tutoring system must support messaging.

PP7: For users to play educational games, the tutoring system must give users access to games.

PP8: For users to be rewarded for showing desired learning behaviour, the tutoring system must support various reward systems such as access to games and virtual rewards.

PP9: For users to receive feedback from the system on their progress with the learning outcomes, the tutoring system must support user monitoring and evaluation.

PP10: For users to enjoy much more than social media experience, the tutoring system must support rich media.

PP11: For users to exercise choice on whom they wish to interact with, the tutoring system must support selection of the target of a user-to-user interaction.

These hypothesised prescriptive propositions form the basis for evaluation of the designed artifact through observation and measurement, as described in the DSR evaluation phase in section 6.5. The development phase is discussed in the next section.

6.4 Development of the Tutoring System

The DSR process treats *Solution Suggestion* and *Development* patterns as one. This is because of the circumscriptive nature of solution suggestion and development phases, wherein knowledge that is gathered during development may lead to revision of the suggested solution. These iterations typically go on until there is some satisfaction that the developed artifact adequately meets user requirements. Through a process of stepwise refinement of the suggested solution, the artifact eventually reaches a certain level of acceptability. In the case of this study, the DSR development pattern that was selected was the H/I approach, as discussed in Chapter 4, section 4.2.1. Another pattern that could have been selected was the iterative prototyping pattern, which is characterised by incremental, stepwise refinement of the artifact through several iterations of prototyping, with each iteration making use of the knowledge gathered in the previous iterations to improve the artifact. However, the artifact produced as a result of this study could be presumed to be the basis of many iterative prototyping artifacts that future research could produce.

The development phase was where most of the actual design took place, synthesising existing knowledge, and a well-defined problem definition, into an artifact for solving the problem. Conceptual modelling, an approach used to better obtain and communicate requirements with the users and designers, was applied. Creating a conceptual model ensured that the requirements of such a process were understood, in terms of a set of integrated ideas and concepts about what the system would do, how it would behave and how it would look. Discussions between the researchers and research participants were intended to solicit different perspectives from the participants, while iterative prototyping was used to consider many alternatives. The use of the paper prototypes, the 'big ideas', themes and prescriptive propositions, enabled the researchers to develop sketches (*cf. sections 6.3.2, 6.3.3 and 6.3.4*). The sketches were then later translated into high-level wireframes for the design.

6.4.1 Sketches of the Design Scenarios

To start with, sketches were created, based on typical usage scenarios that would be translated into wireframes by the researchers. The sketches show the skeleton of the application to be designed, the page layout, the navigation system and the interface elements, and how they all work together. In total, six sketches and wireframes were created for this project. The wireframes that we created were "a set of documents that show structure, content, and controls" (Saffer, 2010, p. 151). The sketches were created using Microsoft Visio application, and wireframes were created using PowerPoint. Microsoft Office Visio is a universal graphics program that provides tools to visualise most business and technical tasks by using one product. Visio lets users create and share diagrams of processes, of systems, and of numeric data. PowerPoint is a wireframe tool allowing digitally drawn ideas, which are easily tweaked and changed. It also offers various useful user interface components and icons, and click-through prototypes for demos and testing. It's important for designers to translate the ideas in their heads into a tangible form.

Wireframes are a great way to quickly map out the functionality and flow of an application. Figure 6.2 illustrates high-level functional components of the application homepage, consisting of the following: application Logo, login, new user registration and footer. A description of what is to be placed in each link is given below.

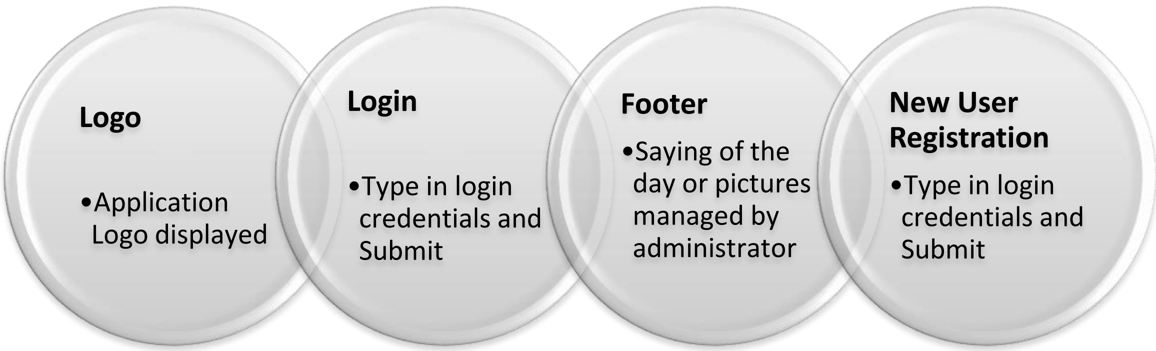

Figure 6.2: High-level functional contents of Application Homepage

Figures 6.3 and 6.4 show the sketches for the tutor and the tutee pages.

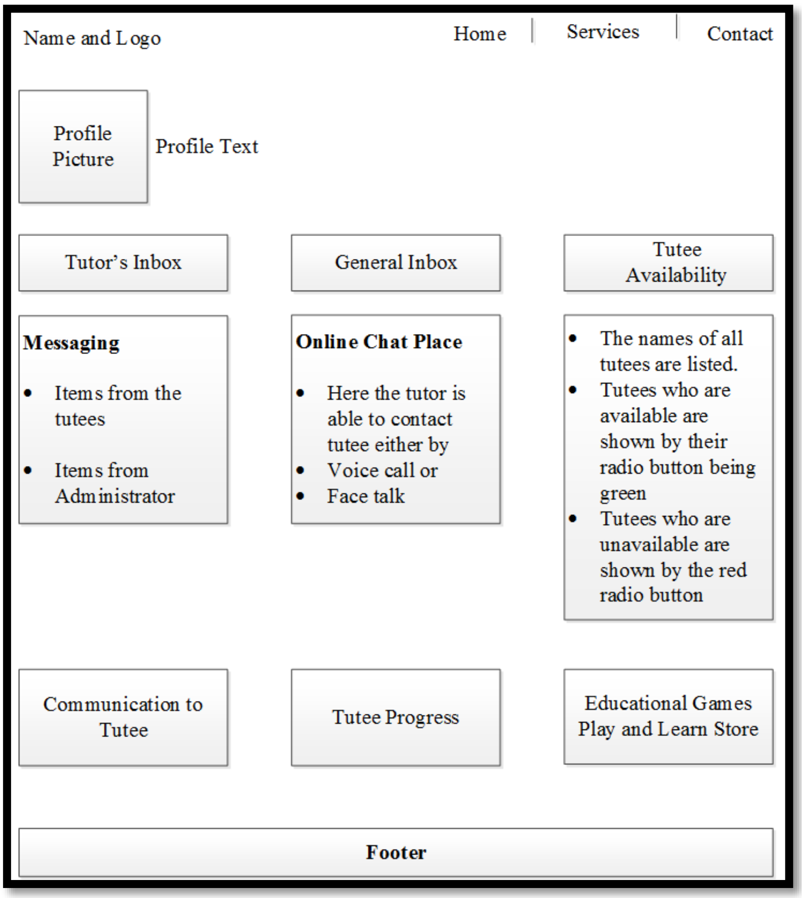

Figure 6.3: Sketch of Tutor page

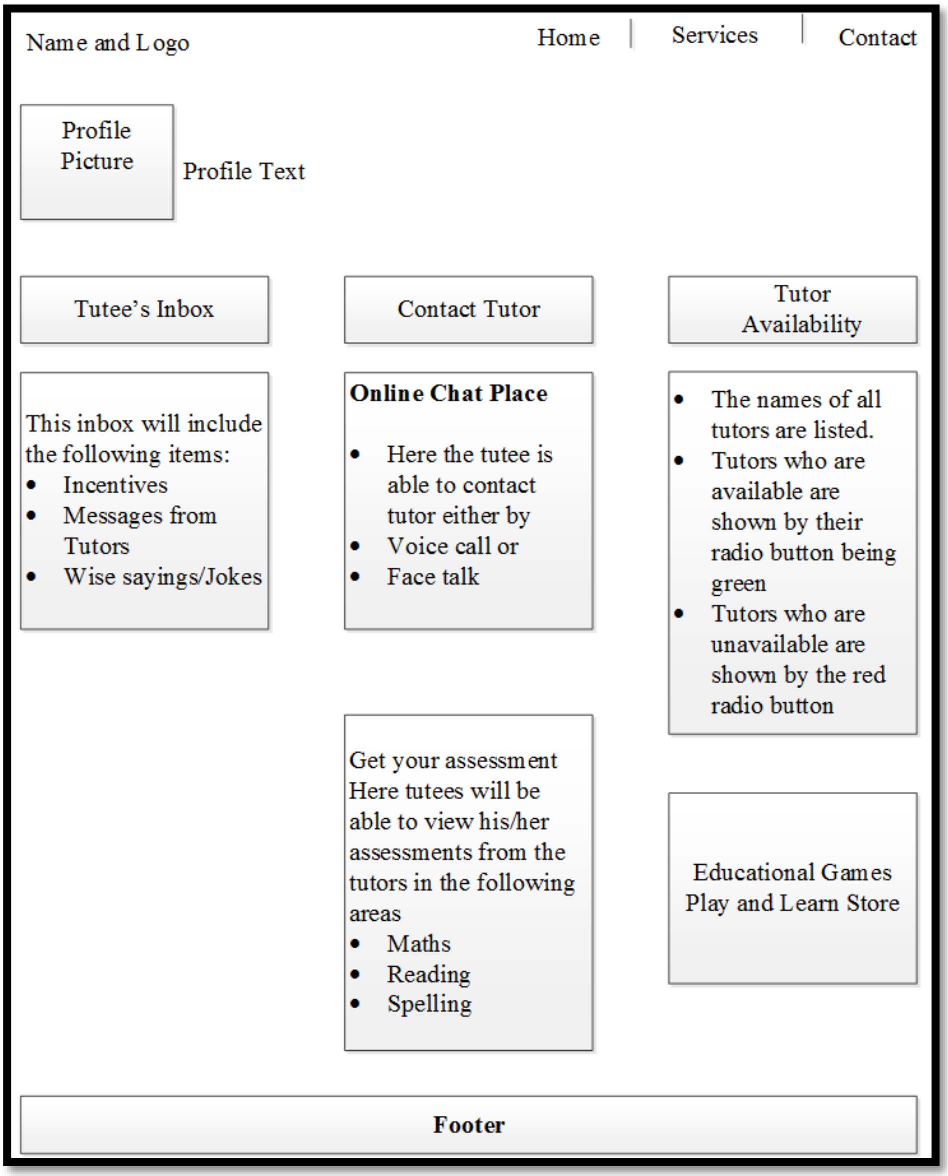

Figure 6.4: Sketch of Tutee page

The sketches give descriptions of the requirements of the homepages, and the details of the homepages are as follows:

Tutor/Tutee profile: This button contains personal information, profile pictures, the title and access to edit the profile for the tutor and the tutee.

General Inbox: The button contains tutee activities that include:

- Homework done by the tutees
- Voice messages from tutees/tutors

- Pictures posted by tutors
- Rewards for good work
- Exercises
- Information from administrator

Tutor Inbox/Tutee Inbox: Both inboxes show how tutors or tutees communicate asynchronously with each other. These buttons allow the use of different information formats, such as voice, graphics and text.

Tutor/Tutee Availability: The button checks the availability of either the tutor or tutee. The names of all tutors and tutees are listed. Availability is shown by the radio button being green, and unavailability is shown by a red button.

Contact Tutor: The scenario here is that a message goes to the tutor, which can be in the form of a photograph (give allowance to take a picture), voice call (similar to Skype voice-only call), face talk, (similar to Skype voice and video call).

Tutee's work (Mathematics, reading, spelling, exercises): These are links that send the tutee straight to the tutor for assistance in Mathematics. Reading and spelling can be done with camera, and exercises can be done in Google format then submitted online.

Assessment Comments: This is the link that provides assessment comments for the tutees. On this link the tutee will be able to view his/her assessment from the tutors in areas like Mathematics, Reading and Spelling.

Play and Learn Store (Games and Videos): The link under game application goes to the "App Store" like interface for games that can be downloaded or played online. The video link goes to a private YouTube channel-like place where tutors can post educational videos.

Administrator: The administrator manages the settings, edit and add applications.

The sketches were then converted into high-level wireframes. The high-level flow diagrams are explained in section 6.4.2.

6.4.2 High-Level Wireframes Created Based on the Sketches

Figure 6.5, below, is a flow diagram representing the flow of user interaction with the profile pages of both tutor and tutee. It shows the participants who will interact with the system, called the external entities, and these are tutors (teenagers) and tutees (younger children). In between the process and the external entities there are data flows (connectors) that indicate information exchanges between the entities and the system.

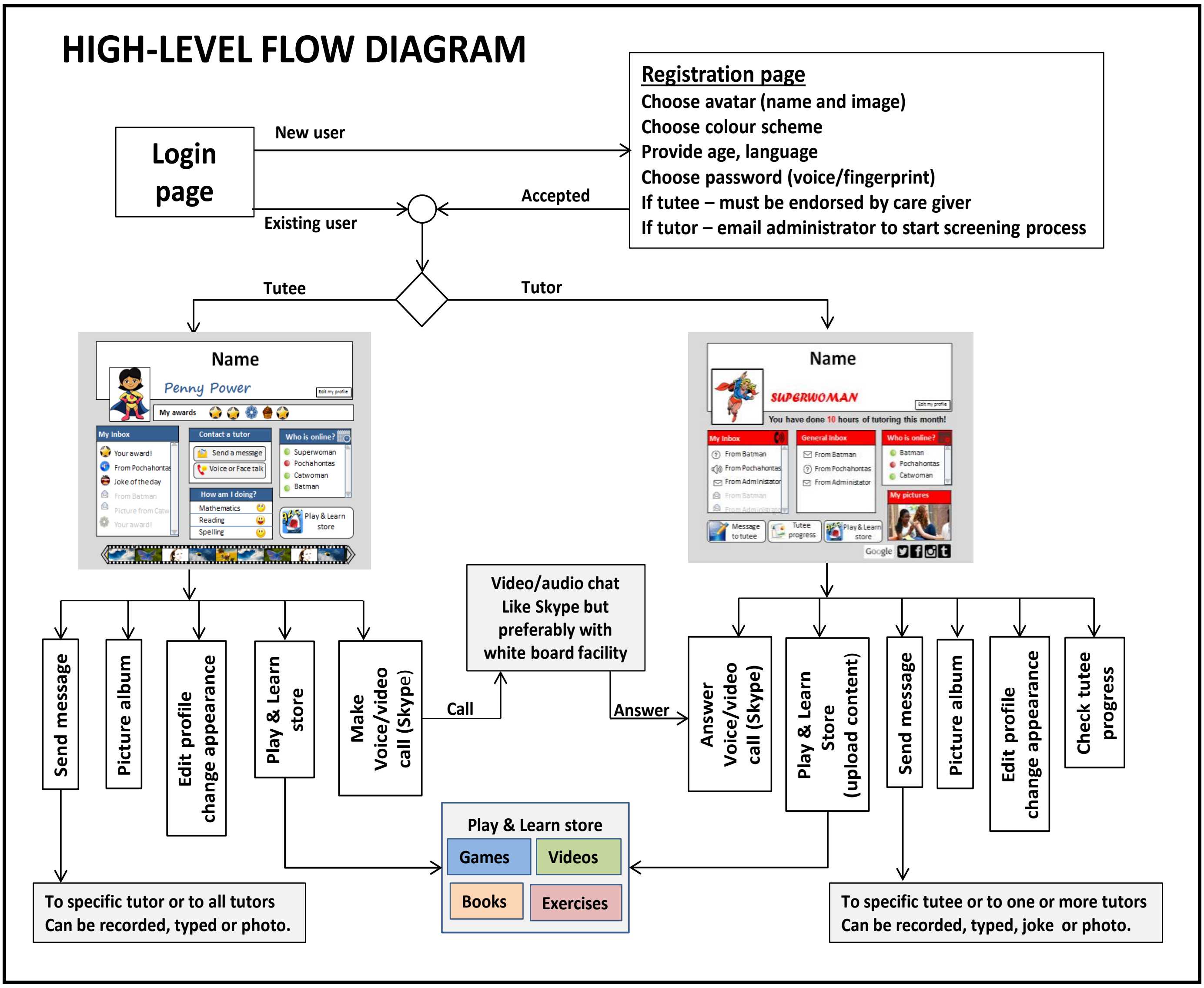

Figure 6.5: High-level flow diagram showing the login function and the tutor and tutee pages

The tutoring system data flow diagram (DFD) contains processes that are similar for the tutors and the tutees. Users must go through login processes, whether as new users or existing users. *Registration page:* The requirements for registration are that the users choose an avatar and name it, and upload a picture. They can choose a colour scheme, indicate their language preference, and set a password. For this study, the tutee password is endorsed by a caregiver, and, in the case of the tutor, the administrator does the screening process.

Once registered, the users have access to their respective profiles. The tutee can interact with a specific tutor, or all tutors, through recordings, photographs or typed messages. The tutee can send a message, upload and download in the picture album, edit their profiles by changing appearance etc., visit the play and learn store and make Skype-like (Skype.tn[6]) voice/video calls. The video/audio chat resembles Skype, but with a whiteboard facility. On the tutee page, the tutors can answer voice/video calls, upload content into the play and learn store, send messages to specific tutees, or to one or more tutees. The messages can also be recorded, typed, and could be jokes or photos, upload on the picture album, edit profile to change appearance and check tutee progress. A detailed description of the process that takes place on each of the profile pages of the tutoring system, is given below.

6.4.2.1 Descriptions of each item on the tutee profile page

Figure 6.6 shows the tutee profile page – which is the decomposition (i.e. breakdown) of the tutoring system process for tutee activities. Each activity is described below. As researchers, we chose the name '*Broccoli Buddies*' as a placeholder name for the tutoring system. The choice of the name and the later change will be discussed in detail below.

[6] Skype.tn referring to Skype-like

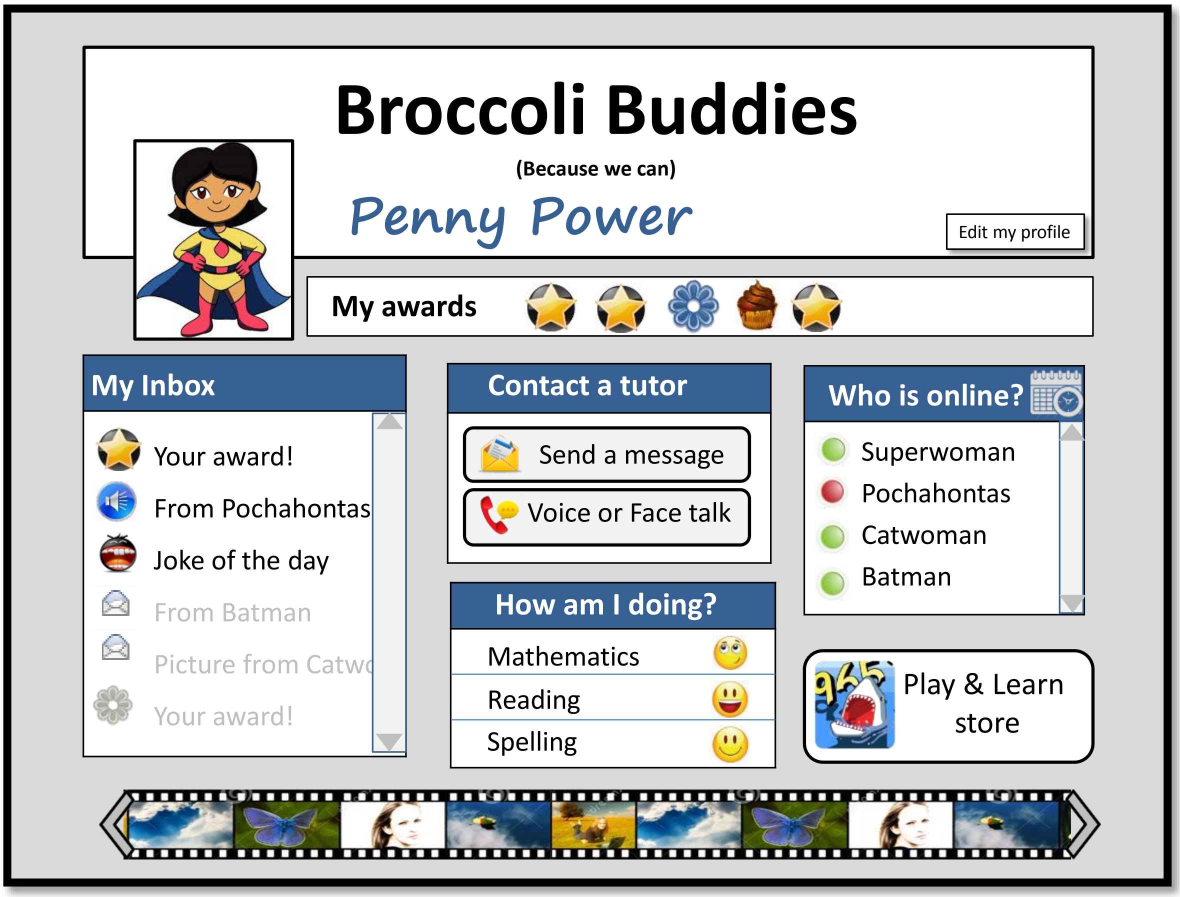

Figure 6.6: Tutee profile page

Avatar and Name: When the user registers, he/she chooses a profile picture and user name from the list of avatars and names (*e.g. Penny Power*) that have superhero themes. The use of such user name and profile picture promotes anonymity. As researchers, we feel that being anonymous and using pseudonyms are important attributes of our developing online culture, and children should not be put at risk out of some populist sense of "decent" behaviour. Bailenson et al. (2006, p. 359) define avatars as "digital models of people that either look or behave like the people they represent". In this study, avatars are used to represent the tutees and tutors on the Internet, as shown in the pictures on the tutor and tutee pages. The children could use substitute names to act as their representative, dealing with others in the digital realm.

Choosing a superhero theme is one way of adding interest to the children's designs, as the superhero often represents an exceptionally skilful or successful person. One of the reasons children love superheroes is the sense of control and power they can exert on the world, vicariously. Using superhero themes allows children to have confidence in themselves. During the design sessions, the participants came up with names that would best describe the tutoring system. So, for the wire framing process, we decided to use Broccoli Buddies (*cf. Figure 6.7*), one of the names on the poster created by one group of participants. The idea was to later discuss the names with the participants and choose a name from all the posters that best described the tutoring system.

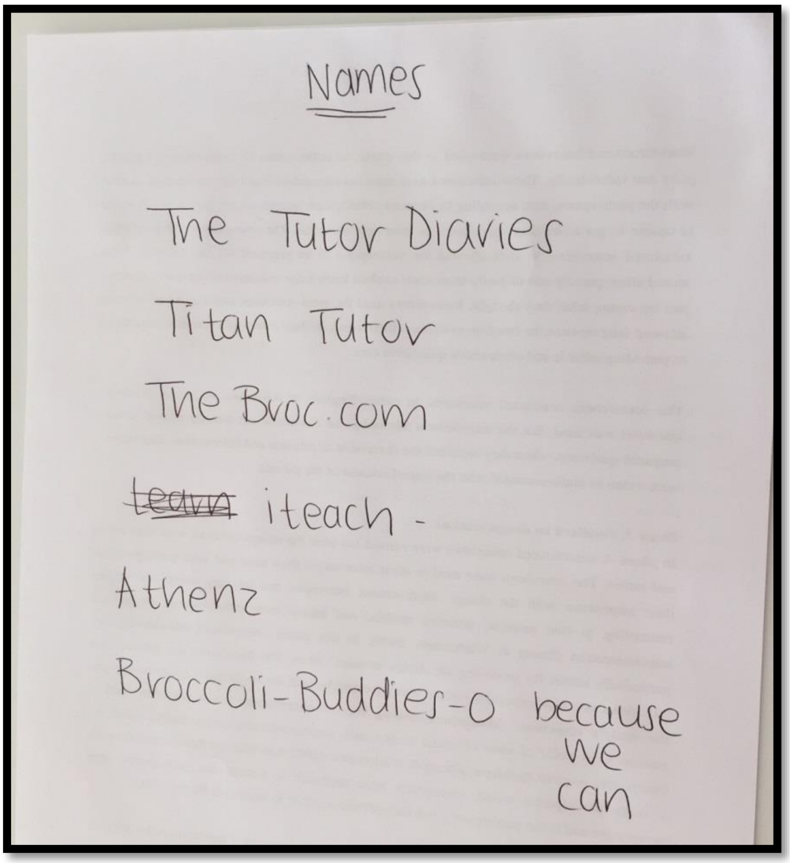

Figure 6.7: Placeholder name for the tutoring system

Edit my profile button: This button would allow users to change the colours and style; should they choose to change their avatar identity, they would lose awards collected until that time. They should be allowed to remove themselves, but must be warned very clearly before it is actually done.

Inbox: This is where the tutors communicate asynchronously with tutees. The message types include award, joke of the day, text messages, marked exercises, voice and images.

How am I doing?: This indicates to the tutee where they are doing well or falling short. In this study only smiley faces are used; the smile is just wider for better performance.

Contact a Tutor: A tutor can be contacted in two ways:

i) Through a message which can be a voice, text, or picture message.

ii) Through a Skype.tn call that can involve voice or video. Ideally there should also be a whiteboard that both parties can write on during the call.

Who is Online?: When a tutor or tutee who is in this tutee's group is online, their availability for voice or face talk is indicated by a green light.

Schedule Icon: The schedule icon on the "who is online" label shows the schedule of when the different tutors are available.

Photo Strip: This is the tutee's photo album. Clicking on it opens a photo in a slide show format, where tutees can add or delete photos.

Play and Learn Store: The tutee is taken to the "app store"-like page where they can choose between available games, books, exercises and videos.

6.4.3.2 Descriptions of item on the tutor profile page

In Figure 6.5, focus is both on the interactions between the system and external parties, and the internal communications among interfaces. Figure 6.8 shows the tutor profile page and descriptions of each of the elements are given.

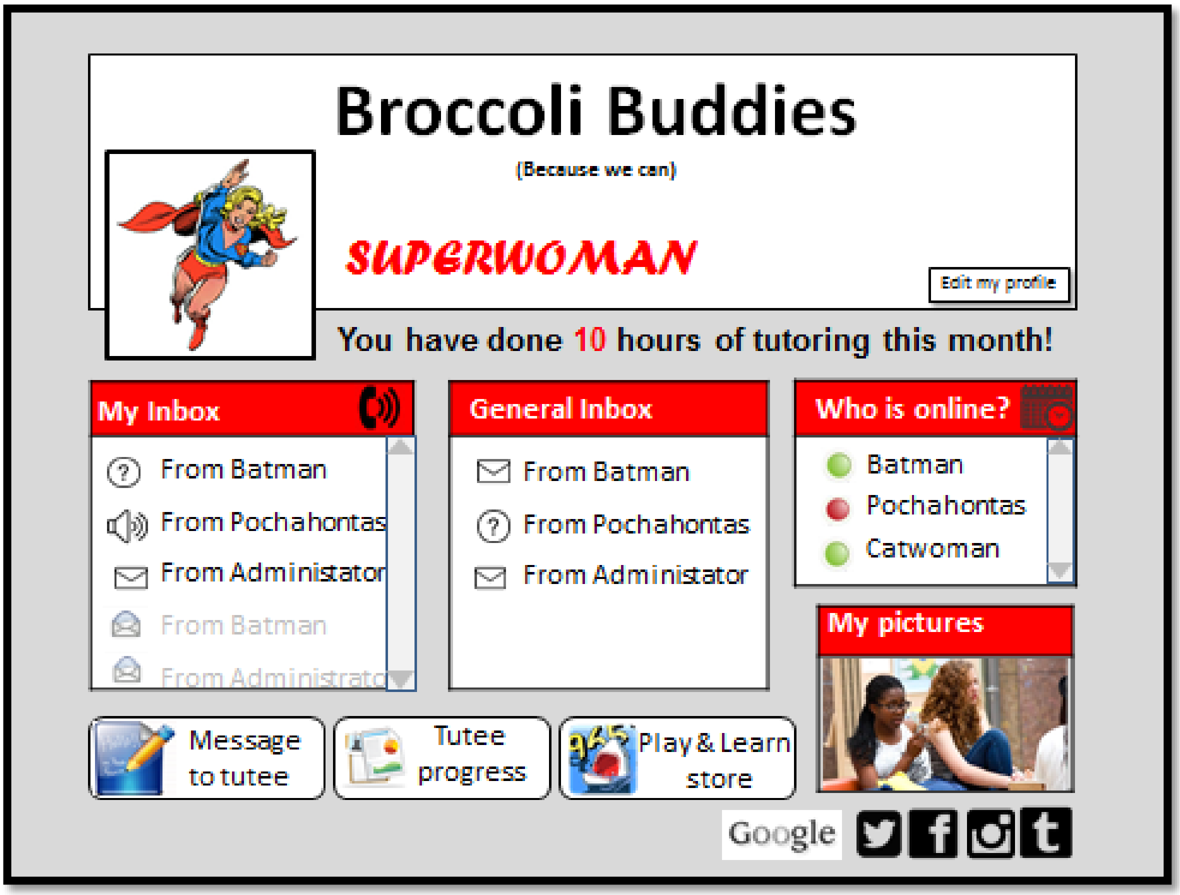

Figure 6.8: Tutor profile page

Avatar and Name: (Superwoman, Broccoli Buddies): Like the tutee, when the user registers, he/she chooses from the list of avatars and names that has a superhero theme.

Record Keeping: The system keeps record of the time the tutor is available and it also checks if they are active.

Edit profile button: The button allows users to change the colours and style.

Inbox: The messages from tutees, tutors or administrators get to the specific tutor. The message type again includes text, voice or an image. An urgent message must be indicated by a designated icon (e.g. a big red H) to indicate help required.

General Inbox: Messages are sent to all tutors from tutees, tutors and the administrator. Message types include text, voice or picture.

Schedule Icon: The schedule icon on the "Who is online" button shows the schedule of when which tutor is available. Tutors can edit/change their own availability on the schedule.

Who is Online?: The button shows the person available online. Tutors can click on these names to view a specific tutee's profile.

My Pictures: This is the tutor photo album, and clicking on it opens a photo in a slide show format, where they can add or delete photos.

Message to Tutee: The message can be a voice, text, picture award, marked exercises, joke of the day.

Tutee Progress: This takes the tutor to a page where they can look at the tutees' progress so that they can decide on a plan of action to help them.

Play and Learn Store: It takes the tutor to the "app store"-like page where they can upload new games, books, exercises and videos.

Social Media Icons: When the tutor creates a profile, they can indicate which social networks they want to link to. Those icons are then displayed here for quick access.

In section 6.4.2, descriptions of icons found on the tutee and tutor profiles were discussed. The following section, 6.4.3, discusses feedback from the participants on the descriptions of each icon on the high-level wireframes.

6.4.3 Discussion of the high-level wireframes at the children's centre

6.4.3.1 Feedback from participants

The high-level wireframes were discussed with some of the tutors and tutees. The two researchers and four tutors went back to the centre on the 20 May 2015, where they met with four tutees to discuss the activities of each icon on high-level wireframes. The high-level wireframes represented the researchers' thoughts on what the system should be like. The participants were there to give us their opinions on where to change things and do things differently. The discussion was conducted in Afrikaans and later transcribed and translated into English. Table 6.1 tabulates the suggestions given by the participants on some of the links.

Table 6.1: Suggestions to improve the profiles

Links on the profiles	Remarks	Suggestions
1. Avatar and Superhero names	This section was well received by the participants. They liked the idea of choosing their own superhero names from the list provided.	Tutee participants preferred editing their own profiles and also changing their superhero names from time to time, as long as they informed the administrator.
2. How am I doing?	There were smiling faces next to the subjects to indicate how well the students were performing in those subjects. The first reaction from the participants was that they should not all be smiling faces, especially when a tutee has not done well in a subject.	i) The participants suggested that stars or marbles be used, e.g. ten stars for work well done and one or two stars when the children have not done well. The number of stars would be determined by how well a tutee has performed. ii) Another suggestion from participants was that a variety of subjects be added on the "how am I doing" link so that tutees have a wider choice of subjects to choose from and tutors are able to see the subjects that appear.
3. Who is online?	Two of the participants did not understand what the "Who is online" link meant. There was a suggestion that this be changed to "Who is available".	Participants finally settled for "Who is online?"

4. Calendar	Some of the participants, all tutees present, had a problem with visibility of the calendar next to the “Who is online” link. It was not visible enough, and others did not understand what this icon meant.	They suggested that when the icon is selected, it must show the name ‘calendar’.
5. Urgent Matters	One participant asked how urgent matters could be treated, i.e. when a tutee requires urgent assistance from the tutor.	One participant suggested that there be an icon which flickers like an ambulance siren to alert the tutor or administrator that someone requires immediate assistance.
6. General suggestions	Homework feedback	A suggestion was made that a way should be created for the tutee to let the tutor know how urgent he/she requires feedback.

The final discussion was on the choice of name for the system by participants, since the placeholder name, “Broccoli Buddies” used on the high-level wireframes (*cf. section 6.4.2*) was a temporary name chosen by researchers from the list given by participants.

6.4.3.2 The choice of name for the system

The name of the system was chosen from a list of names that the participants had come up with in each of the groups during the design sessions. The researcher compiled the names together, as shown in Figure 6.9.

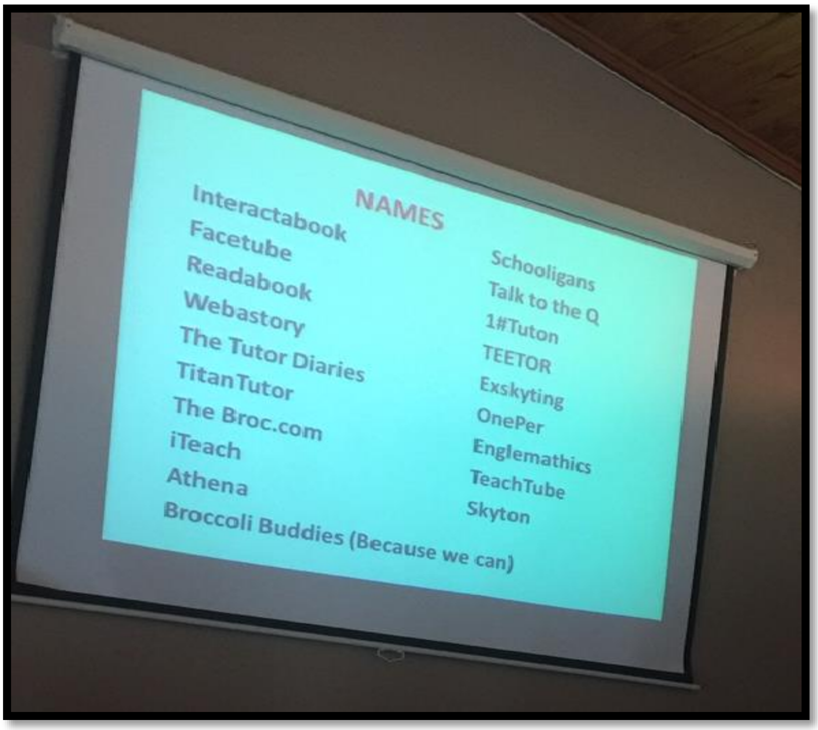

Figure 6.9: Names that were listed as potential names for the system

Discussion of names ended with all participants choosing the name TitanTutor. The reason for choosing this name was that, TitanTutor was applicable to what the system would offer as it sounded powerful and influential and reflected a positive, strong image. We incorporated the suggestions into the tutoring system. The next step was now to convert the artifact into a workable solution through coding. A technical specification document was produced, that defined the set of requirements that the tutoring system would meet or exceed.

6.4.4 Technical Specifications

Technical specifications describe the detail of either all or specific parts of a design, such as requirements lists, functional designs, user stories, graphics design mock-ups, usability studies, UML diagrams, business process diagrams, data model specifications, etc. The purpose of a technical specification in a software development project is to define the customer's technical requirements that will be addressed by the project, and also to give the reader a broad general understanding of the system or component. In this study, the specifications were prepared to guide the programmers in the implementation of TitanTutor. The technical specifications were prepared in conjunction with the high-level wireframes described above. A set of use cases described below were extracted from these high-level wireframes:

1. Roles

Various roles were identified from the high-level wireframes:

- *User:* Any person that might want to identify himself or herself to the system.
- *Tutee:* Any person who is authorised to use the system to learn.
- *Tutor:* Any person who is authorised to use the system to teach.
- *Admin:* Any person who is authorised to manage user accounts.

2. Use cases

Several use cases were identified from the high-level wireframes discussed in section 6.4.2, and organised according to the roles identified above.

As a User I want to:

- *register*
- *log in*
- *log out*
- *manage my profile*

As a Tutee I want to:

- *send a message to a tutor* (text, image, recording)
- *see my sent messages*
- *upload a picture to my picture album*
- *see all the pictures in my picture album*
- *remove a picture from my picture album*
- *browse the store*
- *download an item from the store*
- *make a video-audio-interaction call to a tutor*
- *see my progress*
- *read messages from tutors*
- *see which tutors are available*

As a Tutor I want to:

- *send a message to a tutee* (text, image, recording)
- *see my sent messages*

- *upload a picture to my picture album*
- *see all the pictures in my picture album*
- *remove a picture from my picture album*
- *browse the store*
- *upload an item to the store*
- *remove an item from the store*
- *make a video-audio-interaction call to a tutee*
- *check a tutee's progress*
- *read messages from other tutors*
- *read messages from tutees*
- *see which tutors/tutees are online*

As an Administrator I want to:

- *manage user accounts* (e.g. reset passwords, block users who are misbehaving)
- *moderate images in the picture album*
- *whitelist and blacklist external resources in the store*
- *see log files of all interaction*
- *be able to delete any harmful content (*e.g. inappropriate messages)

3. Conceptual architecture

From the use cases it is possible to formulate a conceptual architecture which is given in Figure 6.10.

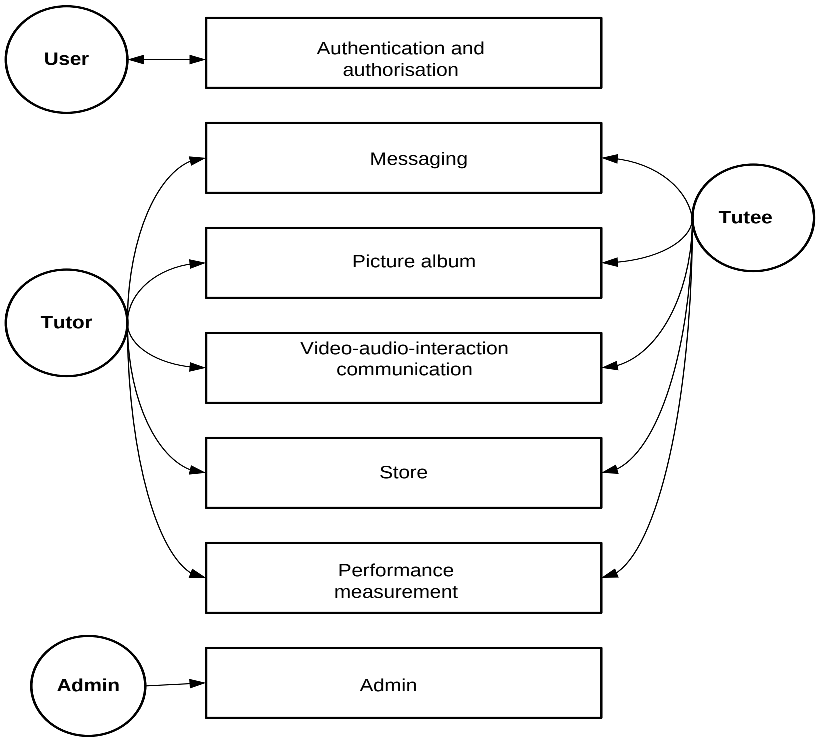

Figure 6.10: Conceptual Architecture

Several logical subcomponents can be identified from the diagram:

i. *Authentication and authorisation*: authenticating users (log in, log out) and authorising users (determining what a user may or may not do in the system).

ii. *Messaging*: facilitation of messages between tutors and tutees. Messages could contain text, images and audio recordings.

iii. *Picture album*: facilitation of managing pictures in a virtual album.

iv. *Video-audio-interaction communication*: facilitation of a communication channel that has video, audio and some kind of education-orientated interaction facilities, such as a virtual interactive whiteboard (*cf. http://www.doceri.com/ as an example*).

v. *Store:* facilitation of educational resources that tutors can upload for tutees to access, such as the International Children's Digital Library (http://en.childrenslibrary.org/).

vi. *Performance measurement*: the setting of tutees' progress by tutors, as well as the viewing of progress by tutees.

vii. *Admin:* administrative functions such as managing user accounts, moderating images and whitelisting or blacklisting external resources in the store.

4. Non-functional requirements

The following non-functional requirements have been identified:

- *Content control*: The particular system will be used in a childcare facility as discussed previously, so the safety of the children is crucial. The system contains resources that live on the Internet and are external to it (i.e. typically, items in the store subcomponent from the section below, such as the International Children's Digital Library at http://en.childrenslibrary.org/). The requirement is that tutees are able to access only resources that they are allowed to access (typically those in the store), and nothing else. Internet browsing will have to be restricted. This requirement will most probably have to be implemented by software and hardware different from the system itself (and by a service provider with the appropriate expertise). Possible solutions are discussed in section 6, below.
- *Comprehensive event logging*: Since this system is also part of a larger research project, comprehensive logging on each event that takes place in the system, is required.

5. Technical solution candidates

This section will outline possible technical solutions to the requirements identified above.

Authentication and authorisation

Off-the-shelf solutions: Typically, each programming language and its family of frameworks will have its own solution to authentication and authorisation (e.g. Rails will have Devise). It may also be possible to use third-party services like Stormpath. Stormpath offers a comprehensive user management service in the cloud. HTML 5, CSS 3, ASP.NET MVC Razor 5 and JavaScript were used to implement TitanTutor user authentication and authorisation, with JQuery providing database query capability.

Messaging

Non real-time messaging: These messages do not technically have to happen in real-time, so a database approach (as opposed to, for example, a Web sockets approach, where communication is instantaneous) for messages is suited. These messages act more like e-mail than instant messaging.

Picture album

- *Image moderation*: Since the system will be used in a childcare facility, images must be moderated to ensure their safety. Image moderation can be built in as part of the admin role's responsibility. Image moderation can also be outsourced to an external image moderation service such as CrowdFlower Image Moderation.
- *Storage:* Images will have to be stored outside the app infrastructure, to ensure that the infrastructure remains scalable. Amazon Web Services S3 is suggested to store images.

Video-audio-interaction communication

This subcomponent is arguably the most technically complex. The following tools were used in the implementation:

- *Existing frameworks and standards for real-time video-audio communication:* WebRTC is the de facto library for building real-time video-audio interaction communication platforms, and is supported by Google, Mozilla and Opera. SimpleWebRTC is a simple JavaScript library built on top of WebRTC (*cf. talky.io as an example of SimpleWebRTC in action*).
- *Existing tutor-tutee interaction applications*: There are many so-called "whiteboard apps", some of which also provide real-time video-audio communication in addition to tutor-tutee interaction functionality. Open Sankoré is a good example of such an application.
- *Open source collaborative drawing applications:* These applications are more likely to be easy to integrate due to the fact that they are open source. See, for example, Draw pile. Twiddla was used to develop the whiteboard functionality for TitanTutor application. Twiddla allows an unlimited number of users to remotely collaborate on one whiteboard by adding their markups to the whiteboard. In this case, the tutors can demonstrate how to solve a mathematical problem and tutees can indicate which part of the solution they do not understand clearly.
- *Technologies and third-party services that can be used to build a tutor-tutee interaction application*: There is a range of existing technologies that can be used to build your own tutor-tutee interaction application. One could, for example, use Web sockets to create a collaborative drawing canvas. Another option is a hosted service such as Firebase. Using something like Firebase might be the simplest and most flexible solution.

Store

Content control:

The store is a simple list of external resources uploaded by tutors. The two important requirements here are that administrators should be able to control what external resources get uploaded, and tutees should be prohibited from browsing away from these external resources (to Facebook, for example). The first requirement is simply something that can be built in to be part of the admin role's responsibility. The second requirement will likely be some external software application that restricts tutees' browsing. Assuming that the system specified will be a Web application, the simplest solution is to use the browser's built-in moderation facilities (for example, Content Advisor in Internet Explorer). There are also commercial solutions available such as Browse Control, which could restrict access for all the computers on a single network. The latter option would give more flexibility. The end decision will have to take into consideration how many computers or devices will be used for TitanTutor in the childcare facility.

Performance measurement

This functionality would likely be a bespoke piece of functionality for this particular system, and will have to be specified in more detail as soon as the requirement is understood better. For example, where video communication is involved, latency is an important performance measurement to ensure good end user experience.

Administration

Likewise, administration functionality can be developed in a similar manner to how a performance measurement solution is implemented.

6.4.5 System Implementation

The tutoring system was developed and implemented according to the suggested design ideas. A team of programmers was appointed to convert the detailed designs into executable computer code, using the technical specifications given in section 6.4.4.

Implementation decisions

The avatars and the associated login wizards were implemented by adding each user (Tutor or Tutee) to the system by a user with administrator rights. When a user logs in for the first time, he/she is directed to the character setup page. Themes were used for the characters that tutors and tutees could choose from, as shown in figures 11 and 12, below.

Figure 6.11: Tutee select and maintain character overview

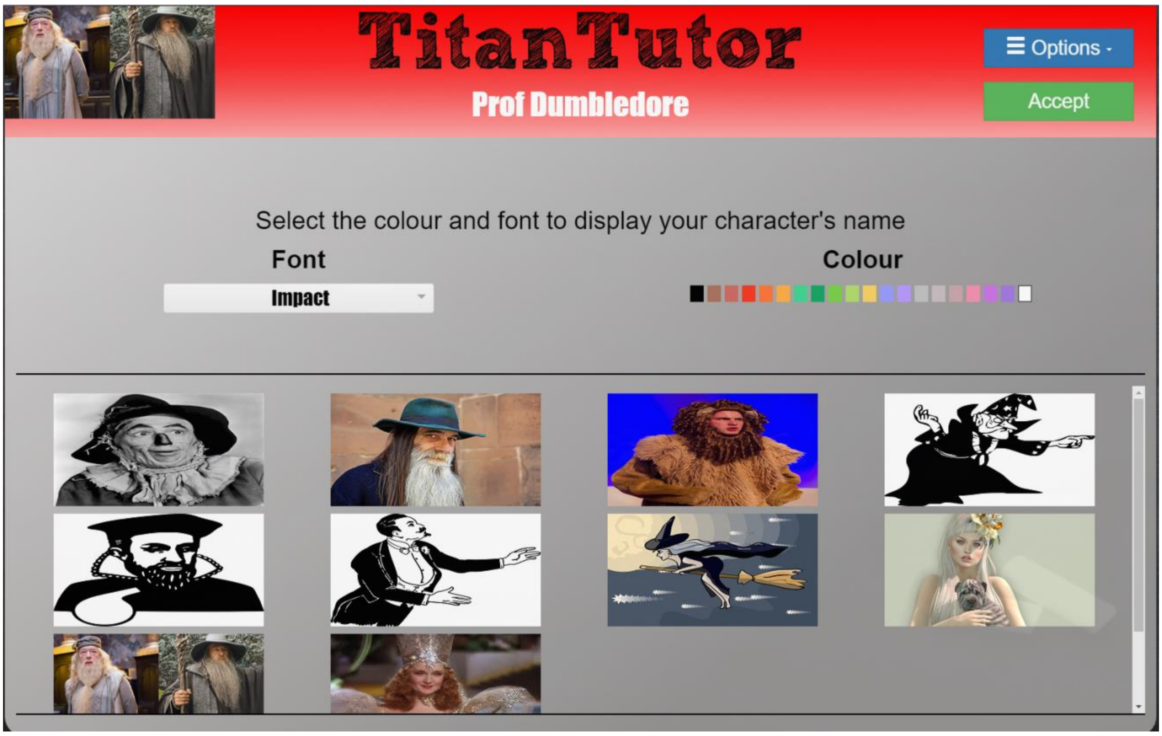

Figure 6.12: Tutor select and maintain character overview

Tutors whose characters had a wizard theme, could choose any character that was unique, within the context of the groups in which they tutored. It is not possible for a tutor to choose the same character as another tutor for one or more of the groups that they have been assigned to. Tutees whose characters have a comic book theme, can choose any character that is unique in their group. It is not possible for them to choose the same character as one of the other tutees in their group.

On the character setup page, users are able to choose the font style (font family) and colour in which they would like their character's name to be displayed. When the user logs in for a second time, after having set up his/her character, the choices will appear, and the user would be directed to the homepage, with the character and styles showing as selected. The characters used in this study were sourced from IconArchive.com and other sources which made the images available for free. This design iteration focused on building the core functionality for a prototype of TitanTutor. For this reason, we sourced free images that were easily downloadable just to showcase how the system would work. The system is a prototype, and not yet available in the public space, or being used commercially; therefore, there are no intellectual property issues. The sourcing of new characters and images will be done when the point arrives that TitanTutor is marketed as a commercial product and available on the Internet for all to use. Some of the images depicting the TitanTutor user interface are given below. The detailed contents of figures 6.13 to 6.16 were discussed in sections 6.4.2.1 and 6.4.2.2. The ASP.NET technologies were used to implement the sourcing of information required in the dialogue boxes. The CSS3 technology was used to format user interface colours and fonts.

Figures 6.13 and 6.14 are tutor and tutee profile pages.

Figure 6.13: Tutee homepage overview

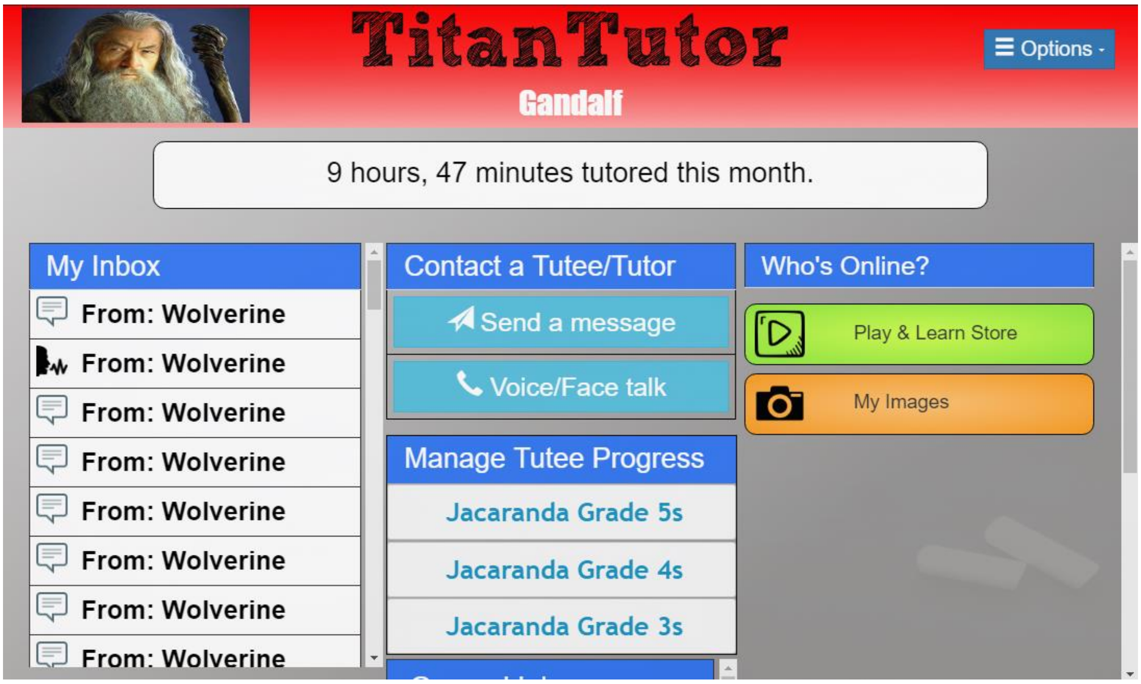

Figure 6.14: Tutor homepage overview

The following figures represent each link on the tutor/tutee profile pages. Figure 6.15 represents the award strip. Tutors can award tutees with different kinds of awards for different kinds of progress shown. The award arrives in the Inbox and when the tutee opens it, it is transferred to the strip.

Figure 6.15: The award strip

All users of the system must go through login and logout processes, whether as new users or existing users. The login and logout details as shown in figures 16 and 17, are authorised by the caregivers for the young children, and by the administrator for the teenagers.

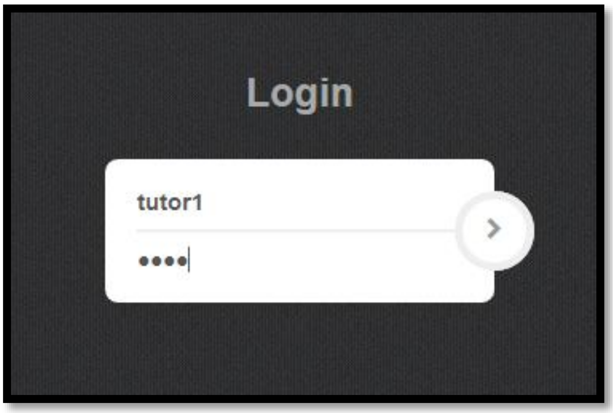

Figure 6.16: Login screen ***Figure 6.17: Option menu***

Figure 6.18 shows the ways to contact a tutor or tutee, either by sending a message or through voice or face talk.

Figure 6.18: New message box

Figure 19 shows an example of the person who is available online, whether a tutee or tutor. Tutors can click on these names to view a specific tutee's profile.

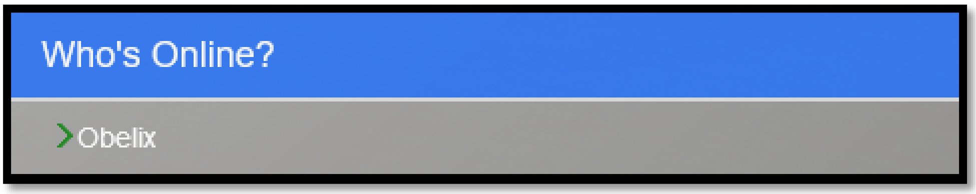

Figure 6.19: Who is online?

Figures 6.20 to 6.22 are showing the ways progress of tutees is managed. If the tutee is not doing well, a sad face icon is shown, and when doing well, a smiley face is shown.

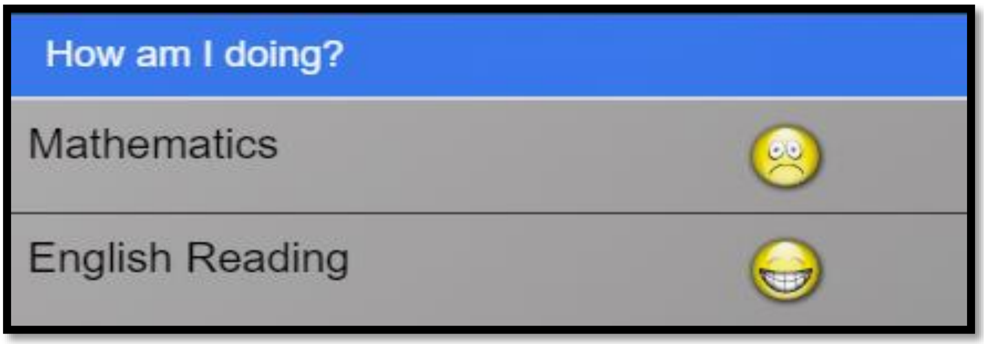

Figure 6.20: Tutee progress

Figure 6.21: Tutor manage tutee progress accordion

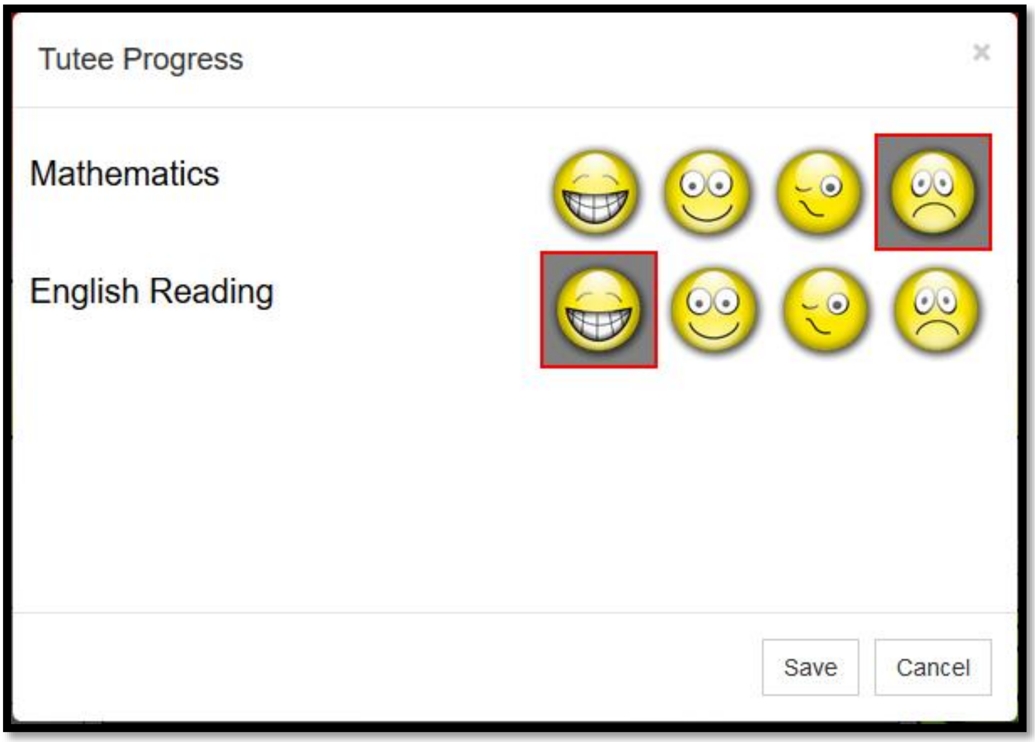

Figure 6.22: Tutor update tutee progress

Messages can be sent in various forms – for example, a text, a voice recording, an award, a question or a picture message (*cf. Appendix 4*). Figure 6.23 shows an audio recording message send to a tutee by a tutor.

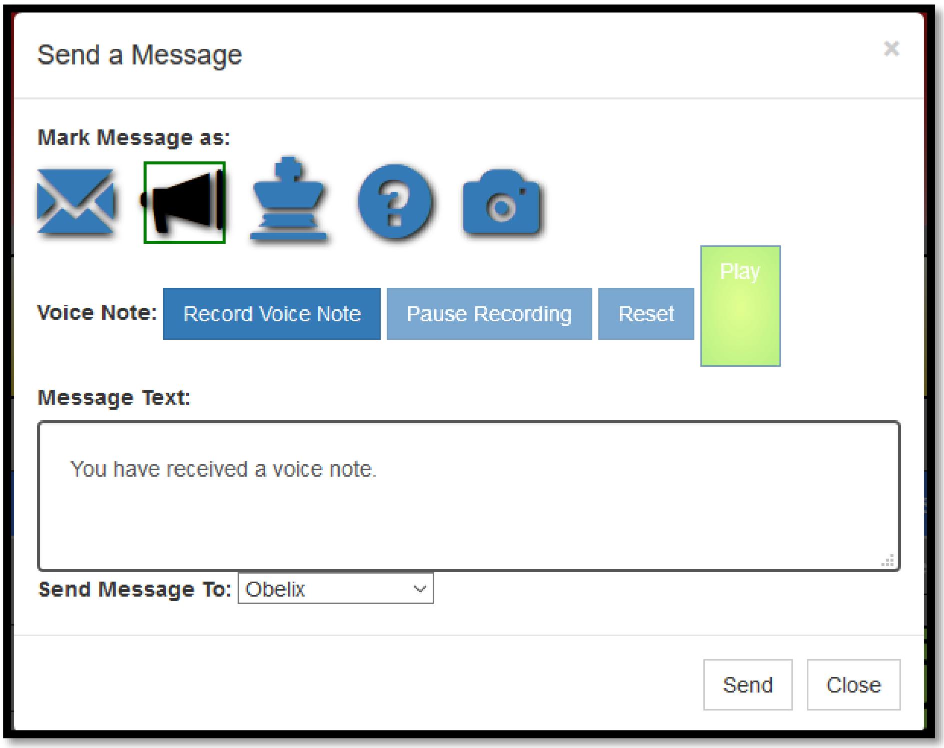

Figure 6.23: Compile audio message

Figures 6.24 and 6.25 shows the Play and Learn Store, where a tutee is taken to the "app store"-like page where they can choose between available games, books, exercises and videos.

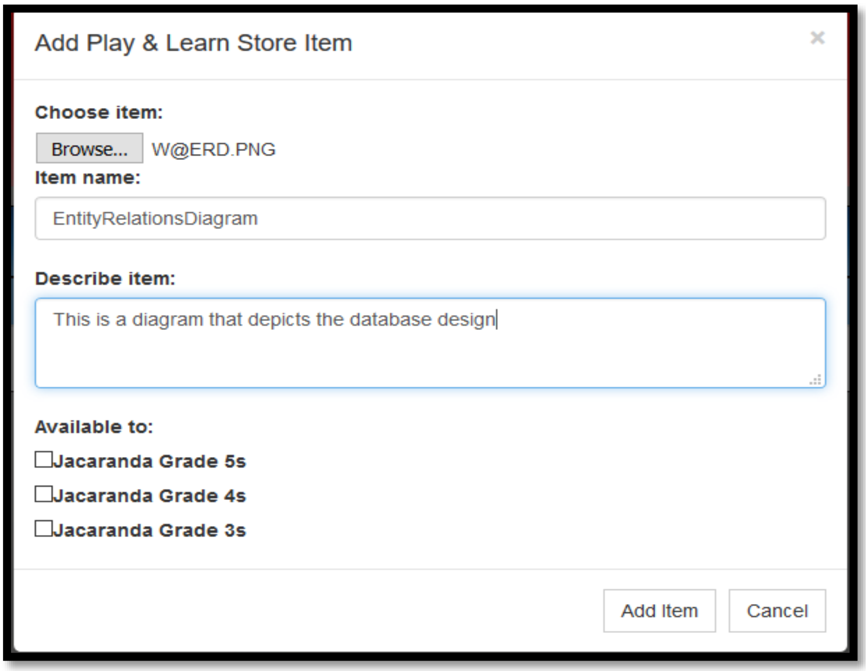

Figure 6.24: Play and learn store page

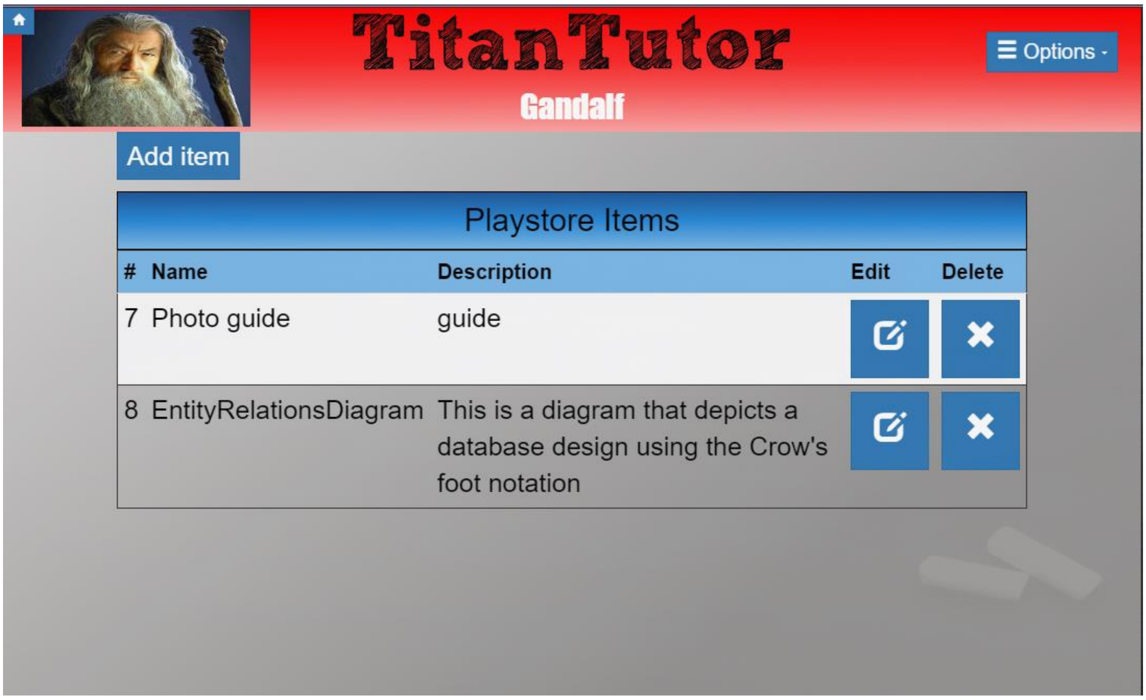

Figure 6.25: Play store tutee items

Figure 6.26 shows the facilitation of a communication channel that has video, audio, and some kind of education-orientated interaction facilities, such as a virtual interactive whiteboard to be used by tutees and tutors.

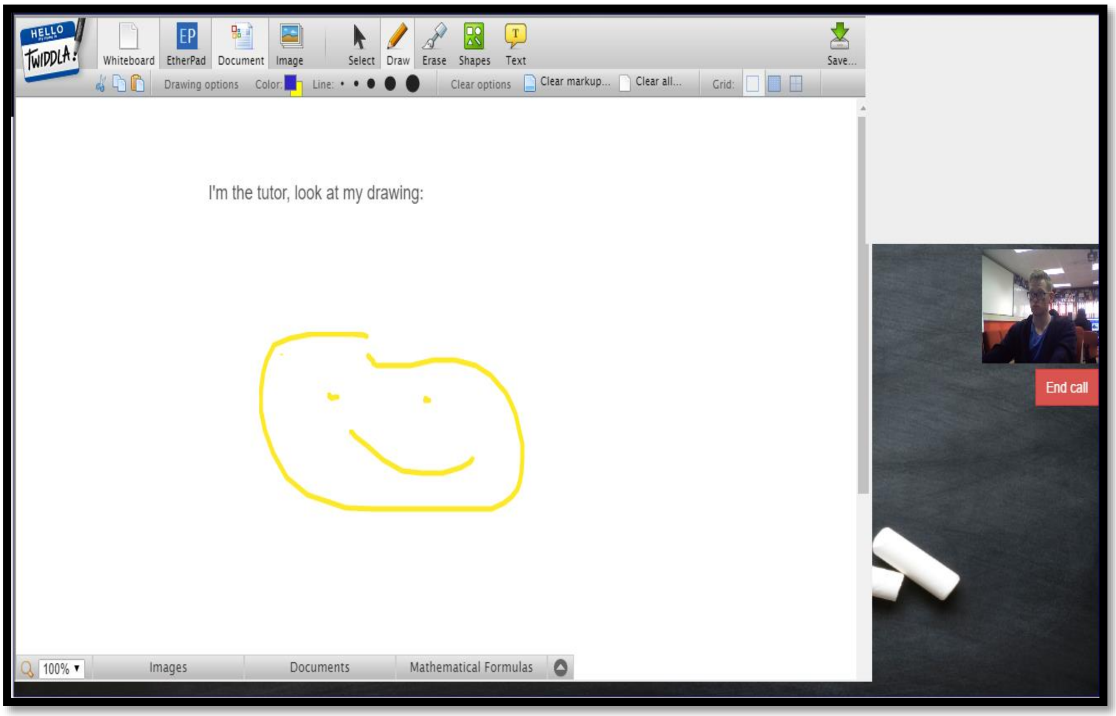

Figure 6.26: Video chat page with a whiteboard

More images depicting the interface can be found in Appendix 4. Section 6.5 discusses the evaluation of TitanTutor. However, the researchers decided to drop the picture album link, "My Image", for children's privacy, although the children wanted it.

6.5 Evaluation of TitanTutor

After the development and the implementation of the tutoring system, it was necessary to do an evaluation of TitanTutor. Evaluating an artifact is regarded as crucial for DSR (Prat, Comyn-Wattiau & Akoka, 2014; Sonnenberg & Vom Brocke, 2012). According to March and Smith (1995), evaluation in DSR aims at determining the progress achieved by designing, constructing and using an artifact in relation to the identified problem and the design objectives. To systematically show if such progress is achieved, evaluations should be guided by evaluation criteria (Sonnenberg & Vom Brocke, 2012). In this section we discuss the evaluation process of the TitanTutor artifact.

6.5.1 Execution of the Usability Evaluation

Within DSR, researchers develop artifacts to solve problems and evaluate their value (Hevner et al., 2004; March & Smith, 1995; Vaishnavi & Kuechler, 2015). To evaluate the TitanTutor solution, researchers in this study used the *demonstration* pattern and usability evaluation. The process was to first implement the tutoring system as a Web application, and then to demonstrate that, functionally, it performed its intended function. To demonstrate that the TitanTutor system was usable, researchers involved real users to represent participants, providing them with real tasks to do on the system. The users then used sticky notes to write down likes, dislikes and design ideas to critique TitanTutor's functionality. Recommended changes were then implemented. The tutoring system was then tested again as many times as possible, generating circumscription knowledge in the process. A post study usability questionnaire session was conducted. Exhaustive and iterative testing of the TitanTutor increases the confidence in the reliability and validity of the artifact.

Usability evaluation methods (UEMs) were used to evaluate the usability of the designed product, and to identify the problem areas. Usability is a measure of interface quality that refers to the effectiveness (meeting requirements), efficiency (ease of use) and satisfaction with which users can perform tasks with a tool (Bevan, 1995). Evaluating usability is considered an essential part of the system development process, and a variety of methods can be used (Dillon, 2001; Federici & Borsci, 2010).

6.5.2 Execution of the Usability Evaluation Process

The testing of the system was conducted at the Informatics Design Labs at the University of Pretoria. The session took two and a half hours. A group of 15 participants – five teenagers and five young children, three facilitators and the two programmers participated in the testing. The teenagers and young children participants' parents and guardians signed consent forms (*cf. Appendix 1*) for this activity. The aim of the evaluation of the system was to critique TitanTutor's functionality. This was done by involving actual users in using the system in a realistic manner. This would assist the researchers in identifying any usability problems, and, with the help of programmers, fix the problems. The session went through some various steps as follows:

1. Warm-up

Children and facilitators gathered together to have snacks, chatting to each other, and others played a table-soccer game.

2. Circle Time

Everybody then sat in a circle to introduce themselves, and answer the "question of the day". The question was "What do you like and what do you hate most about school, studying or work?", depending on where you are currently.

3. Activity 1-Exploring the TitanTutor

The children formed groups of two, each comprising tutor and tutee. There were three facilitators who were assisting the groups. Two programmers were assisting with technical problems. The researchers explained to the participants that the aim of this exercise was to test the usability of the system, rather than testing the ability of participants, so any problems encountered would be regarded as system problems. Appendix 5 shows some of the tasks that the participants could do.

Figure 6.27 shows some of the participants working in groups of two, and some of the facilitators assisting them. The participants were quick to point out what was fun and what bored them. Some of the participants, especially the teenagers, jotted down their ideas on sticky notes. Facilitators were jotting down the ideas of the young children.

Figure 6.27: Participants working in groups (photos included with permission of the parents and children).

Even though the children were working in pairs, they were asked to come up with their own individual thoughts for the sticky notes. Although facilitators may have helped children with the physical act of writing these notes, the ideas were generated by the children. These notes were put on a whiteboard and categorised into likes, dislikes and design ideas (*cf. Figure 6.28*). This resulted in comments from the participants.

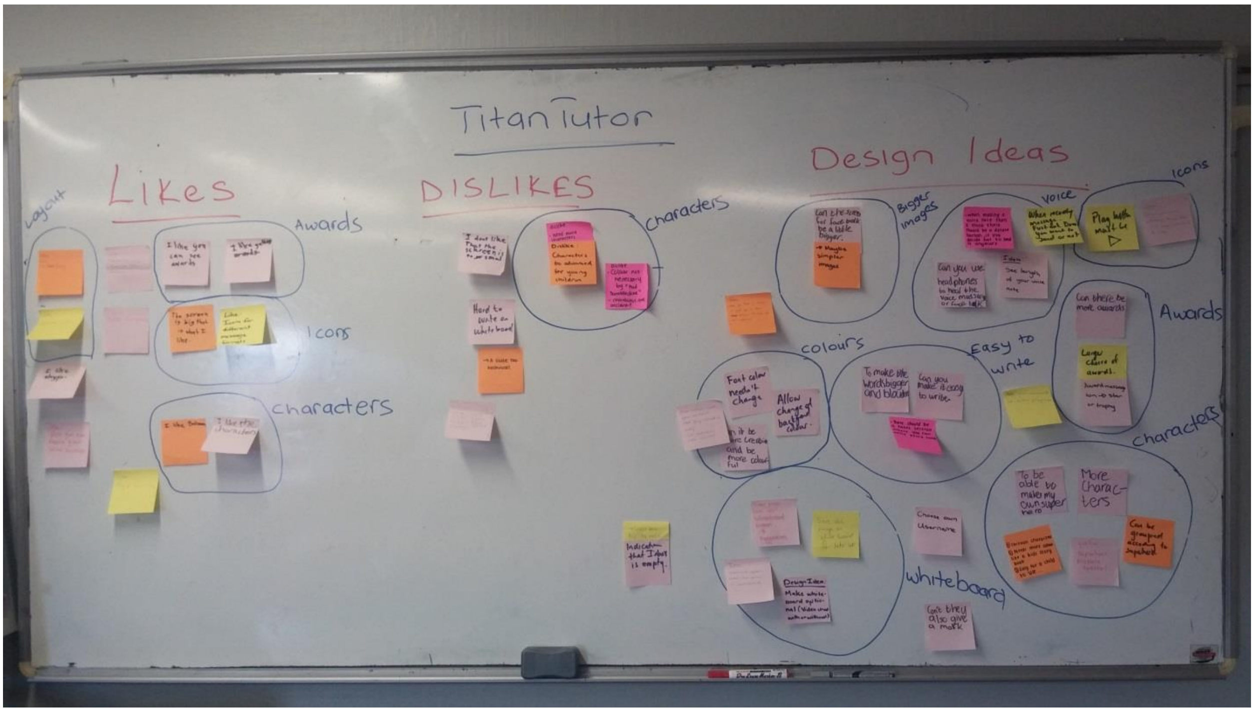

Figure 6.28: Sticky notes collected during the usability testing of TitanTutor

The researcher organised the sticky notes into general commonalities or themes, which drew the attention of the group to areas of design that needed improvement or those that should remain the same.

4. Likes/Dislikes/Design Ideas Themes

There was the possibility of more than one idea arising from each sticky note. It was therefore important to look at each individual sticky note to assess the ideas that the participants expressed. The researcher looked for things that belonged together, and formulated themes that were organised into coherent categories.

5. Discussions

After the session, during which the children provided individual and pairwise feedback, we conducted a group interview, with the programmers taking the participants through all the functionality of the system. The interface was displayed on a large screen. More design ideas emerged and were recorded by the researchers. Table 6.2 shows the content of the sticky notes organised into general commonalities by the researcher. The researcher summarised the main design ideas that emerged from the analysis of this content. These ideas offered insights into the areas of the artifact that needed improvement or revisiting.

Table 6.2: Results from a sticky note session

No.	LIKES	CONTENT OF STICKY NOTES
1.	Layout	The layout is user-friendly
2.	General inbox	I like the General Box idea
3.	Tutoring Time	Showing how much time has been spent on tutoring
4.	Tutee progress	I like tutee progress section as it shows me how I am doing
5.	Icons	Icons for different message formats
6.	Awards	• Seeing awards • Getting awards
7.	Skype	Skype.tn interface
8.	Screen	Big screen
9.	Characters	• I like Batman • Like all characters on the system
10.	Play and Learn Store	I like the play and learn store for the games
11.	Voice Message	I like that you can pause your message
	DISLIKES	
1.	Whiteboard	Difficult to write on
2.	Screen	Too small
3.	Colour	• Bright colours required • Colours not necessary
4.	Characters	• More characters required • Too advanced for young children • Characters are ancient
5.	Technical Issues	• Losing connection • English very low • Do not like sharing the mouse • Call mischief • Send pictures
	DESIGN IDEAS	
1.	Colour	• Interface should be more colourful • Text should be grey instead of white • Font colour need not change, maybe background • Allow change of background colour • Needs more colour like a kid's story book.
2.	Characters (Superheroes)	• To be able to make my own superhero • More characters required • Can be grouped according to superheroes

		• Also include cartoon characters • Also include girlie superheroes picture options
3.	Whiteboard	• Make whiteboard optional. Video chat with or without. • Username appears when user draws on whiteboard • Save the image on whiteboard for later use • Homepage – icon should be on whiteboard screen • Whiteboard must be easy to write on.
4.	Awards	• More awards required/Large choice of awards • Awards message icon to be a star or a trophy.
5.	Buttons/Icons	• Choose own username • Play button must be Δ • Show image icon • When you hover a heading it should give you a short description for those who do not know or understand what the icon means.
6.	Voice/Voice talk	• Call notification should be more insistent • When making a voice note, then I think there should be a delete button if you decide not to send it any more.
7.	Inbox	• There should be a scroll bar on “my inbox” • Indicate or show when ‘inbox’ is empty.
8.	Message	• When recording message, first ask do you want to send or not
9.	Screen	Screen for face talk to be a little bigger
10.	Comments	Tutor add own comments on tutee progress
11.	Images	Be simpler
12.	Text	• Read messages could appear less distinct • Text should be big enough and bolder for the sake of young children • There should be a notes section where one can write extra notes.
13.	Technical	• It must not be too technical • Easy for young children to use on their own.
14.	AOB	• Can tutor give a mark • Use of headphones to hear the voice messages or face talk • Different themes that are customised to user.

Post study usability questionnaires (*cf. Appendix 5*) were completed by participants to assess user satisfaction with the TitanTutor system. The ten (10) participants were, overall, satisfied with how the TitanTutor prototype was working, although there were teething problems that needed to be addressed in future revisions. The demonstration of the usability of the TitanTutor showed inadequacies of the solution, especially on the use of the skype.tn activity. Through this process of usability evaluation, *Development*, *Evaluation* and further, *Suggestion*, were iteratively performed in the course of design (Vaishnavi & Kuechler, 2015). The basis of the iteration was the flow from partial completion of the cycle back to *Awareness of the Problem,* as indicated by the *Circumscription* arrow in Figure 4.4.

6.6 Adapted Design

After the evaluation of the designed artifact, some changes were implemented. The screenshots below summarise the changes. The general changes done on all screens were to make the font bigger for ease of reading, and also to make the interface more colourful. On the awards link, more awards were added, with the awards message icon to include stars or trophies. More characters, ancient and recent, cartoons and girlie characters, were added. A scroll bar was added on both "my Inbox" and the general Inbox links, to allow users to easily move the window viewing area up or down. When users hover over an icon, it should give them a short description, or hints for those who do not know or understand what the icon means.

6.7 Conclusion Regarding the Design of the TitanTutor System

The *conclusion* phase of DSR indicates completion of a specific design solution. In this study, the design solution was concluded by testing the application with the design group. The results from the evaluation by the participants show that the solution is feasible, usable and acceptable. According to Vaishnavi and Kuechler (2015), new knowledge production is shown by *Circumscription* and *Operation and Goal Knowledge*. The Circumscription process generates understanding that can be gained from the specific act of construction. As a conclusion of a research cycle, this phase leads us to the output of a DSR project, which is the design science knowledge contribution of this study. Chapter 7 describes the contributions that this study provided.

6.8 Summary

This chapter presented the design, development and evaluation of TitanTutor system. The DSR approach was adopted, where each phase of the DSR was discussed, based on the patterns applicable at each phase. The primary focus of this chapter was to provide descriptions of the process of design and development of TitanTutor from 'big ideas' to prototypes, then high-level wireframes, to developing the system into a workable solution through programming. Evaluation of TitanTutor was conducted using usability testing, and the results were discussed. Chapter 7 describes the different contributions made that include theoretical and practical contributions. Chapter 8 concludes with a discussion of lessons learnt from the literature study, an answer to the research question, the limitations of the study, and future work.

CHAPTER 7: RESEARCH CONTRIBUTIONS

7.1 Introduction

Claims of contribution to the body of knowledge are made in accordance with the aims and objectives of the study, as set out in Chapter 1 of this thesis. DSR was discussed in section 4.2.3.2 as the methodology to execute the research plan. The design, implementation and evaluation of the system were discussed in chapters 5 and 6, in accordance with the approach described by Vaishnavi and Kuechler (2015). This chapter is concerned with the scientific merit of the study as a whole. Section 7.2 discusses the design framework that forms the main contribution of this study. Section 7.3 describes a summary of the research contributions of this study. The knowledge contributions, from contribution type to artifact contribution, are discussed in section 7.4, while section 7.5 summarises the chapter.

7.2 Defining the CD2C Design Framework

This section defines the *Co-Design by Children for Children (CD2C) Design Framework*, which forms the main contribution of this study. The design framework was derived by synthesising the knowledge gained from this research, as explained in the following paragraphs. Figure 7.1 illustrates the CD2C Design Framework.

The analysis of the results from the cooperative design phases presented in Chapter 5 identified certain socio-environmental contexts that influenced how teenagers and young, vulnerable children could co-operate as design partners. On the one hand, the environment of privilege in which the teenage research participants found themselves determined the motivation strategies that could be employed to encourage them to participate in cross-age tutoring activities. On the other hand, the underprivileged environment of the young child research participants defined their responses to acts of kindness from the privileged teenagers. It was evident that a complex interplay of these diametrically opposite socio-environmental impacts was central in defining the power relations that shaped the outcomes of the co-design sessions, as described in Chapter 5, section 5.4, and illustrated in Figure 7.1.

In Chapter 6, the outcomes of the Cooperative Design activities, namely, prototypes, ‘big ideas’, themes and prescriptive propositions, were then mapped onto the DSR research strategy steps (awareness of the problem, solution suggestion, development, evaluation and conclusion), as discussed in Chapter 4, section 4.2.3. In Figure 7.1, the outcomes of the

Cooperative Design process are illustrated as the inner activity flow of the CD2C Design Framework, while the mapping to DSR process steps is indicated as the outer activity flow. Considered individually, the inner activity flow of Figure 7.1 illustrates the established Cooperative Design process, while the outer activity flow represents the Design Science Research process steps. Considered as a unit, those activity flows, together with the corresponding mappings between the outcomes of cooperative design and DSR process steps, represent the CD2C Design Framework, which provides a guide of how co-design by children from different age groups and life circumstances should be undertaken. The circularity of the activity flows demonstrates the iterative nature of design processes, each iteration representing an increasingly more abstract and general design framework. However, the circumscriptive nature of design processes is enabled by the double-headed arrows radiating from the socio-contextual circle in which the design partners find themselves. So, for example, if a prototype resulting from the DSR Solution Suggestion step uncovers an anomaly that cannot be explained away using the co-design partners' current awareness of the problem, they can always go back to the DSR Awareness of the Problem step to revisit their understanding of the problem.

In order to instantiate the CD2C Design Framework, a practitioner starts by calibrating the socio-contextual circle of the co-design partners, which represents the environment in which the co-design partners find themselves. This entails the practitioner obtaining some understanding of the social environment and context of the co-design partners, and shaping that environment to suit the co-design outcomes. Typically, the co-design partners are given an opportunity to voice their fears, likes and dislikes, in order for the practitioner to gauge their personal circumstances, and to determine how to motivate them to participate as equal partners in the co-design process. Such knowledge is essential, not only for explaining behaviours displayed by the co-design partners, but also for shaping those behaviours using the appropriate methods from motivation theory, as discussed in Chapter 1, section 1.4. Calibrating the socio-contextual circle of the co-design partners is also important for understanding and shaping the power relations between the co-design partners. Once the socio-contextual circle of the co-design partners has been calibrated, DSR Step 1 (*Awareness of the Problem*) can commence.

Typically, the co-design partners are given an opportunity to familiarise themselves with the problem. The practitioner plays a significant role in ensuring that the co-design partners have the same understanding of the actual problem. In the case of this research, the actual problem was about how to co-design an artifact that the co-design partners would later use to support each other with numeracy and literacy skill acquisition. An adequate and common understanding of the problem triggers the beginning of DSR Step 2, *Solution Suggestion*.

In the DSR *Solution Suggestion* step, the practitioner gives the co-design partners a platform for creativity. The co-design partners use bags of stuff, as discussed in Chapter 4, section 4.2.4, to document prototypes of solution suggestions from focus group activities. The prototyping activities are then summarised into 'big ideas', as discussed in Chapter 5, section 5.4, to form the basis for the functional specification required for DSR Step 3 (*Development and Implementation*).

The co-design partners take the 'big ideas' from the DSR *Solution Suggestion* step, and classify them into design themes, which define the common design features from the two groups making up the co-design team. Prescriptive propositions are then formulated to capture the key measurable characteristics of the artifact under construction, thus forming the basis for the evaluation of the resulting artifact in DSR Step 4 (*Evaluation and Conclusion*). After this, the next iteration in the process of stepwise refinement of the resulting artifact can begin. The following section summarises the research contribution.

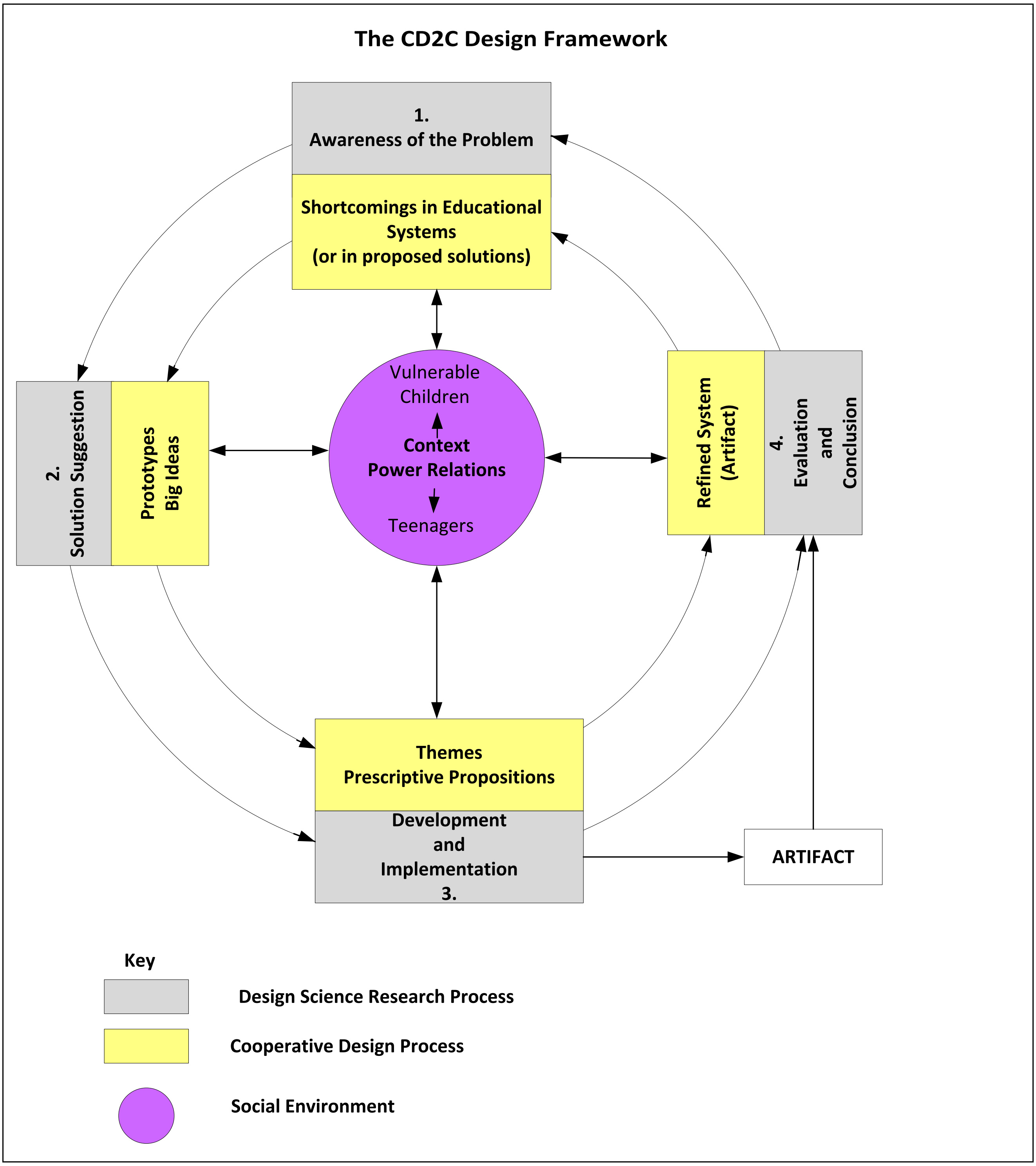

Figure 7.1: Co-Design by Children for Children (CD2C) Design Framework

7.3 Research Contributions

7.3.1 Gregor and Hevner's Knowledge Contribution Framework

Published DSR works "are analysed in terms of their new knowledge contribution and the patterns used in the performance of the research" (Vaishnavi & Kuechler, 2015, p. 309). The contribution of the work reported in this study is examined for its type as well as content. The type of knowledge contribution is discussed with respect to the knowledge contribution framework as given by Gregor and Hevner (2013), wherein knowledge is classified into four categories, namely *invention*, *adaptation*, *improvement* and *routine design*. These knowledge categories were discussed in Chapter 4, section 4.2.3.2. The design science knowledge content of the contribution is analysed to determine whether or not it can be represented as a design theory, and the status of such a theory (Vaishnavi & Kuechler, 2015). The analysis in section 7.3.2, below, is done from the following six core perspectives, as given by Gregor and Jones (2007):

i) *Purpose and Scope*: Provides a clear description of the purpose and scope of the new theory – i.e. the design theory produced should be new, interesting and true.

ii) *Construct:* Theory describes all existing or new entities or concepts relevant to the description of the theory.

iii) *Knowledge of Form and Function:* Includes the full description of models, frameworks, methods and/or other abstract artifacts that form the body of the design science knowledge.

iv) *Abstraction and Generalisation:* Generality and abstractness are the hallmarks (symbols) of theory. A theory should cover a variety of ways that the theory will get instantiated or changed, or even allow evolution, adaptation, or learning of the resulting artifacts without affecting the theory.

v) *Evaluation and Validation Propositions:* The theory should be evaluated for its truthfulness – i.e. assertions made, based on the theory, have been tested in an appropriate manner.

vi) *Justificatory Knowledge:* Includes references to justificatory knowledge that can provide a reasonable degree of justification of the theory.

With regard to DSR patterns, it is important to identify patterns and processes that are applicable to the study. The patterns used for this study were identified by reference to the general methodology of DSR discussed in Chapter 4, Figure 4.3, and the DSR phases. Sections 7.4 and 7.5, below, discuss the research contributions pertaining to this study.

7.3.2 *Knowledge Contribution*

The type of knowledge contribution from this study was *improvement* (*cf. Figure 4.5*). The study addressed the *existing problem* that previous studies on cooperative inquiry were based on adults designing with children for children. The *improved solution* developed in this study was about cooperative inquiry among children of different generations (age groups) and life circumstances as co-design partners, with little adult intervention. The novel aspect was the design and development of an artifact, the TitanTutor cross-age tutoring system, by teenagers and young children as equal partners in the design process. This contribution is related to the answer to research sub-question 6. This novelty continued with the abstraction of the TitanTutor to derive the CD2C Design Framework as a blueprint of how to design a cross-age tutoring system using children of different age groups and life circumstances as co-design partners.

Work in technology design processes is interdisciplinary. This work provided important contributions to researchers in the areas of Cooperative Inquiry (CI), Human Computer Interaction (HCI) and Design Science Research (DSR). The focus of the study was on defining a method of how children could co-design a cross-age tutoring system for use by other children. The study advanced research on the involvement of underprivileged children in cooperative design with other, more privileged children, especially in a developing world context. In that respect, knowledge contribution to the field of CI took the form of a better understanding of the motivational factors that would positively influence teenagers to make use of their ubiquitous knowledge of social media to co-create a useful artifact for their own use in support of less privileged younger members of society.

The study also provided a better understanding of the power relations that may exist between privileged teenagers and underprivileged, younger children, and the impact of such disparity in privilege on cooperative inquiry between the two groups. Awareness of these power relations is expected to lead to better cooperative inquiry outcomes. The research results could potentially be used to encourage design project leaders to involve children in developing countries in technology design, where the target end users are also children.

The type of knowledge contribution to the field of HCI was also *improvement*. Whereas usability theory concepts such as efficiency, effectiveness, satisfaction, accuracy, recall and emotional response (Nielsen, 1993, 1994; Schneiderman, 1998) are well established, usability evaluation of the TitanTutor artifact showed the importance that the concepts of presence, privacy, security and messaging had to usability of social media based artifacts. Therefore, this study has contributed to the improvement of usability theory, with the proposed addition of these concepts as fundamental concepts of usability theory relevant to social media based platforms, answering the research sub-question 5.

Design science knowledge contribution of this study rested in the TitanTutor artifact and the CD2C Design Framework. The TitanTutor artifact contributed knowledge to Design Science Research through its construction and design science theory building. This contribution is in answer to research sub-questions 2, 3 and 4. The CD2C Design Framework added design science knowledge to DSR to the extent that the framework provided DSR practitioners with guidelines on how co-design of a cross-age tutoring system could be undertaken by children of different age groups and life circumstances, giving an answer to the main research question.

7.3.3 Practical Implications of the Design Contribution

In chapters 2 and 3, a body of literature that investigated cooperative design processes and cross-age tutoring, was discussed. Although researchers in many of these studies mentioned the benefits that they felt participating in a technology design process may have had on the children who participated in them, there has been no published research investigating cooperative design by children of different age groups and life circumstances. The potential practical implications of the research contribution to design science are that children involved in technology design may experience positive social and cognitive experiences while on a technology co-design team. Knowledge gained from the literature studies summarised in chapters 2 and 3 indicated that the absence of published research reports on cooperative inquiry among children of different age groups could potentially open up new research directions for Cooperative Inquiry.

Another contribution of the current research is to fill the void of information on the design experiences of children who are intimately involved in a technology co-design process with other children of different life circumstances. Specifically, the study shows that the societal context of co-design partners plays an important role in determining the success of a co-design project. Thus, on the one hand, privileged children require specific motivational approaches consistent with their position of privilege in society, as discussed in Chapter 5, section 5.2. On the other hand, working with underprivileged children as co-design partners requires sensitivity to their vulnerable position in society, as discussed in Chapter 5, section 5.3. Thus, the societal context of co-design partners must be taken into account as one of the key success factors for co-design by children of different age groups and life circumstances. Inequality between privileged and vulnerable children manifests itself in the power relations that play out between the two groups. These power relations determine how the co-design partners position themselves as co-design partners. The main driver for putting together a diverse group of co-design partners is to emphasise the strengths while minimising the weaknesses arising from the differences. This work provided an initial foray into investigating these phenomena, thus providing impetus to other researchers who are interested in this area. This work provides information from a targeted, directed and formal investigation, specifically investigating children from different generations and life circumstances, as co-design partners.

The study shows that children from different age groups and different life circumstances are able to design a system together that can assist their peers with homework and test preparation support. Specifically, the study shows that vulnerability and skewed power relations can be managed, to enable co-design partners from different age groups and life circumstances to participate as equal partners in a co-design project. An understanding of the key success factors of a co-design project resulting from diverse societal contexts of the co-design partners is essential in unlocking synergies between co-design partners. Thus, for example, the research shows that privileged teenagers require special motivational tools to encourage them to participate in co-design projects with less fortunate younger children. An understanding of Vygotskian cognitive theory and behavioural theory is required to maximise the participation of vulnerable children as equal co-design partners with more privileged teenagers. The current work on cooperative design with teenagers and young children provides data to those interested in children of different age groups and vulnerability designing together.

In addition, some aspects of the current work fit within the area of educational research, including work on peer relations, social development theory, motivational theory, and literature on social media. The Vygotskian lens allows for examining cognition through the social domain. Vygotsky's theories stress the fundamental role of social interaction in the development of cognition (Vygotsky, 1978), as he believed strongly that community plays a central role in the process of 'making meaning'. Vygotsky states that cognitive development stems from social interactions from guided learning within the ZPD as children and their partners co-construct knowledge. According to Vygotsky (1978), much important learning by the child occurs through social interaction with a skilful tutor. The tutor may model behaviours and/or provide verbal instructions for the child. Vygotsky refers to this as cooperative or collaborative dialogue. The child seeks to understand the actions or instructions provided by the tutor (often the parent or teacher), and then internalises the information, using it to guide or regulate their own performance.

According to Vygotsky, this type of social interaction involving cooperative or collaborative dialogue promotes cognitive development. Vygotsky also views interaction with peers as an effective way of developing skills and strategies. He suggests that teachers use cooperative learning exercises where less competent children develop, with help of more skilful peers, within the ZPD. The results from the current work on cooperative design with privileged teenagers and underprivileged younger children, provides evidence of the ability of children, from whatever societal background, to rise to the challenge of co-designing with other children, given the opportunity. This directly supports Vygotsky's perception of social interaction as playing a fundamental role in cognitive development.

Cooperative design in a developing world context improves current practice in ICT for development. With regard to the design of technology for development, a CI technique that is also recommended is the use of audio recordings to supplement accepted cooperative design techniques (Gelderblom et al., 2014). The technique has not yet been widely used in research. The suitability and success of the use of this approach by vulnerable children and teenagers, depends on removing the communication barriers created by the power relations between children of different age groups and life circumstances. The context within which we conduct research with children is an important factor to consider when asking children to voice their opinions. Researchers have used different approaches and systems to tap into the minds of children and to give them voice.

This thesis contributes to the discussion around co-design practice between children of different age groups and life circumstances, providing props for reflection for practitioners. Practical applications of the research results were demonstrated in Chapter 6. That demonstration served as proof that the artifact thus co-designed indeed served the desired purpose. The next section discusses the contribution of this study to the advancement of Design Science theory.

7.3.4 Theoretical Implications of the Design Contribution

Theoretical contributions are useful in the pursuit of future knowledge. They advance our understanding by providing inherently reusable constructs and ways of thinking about problems. Theoretical contributions must be validated for novelty, importance, and descriptive and predictive power. Figure 7.2 illustrates the general inductive process of theory building, adapted from Carlile and Christensen (2005).

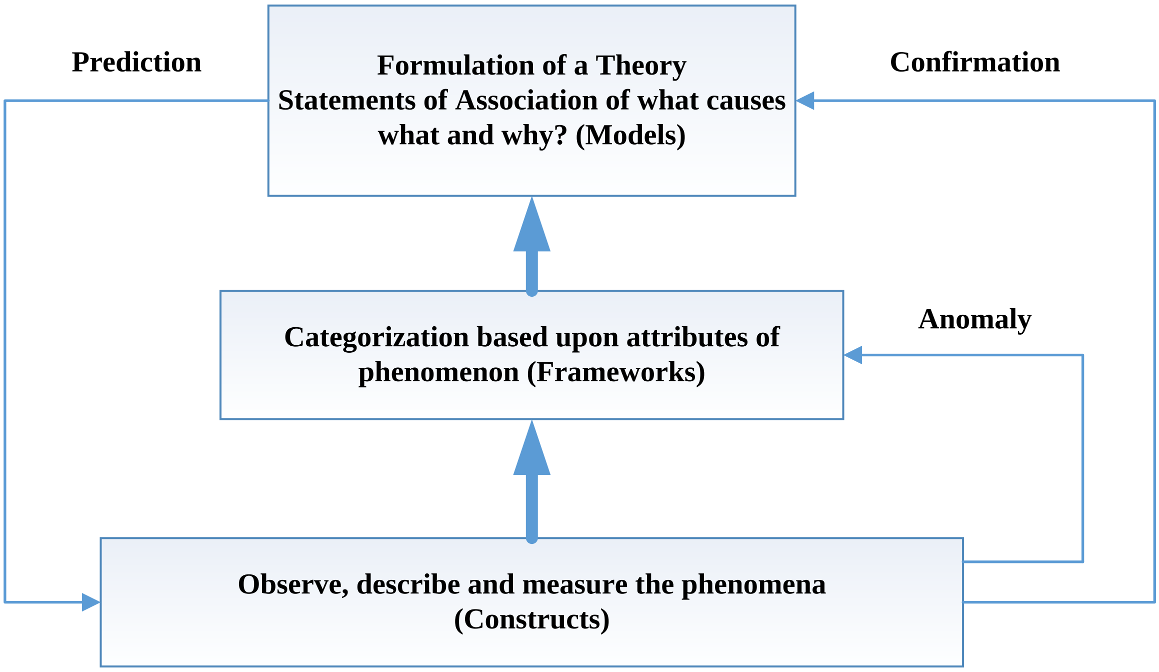

Figure 7.2: General Inductive Process of Theory Building (Source: Carlile* & Christensen, *2005)

The three-step general inductive process of theory building begins with observation of a phenomenon of interest, its description and measurement. The outcome of this step is a construct or artifact whose main objective is to afford the observer full understanding of the phenomenon of interest. In the second step, properties of the construct that represents the phenomenon are categorised into groups of properties each group of which identifies a certain theme. Such classification into themes represents the beginnings of a framework. The relationships between the themes are then defined to represent the models of the real life phenomenon. A construct could reveal anomalies that then require a reclassification of the properties of the construct. Alternatively, observation of a phenomenon could provide confirmatory evidence of causal relationships between properties of a phenomenon. Theory assists in predicting future observations of a phenomenon.

The following is an assessment of the contributed design science knowledge as a design theory, with respect to the six core perspectives of Gregor and Jones (2007), discussed in section 7.3.1. The design theory developed is a framework for co-designing by children from different age groups and life circumstances. It essentially states that cooperative design by children from different age groups and life circumstances is tempered by socio-environmental context and power relations between the co-design partners.

Purpose and Scope

The purpose of DSR theory building in this study was to construct a design framework (CD2C) for co-designing by children from different age groups and life circumstances. The scope of the framework was limited to a developing world context. An artifact, the TitanTutor, was built as part of the process of inductive theory building. The CD2C Design Framework was then induced from this artifact as a Design Science inductive theory of how the process of co-design by children of different age groups and life circumstances should proceed. This study emphasised the point that, through the use of cooperative design, children should be given “a voice” in the design and development of technologies that are meant for use by children. The involvement of the children in the design of the system is expected to contribute to a long-term interest in science and technology. The following steps discuss inductive theory building for the CD2C Design Framework.

Step 1: Observation (Constructs)

The researchers observed the co-design process, and carefully measured and recorded what they saw, as discussed in Chapters 5 and 6. Several constructs emerged as a result of those observations. Audio recordings (later transcribed) were the main constructs that captured how the children had experienced the face-to-face tutoring sessions of Chapter 5 (*cf. Appendix 6*). The design sessions of Chapter 5 produced prototypes as the main constructs, serving as precursors to the next construct category of 'big ideas'. The 'big ideas' were then converted to themes, from which prescriptive propositions (as discussed in Chapter 6, section 6.3.5) were then derived. The prescriptive propositions served as functional specifications for the design of the TitanTutor. Later, the implementation of the prescriptive propositions was evaluated, using the method of usability testing and sticky notes, as the research participants used the system under observation by the researcher.

Step 2: Classification

The main design constructs were classified into Prototypes, 'big ideas', Themes and Prescriptive Propositions. Classification was also used in the process of describing test cases for the evaluation of the prescriptive propositions of Chapter 6. For example, the prescriptive proposition of navigability was used to categorise the set of tests that would be needed for usability evaluation to test the ease of navigation of the artifact.

Step 3: Defining Relationships (Models)

The researchers explored the relationships between the socio-environmental contexts of co-design partners and the power relations resulting therefrom. The outcome of such an exploration was important in defining how using established motivational theory and teenage research participants, could be motivated to participate in the research project. Equally importantly, using established cognitive and behavioural theory, the researchers also explored how to provide the right socio-environmental atmosphere for vulnerable children to participate as equal co-design partners with privileged teenagers. The researchers then explored the relationships between design prototypes, 'big ideas' and prescriptive propositions as part of the cooperative design of the TitanTutor artifact. Design prototypes gave rise to 'big ideas', which in turn gave rise to prescriptive propositions in the design of the TitanTutor artifact. The prescriptive propositions were then used to develop test cases for the evaluation of the TitanTutor artifact using established Usability Testing methods. The strong theoretical bases of the relationships identified in these considerations gave justificatory evidence of the sound theoretical footing of the CD2C Design Framework that was induced from the TitanTutor artifact.

Knowledge of Form and Function

The TitanTutor artifact was illustrated in Figure 7.1. Examples of some aspects of a specific implementation of the TitanTutor artifact can be found in Appendix 4. Design knowledge of the TitanTutor artifact was gained through its construction, while knowledge of its function was obtained through its use by the research participants, and evaluation using the methods of usability testing. The CD2C Design Framework was described and illustrated in section 7.2. Future researchers have the opportunity to create instantiations of the CD2C Design Framework, as part of the iterative process of theory building and improvement, with the aim of achieving abstraction.

Abstraction and Generalisation

In this study, the CD2C Design Framework was proposed as a guide for co-design by children from different age groups and life circumstances from a developing world context. The TitanTutor represented a specific co-design artifact from which the CD2C Design Framework was induced as part of the Design Science Theory Building process. Future researchers have the opportunity to instantiate the CD2C Design Framework in different ways. An instantiated system could even be changed, as long as it complies with the underlying design framework. Even though the design science theory developed here pertains to co-design by children from different age groups and life circumstances in a developing world context, the researcher believes that the CD2C Design Framework could also be abstracted to the design of any product by any group of co-designers. The important thing in any of the possible instantiations of the CD2C Design Framework is to identify the specific societal, individual and group characteristics of the co-designers that make them unique and that have a bearing on the design outcomes, and then to modulate the design process with those aspects.

Evaluation and Validation

Chapter 6, section 6.5 discussed the evaluation and validation of the functionality of the TitanTutor, using the methods of usability testing. As a design artifact from which the CD2C Design Framework was induced as part of Design Science theory building, the TitanTutor is a specific implementation of cross-age tutoring systems for literacy and numeracy skills acquisition for children of different age groups and life circumstances. Specifically, the TitanTutor practically exercised the prescriptive propositions of Chapter 6, section 6.3.5. Tests for validity of the prescriptive propositions were conducted as part of the post-implementation phase, wherein a focus group of representative end users exercised the TitanTutor and provided the researcher with feedback related to their user experience. To the extent that the TitanTutor functioned in accordance with its specifications, the possibility of co-designing by children of different age groups and life circumstances was practically proven. The degree of acceptance of the TitanTutor by other child end users of the product was established through the post-implementation testing focus group meeting, as described in Chapter 6, section 6.5.4. The established theoretical foundations of the TitanTutor artifact (Vygotskian Cognitive Theory, Behavioural Science, Motivational Theory, Cooperative Design, Design Science Research and Usability Testing) provides justificatory evidence of the theoretical basis of the CD2C Design Framework which emerged as a design science inductive theory of co-design by children from different age groups and life circumstances. Evaluation and validation of the CD2C Design Framework will be left to future researchers to accomplish as part of the iterative process of theory building and improvement with the aim of achieving abstraction.

Conclusion on the Status of Design Theory

Based on the preceding evidence, the study contributes a nascent co-design theory. The South African design research community can build upon this work to create a well-developed and general co-design theory for tutoring systems, designed and developed by children from different age groups and life circumstances. In its current form, the CD2C Design Framework is relevant for the co-design of a cross-age tutoring system by children from different age groups and life circumstances. However, at the abstraction level, the CD2C Design Framework could be extended to apply to the design of any product by any groups of co-designers.

7.3.5 Artifact Contribution

Artifact contributions are designs that reveal new opportunities. They are, by definition, dependent upon inventions or improvements that are instantiated as prototypes, sketches, etc., and are often somewhat functional. Novel designs may be prototypes or sketches whose purpose is to exhibit new possible features. Artifact contributions are often accompanied by empirical evaluations. They are best evaluated on the basis of 'what they make possible', 'how they do so', and 'what new possibilities they open'.

In terms of the design of the TitanTutor artifact, Cooperative Design was used:

- To provide an overview of the process steps of how to co-design the artifact;

- To provide practical advice in the planning stages of design (e.g. what motivates teenagers as co-design partners, what behavioural traits are common among vulnerable children, etc.) or when choosing options during all the stages of design;
- To build prototypes;
- To stimulate big ideas; and
- To develop and evaluate the artifact based on the prescriptive propositions.

Design Science Research provided a methodology for the construction of the TitanTutor artifact. Considered together, Cooperative Design, Design Science Research, the socio-environmental context of the co-design partners, and the relationships between them, provided the basis for inductive theory building for the CD2C Design Framework as a guide to how co-design by children from different age groups and life circumstances should be conducted.

Therefore, the DSR work done in this study was analysed in terms of the new knowledge contribution and the research patterns used in the performance of the research. This research was an example of learning and investigation through artifact creation, which is the most fundamental characteristic of DSR.

7.4 Summary

The proposed CD2C Design Framework contributes knowledge to the cooperative inquiry practice of co-design by children of different age groups and life circumstances. The framework has theoretical foundations in Vygotskian cognitive theory, cooperative design theory and Design Science Research theory. In that regard, the proposed framework was induced from the TitanTutor artifact with theoretical rigor. The TitanTutor artifact was a specific co-design construct of the DSR process, providing proof of the concept. With the work presented here, this study succeeded in providing young children with an artifact that they could use for homework support, and a design framework that future researchers can instantiate in order to create similar artifacts.

In Chapter 8, I will present lessons learnt from the literature review and design processes. I will also present answers to the research question. In addition, I will discuss implications and limitations of the study, and possible future directions for the research.

CHAPTER 8: CONCLUSIONS AND FUTURE WORK

8.1 Introduction

In this chapter, conclusions are drawn from the research reported in this thesis. The whole process of the study, from its rationale to its results, is summarised in section 8.2. The lessons learnt from the literature study and the design processes are presented in section 8.3. While some of the research questions posed in Chapter 1 have already been answered in previous chapters, section 8.4 answers the remaining research questions. Limitations of the study are presented in section 8.5, while section 8.6 proposes future research directions to develop the research further and to overcome some of the limitations. Concluding remarks are summarised in section 8.7.

8.2 Research Summary

Involving end users in the design process has raised debate in the HCI and Cooperative Design communities. Some researchers have shown that involving users, especially children, in the design of products that are intended for children enhances design outputs, with improved usability, meeting user needs, increasing user satisfaction and product acceptance (Mazzone, 2012; Abras et al., 2005). However, some researchers believe that involving end users can bias designers' imitative designs, as users can express their preference in terms of the design with which they are already familiar (Panne et al., 2003). Others believe that paying too much attention to end users may erode the role of the designers, whose vision and creativity are essential for innovation (Hekkert & Van Dijk, 2001). Although we are aware of such debates, people remain interested in researchers' and designers' attempts to constructively interact with end users, and support the idea that users can and should play a role in designing the products they use.

Designing for children by children is crucial, as it helps in understanding and capturing the needs of the children and meeting their requirements. Several researchers have shown that co-designing with children narrows the gap that exists between adult designers and child users (Druin, 1999; Nesset & Large, 2004; Markopoulos & Bekker, 2003). This study identified the existence of a research gap in co-design practice, whereby there is little to no evidence of co-design projects being undertaken by children of different generations (age groups) and life circumstances.

This study identified the need for cooperative inquiry to be adopted as a design practice in developing countries, in order to narrow the gap in design practices between developing (South Africa, in particular) and developed countries. Co-design by young children and teenagers as design partners resulted in the breaking down of power relations between the different generations, resulting in richer design outcomes. The study followed a Design Science Research process, with emphasis on designing a framework that builds knowledge through the construction of an artifact and the evaluation of its perfomance (Vaishnavi & Kuechler, 2015). The thesis reported on the progress through the research process, from the awareness of the problem phase, solution suggestion, development and evaluation, to the conclusion phase which indicated completion of a specific design project. The evaluation of each artifact, according to the approach described by Vaishnavi and Kuechler (2015), was discussed in Chapter 4, section 4.2.3.

Drawing knowledge on co-design practice from the review of the literature, face-to-face tutoring, and co-design sessions, was practical validation that co-designing among children can be done. The following section discusses the lessons learnt from the literature review and the design process.

8.3 Lessons Learnt from the Literature Review and the Design Process

The value of research is appreciated if its results solve problems or answer questions. The magnitude of this value depends on the quality of the research effort. As such, research is, in general, measured according to its validity and reliability, in terms of the knowledge claims that result from the research literature. The context of the research effort plays an important role in the process of establishing the validity of the research results produced. Results, in essence, contribute to the existing body of knowledge, so that the understanding of the field of study can move forward.

8.3.1 Lessons Learnt from the Literature Review

The review of the literature around cross-age tutoring, social networking platforms and cooperative design described in Chapters 2 and 3, identified relevant aspects with regard to tutoring and cooperative design with children. The literature on cross-age tutoring and design afforded the researchers a deeper understanding of these practices in the context of South

Africa, and allowed gaps to be identified. This understanding has been used as a starting point for the development of an artifact that could help in bridging the gaps that emerged.

- Peer tutoring or cross-age tutoring was found to be beneficial, in that it provides an opportunity for students to receive individualised attention and support in an extremely effective manner.
- It promotes a more cooperative environment that leads to improved student attitudes toward homework, and positive academic, attitudinal and socio-emotional outcomes for students who participate as tutors or tutees. Peer and cross-age tutoring programmes also provide another avenue by which students who may otherwise be hesitant to approach teachers or parents, could access help from peers young and old. The young participants reported that they felt more comfortable working with the teenage tutors, during the face-to-face tutoring sessions.
- Participation in tutoring programmes results in both academic and affective improvements for a variety of learners, including low-achieving learners, those from underprivileged backgrounds, and learners with behavioural challenges. Students also benefited from the opportunity to interact with peers and older student role models in a positive and productive manner, demonstrating improved social skills. These benefits have been witnessed among both regular and special education students across a variety of different subject areas and at all grade levels, including elementary schools, middle schools, high schools and colleges (see Chapter 2).

However, from the research and studies done in South Africa, it is evident that cross-age tutoring outside the school environment has not been widely researched, accepted and practised, let alone cross-age tutoring using technology. Studies on cross-age tutoring using social media (as mentioned in Chapter 2) are few, and not systematically evaluated and representative of all user groups. Vygotsky’s theories emphasised that children learn more when actively working together. He stressed the importance of collaborating with a more competent partner (Vygotsky, 1978). In a tutoring relationship, a more competent tutor can offer instruction at a level just beyond the tutee’s individual capability – that is, within the tutee’s ZPD (Vygotsky, 1978).

The literature review on cooperative design (see Chapter 3) highlighted the importance of involving children as co-designers in the design of artifacts that are intended for them as end users. Research has shown that cooperative design has been used extensively by researchers in developed countries. No examples of cooperative inquiry with children in developing countries, including South Africa, could be found in the literature. One explanation is that issues relating to the context of the developing world (e.g. cultural aspects and socio-economic circumstances) have made it difficult to initiate and implement cooperative design efforts, as stated by Gelderblom et al. (2014).

Chapter 3 reviewed literature related to the topic of cooperative design with children, including establishing Vygotsky's work as a theoretical framework for the study. The chapter explained and described the characteristics of cooperative inquiry, and identified gaps in research on it. Co-design approaches are based on principles such as the importance of involving children in the design of technology intended for children, iteration of analysis, design and evaluation stages. Cooperative design is a useful practice to get end users to design more user-centred products, but rely on designers for finalising the design into a workable solution. It is important to take into account that cognitive and emotional development, and cultural and social background, are important variables that influence the capability of children to interact with technology and participate in co-design sessions.

While much research has been done examining the technology that resulted from the design processes, and the impact of this technology on the children who are the end users of the technology, there was a lack of targeted research on the impacts that participation in a technology design process can have on the children involved (Guha, Druin & Fails, 2010). Technology design process researchers have indicated their interest in this topic by speculating on what the impacts of technology design processes on children might be.

8.3.2 Lessons Learnt from the Design Process

Chapter 5, section 5.4, described lessons learnt from the design process of this study. In this section, a brief summary of these lessons learnt are given as follows:

- Good design is design that is conducted with the end users rather than on end users. This study showed that children are quite capable of developing a system on their own with little interference from adults. The cooperative inquiry used in the design process allowed every member of the design team to initiate and exert influence on the design of TitanTutor. The method helped in fostering connectedness in child designers. The researcher learnt that, through CI, knowledge generation is placed in the hands of everyone, including children.

- Co-design is a useful practice to get users' real insights in developing a system. The variety of competencies of the participants in the co-design sessions done in this study helped in optimising the value of each one's contribution.
- Decisions on each organisational aspect of co-design sessions (e.g. grouping of participants, space used, materials employed, time allowed, etc.) have an impact on the overall outcome. Considering how to engage children in the activities benefits the outcome of the design process. This engagement can be achieved by using a variety of channels (face-to-face tutoring, audio or video recordings, etc.) to allow children with different abilities to express themselves.
- Planning for flexibility, in terms of resources or time used for the activities, helps in dealing with unpredicted changes in the circumstances of the sessions that can influence the outcome.
- Challenges can be encountered, e.g. logistics, time constraints, language barriers (section 5.4.2.3) etc., when children from different age groups and socio-economic backgrounds co-design, but, if managed well, the diversity of preferences from the different groups should result in designs that are better on account of richness in diversity.
- Giving more opportunities to the child designers can result in their becoming comfortable with the methods and techniques of a design process.

The lessons learnt from the co-design phases and DSR steps served to reinforce knowledge on the different elements that belong in co-design sessions, and therefore contribute towards answering questions on design. The variety of competencies of the different participants in co-design sessions have to be clearly identified, in order to define their roles in the process and to optimise the value of their contributions. Considering how to engage children in the activities, e.g. face-to-face tutoring, can benefit the outcome of the co-design sessions. Lessons learnt contributed to the formulation of answers to the research question: *'How can a cross-age tutoring system be designed for implementation on a social networking platform to support* *numeracy and literacy skills acquisition?* In order to further define the scope of the research, this question was broken down into sub-questions which are discussed in section 8.4.

8.4 Answers to the Research Question and Sub-Questions (SQ)

The research process throughout the study progressively provided answers to the six research sub-questions, and led to answering the main research question (section 1.2.4) as detailed in the following section. The answers are rich descriptions based on the rigorous study of relevant literature and the design process.

8.4.1 SQ1: To what extent are teenage tutors willing and able to provide learning support to foundation phase learners who do not have access to such support?

This sub-question was answered in detail in Chapter 5, section 5.2. Interviewing teenagers about possible participation in a cross-age tutoring system based on a social networking platform, revealed that the teenage girls in grades 9 and 10, who were interviewed, to a large extent were clearly willing to participate in cross-age tutoring for reasons ranging from intrinsic gains to purely external rewards. Teenage boys in these grades who were interviewed, were willing to participate in the designing of the system, rather than in tutoring. A possible way to resolve the challenge of motivating teenage participants to take part in tutoring, could be to reward them for tutoring.

8.4.2 SQ2: What are the best practices in providing after-school numeracy and literacy tutoring to grades 3 and 4 learners?

Observations of face-to-face tutoring and audio recordings yielded some basic practical guidelines which could be useful in providing after-school numeracy and literacy support to grades 3 and 4 learners. They are as follows:

- Regular and consistent one-on-one tutoring with a specific tutor. This helps the tutee to connect with a specific individual, rather than working with a different person in every session.
- Tutors should have other activities ready, in case the tutees do not have specific homework or test preparation to do (e.g. using real-world activities related to numeracy or literacy that children already appreciate and enjoy).

- Collaboration between peers. If the tutees need to be paired up, they need to be friends because it is difficult to work with two or more who do not get along.
- Using educational games that target numeracy and literacy strategies and skills. These games can be competitive, cooperative, and encourage involvement. A detailed discussion on educational games is given in the next section.

We also found some valuable literature sources to answer this question. Tutoring complements great teaching. Across empirical studies conducted, several practices have consistently emerged in successful programmes (Chapter 2). Best practices in providing after-school mathematics and literacy tutoring to grades 3 and 4 learners can help in building skills for achievement, and increase learners' motivation to learn. The researcher therefore incorporated the best practices found in the literature, in the design of the artifact. Best practices we found in the literature were as follows:

a) Tutee Recruitment and Management

A clear plan of recruiting and managing tutees should be implemented, by determining which tutees the application can best serve. In order to most effectively reach the identified group, a strategic plan must be created. The tutee enrolment and registration must be managed (Bixby, Gordon, Gozali-Lee, Akyea, & Nippolt, 2011; Topping, 1995, 2008; Topping et al., 2003, 2004, 2011).

b) Tutor Recruitment and Management

There must also be a clear plan to recruit and manage tutors. It is a best practice to develop a consistent and systematic screening process, e.g. volunteer applications, interviews, background checks and reference checks, etc. High-quality tutors who are committed, who can easily master the material content, and must have an acceptable level of interpersonal skills, are to be recruited. Tutors must be able to work closely and positively with the tutee (Gordon, 2008; Bixby et al., 2011). On the management side, there must be a plan for tutor supervision, as well as incentives for tutor retention and recognition.

c) Tutor Training

Initial and ongoing training opportunities must be offered, in order to build the capacity of tutors to best meet the needs of tutees. Tutors will need to be taught to give clear directions, encourage, and praise tutees for their efforts. Tutors need to be informed about the purpose of offering homework support and their responsibilities as tutors. Tutors must make a consistent time commitment, and have a positive relationship with the tutee (Gordon, 2008; Bixby et al., 2011).

d) Tutoring Intervention

There must be tutoring interventions tailored to individual learners' needs and progress. The interventions must be aligned with the school curriculum on homework. Achievements of best practices are a process of continuous improvement (Hott, Walker, & Sanhi, 2012; Gordon, 2008; Bixby et al., 2011).

e) Engaging with Families and Schools

Family involvement is a key factor for a learner’s success. The involvement can be in the form of supervision, to see if the tutees are doing their work. The creation of a strong relationship between teachers and school management results in success in the improvement of homework by tutees (Shute, Hansen, Underwood, & Razzouk, 2011). In the case of this study, vulnerable children in the care centre found family support in the care staff, who played familial roles to the children.

f) Evaluation

A plan must be put in place for researchers to use systematic evaluation to assess the impact on student outcomes and inform continuous improvement. The tutees deserve quality homework support, so regular and systematic programme evaluation should be implemented, as it is an effective practice related to significant tutee gain. With evaluation, researchers are able to measure the effectiveness of the system and its impact on users (Hacker, Dunlosky & Graesser, 2007).

8.4.3 SQ3 Which elements of face-to-face tutoring can be incorporated into a tutoring system with similar characteristics to a social networking platform?

This question was answered fully in Chapter 5, section 5.3.2. Tutees listening attentively to a tutor reading a passage proficiently to them was an element of face-to-face tutoring that could potentially help tutees improve their own reading skills. In addition to that, there were verbal prompts which the tutors used to help tutees read words correctly. Repeated readings of a homework passage also assisted tutees in improving and mastering of the passages read. In the system designed, audio was added to allow tutees to read aloud while the tutor followed the reading and provided verbal prompts any time they were required.

The other element of face-to-face tutoring that can be incorporated into a social networking-based tutoring system is the use of the whiteboard functionality. On the system designed, an interactive whiteboard was added to allow tutees to handwrite homework which could be transformed into text and saved. The whiteboard functionality would be a powerful tool allowing tutees and tutors to interact and collaborate. On the one hand, tutees can manipulate the elements on the board by using their fingers as a pointing device directly on the screen. On the other hand, tutors can use the whiteboard to add comments on a tutee’s work, or highlight elements and even demonstrate the content available in the system. When offering feedback, the tutor can call upon the tutee to interact with the whiteboard. The tutor sits at the computer, with the tutee at the whiteboard, and they share suggestions and contribute ideas. The whiteboard promotes discussion and participation.

From the design sessions discussed in design phase 3 in Chapter 5, section 5.3.3, a fundamental component of successful tutoring that was included in the design in which the tutee would actively and willingly engage in learning through homework, was a video and audio-chat functionality. During face-to-face tutoring, the tutees appreciated the physical presence of the tutors, which resulted in their getting attached to each other. It was therefore important to include the video and audio functionality in the design, as this would allow tutors and tutees to see and hear each other, and get to know each other as well – resulting in building trust.

During face-to-face tutoring, some of the activities introduced by tutors were games, especially during those times when tutees had no homework or had completed or done well in their homework. An “app store” with a variety of games, e.g. mathematics-oriented games and intellectual puzzles, was included in the design in order to engage tutees. There was also inclusion of ordinary games to reward tutees who had done well in their homework. Research has shown that educational games can promote understanding of numeracy and literacy (Chapter 2). These games are fun activities that develop targeted mathematics strategies and skills by leveraging students’ natural inclination to play. Educational games have repeatedly been proven to increase students' understanding and achievement in mathematics (Kamii &

DeVries, 1980; Peters, 1998; Hildebrandt, 1998; Ortiz, 2003; Holton et al., 2001). The opportunity to engage in games and tutoring gives learners the practice, application and special help they need to achieve higher levels of performance. Research has shown that games can provide a rich context for social and mathematical development (Hildebrandt, 1998) and the provision of a safe environment for students to make errors (Holton et al., 2001).

8.4.4 SQ4: What considerations should be taken into account when tutoring children from socio-economically disadvantaged contexts?

Answers to this question are taken from the activities of phase 2 of the design process discussed in Chapter 5, section 5.3. Researchers are to take into consideration the more pronounced power relations which are brought about by unfavourable social and socio-economic circumstances (Gelderblom, 2014; Gelderblom et al., 2014). Power relations are an influencing factor in successfully providing children with a voice. Young children in this study communicated their ideas through individual recorded stories. After every session of face-to-face tutoring, both tutees and tutors audio-recorded their experiences, which were later transcribed by researchers.

The idea to use audio recorded individual stories was a way for the children to provide personal feedback on the face-to-face tutoring sessions. These recordings were used as additional input into the design of the online tutoring system, i.e. in order to supplement the data gathered through cooperative inquiry. The impact of power relations was diminished when the children made individual, private recordings, compared to how power relations would have impacted communication had the young children been in direct, face-to-face communication with the adults. It is therefore important when tutoring children from socio-economically disadvantaged contexts, for researchers and tutors to understand that they are working under different circumstances. The children they will be dealing with are vulnerable, so it is important to create a warm, supportive environment, and maintain a good tutor-tutee relationship.

Arnot and Reay (2007) discussed the influence of the context on what children contribute in collaborative educational design by referring to children’s “pedagogic voice” and “pedagogic identity”, as determined by the power relations present in schooling contexts. Researchers should distinguish between the social identity and communication patterns shaped outside of school, and those developed within the hierarchical system of schools. In listening to the pedagogic voice, we can overlook the real message. Marginalised children may be silenced by the fact that they have never learnt what constitutes a “legitimate text” in an unfamiliar context (Arnot & Reay, 2007, p. 320). The scripts that they associate with a specific aspect of their context (such as social class) may be the ones they fall back on. Christensen (2004) emphasises the importance of children’s silence, because the fact that they do not want to give an opinion may be significant in the research context.

A child’s ability to learn is dependent on the established environment of appreciation for their ethnic, linguistic and socio-economic background. Therefore, when tutoring children from such backgrounds, diversity is to be viewed as an important resource, so that the children feel valued and become more actively involved in learning. Consider inclusivity and embracing and integrating the young children’s diversity in the group. This consideration can assist in closing the achievement gap that falls along socio-economic lines, and removing the difficulty for participants to collaborate at an equal level, as social structures sometimes influence group dynamics.

As a tutor, it is of the utmost importance to listen, talk and communicate with tutees as key strategies in terms of getting to know them, because sometimes they have personal issues that are impacting on their lives, which are affecting their learning, so sometimes just listening and knowing them can have a huge positive impact. Tutors should be available and approachable to guide tutees’ learning. These approaches hold potential as a mechanism for giving vulnerable young children a voice in design.

8.4.5 SQ5: What are the current practices, experiences and limitations of using social networking tools to support tutoring?

An answer to this question was given in Chapter 2, sections 2.4 to 2.6. Social networking is used to refer to the many tools and applications that enable Web users to interact with others, to generate content, and to access information in ways that they can personalise for their own needs. There are numerous social networking tools available for learning. Social networking tools that could support tutoring are discussed in Chapter 2, section 2.5.2. TitanTutor was designed by creating our own Facebook-like social networking site. The aim of the service was to provide convenient tools for interaction and tutoring support. Young children were to post their work so as to share and discuss homework tasks, and build their support through interaction with tutors. TitanTutor has a facility where both parties need to use a Skype-like application. Skype allows communication (audio, video and text) over the internet. Tutors can create a one-to-one video call with tutees on Skype. Audio conversations via skype-like application are required especially when tutee wants to read aloud to the tutor. The function works asynchronously in that tutee can leave a message or send homework and tutor can see the message anytime he/she logs in. As long as both parties have a webcam device, the tutoring session would be as good as a physical one.

Tutoring through social networks has been conducted in and outside South Africa. Social media have provided multiple dimensions for developing creative learning strategies that allow students to connect formal and informal learning settings. Facebook, for instance, has been used for educational functions such as communication among tutors and tutees, peer evaluation and collaboration and resource/material sharing, delivery of homework and by sharing homework, projects, and ideas; collaboration consists of activities such as exchanging multimedia resources, videos, audio materials, animated videos, resources and documents (Mazman & Usluel, 2010). MXit has been applied in certain teaching and learning contexts in South Africa (Butgereit, 2007, 2009; Butgereit & Botha, 2010). This initiative has valuable results for most educational contexts where social media in Higher Education is embraced. As a social media platform, MXit has been used to offer maths homework support to high school learners, mostly by undergraduate volunteer tutors.

Some projects implemented outside South Africa, for example, is project K-Net of 2008, which targets secondary at risk ninth graders to increase their mathematical skills through mobile smartphones and also the St Mary’s city schools mobile learning technology (Parsons, 2013), where third grade students in Ohio use cell phones for learning in schools and at home. Students communicate and collaborate with one another and have access to tutors in and outside of school.

What is common among many of these uses of social media for learning support is the lack of formal structure. Learning standards, monitoring and evaluation systems, and governance provide much needed structure to brick and motor educational systems. The same kind of formal structure is needed with social network-based learning settings.

In Chapter 2, section 2.5.4, a discussion on cyber safety was undertaken. The general concern was the increase in cyber-bullying activities among young and vulnerable Internet users. Technology, and the risks associated with it, are constantly evolving. The fact that there are risks is no reason to avoid using technology, or to keep it away from child users. But it is important to think of ways to increase privacy. The security issue on how to protect both the tutors and the tutees from malicious intent, and the protection of the tools to be used, was discussed by the researchers and the participants. The following solutions were considered:

- Instead of a password, we could have a device which could be a camera, and on the camera there would be the tutor or tutee's own profile.
- A short sequence of digits could be used as a personal identification number (PIN) endorsed by caregivers.
- Users could choose to mask their real identities. This can be done via anonymity, either by providing no name at all, or pseudonyms.
- Administrators can pick a file-sharing service that lets them create "private" folders, so that only people with access credentials can see these files.

Security risks are a problem, but the benefits of today's technology are life-changing. In this study, tutors and tutees were required to sign in with some sort of unique identifier that protected their privacy. They came up with code names as the usernames (e.g. Monkey-nuts) which are known only by the users of the system.

8.4.6 SQ6: How does cooperative inquiry contribute to the success of designing an online tutoring system?

Cooperative inquiry, as mentioned in Chapter 3, section 3.3, is a widely adopted method for involving children as full partners in technology design. Our approach was the collaboration of children from intended user groups, teenagers and young children, to design a cross-age tutoring system using the cooperative inquiry method. An important contribution of the cooperative inquiry method to the success of the TitanTutor, was the removal of the researchers' own biased assumptions about how to design a solution that privileged teenagers would be motivated to use in support of vulnerable children, by letting the intended end users co-designs the solution. While on the one hand, cooperative inquiry enabled privileged teenagers to channel their ubiquitous use of social media in directions that benefitted vulnerable children, on the other hand, cooperative inquiry enabled vulnerable children to restore the belief in their ability to be creative, despite their social circumstances (Druin, 1999). Creative ideas ('big ideas') that were produced by children became the prescriptive propositions that contributed to the design of TitanTutor. It is generally accepted that design requires creativity, and it is a commonly held belief that children are more creative than adults (Sawyer, 2003).

The design team engaged in a variety of brainstorming activities in order to generate new ideas to incorporate into the design. Effective activities included drawing designs on paper, and low-tech prototyping. Cooperative inquiry was a suitable approach for vulnerable children; success depended on the removal of the communication barriers created by adult-child power relations. The context within which we conduct research with children is an important factor to consider when asking children to voice their opinions. Researchers have used different approaches and systems to tap into the minds of children and give them voice. The use of technology in this regard has proved successful in a number of the studies that we discussed. With regard to the design of technology for development, we can recommend the use of audio recordings as supplement to the accepted CI methods, especially when vulnerable children are involved as co-designers. If the problems identified in this research are addressed as suggested above, the power imbalances will be reduced, and the children will be able to make useful contributions into the design.

Together, the answers to the sub-questions, as discussed in the preceding sections, contributed to providing the answer to the overarching question, which follows in the next section.

8.4.7 Answer to the main question

In this study, the researcher set out to answer the question: '*How can a cross-age tutoring system be designed for implementation on a social networking platform to support numeracy and literacy skills acquisition?* The answer to this question was the answers of the sub-questions discussed above and the description of how the TitanTutor was designed, as discussed in Chapter 6, section 6.4. The first step in the co-design of the TitanTutor was to establish the co-design context of the co-design partners. This required, first, an investigation into how privileged teenagers could be motivated to redirect their ubiquitous use of social media-based platforms to the worthwhile cause of supporting after-school cross-age tutoring activities. This was then followed by establishing the co-design context of the vulnerable children, which revealed the power relations that needed to be managed. With the context established, face-to-face design sessions were then conducted to immerse the co-design partners in the design context, so that they knew exactly what it entailed when they had to design the artifact. The co-design partners created private recordings after each co-design session, to reflect on their experiences. These recordings were used as data to inform the design. Before designing the solution, the researchers came up with scenarios that would help focus design efforts on the users' requirements. Low-fidelity paper prototypes helped in enabling early visualisation of alternative design choices, which in turn would help in provoking innovation and improvement. The low-fidelity paper prototypes conveyed how the teenagers and young children would perform tasks. Ideas that came out of the prototypes were translated into 'big ideas'. The 'big ideas' were then translated into themes, which in turn were synthesised into prescriptive propositions (PPs) of the *Solution Suggestion* step of the DSR approach. The use of the paper prototypes, 'big ideas', themes and prescriptive propositions, enabled the researchers to develop sketches of the solution. The sketches were then later translated into high-level wireframes of the design. The next step was to convert the wireframes into a workable TitanTutor artifact, through coding. The artifact was then evaluated based on the set of prescriptive propositions that formed the basis for a set of technical specifications that defined the set of requirements that the tutoring system would meet or exceed.

As stated in section 8.4.5, there are many social media-based platforms already in use. To choose one of these platforms for the implementation of a tutoring system that maintains the security and privacy of its users, requires a thorough security audit to be conducted on each of them. However, security is not the only objective of such tutoring systems. So, the final selection may also depend on an assessment of how the platform meets the other objectives. Most often, not all objectives can be met without significant modification of the existing social media-based platform. In the end, trade-offs may have to be accepted, or, development from scratch, at the risk of significant effort, may have to be considered.

To add to the above discussion, the description of a repeatable method on how to achieve consistent designs of cross-age tutoring systems that could be designed and implemented on social networking-based platforms, are given. Such a repeatable method of design can be found in the CD2C Design Framework, as discussed in Chapter 7, section 7.2. Therefore, while the co-design of the TitanTutor artifact by vulnerable young children and privileged teenagers was an important contribution of this study to Cooperative Design practice and Design Science Research, the main contribution of this study was the CD2C Design Framework. The framework provides a guideline on how children from different age groups and life circumstances could co-design a technology solution intended for them as end users. In that respect, the design of *a cross-age tutoring system based on a social networking platform to support numeracy and literacy skill acquisition* would constitute a specific instantiation of the CD2C Design Framework. The process of instantiating the CD2C Design Framework was discussed in Chapter 7, section 7.2.

8.5 Reflection on and Limitations of the Study

This study focused on a small group of young children and teenagers attending schools around Pretoria. While these findings are not necessarily generalizable, they may, however be transferable to comparable contexts.

The importance of literature reviews to any research endeavour is well known. The main problem of an appropriate literature review is how to select the material in such a way as to be representative of the study at hand. It was not possible to include all the possible literature existing in the field of cross-age tutoring and literature on co-design practice with children because a lot has been written on these topics and some were not in the scope of this study. However, the researcher reported on the literature she believed was essential for her study.

The theoretical framework that resulted from the literature review is only one of the many possible outcomes that could have been derived. Research of a qualitative nature such as this study is liable to have many different approaches and interpretations. It can be argued that the theoretical framework was derived from a very specific perspective on design.

The appropriateness of the Design Science Research strategy to the research problem was a lesson learned during the process of research, and not at the start of the research journey. Research paradigms include many philosophical aspects that make the understanding of what is appropriate at times completely inconceivable. The application of a DSR methodology to a conceptual research problem was harder to achieve than initially thought.

It is not only the capacity and skills of the research participants that impact participation. The multilingual context within which this research was conducted resulted in a situation whereby the majority of the child designers did not speak the researcher's language. Also, not all the child participants spoke the same language. This posed a challenge and the researcher was dependent on a co-researcher to translate and interpret.

Overall, the completed study had a huge impact on me as a researcher. It strengthened my commitment to working with children in a respectful and empowering manner. This commitment has been growing from the time that I was studying for my Master's and involved children in my study. I continue to believe in the power of respecting children, and that through this respect we can greatly impact both their lives and our own in a positive manner.

8.6 Future Directions

The limitations mentioned above can be seen as possibilities for future investigation. As this research was an initial investigation into this field of study, it has laid the groundwork for future work in the area of designing technology with children and the impacts that it may have on those children in developing countries such as South Africa. There are many directions that future work in this area could take. As noted in Guha et al. (2010), the strongest results will occur when multiple researchers in many locations undertake similar research. If researchers across Africa, and the world at large, were to undertake case studies investigating the nature of involving children of different age groups and life circumstances in technology design processes, the results could be compared. Similar results would lend credence to those found here; dissimilar results would indicate that findings need to be revisited or further explained based on differences in context. Future researchers could also investigate possible ways to improve abstraction of the CD2C Design Framework, thereby increasingly making the latter the universal model of how co-design by children from different age groups and life circumstances should be conducted. Longitudinal evaluation of the TitanTutor over a longer period of time could also be considered. Having solved the smaller problem of co-design with children from different age groups and life circumstances with the CD2C Design Framework, future researchers could then put the CD2C Design Framework to the test in solving the bigger problem of improving literacy and numeracy skills acquisition by schoolchildren of any age group and life circumstances.

This study is a step towards understanding the role children can play as leaders in CI sessions. Child design partners in developing countries may develop further interest in being the leaders of their own personal projects or the projects of others. This study has shown that children can lead co-design sessions, but that support is needed to help them manage, interpret, organize and direct the sessions. In the future, we suggest that researchers examine the possibility of children leading a series of design sessions from idea inception to a more finalized product. Researchers should also investigate whether children can lead a CI session for projects that are not their own personal creations. Finally, researchers may want to consider the role of design techniques for child-led sessions. Future studies could evaluate other design techniques and the supports needed for children to lead these sessions.

We are aware that this research is just a first step in understanding the dynamics involved in cooperative design by children of different age groups and life circumstances in a developing world context. We acknowledge that there might be different challenges to participating in co-design in different developing countries. To this end, we propose to conduct more longitudinal studies under comparable circumstances. Instead of focusing on recording and analyzing only early design stages, as done here and in other literature so far, we would like to suggest broadening the research and project horizon to also include other developing countries and complete design lifecycles.

Another vein of future work is to use the findings from this study as a starting point to further investigate specific social and/or cognitive experiences of children who participate in a technology design process. For instance, this study revealed that young children and teenagers can work as design partners of a cross-age tutoring system, with little adult interference. A future study could involve the deployment of this cross-age tutoring system to a larger audience.

This study also lays the groundwork for future qualitative studies of technology design processes such as CI in educational settings. This could be a very interesting direction for research in the area of cooperative design of a cross-age tutoring system that could be of use in peer tutoring in a school environment. Future work could look at co-design among peers or adult-child co-design partners within CI. If educators were interested in understanding how CI could be employed in an educational setting, they may first want to study its effectiveness.

Comparative or intervention studies could be developed between classes using a traditional method of face-to-face tutoring versus an online tutoring method. There are also potential avenues for this research which were not fully explained by the study. The study included only teenage girls for tutoring and designing. In the future, researchers could explore the impact of cooperative inquiry experiences that would include teenage boys, or boy-only tutees, to explore gender differences, or mixed genders to explore complementarity.

Thus, there are many avenues to be explored for future work in this area. The current work has laid an important background for those who wish to study the phenomenon of young children and teenagers participating in cooperative design. It has provided a starting point for those interested in studying this area in developing countries.

8.7 Summary

The aim of this study was to investigate social media as a platform for a cross-age tutoring system, whereby teenagers from privileged communities would provide learning support to younger children whose access to learning support was hampered by unfavourable socio-economic circumstances. Research has shown that there are problems with education in South Africa, with regard to very low literacy and numeracy levels (Chapter 1). These problems develop in the early grades when children are expected to start acquiring literacy and numeracy skills. There are a variety of reasons for this, including a shortage of properly trained teachers (especially in the rural areas), insufficient basic resources such as water, electricity, proper school buildings, and lack of after-school learning support due to low literacy levels of caregivers or just absence of adults who are available to help (Gelderblom, 2014). These problems cannot be solved simultaneously, and our aim was to take one of these problems – lack of homework support – and find a technology-based solution that might help reduce the problem. The broad idea was to create a social media based platform whereby teenagers from privileged communities in South Africa would provide online homework support to young children from disadvantaged communities, using ubiquitous mobile technologies. The primary point of departure was that we should rely heavily on children to design this system. Both teenagers from privileged environments and young children from underprivileged communities acted as co-design partners.

In this study we came to the conclusion that, rather than second-guessing children and making assumptions about their needs, they be involved in the design process in order to create applications that they would find usable. The young children were involved in the design process from the very start, producing the TitanTutor artifact as the outcome of the co-design process, with the CD2C Design Framework emerging as an abstraction thereof. The Cooperative Inquiry approach can contribute to new technology, not only by involving children in the evaluation of software, but also in generating new design ideas. Creative ideas produced by children can be general concepts of how technology can be used and suggestions about the ways in which the user can interact with the technology.

Young children from disadvantaged backgrounds should be given the opportunity to co-design products that are intended for their own use. I believe that cooperative design can be practised in education and design communities, and that there is potential for continued interesting research in this area. The goal of cooperative design projects should not be to merely develop useful solutions, but also to yield intangible results such as psychological empowerment of the design participants. Any design project should be based on a strong understanding of the history, culture and society of the area where the product will be used. It is our hope that other researchers will continue to examine the important issues of how tutoring systems could be designed for implementation on social networking platforms to support learning.

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APPENDICES

Appendix 1: Ethical clearance Documentation

a) The Ethical Clearance

UNISA college of science, engineering and technology

Bester Chimbo (32950063) 2013-05-31
School of Computing
UNISA
Pretoria

Permission to conduct research project

Ref: 065/BC/2013

The request for ethical approval for your PhD in Information Systems research project entitled **"Cooperative Design of a Cross-Age Tutoring System based on a Social Networking Platform"** refers.

The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee (CREC) has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your study as set out in your proposal and application for ethical clearance.

Therefore, involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the CSET Executive or the CSET CREC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Please note that if you subsequently do a follow-up study that requires the use of a different research instrument, you will have to submit an addendum to this application, explaining the purpose of the follow-up study and attach the new instrument along with a comprehensive information document and consent form.

Yours sincerely

Chair: School of Computing Ethics Sub-Committee

University of South Africa
College of Science, Engineering and Technology
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone + 27 2 429 6122 Facsimile + 27 12 429 6848
www.unisa.ac.za/cset

b) The consent letters

Dear Parent/Guardian

I am Mrs Bester Chimbo, a PhD student in the School of Computing at the University of South Africa. I am conducting research to investigate social media as a platform for a cross-age tutoring system whereby teenagers would provide learning support to younger children whose access to learning support is hampered by unfavourable socio-economic circumstances. I am working under the supervision of Prof Helene Gelderblom. l am kindly seeking your permission to include your child …………………………………..………..as a tutor in this research. Please read this consent document carefully. If you grant permission for your child to participate in this study, please sign the agreement at the end of the form and return it to me.

Title of the research project:
Cooperative design of a cross-age tutoring system based on a Social Networking Platform

Purpose of the research study:
The purpose of the study is to investigate social media as a platform for a cross-age tutoring system. The ultimate goal is to provide homework support to children who do not have regular access to one-on-one homework support.

What the study entails:
The study entails the design of a user interface for a cross-age tutoring system, using cooperative design. The design team will consist of myself, my supervisors, six grade 3 and 4 children from the President Paul Kruger Children's home in Villeria, six teenagers who will act as tutors and co-designers, and staff from the children's home.

Please take note of the following:
There will be face-to-face tutoring sessions in August between the six teenage tutors and the six grade 3 and 4 participants. Your child will be one of the tutors. Thereafter, we will have one design session per week for 3 or 4 weeks in September with all twelve young design partners. The result of this will be designs of prototypes for the tutoring system that will be used to develop one final prototype. The researchers will provide transport as required.

Your child is not expected to have any tutoring or design experience. They will always be supported by adults during the process. No sessions will be video recorded. Photographs of the children will only be taken/published if it can lead to benefit for the children or the children's home and if the caregivers/parents give their written consent.

Venue:
The study will take place at President Kruger Children's Homes in Pretoria.

Time required:
The face-to-face tutoring sessions in August will require the tutor to be available once or twice per week for an hour of tutoring maximum. We will work out a schedule according to all the

children's availability and will be adaptable to their individual schedules. The design sessions in September will take place once a week for two hours. Again, we will schedule this at a time that is convenient for all involved.

Confidentiality:
The data collected will be used only for research purposes and anonymity will be preserved. Your child's name will not be published in any reports or theses.

Risks:
There are no known risks associated with this experiment.

Your child's rights as a participant are as follows:
Your child has the right to withdraw from the study at any time for any reason.
At the conclusion of the experiment, you may see your child's data, if you so desire.
If you decide to withdraw your child's data, please inform the facilitators immediately.

Finally, we greatly appreciate your child's time and effort for participating in this study. Please do not hesitate to ask if you have any questions about the study.

My contact details are as follows:

Email address: chimbb@unisa.ac.za
Phone number: +27128072117
Cell number: +27823338815

Agreement (parent or guardian):

Your signature below indicates that you have read this consent form in its entirety and that you voluntarily allow your child to participate.

Name & Surname:		Contact Tel.no:	
Signature:		Date:	

Agreement (participant):

Your signature below indicates that you have read this consent form in its entirety and that you volunteer to participate.

Name & Surname:		Contact Tel.no:	
Signature:		Date:	

President Kruger Children's Home

31 ste Avenue
Villieria
Pretoria
0186

Dear Principal

I am Mrs Bester Chimbo, a PhD student in the School of Computing at the University of South Africa. I am conducting research to investigate social media as a platform for a cross-age tutoring system whereby teenagers would provide learning support to younger children whose access to learning support is hampered by unfavourable socio-economic circumstances. I am working under the supervision of Prof Helene Gelderblom. l am kindly seeking your permission to include six grade 3 and 4 children at your Centre as tutees in this research. Please read this consent document carefully. If you grant permission for their participation in this study, please sign the agreement at the end of the form and return it to me.

Title of the research project:
Cooperative design of a cross-age tutoring system based on a Social Networking Platform

Purpose of the research study:
The purpose of the study is to investigate social media as a platform for a cross-age tutoring system. The ultimate goal is to provide homework support to children who do not have regular access to one-on-one homework support.

What the study entails:
The study entails the design of a user interface for a cross-age tutoring system, using cooperative design.The design team will consist of myself, my supervisors, six grade 3 and 4 children from your centre, the President Kruger Children's Home, six teenagers who will act as tutors and co-designers, and staff from the children's home.

Please take note of the following:
There will be 10 face-to-face tutoring sessions in August between the six teenage tutors and the six grade 3 and 4 participants. Thereafter, we will have one design session per week for 4 weeks in September with all twelve young design partners. The result of this will be designs of prototypes for the tutoring system that will be used to develop one final prototype. The researchers will provide transport as required.

No sessions will be video recorded. Photographs of the children will only be taken/published if it can lead to benefit for the children or the children's home and if the caregivers/parents give their written consent.

Venue:
The study will take place at President Kruger Children's Homes in Pretoria.
Time required:

The face-to-face tutoring sessions in August will require the tutors and tutees to be available once or twice per week for an hour of tutoring maximum. We will work out a schedule according to all the children's availability and will be adaptable to their individual schedules. The design sessions in September will take place once a week for two hours. Again, we will schedule this at a time that is convenient for all involved.

Confidentiality:
The data collected will be used only for research purposes and anonymity will be preserved. The names of the children will not be published in any reports or thesis.

Risks:
There are no known risks associated with this study.

Benefit for the Children's Home:
The biggest benefit will be the developmental gains for the young design partners who will learn about design and design thinking. They will experience the empowerment of using a technology that they themselves helped to design. On a more tangible level, Prof Helene Gelderblom received funding for the project cross-age tutoring using social networking platforms. Part of the funding is for technology. The children's home will receive some computer equipment and Internet access to the value of R50 000 in the design phase (2013) and Internet access will also be paid for in the testing phase (2014). This equipment will be used to design and test the system, but the staff will have control over the equipment and Internet access. When the project is complete Prof Gelderblom undertakes to raise funds to sustain Internet access for at least 2 more years.

The children's rights as a participant are as follows:
They have the right to withdraw from the study at any time for any reason.

Finally, we greatly appreciate the permission you granted us to work with the children at the home for this study. Please do not hesitate to ask if you have any questions about the study.

My contact details are as follows:

Email address: chimbb@unisa.ac.za
Phone number: +27128072117
Cell number: +27823338815

Agreement (principal):

Your signature below indicates that you have read this consent form in its entirety and that you voluntarily allow the children named below to participate.

Name & Surname:		Contact Tel.no:	
Signature:		Date:	

The children to be involved in the study:

No:	Name of Child:	(Male/Female)	Grade:	Age:
1.				
2.				
3.				
4.				
5.				

Appendix 2: Questionnaires

a) Questionnaire on willingness to participate in tutoring

We are carrying out an interview to determine what would motivate children who are in grades 8, 9 and 10 in providing homework and test preparation support, with special attention to literacy and numeracy support to children in grades 1, 2 and 3.

1. Would you like to be part of a tutoring project in the role of a tutor? Why?
2. What would motivate you to accomplish the task of tutoring? Why?
3. What motivates you to accomplish difficult/new tasks?
4. Do you think most teenagers will feel the need to participate in this project? Why?
5. How important is recognition to you?
6. How important is responsibility to you?
7. Do you think it would be a good idea to offer the teenagers an iPad or other gadgets similar to it to motivate them to participate?
8. Do you think having it as a Facebook App is a good idea?
9. Would you like to help the same children over a longer period of time?
10. Would you want to help different children throughout the project?
11. Do you think boys would also want to do tutoring in this project?
12. Do you currently use social networks for your homework or school related things?

b) Tutor Questionnaire

1. What is your gender?

   Male ☐

   Female ☐

2. What is your age?

   ☐ years old

3. Which Grade are you in?

   Grade 9 ☐

   Grade 10 ☐

4. Do you own a cellphone? Yes ☐

   No ☐

5. If yes, what type of cellphone is it? ☐

6. Do you own a tablet? Yes ☐

   No ☐

7. Do you have access to a desktop computer/Laptop? Yes ☐

   No ☐

8. Do you have internet access at? Home ☐

   School ☐

   Other ☐

   Specify other ___________________________________

9. List as many as possible what you use your cellphone/tablet/computer for:

Cellphone	Tablet/Laptop	Computer
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

10. Have you tutored anyone before? Yes: ☐

No: ☐

11. If yes what type of tutoring have you done?

12. Tick the social networking platforms below that you are aware of:

Social networking platforms	**Aware**
1. Facebook	
2. Twitter	
3. Instagram	
4.YouTube	
5. Pinterest	
6. BBM	
7. Skype	
8. Other	

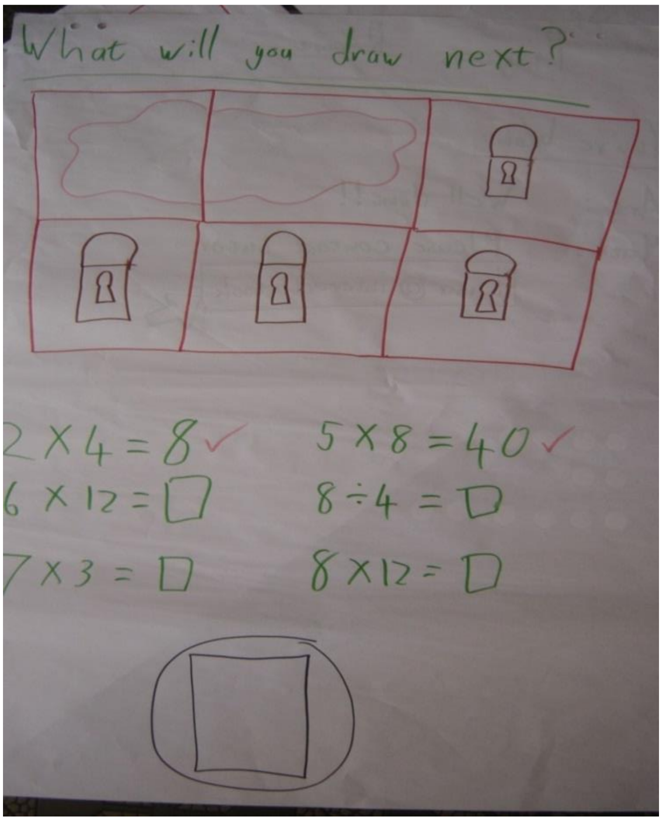
Specify:____
____
____
____
____
____

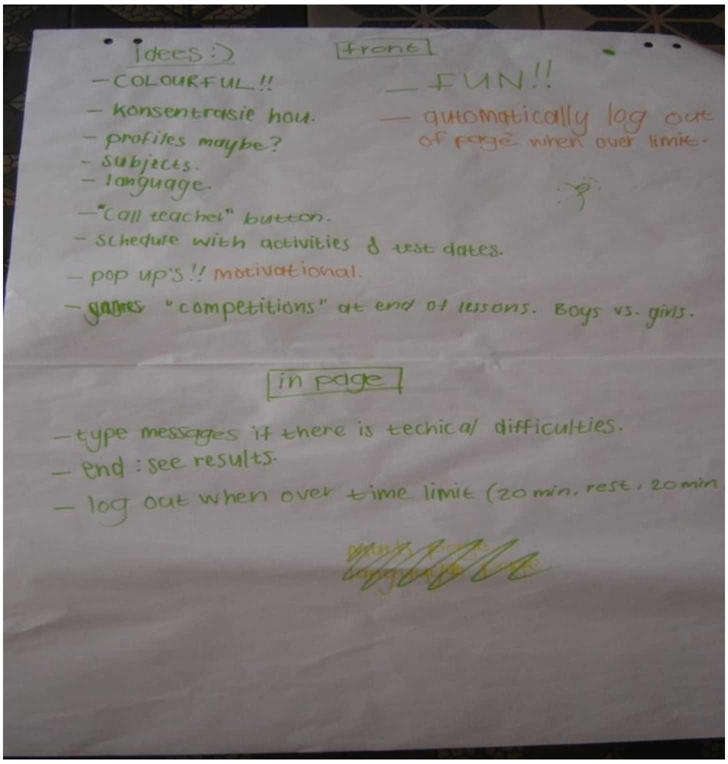
3. List below the social networking platforms you have/are used for pleasure:

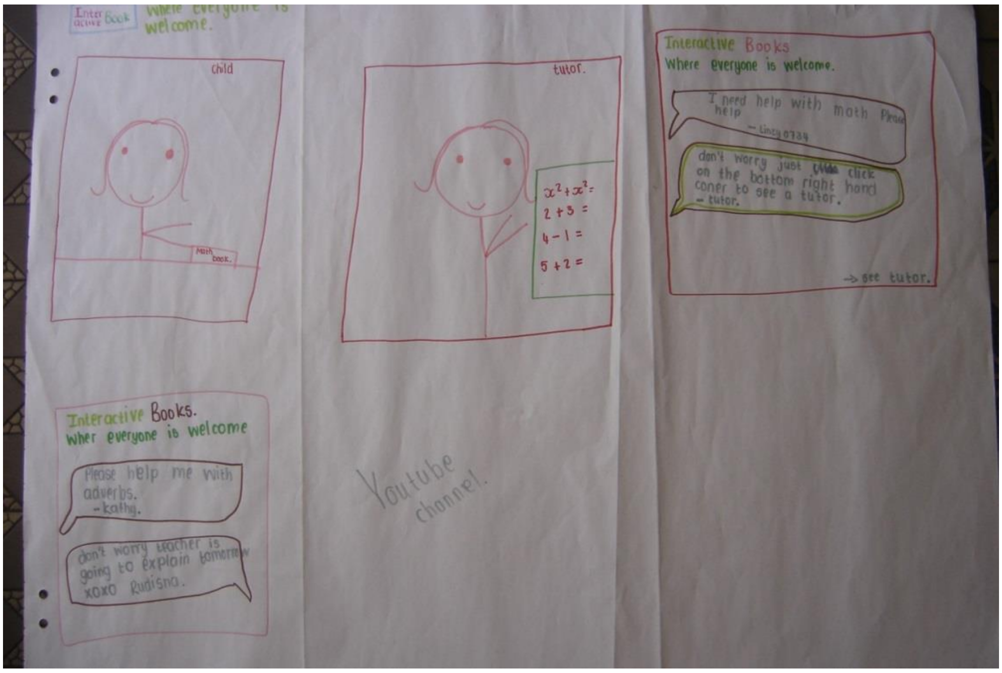
4. List below the social networking platforms you have/are used for educational purposes:

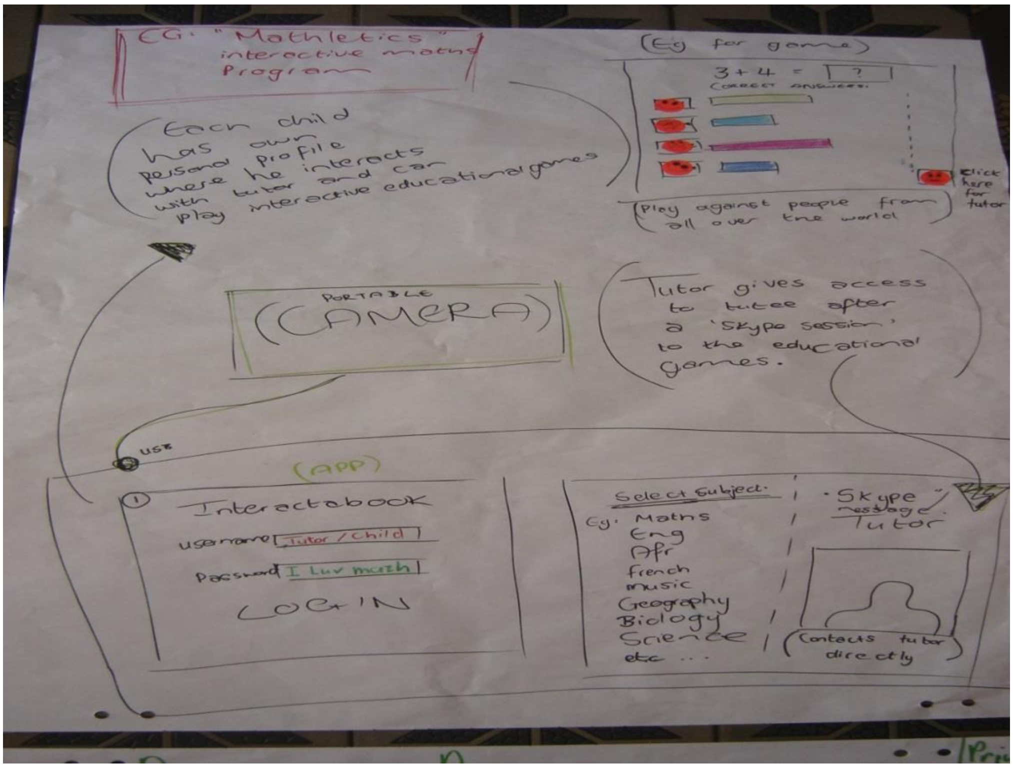
****

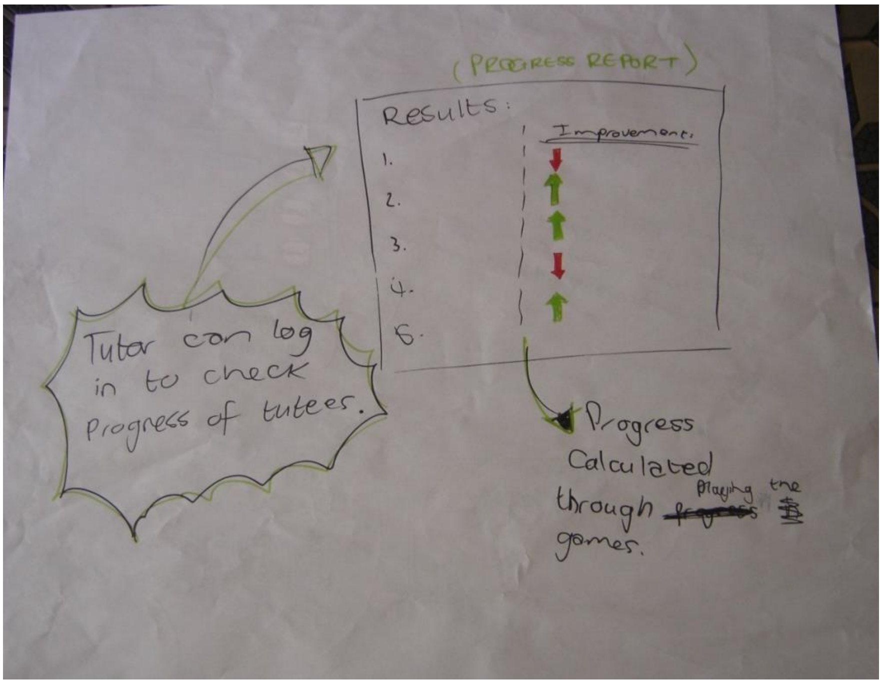
Appendix 3: Paper prototypes

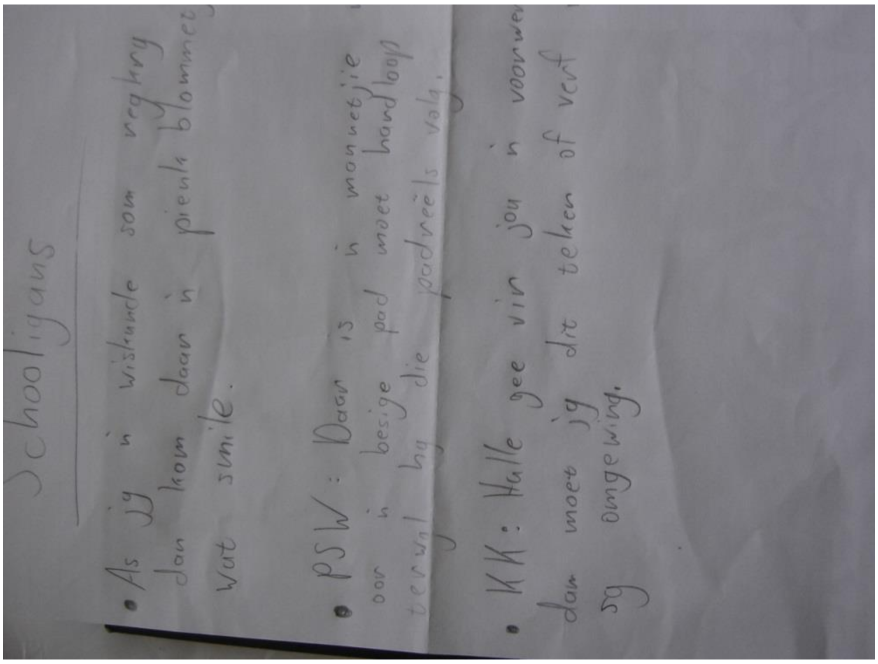





Interactive Books
Where everyone is welcome.
child
Math book.
tutor.
$x^2+x^2=$
2+3 =
4-1 =
5+2 =
I need help with math Please help
don't worry just click on the bottom right hand coner to see a tutor.
- tutor.
→ see tutor.
Interactive Books.
wher everyone is welcome
Please help me with adverbs.
-kathy.
don't worry teacher is going to explain tomorrow
xoxo Rudisna.
Youtube channel.


EG: "Mathletics" interactive maths Program
(Eg for game)
3 + 4 = ?
CORRECT ANSWERS:
Click here for tutor
Play against people from all over the world
Each child has own personal profile where he interacts with tutor and can play interactive educational games
PORTABLE
(CAMERA)
Tutor gives access to tutee after a 'Skype session' to the educational games.
USB
(APP)
1
Interactabook
username Tutor / Child
Password I Luv math
LOG IN
Select Subject.
Eg. Maths
Eng
Afr
French
music
Geography
Biology
Science
etc ...
'Skype' message
Tutor
(Contacts tutor directly)


(PROGRESS REPORT)
Results:
Improvement.
1.
2.
3.
4.
5.
Tutor can log in to check progress of tutees.
Progress Calculated through ~~progress~~ playing the games.


Schooligans
As jy 'n wiskunde som regkry dan kom daar 'n pienk blommet
wat smile.
PSW: Daar is 'n mannetjie oor 'n besige pad moet handloop terwyl hy die padreëls volg.
KK: Hulle gee vir jou 'n voorwe dan moet jy dit teken of verf sy omgewing.


Love
Love
CATHY
EMMA


BONJOUR, BATBOY!
AFRIKAANS
ENGELS
SOTHO
XHOSA
ZULU
GAMES:
LOG IN
FAMILY PHOTO
MARGIE


ENRICO


KYLA

Appendix 4: Tutors' design ideas

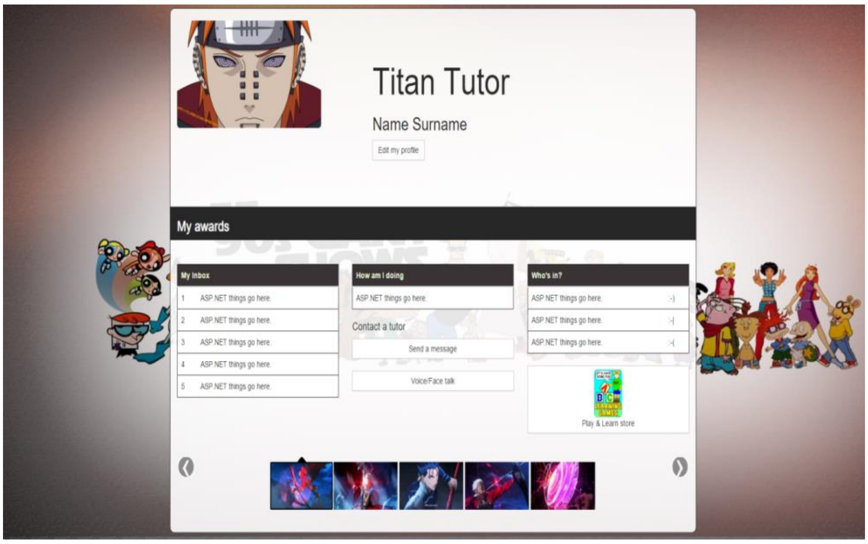
Summary of the related ideas regarding the design of the system from the tutors

No:	Overall Idea	Related design of the system main ideas
1.	Tutor/Tutee Profiles	• Tutors believe that there should be a profile for both the tutor and the tutee, with all the information required on how to access the system. • Profiles will help the tutors and tutees to see who is available to assist or help. They will be able to see from their respective screens the tutors who are available to help or tutees who need help. • There must be buttons that a tutee can press when he/she requires help immediately.
2.	Interactive tutor links:	• If a tutee needs help in Mathematics, for example, there must be a link which will send the tutee straight away to the tutor. • There must also be a link a tutee can use to talk to the tutor. • There can also be an inbox place where a tutee can send in messages to the tutor – e.g. "I need help with English adverbs" then tutee can go into a YouTube-like channel where they can access a whole lesson on adverbs (pre-made lessons). • Tutors who are unavailable at certain times can visit sites with pop-up questions, and respond at any time. For example, a tutee can post a homework history question like "When was Napoleon born?", then the tutor who is familiar or knows the answer can respond to this question. • Again, if the tutor is unavailable, there must be a link option called 'revision' to take them to a database with everything, from English to Mathematics, they have done, so they can read through some of the work as test preparation. • The site should also have a time frame for tutees to be there, so that they all get a chance to get help from the tutors.
2.	Educational games: Mix fun and education by learning and playing games	To motivate the tutees to visit the site when doing test preparation, the tutors will have a link which will take them to different game pages – e.g. • Art games • Mathematics games • No pressure games, but fun games

		• Get points (games) • Boys and games compete The tutees will have the choice to choose from the different types provided.
3.	Rewards and Encouragement	• If the tutee is making progress, then the tutor should reward the tutee by either allowing the tutee to access some interesting games on the site. • There are pop-ups that can come up with messages like. “Oh dear, you are a genius”. • Must stay full-time to get rewards or finish the whole game process to be rewarded.
4.	Progress report	• Progress report is required from both tutors and tutees. • The tutor report will have information on those parts the tutees are struggling with in their respective areas. • The tutee report will show a link to provide incentives to those doing well, or those struggling will contact tutors. • Having a progress system, where tutors can prepare a progress report with a lot of fun. The tutor can access the work done by a tutee. • If the tutee is making progress, the tutor will reward the tutee by increasing the tutee’s steps on the ladder or making them access interesting games.
5.	Communication channel	Communication should play a vital role in this system. So, the process will be that computer/phone starts to buzz. Tutor connects pad/tablet or computer to Internet. • Quick guide (pop up) • Session of 20 minutes • Break of 5 minutes • General talking session • Click on words to get meaning or pronunciation • Automatic timing • Emergency button (before text)
6.	What to be done in the sessions	• Link will send you to tutor straight away • Tutees must be free to choose the student tutor who knows the subject • Child can choose subject he/she wants help with • Tutee can see which tutor is available • Can also speak to a friend not necessarily tutor • Places for schedules • Notification to contact tutor if you do something wrong

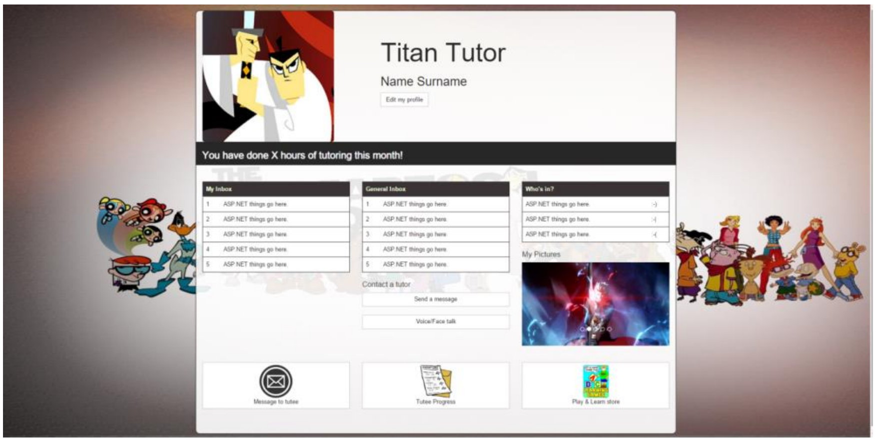
		• Sessions come later once they have paired up • Choose between list of books
7.	Social networking platforms that can be re-created	• Own your tube channel with pre-made lessons • Skype and Facebook collide • Interact a Book • Live YouTube recordings
8.	Feedback	• Tutors can post feedback on the tutee's profile so that other tutors will be able to view and see the problems tutees will be encountering and how they can help • Database for revision if tutor is not around • Writing with mouse to give feedback immediately • Option to see results

Appendix 5: Screenshots of TitanTutor

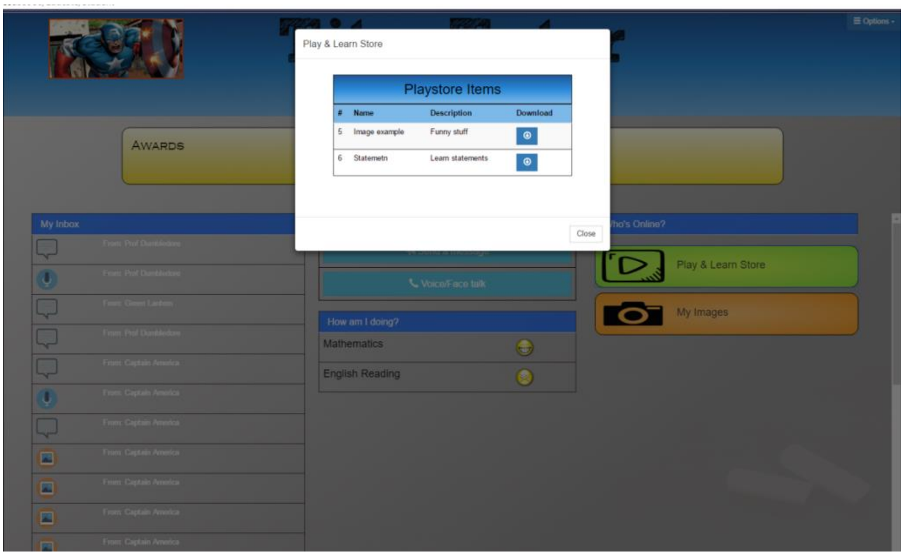


Tutee Homepage

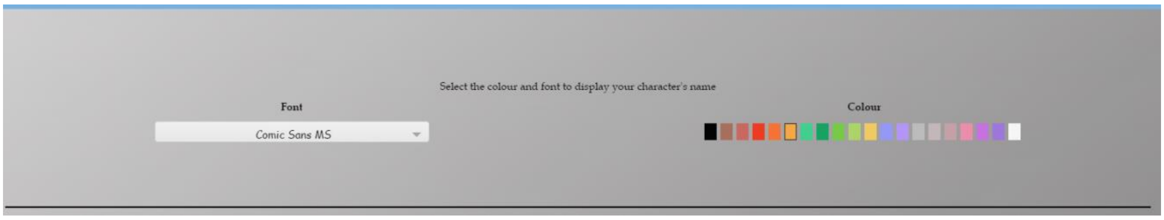
Tutee_My Images



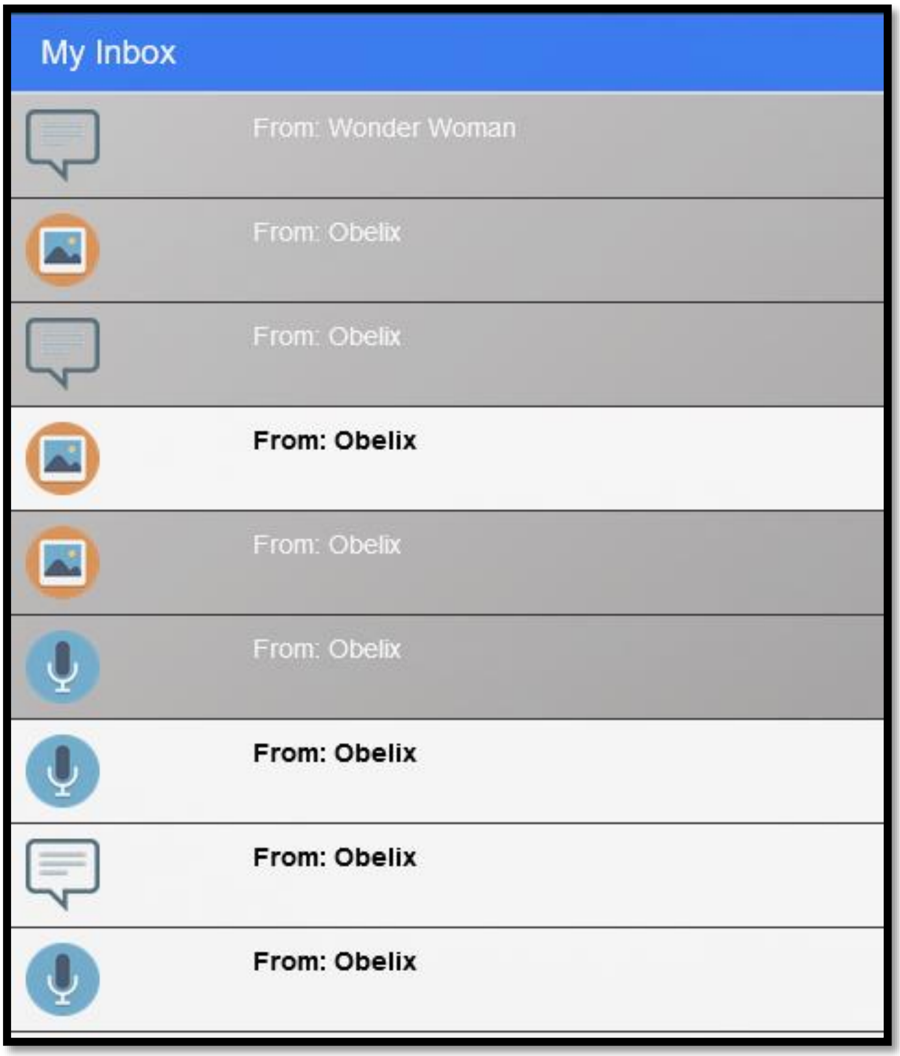
Tutor Overview



Play and Learn Store

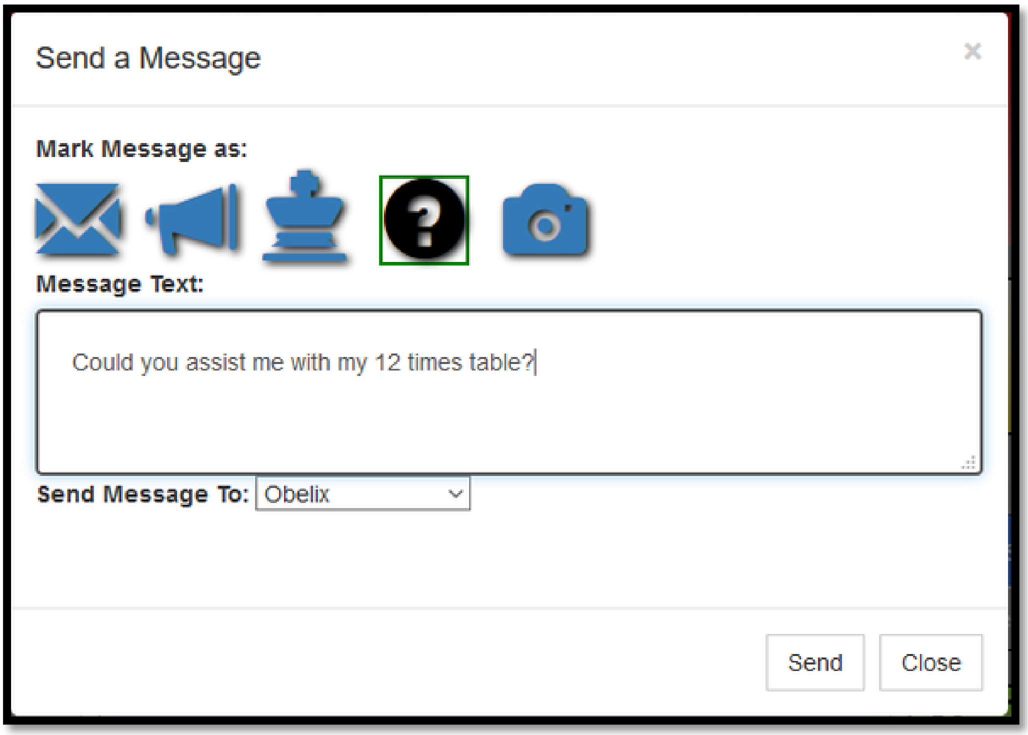


Character font size options

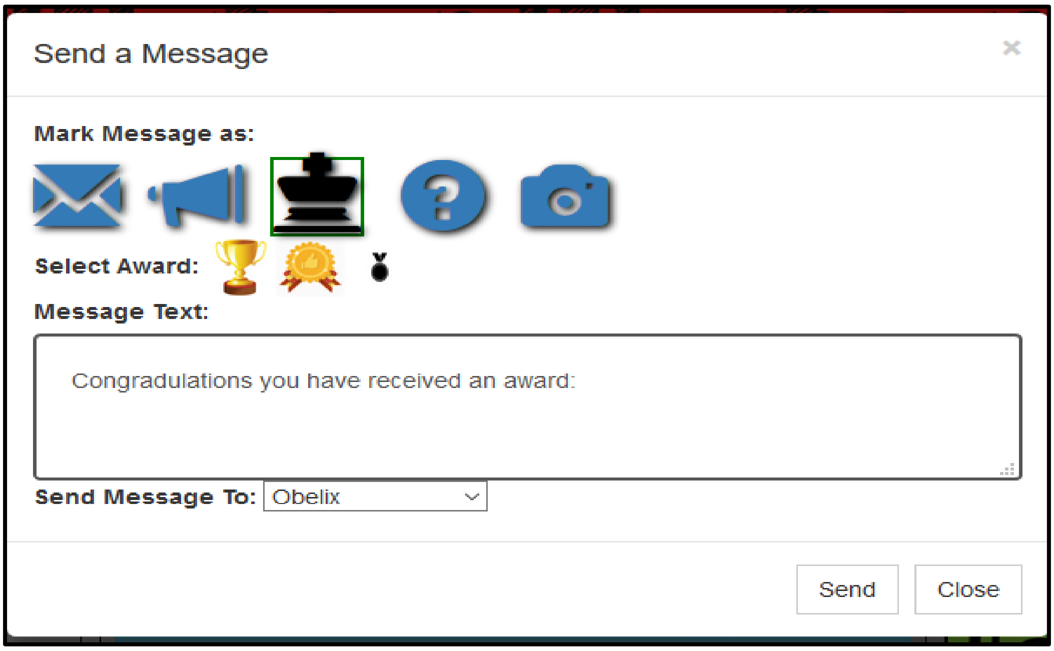


Tutor_ My Inbox

Tutee and Tutor banner previews



Sent a question



Compile award message

Appendix 6: Tasks and post study usability questionnaire

a) Tasks used for TitanTutor Usability Testing

Tasks	Tasks Descriptions	√
Login details	Open and log onto TitanTutor site.	
Send Message	Create and send a message to Tutor/Tutee.	
Read Message	Open and read a message from Tutor/Tutee.	
Reply Message	Reply to a message from Tutee.	
Send Message to outbox	Send your message to Outbox.	
Open and View Tutee work	Open and view the work send by Tutee.	
Open and View Tutor feedback	Open and view feedback from Tutor.	
Search Tutor	Search for a particular Tutor.	
Open and Access Tutee’s work.	Open and access Tutee’s work.	
Open and Access Games	Open and access games from Tutor	
Give Feedback to Tutee	Give feedback to the Tutee.	
Skype Tutor or Tutee	Skype Tutor/Tutee	
Move Games	Move games	
Forward work	Forward work to either Tutor or Tutee.	
Add a Picture/Photo	Add a picture or photo.	
Attach Work and Photos	Attach a photo or work.	
Contact Technical Support	Find out how to contact technical support.	

b) The Post Study Usability Questionnaire

		Strongly Agree							Strongly Disagree	
			1	2	3	4	5	6	7	NA
1.	Overall, I am satisfied with how TitanTutor is working.									
2.	It was simple to use TitanTutor.									
3.	I was able to complete the tasks quickly using TitanTutor.									
4.	I felt comfortable using TitanTutor.									
5.	It was easy to learn to use TitanTutor.									
6.	I believe I could use TitanTutor effectively.									
7.	It was easy to skype on TitanTutor.									
8.	It was easy to find information I needed.									
9.	The information was effective in helping me complete the tasks.									
10.	The organisation of information on TitanTutor screen is clear.									
11.	TitanTutor was pleasant to use.									
12.	I like using TitanTutor for homework support.									
13.	I like using TitanTutor for test preparations.									
14.	I like playing the educational games on TitanTutor.									
15.	TitanTutor has all the functions and capabilities I expect it to have.									
16.	Overall, I am satisfied with TitanTutor.									

Appendix 7: Transcriptions of face-to-face recordings

CROSS-AGE TURORING PROJECT (Transcriptions completed on 26 November 2013). Transcriptions of recordings made by kids at the care centre as well as some of the tutors (translated from Afrikaans to English). *(Please note that the names used are not the real names of the participants)*

RECORDINGS OF PARTICIPANTS

No:	**Tutor/ Tutee**	**Recording**	**Date and of time of the recordings**
		SAMSUNG PHONE:	
1.	**Tutor Maria the tutor and the tutees**	**She was explaining to the kids how to use the recorders and how to make their recordings:** You press the red button and then you speak. Like I am speaking now: Hello I am Maria today was really nice because I did my mathematics. Then you press the red button again. Then, if you want to listen to yourself – you don't need to – you press that button on the side. Kid's voice: The bottom one or the top one? (She then plays back what she has recorded.) Kid's voice: So who is going first? Maria again: So OK – if you get the thing (recorder) then you start by saying your name, to say who helped you, like Maria or Lizzie. Kid's voice: But how are we going to remember the names? Maria: If you don't remember my name, say …. Kids voice: The girl with … the blue eyes. Other kid: Say the girl with the glasses and the one without the glasses. Maria: Ok that's if you don't remember our names. Kids voice: Or the girl whose hair is messy or the girl whose hair is right. Maria: Yes, or you can just say what I was wearing or whatever. Tell us what work you did… if you did your maths homework. (Kids' voices) All right wait, we can do that now, we can do that now. So then you begin and you say ok my name is Israel I had class with Maria today, it was nice because I did my mathematics…and then you tell us what you experienced and how it was for you. Kids voice: Can we go in and then come out and then play it here in front of	**29/08/13**

		everybody. Maria: No. Everybody talking together: no, nobody should hear. You just say it to yourself. But are you going to listen to it. Maria: No it is your story. Kid's voice: But if we want to. Other voices: no we don't want to. Kid's voice: So how are you going to know what it is? Maria: we are not going to be here if you do it. Kid: Where are you going to be? Maria: We're going home. Kid's voice: So we are going to keep this thing here? Maria: Yes, "tannie" Ann-Mary will keep it. OK, so after every session "tannie" Ann-Mary will come and give them to you, ok? Then you are going to record. You are going to say what your name is, who helped you to study that day, what work you did, and how you feel about the day. Then if you are done, you press the red button again. Then you come out and you give it to the next one. And if you are all done then you take all the machines to "tannie" Ann-Mary. Kid's voice: Who? Maria: Elisna …. Rose. Kid's voice: Can I say something? Maria: Yes. Kid: Are we going to do it now while you are here? Many voices talking together. Kid's voice: I don't understand. You say 'now'. So are we going to do it while you are here? Maria: No, you are going to do it and we will now go. Kid's voices trying to summarise what will happen. Lizzie saying: And remember everybody it does not record when the light is flashing. It only records if the light is on all the time. (Then Maria tests it in front of them – that recording is transcribed separately as Recording 8 on Recorder 3B.) Maria then says: Now I want to listen to what I have said to hear if I sound good. Then I press Play. Bester then says: Can I just come in there. I hope that you are also telling them they must just record their experience, what they experienced and how it is. (this because Bester could not follow the Afrikaans and she wanted to make sure the correct message came across.) Maria: yes, so you only tell us about what happened today. You don't tell us some or other story about the weekend. Ok Joseph? Deal? Kid's voice: Make a pinky promise. Kid's voices doing "pinky promise".	
From folder Recorder 1A:		**RECORDINGS ON THE DIGITAL VOICE RECORDERS:**	

2.	**Tutee Caroline**	*Recording 1:* Hello I am Caroline. It was very nice to do Maths with Lizzie. She is very nice and I would like to learn more with her. *Recording 2:* It was very enjoyable. I would like to do Maths again, more Maths. It was nice to be with Maria and to talk and everything. *Recording 3:* The girl with glasses. She's cool; she's pretty. We are naughty in her class – we laugh a lot. *Recording 4:* Repetition of previous recordings – nothing new.	**29/8/13**
From folder Recorder 2A	**Tutees**	***(most of this sounds like them practising to use the recorder)***	
3.		*Recording 1:* It was very nice to be with the adult ("tannie") and to work with her and do more sums and play again. OK bye. *Recording 2:* I love the adult ("tannie") and I am glad to do sums with her again. Bye. *Recording 3:* It was very nice to be with the adult ("tannie"). I love her, I just want to do more sums. *Recording 4:* Nothing. *Recording 5:* Nothing (except I know how to do it, I know…)	
4.	**Tutee Joseph**	*Recording 6:* Speaks in English: It was very nice to be here and I … I… I don't really know what to say but I am going to speak in Afrikaans so just ask somebody else. Then continues in Afrikaans: It was very nice for me to be here and I don't know how to say thank you very much but the day was nice. We did sums on the board, we learnt mathematics, we actually did a lot of things. And I am going to miss you when you go away. I miss you every single time. And thank you for doing this from your hearts. I say you must just have a nice rest of the day and thank you that you can help us with these things and that other adult ("tannie") that is English …(then speaks English)… She's great you know. She's just wonderful. I like what she does. She's very …. Very …. I don't	

		know what to say but … (goes back to Afrikaans) … she's sweet and nice. And what I want to say to you is thank you that we can be with you today. I know you do this from your hearts. And I love you all and …yes…we play nicely. You make conversation with us if there are problems and all that kind of things. I just want to say thank you. I am Joseph van Wyk in Grade 4. Please just remember my name. You must listen to this recorder – I ask please because this is the best one that you will ever hear. And the longest one. It comes from Joseph van Wyk in grade 4. (Then repeats the last sentence in English.) Continues in English: thanks for the best day you gave me. And say to your customers they are very pretty. Thank you, from Joseph van Wyk. Your pleasure. Yeah, that's all I want to say. Thank you for a nice day. *Recording 7:* My name is Joseph van Wyk. Thank you that we can be here today en we play nicely and do nice things. The tutors ("tannies") help us if we get hurt and with many things. Yes and the place is pretty and we doing nice sums. (Then speaks English.) I just want to say my name is Joseph van Wyk. Thank you for a nice day. I don't know how to pleasure (means how to thank you) but it was great today. Now I am playing inside here and my heart is very sore that you are going away because you do all the things you can for us. And thanks for that. And I know you do it out of your heart. All three our boys are saying thank you for a wonderful day. (Then back to Afrikaans.) And "tannie" can "tannie" that is Afrikaans please tell the other "tannie" that I give my whole heart to her because she was great today. And I just want to say that I had a wonderful day. I don't know about the others. And your name is again …. I don't know what your name is but I also don't know what that other tutor's name is that was here last time with the braces and the glasses, but I want to say thanks to you too. Then in English: I just want to pleasure (stet) you for everything you do to (stet) us but the other one who was here with the "draads and the brils" I just want to pleasure you all please. And we're having a nice day with you and we know you are doing it out of your hearts. I love you. Then in Afrikaans: I love you as well and can you please look after your body well. And you must go home safely today. And you must just enjoy it. (Then again, in English.) You must take care of your body. You must have a nice trip. You must go very carefully home. And don't make "ongelukke" (accidents).	

From folder Recorder 3B:		***Contributions from the tutors, tutees and researchers***	
5.	**Tutor Tutees Researcher**	*Recoding 1:* Tutor explaining how the recorder works and adult asking when they will be done – no data here. *Recording 2:* Still explaining how it works – no data. *Recording 3:* Still explaining – no data. *Recording 4:* No data. *Recording 5:* Whispering. Someone doing a wolf howl. Whispering. Then some says: "Really Katty". *Recording 6:* Bester speaking to a tutor. No data. Recoding 7: Children practising with the recorder still. No data.	**15/08/13**
6.	**Tutor Maria**	*Recording 8:* In this recording Maria (tutor) gives them an example of how they can record. She says the following: My name is Maria, uhm..I had class with Lizzie today…We did my Maths homework. I really enjoyed it, but I think nananana… and next time I want to do more "this" and I would prefer Maria to speak to me in "this" way…and whatever. Then I am now done.	
7.	**No name**	*Recording 9:* (No name provided) Okay. I enjoyed it here today. And I would like the tutors and them to come again. And I just want to thank Jesus that he gave us such wonderful people. I want them to come every day, please. And thank you that they help us with maths. I enjoy maths. Thank you very much.	
8.	**No name**	*Recording 10:* First voice on this recording: I enjoyed today because the tutors ("tannies") helped me nicely and I did "lekker" mathematics and the tutors ("tannies") are nice ("oulik") and I have	

		many friends and the maths was nice. Yes, and they really helped me very well and all those things. They are good people. Second voice on this recording: I just want to say thank you for more people that helped us. And I want to say thank you that we are in the children's home and that Uncle Kobus and them care for us. And I also want to say thank you very very very much that we have a roof over our heads and that we have people that can teach us – like department people. And I just want to say thank you that You (formal Afrikaans "you" – "U" as one would address God in prayer) in this class can hear Your building work ("bouwerk") on me. "Kry ek sonder U die mure waterplas" (directly translated this is: Get I without You the walls level." Waterplas" should be "waterpas" which means "level" as in building a wall level - I assume this sentence comes from a sermon or prayer. This is very interesting and from one perspective quite amusing, because "waterpas" = level may be a difficult concept for the child, therefore she heard it as "waterplas"=water puddle.) Lord, thank you we could have another enjoyable day today. I just want to thank You for the day that we could have today. I really enjoyed it. I just please want you Lord to be with us tonight and with the people that taught us today. And thank you that we can something nice every day. Please forgive everybody's sins.	
9.	**Tutor Katty** **Tutee Israel**	*Recording 11:* First voice: Thank you that we could have another wonderful day today, and thank you for the people who came to visit us today. And I just want to ask that they all … just … arrive safely home and thank that they are here for us to teach us mathematics. Thank you very much for that. From Katty. Second voice: I am Israel. It was very nice to be with the tutor ("tannie") with the blonde hair. I want to do more maths and I want to talk to her more. Third voice: My name is Joseph and I enjoyed today. The tutors chat with you and we do nice maths. Do all my work and we play here and do a few things. I played a bit with the doll's house. And here is for the other lady ("tannie"): (Then speaks in English) We love the things what we do here. They help us and I played with the house inside here. And we are having fun and we are …	

	Tutee Joseph	we are … just loving it. They helped us doing our "house" work (meaning homework). So, just tell them I love them. Thank you.	
From folder Recorder 3C:			
10.	**Tutee** **Tutor** **Tutee** **Researcher** **Tutee**	*Recording 1:* I did not enjoy it today because Katty and Rose were very nasty to me. And it was also nice because the other girl (meaning the tutor) was here. *Recording 2:* (This recording is more interview style with the tutor asking the tutee questions). Tutor: Okay, so tell me what did you feel happened today, this afternoon here? Tutee: Okay, giggles, uhm…you ("tannie") helped us. We read. And you asked us what we do in maths, and that's all. Tutor: So do you think more could have happened? Tutee: I don't know. (Researcher then tells tutor to leave her to record by herself. Tutor then says she is done, but the researcher says she must record one without the tutor.) *Recording 3:* Today I had a maths lesson with "tannie" Martha. We did nice things. Caroline was very naughty, but yes … It is nice to have "tannie" Martha. She's cool. I hope she comes every time. She's a good person ("tannie"). We learnt from her. She asked what we do in maths and I told her we do fractions and like all those things. Then she said OK and then I said yes … *Recording 4:* (Continuation from recording 3) … she asked what we did and I said fractions and tables. And she's cool.	

	Tutee Katty	*Recording 5:* Thank you Martha that you came to visit us today. And I just want to say thank you very much that you have good hearts for us. And that you always send us out (stet) and that you are willing to help us. You have good hearts. I just want to say that. And thank you for people that are always here for us and not always gone. And can you please help so that …. (puts up a weird voice) thank thank you… (normal voice) that you are always there for us. And I just want to say thank you that this "tannie" and the other "tannie" can be here. Because I enjoy it when they are here. It is nice when they are here. And I want them to be here for us always. And always help us with everything. And I just want that they will come and help us forever, but if they can't it is OK. As long as they are sometimes willing to help us. I just want to say thank you for the tutors that come and for the other people. And that we can learn maths. And thank you that we have "tannie" Ann-Mary and uncle Kobus and them. And I want to say thank you for You (now addressing God) who made the world … that there are people with good hearts … and who can prepare themselves. And I just want to say that we could have another wonderful day Lord. And I want to ask You if You can please help that the people who are not as fortunate as us, that they …. The people who do bad things, that they will be forgiven. I ask please. Lord, can I just ask that we have another nice day today. Thank you – from Katty.	
		Other recordings from tutors after some tutoring sessions:	
11.	**Tutor Martha**	**Martha (alone in car with Bester):** OK, today I tutored the kids for the first time. I had all six because I was the only one that could be there today. First the three girls and then the three boys. The girls took quite a while to first calm down and they didn't want to say what they wanted to study. So we sat and read the whole time. It was a bit difficult because.. uhm they all wanted to talk at the same time and did not want to give each other turns. They bad-mouthed each other. The one became a little upset because the others were rude to her so it wasn't a very successful first time to tutor. But then the boys were much better. Very peaceful. And they told me how they	

		wanted to study, so that worked for a while. But then they wanted to play on the computer. There was an educational game that they tried to get going the whole time – which they couldn't. At least the one tried to study the whole time … and they said that they did study beforehand. Yes…so…	
12.	**Tutor Lizzie** **Tutor Maria**	**Lizzie (in car with Maria and Bester):** Hi, my name is Lizzie. I worked with Joseph, Carolineand Rose. In the beginning it was quite difficult to get started. I think it was because it was an unusual situation for them. Uuhm. All three had homework. They are in the same grade, so we did homework together – Maths homework. Uuuhm…and…Rose and Joseph were very busy. But…yes…and Carolinewas quiet and took a little longer with her homework. But when we got going it went well ("was lekker"). And I think we should rather – because they are in the same grade and they know one another – they are friends and just want to play the whole time. Didn't really want to do their homework. So I think we should rather try to work individually with them, then it will somewhat easier. **Maria (in car with Lizzie and Researcher 1):** My name is Maria. I worked with Hillary and Katty. They were very relaxed ("rustig"). Hillary had to leave at 15:20 for art class and couldn't really get to him but he didn't really have homework. Katty and I did maths and me and Ivanko also did maths. I enjoyed it very much. It was just a bit difficult with such big groups. Especially because there was an age difference, I struggled to get to everybody because they had different homework. I think it will be much easier if we can work with them individually because you cannot give everybody attention in such a short period of time …uhm… with their homework and then speak to them individually and so on. So I think as soon as the other tutors are with us and can help us so that we can have smaller groups it will be easier to do the work. (In the background you can then hear Lizzie saying "Yours was much better than mine", indicating that they could hear each other. Might explain why Maria made some very similar statements to Lizzie.)	

13.		**Recording: Done in researcher's (Helene) car with 4 teenagers present after a session at the children's home. Done on iPad 2 handled by Martha.**	**9 Sep 2013**
	Tutors: **Charity** **Martha** **Juliette** **Research er**	Charity: Am I now first on the thing? OK, am I going to speak first? Martha: Yes. Charity: They were really very cute ("oulik"), did not want to work. Martha: Who did you have? Charity: I had Carolineand Ivanko. They were really very cute, but they did not want to work. They wanted to play the whole time. But they have very interesting stories and they know what goes on their classes (she means at school) so that's good. Juliette: OK, I had Rose. She is a little angel. Compared to my brother she's really an angel. She brought very little work along to do, so maybe next time she should bring more work. But she listened really well. Reseacher 2 (researcher): What did you do with her? Juliette: We read stories and practiced her part in a play. She's going to become actress according to me. She's very good with that. Yes, and that's it. Kristen: I had Katty. We did spelling words, Afrikaans spelling words and a few maths problems, but she's really clever and she listened very well. She is very focused on her work. Martha: Yes, see this is what happens if she and Rose are not together. Kristen: Yes, when she and Caroline started playing together "it was night". (Afrikaans expression for saying things got difficult.) Martha: Yes, precisely. That's why there must be a girl and a boy, a girl and a boy. Rose should be on her own. Martha: I had Hillary and he was adorable and so cute ("oulik"). He made me work. He first did all his homework and then he asked me to do mathematics problems with him. The problems that were actually above his level ("bo sy vuurmaakplek") he did perfectly. So, yes, he is very nice. A second recording during the same trip:	

		Martha: It is different from what I expected. It is very emotional. I didn't expect to become emotionally attached to the kids, but yes Juliette: Rose told me that, each week, I should teach her three new French words. So we are going to learn French. Helene: Yes, see, you can teach them your own things. It needn't necessarily be the homework or the schoolwork. Martha: Yes Hillary also asked that I help him with Japanese (Researcher's note: Martha is teaching herself Japanese so this probably came up in the session with Hillary.) Helene: You could teach them pieces from Shakespeare to recite. Everybody laughs and comments: Yeees, Yeees. That will be so cool. Martha: That will be awesome. Imagine Carolinesaying "Shall I compare thee to a summer's day" (in a Shakesperean voice). Wait, who had Cathy? Did she read you some English. She reads English so well ("mooi"). I actually started crying (referring to when she worked with Carolinein a previous session). Charity: She didn't read Afikaans that well. Martha: Who, Cathy? That's weird, because she does very well in English reading. Charity: But I also read better in English. (The recording ended here, but the researcher made note of a comment made by Martha also on this trip. She said that she didn't want to stop going to the children's home when the project is over.)	