User Experience Metrics for Dr Math®

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Submitted in fulfilment of the requirements for the degree
Magister Technologiae

in

Information Technology

in the

FACULTY OF ENGINEERING, THE BUILT ENVIRONMENT
AND INFORMATION TECHNOLOGY

at the

NELSON MANDELA METROPOLITAN UNIVERSITY

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January 2012

Declaration

I, Zonke Ngaye, s20647307, hereby declare that the dissertation submitted for the degree Magister Technologiae: Information Technology is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

Zonke Ngaye

Abstract

The purpose of this research study is to propose guidelines for providing a positive user experience for pupils using Dr Math®. User experience was found to have a positive impact on the acceptance and adoption of a product. Thus the proposed guidelines contribute in maximizing the adoption and acceptance of Dr Math® among pupils.

This study begins with an introductory chapter that describes the problem that forms the basis for this research. The chapter defines the objectives that this study is intended to achieve in order to accomplish its ultimate goal. The methodology followed to conduct this research study as well as its scope are also defined here. The results from a preliminary survey revealed that despite its potential accessibility, Dr Math® has a low adoption rate. However, when compared to other mobile learning (m-learning) applications for mathematics learning, Dr Math® is more popular. Thus Dr Math® was selected as a case for study.

Chapter 2 of this study provides a detailed description of Dr Math® as a local mobile application for mathematics learning. It was found that the affordability and accessibility of Dr Math® did not necessarily imply a high adoption rate. There are various possible barriers to its low adoption. User experience (UX), which is the focus of this study, is one of them. Thus, a subsequent chapter deals with UX.

Chapter 3 discusses UX, its scope, components and definition and places particular emphasis on its significance in the success of any product. The chapter also highlights the characteristics of a positive UX and the importance of designing for this outcome.

In Chapter 4, a discussion and justification of the methodology used to conduct this research is discussed. This study primarily employs a qualitative inductive approach within an interpretivism paradigm. An exploratory single case study was used to obtain an in-depth analysis of the case. Data was collected using Dr Math® log files as a documentary source.

Gathered data was then analysed and organized into themes and categories using qualitative content analysis as outlined in Chapter 5. Also the findings obtained from the results, which are mainly the factors that were found to have an impact on the user interaction with Dr Math®, are presented here. The identified factors served as a basis from which the guidelines presented in Chapter 6 were developed.

Chapter 7 presents the conclusions and recommendations of the research. From both theoretical and empirical work, it was concluded that Dr Math® has the potential to improve mathematics learning in South Africa. Its adoption rate, however, is not satisfying: hence, the investigation of the factors impacting on the user interaction with Dr Math®, from which the proposed guidelines are based.

Key Words: User experience, mobile user interface design, guidelines, Dr Math®

Acknowledgements

Completing this dissertation has been a long and challenging journey for me. Certainly, I would not have reached this point if it was not for the Love of Almighty God and the support of the people around me. I would like to express my deepest gratitude to the following:

- My supervisor, Prof. Darelle van Greunen, for her guidance and assistance throughout this research;
- Dr Math® team, particularly, Laurie Butgereit, for organizing and getting me access to the Dr Math® log files and for answering every questions I had about Dr Math®.
- My parents, brothers and sisters for their constant source of love, support and inspiration;
- Nelson Mandela Metropolitan University, Telkom, and NRF for supporting me financially;
- My friends and colleagues, for their support and inspiration;
- And lastly, Bronwen Kaplan for language-editing this thesis.

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Chapter 1: Introduction

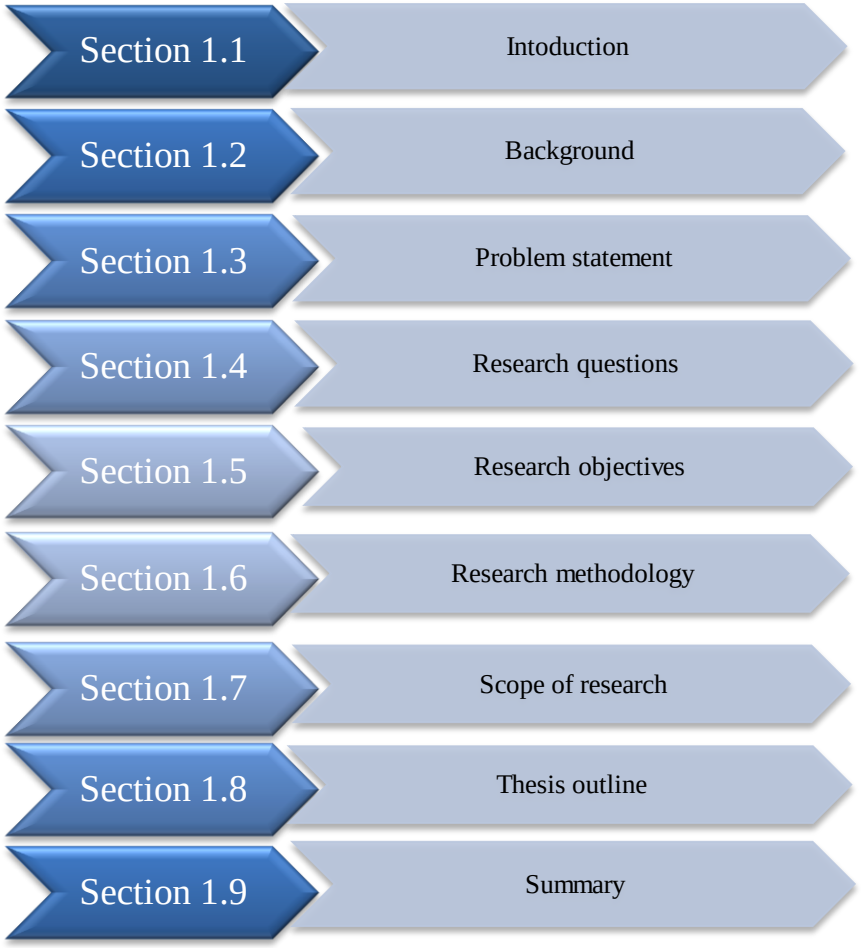


Figure 1.1: Chapter 1 layout

1.1 Introduction

The purpose of this chapter is to provide an overview of the research that was carried out for this study. Firstly, it provides a background to the problem that led to the study's development. Thereafter, the problem statement is presented, followed by the research objectives. Subsequently, a discussion of the research design and methodology is provided, after which the scope of the research and the dissertation outline are presented.

1.2 Background

The issue of mathematics education has been raised by many researchers and it has been of concern for several decades (Butgereit, 2007a; Butgereit & Botha, 2010a, 2010b, 2011; Kitta, 2004). In addition, Butgereit and Botha (2010a, 2010b) further elaborate on this point by

adding that only 7% of South African pupils possess basic mathematical skills necessary to cope with university-level mathematics. However, many researchers emphasize the significance of mathematics in our lives (Butgereit, 2007a; Kitta, 2004). Kitta (2004) elaborates further and states that mathematics is a "language that helps us describe ideas and relationships drawn from our environment"; and that it enables people to solve problems that would not be solved without mathematics skills. In essence, the economy is one of the major fields wherein mathematics education plays a significant role (Butgereit, 2007a).

In response to the economic significance of mathematics education, several reforms in it have occurred over the past several decades. About 30 years ago, Naeve (2001) introduced an innovative approach to mathematics learning by integrating ICT into mathematics education. However, due to challenges regarding the accessibility of the traditional ICT tools in South Africa, this approach was neither an adequate nor complete answer to this problem, as it could only be applied in privileged schools.

A survey conducted in 2007 by the South African National Education Infrastructure Management System (NEIMS) revealed that out of 28 742 schools, 72% had electricity, 40% had landline telephones and only 23% had computer centres. Of this 23%, only 13% had access to the internet. Additionally, in 2008, it was reported that only about 8% of South Africa's population had access to the internet through computers (Vosloo, 2008)

However, with as high as 97% adoption rate of cell phone usage among South African youth, which was reported two years ago by Kreutzer (2009), mobile technology stands a better chance of enhancing mathematics learning. Based on the above findings, mobile learning (m-learning) could address accessibility issues imposed by traditional ICT tools such as computers and landline telephones (Ford & Botha, 2010).

The vast majority of South African youth uses Mxit, the most popular Mobile Instant Messaging (MIM) system (Chigona, Chigona, Ngqokelela, & Mpofu, 2009). Today, given the high adoption of cell phones and Mxit among South African youth, Dr Math®, which uses the

Mxit platform, is an innovative approach that could enhance mathematics learning in South Africa. Thus, Dr Math® was selected as the case study for this research study.

1.3 Problem statement

The high expectations regarding the potential of ICT to enhance mathematics learning in South Africa remain largely unfulfilled. The purpose of this study was to propose guidelines for providing a positive UX for pupils when using a mobile learning mathematics application, Dr Math®.

1.4 Research questions

1.4.1 Main question

- What are the user experience metrics that impact on a positive user experience for pupils when using Dr Math®?

1.4.2 Sub-questions

- What is the Dr Math® program?
- What are the characteristics of a positive user experience?
- Which factors impact on user interaction with Dr Math®?

1.5 Research objectives

1.5.1 Main objective

- To define the user experience metrics that impact on a positive user experience for pupils when using Dr Math®.

1.5.2 Sub-objectives

- To describe Dr Math® as an m-learning tool specializing in mathematics education in the context of South Africa.
- To describe the characteristics of a positive user experience.
- To determine the factors that impact on user interaction with Dr Math®.

Table 1.1 summarizes the research objectives with the methods used to collect the necessary data to accomplish each objective.

Research Objective	Type	Data collection method
To define the user experience metrics that impact on a positive user experience for pupils when using Dr Math®.	Primary	Documentation and Expert review
To describe Dr Math® as an m-learning tool specializing in mathematics education in the context of South Africa.	Secondary	Literature review
To describe the characteristics of a positive UX.	Secondary	Literature review
To determine the factors that impact on user interaction with Dr Math®.	Secondary	Documentation and Expert review

Table 1.1: Research objectives and respective data collection methods

1.6 Research methodology

This research study is comprised of two phases. Phase one entailed conducting a preliminary survey which was distributed to the first year, IT students at Nelson Mandela Metropolitan University. The purpose of this survey was to guide the direction of this study. This survey was divided into three major categories namely:

Personal information – the purpose of this was to gather information about the general background of the schools from where the respondents came. Specifically, the respondents were required to state the town of the school they matriculated from and whether there was electricity or not. They were also asked if they had had computers at school and whether or not they had used them in the classroom. The results showed that the vast majority of pupils had electricity at school and 85% had computers at school: however, only 27% of the respondents had used computers in the classroom. These results are, therefore, in agreement with the existing literature on the adoption of ICT for education in South Africa.

Cell phone usage – the purpose of this category was to obtain a general idea of whether pupils use their cell phones for educational purposes and chat networks such as Mxit, knock-knock,

2go, facebook and more. Based on the results, Mxit was the most popular chat network among the participants. The results of this section contributed in the selection of Dr Math® as a case for this study, since it is available through the Mxit platform.

Mobile mathematics applications awareness – information on which mobile mathematics applications pupils used or have heard about was obtained from this section as well the respondents' perspective on the usefulness of the applications they have used. The pupils who had at least heard of any of the existing mobile mathematics applications were also required to state the source from which they had heard about them. The overall results of this section indicated the majority of pupils (even though this was only 15% of the respondents) had at least used Dr Math®. This indicates the low adoption of mobile mathematics applications in South Africa. The results also revealed that the majority of the respondents had never heard or used any of the existing mobile mathematics applications. Moreover, the results of this section, in conjunction with the results of the previous section, motivated the selection of Dr Math® as a case for this study. For the overall results of the preliminary survey (phase 1) see Appendix A.

The second phase of this research study entailed applying the findings from phase one to conduct an in-depth case study using the Dr Math® program as a case. Phase two was influenced and structured by the Research 'Onion' model by Saunders, Lewis, and Thornhill (2003), depicted in Figure 1.2.

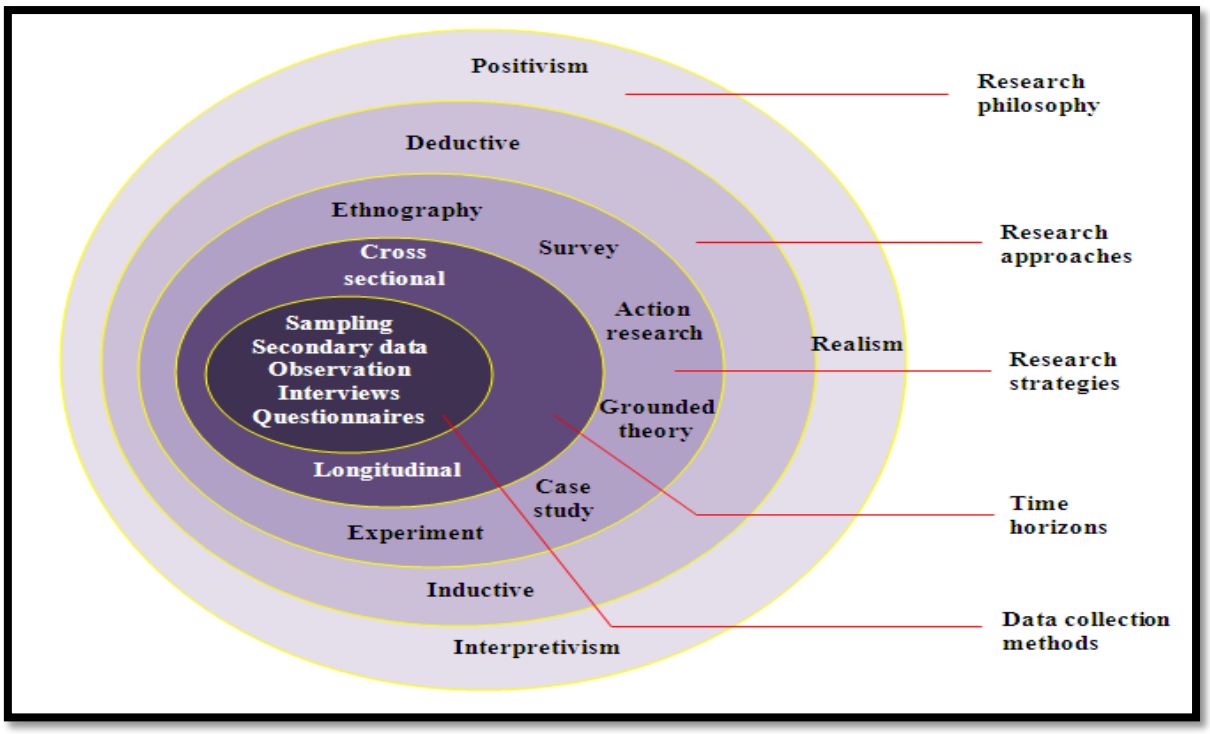


Figure 1.2: The research 'onion' (Saunders et al., 2003)

This study adopted an exploratory case study design of qualitative approach within an interpretivism paradigm. The selection of this approach rather than other ones is substantiated by Yin (2003) one of the most valued sources of case study research. Furthermore, a single case with multiple embedded units of analysis was selected as an appropriate design for this study (Yin, 2003). Primary data was collected through documentation, one of the multiple case study data sources identified by Yin (2003), with Dr Math® log files as a documentary source. The documentary source was supplemented by data from both literature and expert reviews. Qualitative content analysis was used to analyze and organize data into meaningful information (Henning, van Rensburg & Smit, 2004; Mayring, 2000). A focus group of experts was used to promote deep and insightful findings (Anderson & Arsenault, 1998) and also to verify the proposed guidelines. A detailed discussion of the research design and methodology is presented in Chapter 4.

1.7 Scope of research

This research study is mainly concerned with the user experience of Dr Math® users (pupils). The user experience of Dr Math® tutors is not in the scope of this study. Due to the different

types of the existing mobile mathematics applications, it is difficult to generalize the findings obtained from studying Dr Math® across them. Moreover, since the Dr Math® program is South African based, the study is limited to the South African context. Furthermore, the empirical findings of the study are based on 2011 log files, from the end of January to the end of May, a copy of which is attached as Appendix B.

1.8 Dissertation outline

The study is divided into seven chapters as illustrated below:

Chapter 1: Introduction

This chapter provides the background to the study and particularly highlights the problem that motivated the development of this study. The chapter includes elements such as the problem statement, research objectives, research design and methodology and the scope of the research.

Chapters 2 and 3: Literature review

Chapters 2 and 3 present and discuss the selective literature review found in the area of study and attempt to fulfil the first and the second research objectives. These chapters provide a theoretical insight and conceptual framework for this study. Specifically, Chapter 2 focuses on describing Dr Math® as an m-learning system for mathematics learning. Particularly, Chapter 2 reviews a number of studies on the evolution of Dr Math®, its role in mathematics education, its typical users and lastly, reports on the shortcomings of Dr Math®. Chapter 3, on the other hand, focuses on UX as a concept, its building blocks and its various definitions. The UX evaluation is also discussed in this chapter. Furthermore, the chapter stresses the significance of going beyond usability to a broader user experience. It also highlights the characteristics of a positive UX and the implications for obtaining such. It then presents a discussion on UX within the mobile context. The chapter ends with a list of typical factors that impact on mobile user experience.

Chapter 4: Research design and methodology

This chapter describes the overall approach to the research process. The philosophical stance, research approach, strategy, data collection and analysis methods employed in this study are discussed. The chapter also discusses sampling techniques followed.

Chapter 5: Research results and findings analysis

This chapter presents and analyses the results obtained from the Dr Math® log files using qualitative content analysis. In order to produce a research outcome, research findings need to be analysed and interpreted; therefore, this chapter also analyses, interprets and the presents the findings from which the outcome of this study is based.

Chapter 6: Guidelines for providing a positive UX for pupils using Dr Math®

This chapter provides guidelines to assist Dr Math® designers in designing a positive UX. These guidelines are derived from the study's findings. The guidelines are coupled with detailed suggestions on how they can be implemented.

Chapter 7: Recommendation and conclusion

This chapter summarizes the purpose and goals of this research. It restates the research questions and objectives. It also provides a brief summary of the findings in connection with the research questions and objectives. The limitations and relevance of the study are discussed in this chapter. The latter part of this chapter suggests recommendations for future research.

1.9 Summary

This chapter discusses the background to the problem that led to the development of this research study. It also provides the reader with an overview of the whole study with the aim of focussing the reader on the problem at hand. The problem statement and objectives of the study are stated and the research design and methodology outlined. Lastly, the chapter discusses the scope of the research, followed by the outline of the chapters comprising this thesis.

Previous studies reported that mathematics education in South Africa is in poor shape and needs reformation. The current passive, formal, teacher-driven, time-dependent learning approach has negative outcomes for mathematics education. From the discussion of the background of the study, it is clear that mobile technology plays a significant role in mathematics education: it is already at hand. The majority of learners and teachers are already familiar with the technology; therefore, it does not require initial teacher training. The

technology used is cheaper than that used for computers and has neither location nor time constraints. Learners can access educational material anytime and anywhere even though this can be hindered by the reception of the area in which the learner is. However, the high adoption and use of cell phones in South Africa show that this is a minor limitation that can be easily handled.

Previous studies have highlighted that methods that were introduced before m-learning in attempts to solve the mathematics problem in South Africa had accessibility issues. In other words, they were not accessible to a wide audience in the way that m-learning is as they could only benefit pupils who had access to computers and internet. Specifically, according to existing literature on this subject, less than 10% of the entire South African population had access to the internet about two years ago. In essence, Dr Math® was selected as a case through which to investigate the factors impacting on user interaction with mobile tools for mathematics learning. The next chapter discusses Dr Math® as an m-learning tool.

Chapter 2: Literature Review – Dr Math®

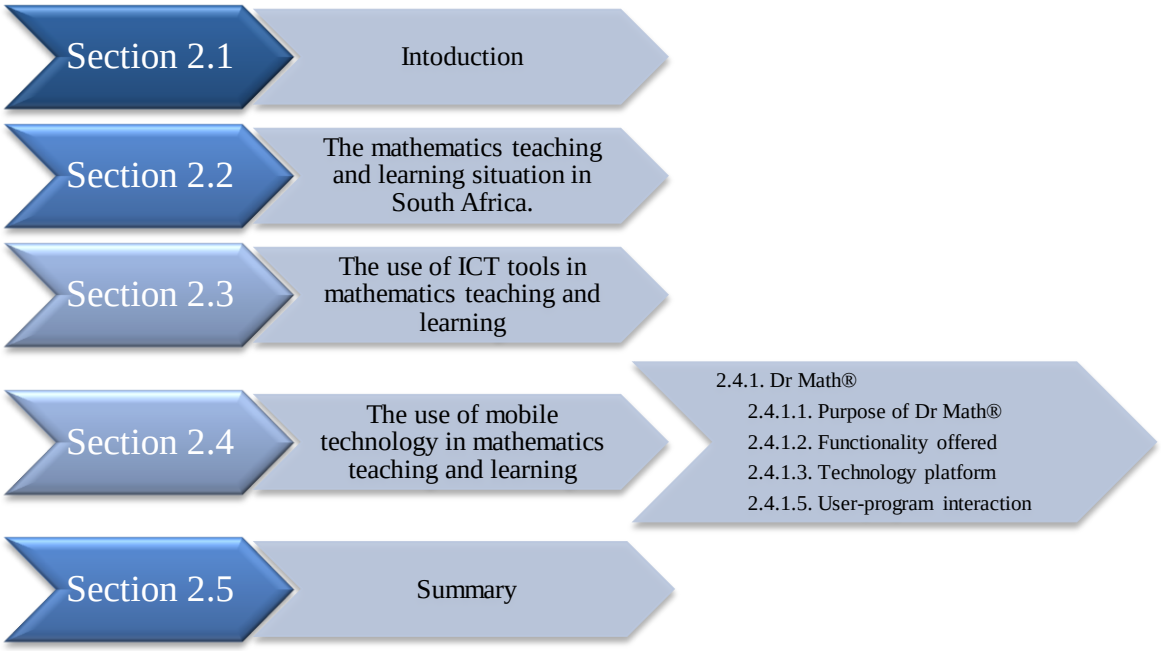


Figure 2.1: Chapter 2 layout

2.1 Introduction

Chapter One outlined the study. This chapter reviews and comments on the theoretical findings relevant to mathematics teaching and learning in South Africa; and the use of ICT tools and mobile technology in it with special emphasis on Dr Math®. A brief overview of the purpose of Dr Math® is presented as well as a discussion on the functionality that it offers. Following this sub-section is a discussion on the technology platform that Dr Math® exploits. Thereafter, a discussion of the pupil-Dr Math® interaction is provided using screenshots to give an idea of the user interfaces that both the tutors and pupils interact with. Following this section is a description of typical Dr Math® users. The latter part of this chapter discusses the shortcomings of Dr Math®.

2.2 The mathematics teaching and learning situation in South Africa

The significance of mathematics is evident in our daily lives (Butgereit, 2007; Kitta, 2004). Kitta (2004) elaborates further and states that mathematics is a "language that helps us describe ideas and relationships drawn from our environment", and that it enables people to

solve problems that would not be solved without mathematics skills. Butgereit (2007) adds that the economy of the country is one of the major areas in which mathematics education plays a significant role. Reddy (2006) supports this view by stating that mathematics is a key to social and economic development of a country.

However, a great deal of research reveals that South Africa is doing badly in mathematics (Bahamóndez & Schmidt, 2010; Butgereit, 2007a; Howie, 2003; Reddy, 2006). In support of this statement, the results from the Third International Mathematics and Science Study Repeat conducted in 1999 revealed that South African students performed very badly compared to other countries (Howie, 1999). Additionally, the research also shows that, even when compared to other developing countries with similar social problems such as the Philippines and Indonesia, South Africa still does remarkably poorly (Howie, 1999). This view is backed up by Howie's 2003 study which revealed that of 741,338 learners who enrolled in mathematics in the year 2000, only 430,005 learners (58%) wrote mathematics examinations and only 45% passed them.

Furthermore, the poor performance in mathematics in South Africa is enhanced by factors such as the shortage of qualified teachers, a lack of basic equipment such as textbooks and laboratory equipment a lack of access to technology and more (Kitta, 2004; Makgato & Mji, 2006).

Shortage of mathematically qualified teachers

The scarcity of qualified teachers is one of the pressing problems in South Africa, especially in mathematics education (Howie, 2003; Kok & Merz, 2004; Matthee & Liebenberg, 2007). Particularly, Howie (2003) and Kok & Merz (2004) state that of more than 80% of professionally qualified mathematics teachers in South Africa only 50% have specialised in mathematics.

Lack of access to basic infrustracture

Glewwe and Kremer (2006) indicate that many schools in developing countries, particularly in rural areas, lack the basic teaching and learning equipment such as such as textbooks,

blackboards, desks and benches. There are cases where even classrooms do not exist: in such cases, classes are held under trees but only when weather conditions are favourable (Howie, 2003). In addition, the lack of electricity is highly likely in such places, making it difficult to make use of certain resources such as technology that can improve mathematics teaching and learning.

Lack of access to technology

A wide range of research shows that technology plays a critically important role in education especially mathematics education (Ford & Botha, 2010; Naeve, 2001; Naeve & Nilsson, 2004; Roberts & Vänskä, 2011). However, Valk, Rashid and Elder (2010) reveal that one-third of the world's population, especially those living in the developing countries, does not have access to printed information, new skills, and technologies that can make their lives better. Furthermore, a research study conducted in 2008 showed that only about 8% of South Africa's population had access to the internet through PCs (Vosloo, 2008).

In essence, this issue is not only a secondary education problem, it carries over to tertiary education. In support of this view, Butgereit and Botha, (2010a, 2010b) report that only 7% of South African pupils possess basic mathematical skills necessary to cope with university-level mathematics. Given the above statistics, it is evident that mathematics education remains an obstruction to economic empowerment in South Africa. Thus, mathematics education should not stop reforming until effective teaching and learning strategies have been developed and implemented.

The next section discusses the use of ICT in mathematics education, teaching and learning.

2.3 The use of ICT tools in mathematics teaching and learning

The status of mathematics education has created a genuine need for a review of teaching and learning strategies. A major initiative in this regard was taken about 30 years ago by Naeve (2001), who introduced an innovative approach to mathematics teaching and learning, that is, the integration of ICT into it. However, due to challenges regarding the accessibility of the traditional ICT tools in South Africa, this approach could not adequately address the

mathematical crisis. This approach could only be applied in schools with the necessary equipment to make the implementation possible. Underprivileged schools with no electricity and other necessary resources did not benefit from this approach.

In support of the above discussion, a survey conducted in 2007 by the National Education Infrastructure Management System (NEIMS) revealed that out of 28,742 schools, 72% had electricity, 40% had landline telephones, and only 23% had computer centres and of those only 13% had access to the internet (Ford & Botha, 2010). Additionally, as mentioned in Section 2.2, recently only about 8% of South African population had access to the internet through computers.

However, with an adoption rate as high as 97% of cell phones among South African youth, which was reported two years ago by Kreutzer (2009), mobile technology presents a better chance of enhancing mathematics learning in South Africa.

The next section provides a discussion on the use of mobile technology in mathematics education.

2.4 The use of mobile technology in mathematics teaching and learning

Due to its high adoption rate, as highlighted in Section 2.3, mobile technology addresses the accessibility issues imposed by traditional ICT tools such as computers, landline telephones and more (Ford & Botha, 2010). In contrast with traditional ICT tools, mobile technology has a potential to deliver learning material at low-cost and to provide learners with unlimited access to the learning material anywhere, anytime (Matthee & Liebenberg, 2007; Virvou & Alepis, 2005). Therefore, the use of mobile technology in mathematics education expands teaching and learning time. It allows teaching and learning to take place at any given time and place. For example, with mobile technology pupils can learn while sitting at the train or bus station, in transit or at home. Also teachers or tutors can interact remotely with the pupils after school or during weekends. Additionally, mobile technology affords a relatively wide range of learners the opportunity to access after-school assistance on one-on-one basis at a very low

cost. The potential benefits that mobile technology can bring to education generate a need to leverage mobile devices to improve mathematics achievements.

Despite the rapid development of mobile technology and the alarming fast rate of mobile penetration in South Africa, the implementation of mobile learning is still in its infancy stage (Liu, Liu, & Yu, 2008). It has, however, a promising future in education, especially mathematics education.

Mathematics education has received the bulk of the attention in this regard due to its high failure rate. Several projects aimed at enhancing mathematics learning by utilizing mobile technology have arisen in South Africa. The growing ubiquity of mobile phones among South African learners and teachers is the major driving force of the development of these projects. These projects include Dr Math®, M4Girls, Imfundo Yam/Yethu, and more (Bahamóndez & Schmidt, 2010; Ford & A. Botha, 2010; Roberts & Vänskä, 2011).

Furthermore, in addition to the high adoption rate of cell phones among teenagers, a vast majority of South African youth uses Mxit, the most popular Mobile Instant Messaging (MIM) system (Chigona, Chigona, Ngqokelela, & Mpofu, 2009). This, therefore, makes Dr Math®, a mobile application available through Mxit, the best innovative approach that could enhance mathematics learning in South Africa. Thus, Dr Math® was selected as a case for this research study. The next section provides a detailed discussion of Dr Math®.

2.4.1 Dr Math®

Dr Math® is a mobile-based mathematics tutoring system available through the Mxit platform, the most popular Mobile Instant Messaging application (MIM), among South African youth (Butgereit & Botha, 2010c; Chigona et al., 2009). Dr Math® links primary and secondary school pupils with mathematically skilled tutors to chat about and discuss mathematics problems and solutions (Butgereit, 2009a). It facilitates real-time, one-on-one interaction between the tutors and pupils (Ford & Botha, 2010).

Dr Math® tutoring services are provided on demand basis. In this way, Dr Math® creates a conducive, personalized learning environment where pupils are in control of their learning. In addition, Dr Math® preserves user anonymity, providing the pupils who are too shy to ask questions in the classroom the opportunity to interact with competent tutors on a one-on-one basis (Butgereit, 2009a). Moreover, some pupils may not want their schoolmates to know that they need additional help. With Dr Math®, this is readily achieved.

The pupils communicate with Dr Math® tutors via Mxit, using their GPRS-enabled cell phones and their own airtime (Butgereit, 2009b). Therefore, from the pupil's side, Dr Math® is location and time independent. Dr Math® extends mathematics teaching and learning beyond the physical classroom, enabling pupils to learn anywhere, anytime. The new Dr Math® platform also enables tutors to work from outside the office. In other words, they can now work from home or computer labs since many are university students, thereby, extending consultation time while saving travelling costs.

The cost-effectiveness of the Mxit platform through which the pupils access Dr Math®, contributes to their willingness to use their own airtime to get assistance with their mathematics homework. Additionally, this cost advantage enables Dr Math® to afford pupils from different socio-economic backgrounds an opportunity to gain access to after-school mathematics assistance. The following sub-section provides a brief discussion of the purpose of Dr Math®.

2.4.1.1 Purpose of Dr Math®

Dr Math®, also known as "Math on Mxit", started in January 2007, as a research project conducted by the CSIR's Meraka Institute (Butgereit & Botha, 2010). The original objective of Dr Math® was to help secondary school learners with their mathematics homework using technology that is on hand (Butgereit & Botha, 2011). Specifically, Dr Math® aims at acquainting pupils with the necessary problem-solving skills while guiding them towards the answers as opposed to supplying them with straight answers (Butgereit, 2007b). The conversation below further illustrates this point.

Speedster: whats the answer of: (10-x) To the power of 2= 9x?

Dr.math: are u taking a cycle test or something and needing an answer?

Speedster: its good to take regular breaks..

Dr.math: do you know how to do (10 -x) power 2?

Speedster: no, its just a test of yesterday and im not sure about the answer..

Dr.math: the rule is first, outer, inner, last. Have you heard of that?

Speedster: yeah (100-x power 2)..

Dr.math: u forgot the inner and the outer parts. you only have the first and the last

Dr.math: the inner and outter are -10x and -10x

This conversation shows how Dr Math® tutors are supposed to assist the pupils, not spoon-feed them with answers. If the pupil was just given the answer, they requested they would struggle answering a similar problem in future, for example, in a test where different numbers are used. The general rationale behind the development of the Dr Math® project was to contribute in mitigating the mathematics crisis in South Africa (Butgereit & Botha, 2010c).

2.4.1.2 Functionality offered

The Dr Math® team reports that many pupils claimed to not have access to a calculator when asked by tutors to do calculations (Butgereit & Botha, 2010d). Additionally, it has been found that even though most cell phones do offer a calculator function, pupils tend not to use it (Butgereit & Botha, 2010d). This could be due to the fact that some cell phones do not support multi-tasking. In other words, pupils would have to terminate their interaction with Dr Math® to access the device's calculator. Thus, the Dr Math® team has embedded a calculator function into the Mxit platform for pupils to use when consulting it (Butgereit & Botha, 2010c).

In addition to the calculator function, Dr Math® enables pupils to learn even when there are no tutors available by offering definitions, formulae, games and competitions (Butgereit & Botha, 2010d). The games and competitions are not only

created to keep the pupils busy when there are no tutors online but, most importantly, to make mathematics learning more engaging (Butgereit, 2009b).

The next section provides a brief background of Mxit, the technology platform exploited by Dr Math® as a medium for providing additional mathematics assistance to the pupils. The Chat Based Call Centre and Tutoring Online (C³TO) platform, which was developed mainly to strengthen the scalability of Dr Math®, is also discussed in the next section (Butgereit & Botha, 2010c).

2.4.1.3 Technology platform

Mxit

Mxit is the technology platform through which Dr Math® services are delivered. It is an MIM, also referred as a "chat system" (Butgereit & Botha, 2010a). Mxit, is a Java application that runs on both GPRS-enabled cell phones and desktop computers that are connected to the internet (Ford & Botha, 2010). Users can easily download the Mxit application. Once the application is successfully downloaded (which normally takes less than three minutes, including the registration process), users can add contacts and start chatting with them. Mxit users can send text-based messages to their contacts or participate in chatrooms (Chigona & Chigona, 2008; Chigona et al., 2009). Mxit users can also chat with users from other online chat communities such as Jabber clients, i.e., Google talk; MSN messenger; and ICQ (Everything.Explained, 2011). Furthermore, messages sent over Mxit cost between one and three South African cents each (Butgereit, 2009a; Chigona et al., 2009). The cost-effectiveness of Mxit is reported as one of the major reason for its popularity among teenagers (Butgereit, 2009b; Butgereit et al., 2010).

C³TO

Mxit was mainly developed for social purposes; thus, it could not meet all the requirements associated with teaching and learning mathematics. This necessitated the need to develop a platform that would counteract its shortcomings. This is when C³TO came to the fore. C³TO is an open-source software platform, which was

developed by Meraka Institute in 2009, using open-source products including Ubuntu Linux system (Butgereit & Botha, 2010a, 2010c). The main aim behind the development of C³TO platform was to enhance scalability of Dr Math® (Butgereit & Botha, 2010c). The implementation of C³TO has introduced various benefits such as optimized operation, easy administration, remote tutoring and other useful functionalities such as capability to send bulk messages (Butgereit & Botha, 2010a, 2010c). C³TO also supports additional educational events such as games, quizzes and competitions. It also enables Dr Math® to provide pupils with additional content such as definitions and formulae when there are no available tutors (Butgereit & Botha, 2010a, 2010b, 2010c, 2010d). The next section illustrates the interaction between Dr Math® program and its users.

2.4.1.4 User-program interaction

There are two major ways to that a pupil can interact with Dr Math®. Firstly, a pupil can chat with the human tutors. Secondly, pupils can interact with it mainly for services that do not entail chatting with tutors. In other words, Dr Math® enables pupils to learn with or without human tutors. Dr Math® tutors chat with the pupils using traditional computers. Figure 2.2 shows a user interface through which Dr Math® tutors interact with the system in order to provide the necessary assistance to the pupils.

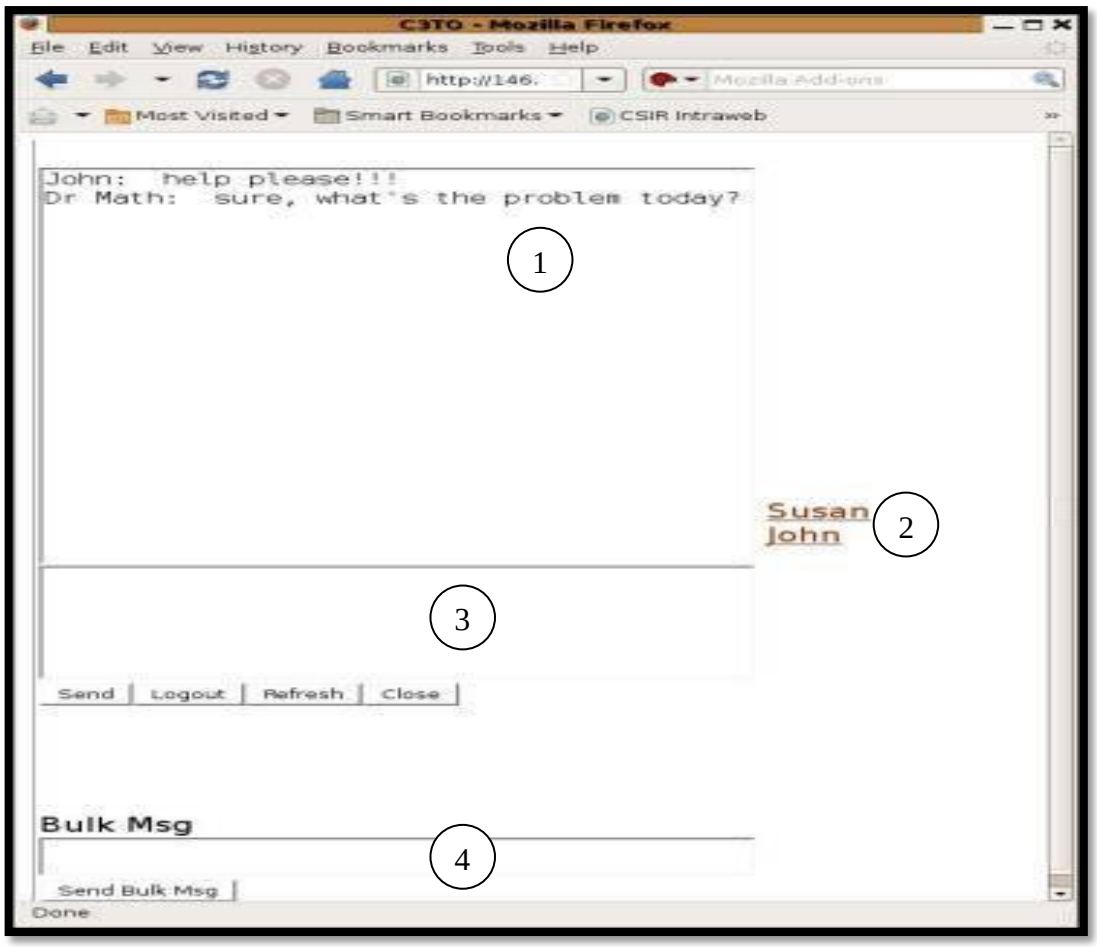


Figure 2.2: Typical user interface for Dr Math® tutors (Maths on Mxit (Group 408), 2011)

The screenshot in Figure 2.2 illustrates a typical interface that the tutor interacts with while tutoring. The screenshot represents Dr Math® after the implementation of the C³TO platform, which has introduced a wide range of benefits including the capability to send bulk messages, as can be seen here. These capabilities can improve the experience of Dr Math® users when used properly. The user interface for tutors offers a number of controls for different purposes, which facilitate the fulfilment of Dr Math®'s ultimate goal. These controls include:

1 – the area where the conversation between the tutor and the pupils is presented.

2 – where tutors get to see the list of the online pupils.

3 – typing area, where the tutor types in messages when chatting with online pupils. When done typing in the message to the pupils they are interacting with, the tutors can click "send" button to send the message. They can refresh the application using "refresh" button, close it using "close" button or logout using "logout" button.

4 – Number 4 represents the area where the tutors type in bulk messages to the pupils. This function can be used to inform pupils about the whereabouts of the tutors.

Figures 2.3 and 2.4 illustrate typical user interfaces for pupils using Dr Math® through their cell phones.

Figure 2.3: Typical user interface for a pupil (Maths on Mxit (Group 408), 2011)

The screenshot in Figure 2.3 illustrates a typical pupil-Dr Math® interaction from the pupil's device. In this instance, the pupil seems to be a new user of the program as Dr Math® normally sends the first message on the screen to new users. The Mxit interface shown in Figure 2.3, through which pupils interact with Dr Math®, supports

text-based messages. The above UI enables pupils to change font size and colour, to express their emotions using emoticons and send multimedia files (depending on the device's capabilities). Mxit does not support graphic presentation; therefore, it is not ideal for geometry problems.

To deal with ethical conditions and the safety of minors, the Dr Math® team informs new users that the conversations will be recorded and reminds them to never give out personal information.

The above UI provides pupils with various controls and features such as:

1 – typical message that Dr Math® sends to the new users reminding them to stay safe on Mxit.

2 – the button with a smile face contains various emoticons that pupils can use to express their emotions, while chatting with their Mxit contacts, including Dr Math®.

3 – "send file" button allows pupils to send multimedia files including pictures. However, this feature is device dependent. Some cell phones do not support the transmission of multimedia files.

4 – The combobox displaying the number "12" allows pupils to change the size of the text. The 12 showing on the combobox represents the current text size.

5 – typing area – text only, no graphic presentation.

As mentioned in Section 2.4.1.2, Dr Math® offers more than just tutoring by human tutors. In other words, pupils sometimes log in to Dr Math® not to chat with the tutors but to participate in competitions, look-up definitions and formulae or to play games (Butgereit, 2009a; Butgereit et al., 2010). The screenshot in Figure 2.4 depicts one of the text adventure games that Dr Math® offers.

Figure 2.4: Typical text adventure game (Butgereit, 2009a)

Figure 2.4 shows "Dr Math®'s missing laptop", one of the text adventure games found in Dr Math®. The following discussion about this game is based on Butgereit's (2009b) description of the "Dr Math®'s missing laptop" game. It consists of a map of four rooms which are separated by interconnecting hallways. To unlock the doors one can either use a digital key pad or a digital remote control. Unlocking the doors to the rooms becomes one of the players' sub-goals as it grants them access to some handy objects. Such objects include a calculator, an LCD torch, a battery charger, a digital remote key, a mathematical text book, and a rucksack, which is normally used to carry all these objects.

In this game, the players are also provided with clues on how to open digital locks. The players often find the clues written on the walls or white boards or are "virtually"

sent to the player via SMS. Since this game was developed to make division more engaging, the clues are in the form of division calculations. Typical clues include:

"Sliding door code is 32/4"

"The code for the digital key is 132/12".

The above clues are taken from Butgereit (2009b). The player is required to do the calculations, take the answer and execute it as a command. When the player manages to successfully executes the necessary clues and commands, he or she gains access to the rooms full of handy objects. The score goes up by one point every time the player manages to successfully complete a task. Here are a few examples of typical tasks and sub-tasks, taken from a study by Butgereit (2009b). The main task, in this instance, is to get a "virtual" cell phone working. The long-term goal however, is to find Dr Math®'s missing laptop. The italicized lines in the transcript below represent the player's input and the bold represents the game's responses.

Look in desk

In the modern gleaming metal desk are a torch, a cell phone and a digital key

Take cell phone

[Your score has gone up by one point]

Examine cell phone

The cell phone is currently switched off

Turn on cell phone

[Your score has gone up by one point]

The bottom line is that the player has to find Dr Math®'s missing laptop (Butgereit, 2009a, 2009b). The process of finding the missing laptop entails navigating through the rooms searching for the hidden objects (Butgereit, 2009b). Figures 2.5 and 2.6 present screenshots showing two examples of a pupil-tutor conversation.

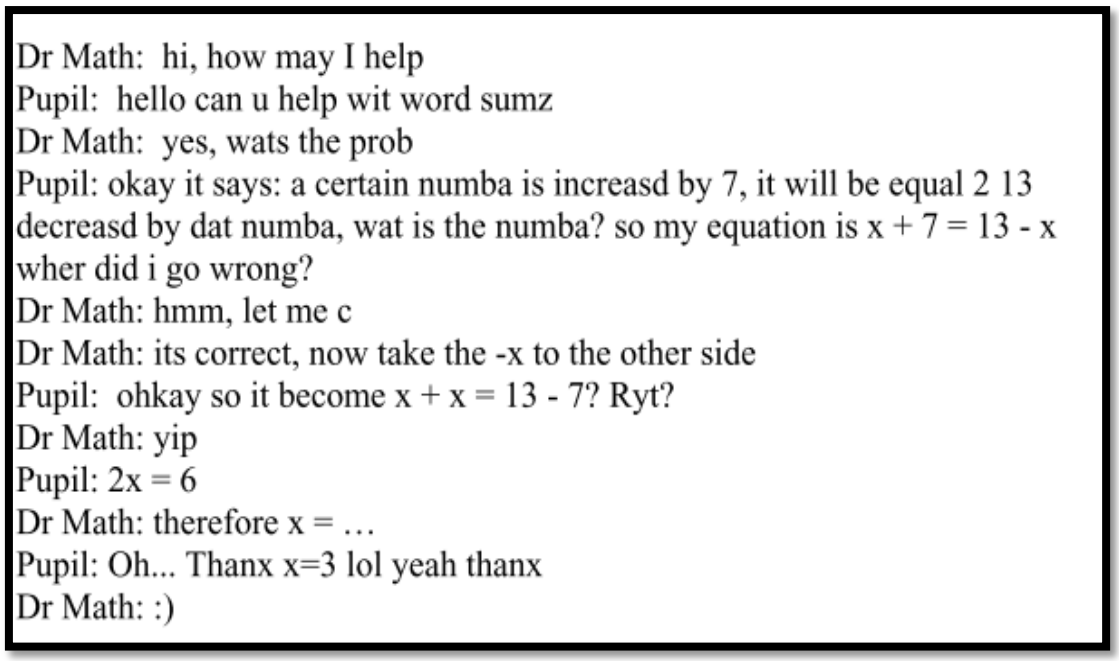


Figure 2.5: Sample of logged pupil-tutor conversations (Butgereit & Botha, 2011)

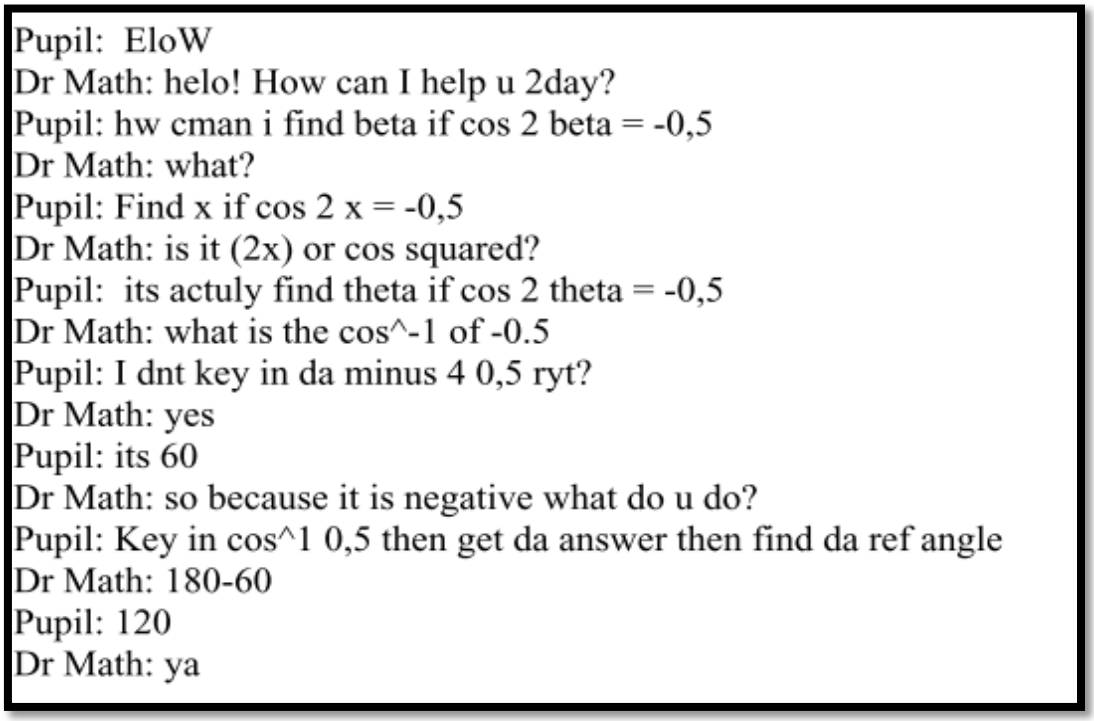


Figure 2.6: Sample of logged pupil-tutor conversations (Butgereit & Botha, 2011)

The screenshots in Figures 2.5 and 2.6 illustrate the typical tutor-pupil interaction. The online tutors normally start the conversation by sending a bulk message to all the online pupils, as shown in Figure 2.5. This message is to inform the pupils that there is a tutor available to

assist them. It often reads as follows: “Hi. What is your math question?” or “Hi, how may I help?” as can be seen in the first line of the conversation in the screenshot shown in Figure 2.5. The pupils who need assistance can then respond, otherwise they can ignore the message and continue chatting with their other Mxit contacts. If the pupil does need help, she or he will have type in the problem. In most cases, the pupils encounter difficulties in expressing geometry questions (Butgereit, 2007a, 2007b). Nevertheless, if the online tutor is conversant with the topic in question, he or she will guide the pupil towards the answer, encouraging the pupil to tackle the problem and help where necessary. Section 2.4.1.5 provides a general overview of Dr Math® users.

2.4.1.5 Typical users

Dr Math® users are mainly primary and secondary school pupils. The majority of these users claim to have access to a cell phone and have a Mxit account (Chigona et al., 2009). This is also supported by the results of the preliminary survey, conducted as part of this research study, which revealed that all the participants had access to cell phones and most of them use Mxit.

Dr Math® users normally use “Mxit lingo” (slang) when communicating with their Mxit contacts and Dr Math®. “Mxit lingo”, as defined by Butgereit and Botha (2011), entails shortening of words mainly by omitting most vowels and other letters and replacing some of those letters or vowels with numbers and symbols where possible. For example, “wat” and “w@” are equivalent to “what”; “gr8” is equivalent to “great”; and “gud9t”or “9t” to “goodnight”. Once the pupil invites Dr Math®, it becomes one of the pupil’s Mxit contacts and pupils tend to treat it as such. In other words, they tend to use this language when interacting with Dr Math®.

2.4.1.6 Shortcomings

Dr Math® is a powerful mechanism for improving mathematics teaching and learning, as it extends learning resources and time. However, it has a fair share of limitations, which are the root causes of the difficulties encountered by pupils when

interacting with Dr Math®. Consequently, these limitations negatively impact on the overall UX of Dr Math®. Such limitations include the following.

Input limitation

The approach of exploiting the Mxit platform, a text-based instant messaging system, has some limitations including input ones. In other words, Dr Math® does not provide mathematical symbols and graphs, making it difficult for pupils to express mathematics problems (Butgereit, 2007a, 2007b). The following example, extracted from a study by Butgereit (2007a) supports this viewpoint.

Pupil: It is geometry

Dr Math: Geometry is often difficult over MXit but let's try.

Pupil: I just need 2 no wat dey r asking... Given: triangle ABC with AB=AC. EDT is the perpendicular bisector of AB. BC producd meets EDT in T. Prove dat BT is th third proportional to BC & AB

Dr Math: hat is EDT

Pupil: A line going thru the triangle perpendicular 2 AB ending at 2 points outside the triangle: E on the side of AB & T on da side of AC wher it intersects AB it is cald D wher it intersects AC it is cald F"

Language restriction

Initially, Dr Math® tutors could only provide mathematics assistance mainly in English (Butgereit, 2007a). However, due to the high demand for help in Afrikaans, Dr Math® decided to add Afrikaans as a second language of communication (Butgereit, 2007a). The following extract illustrates one example of the issues associated with language restriction in Dr Math®.

Dr Math: so you never told me what you moved onto in math after logs

Pupil: I dont know what it's called in english:O

Dr Math: OIC. try it in afrikaans maybe I can understand.

Pupil: Ok its called "rye en reekse":D but that's easy:D

Dr Math: That's beyond my limited Afrikaans vocab. But I'll look it up this weekend...

In addition to language restrictions, tutors and pupils can be both conversant with the official language in use; however, according to Butgereit and Botha (2011), it is still possible for tutors to encounter difficulties in understanding pupils. They further argue that this is especially the case when the tutor is not a local English speaker. This is mainly due to the use of Mxit lingo among pupils when communicating with their Mxit contacts including Dr Math®. The following is one example that was extracted from Butgereit & Botha's (2011) study to provide evidence of this problem.

Pupil: EloW

Dr Math: helo! How can I help u 2day?

Pupil: hw cman i find beta if cos 2 beta = -0,5

Dr Math: what?

Tutor availability

As pointed out earlier, Dr Math® tutors are not always online (Butgereit, 2009b; Butgereit et al., 2010): hence, the implementation of competitions and games (Butgereit, 2009a, 2009b). However, one of the pupils' expectations is to find tutors online especially during the communicated operating times. When such expectations are not satisfied, pupils will be unhappy. However, fortunately for Dr Math®, thus far, there is no similar program in the South African market that they can migrate to, for better availability of tutors. The next section presents a summary of this chapter.

2.5 Summary

Dr Math® is an evolving mobile mathematics application, available through the Mxit platform, a very popular MIM among South African teenagers. In the South African market, Dr Math® is the only mobile mathematics application of its kind. Therefore, pupils who need additional assistance in mathematics do not have a wide variety of options to choose from. Thus, the adoption rate of Dr Math® among South African primary and secondary school pupils is increasing drastically, irrespective of its shortcomings.

Moreover, the experience of users, including emotions, feelings and attitudes that arise before, during and after their interaction with the product (Mashapa & van Greunen, 2010) becomes essentially important to keep and attract new users. This is especially the case when there is a wide range of applications for the users to choose from. The importance of UX may be underestimated and may not seem like such a big deal at this point in time, since Dr Math® is still evolving and has no competition as yet. However, UX is not only becoming a competitive factor but also a determinant of the overall usage of the product. Therefore, Dr Math® developers should strive to design for a positive UX; hence, the next chapter provides an in-depth discussion of UX.

Chapter 3: Literature Review – User Experience

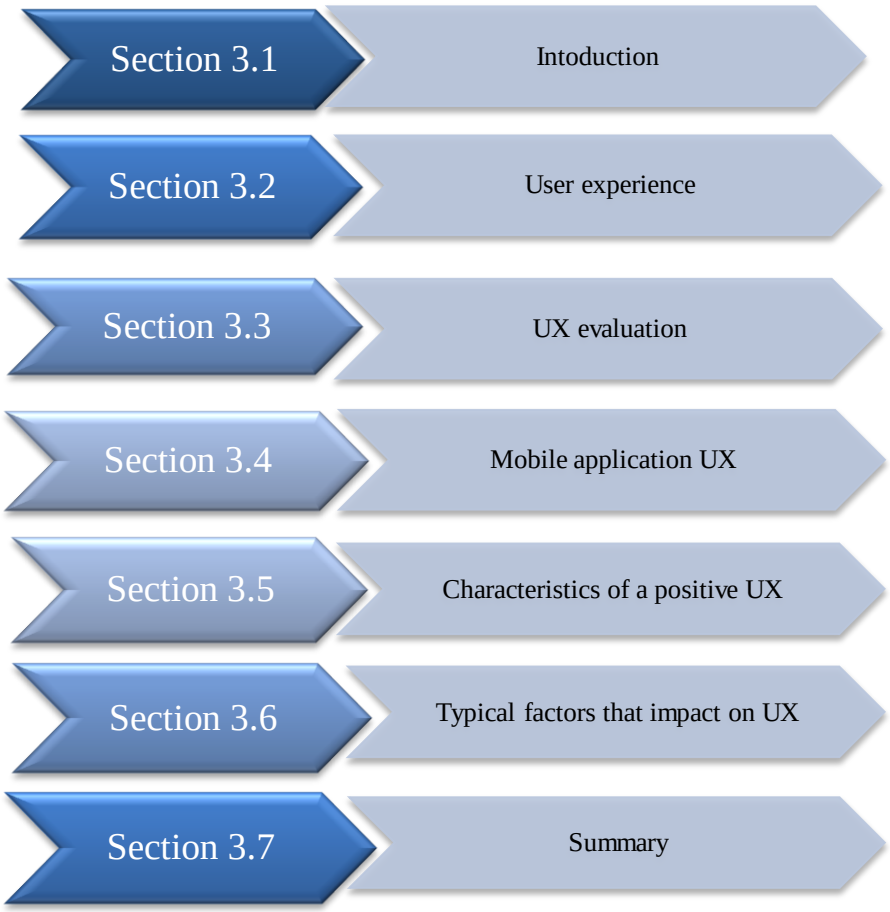


Figure 3.1: Chapter 3 layout

3.1 Introduction

This chapter stresses the significance of going beyond usability to a broader user experience (UX) to maximize the market success of products, and begins with a brief overview of the emergence of UX, followed by its definitions. The chapter then emphasises the differences between UX and usability. Following this section is a discussion of the significance of UX, followed by one on its building blocks. Subsequently, UX evaluation is discussed with special emphasis on UX evaluation methods. Thereafter, the UX of mobile applications and the characteristics of a positive UX, with special emphasis on what designing for a positive UX entails are examined. The latter part of the chapter presents and considers factors impacting on mobile UX.

3.2 User experience

3.2.1 Emergence of user experience

User experience (UX) is an evolving concept which, unlike usability, focuses on user-centred design, which is based on ISO 13407 (1999). Furthermore, ISO 13407 (1999) suggests four user-centered activities that are critical to incorporating usability requirements into the software development process. These are:

- Understand and specify the context of use
- Specify the user and organisational requirements
- Produce designs and prototypes
- Carry out user-based assessment.

Despite the fact that UX is still a developing field with currently no universal definition, it is readily and widely accepted in the HCI community (Law, Roto, Vermeeren, Kort, & Hassenzahl, 2008) and is rapidly gaining a ground in the industry (Jumisko-Pyykkö, Weitzel, & Strohmeier, 2008; Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009). A study conducted by Law et al. (2008), reveals that the multi-disciplinary nature of UX and its complexity, caused by the wide range of blurred and dynamic concepts such as emotional, affective, experiential, hedonic and aesthetic variables associated with it, are some of the factors that impose a barrier to a unified definition for user experience. UX design entails a variety of related aspects that must be catered for. Figure 3.2 summarizes the interrelations between various aspects associated with UX and also its nature and scope.

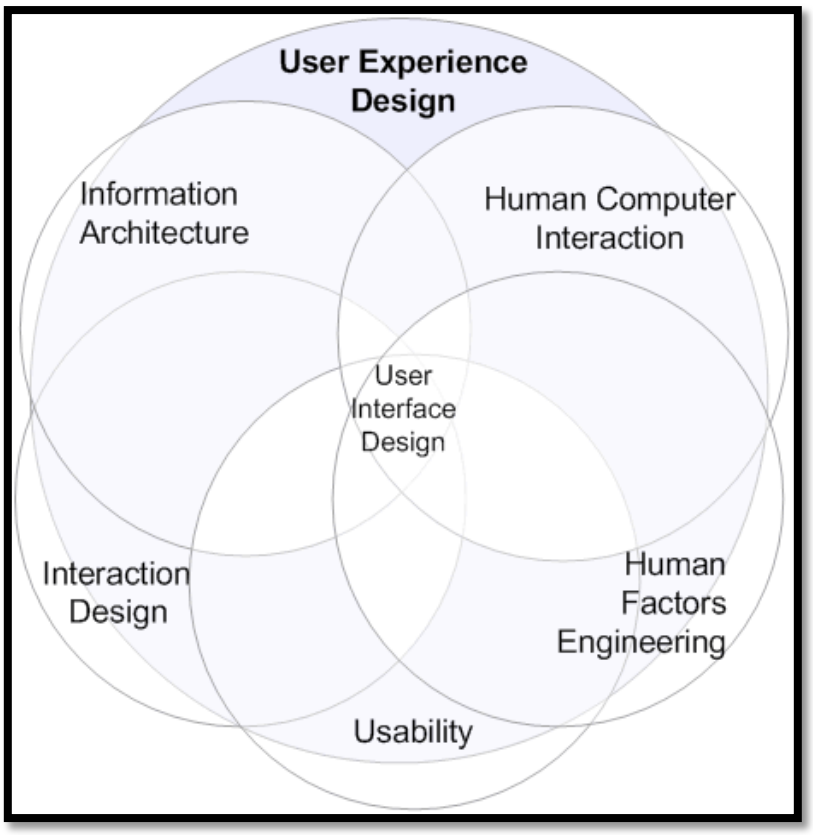


Figure 3.2: UX disciplines (Mashapa & van Greunen, 2010)

Figure 3.2 illustrates the multidisciplinary nature of UX and that it encompasses a variety of fields. It is critical to understand how each of these areas affects UX and how they interact with one another. User Interface Design, which is the heart of UX, will be discussed in Section 3.4. Information Architecture, Interaction Designing, Usability, Human Factors Engineering and Human-Computer Interaction (HCI) are equally essential.

User experience puts greater emphasis on people and their feelings than material. User experience focuses on the subjective aspect of the product use and the emotional satisfaction to be gained after interacting with the product, more than the functionality of the product (Hassenzahl, 2008). The next section provides a variety of definitions of UX by different authors.

3.2.2 Definitions of UX

Ever since the concept of determining the quality of technology products by experience was introduced, UX research has been receiving the bulk of the attention with an enduring

debate on the scope and definition of UX (Law et al., 2009). Even today, researchers have still not found a universal definition for it. In the meantime, researchers define UX based on their personal perception and to fit the purpose of their study. Table 3.1 shows a variety of UX definitions by different authors.

Definition	**Author**
A person's perceptions and responses resulting from the use and/or anticipated use of a product, system or	(ISO DIS 9241-210, 2008)

service	
All the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they're using it, how well it serves their purposes, and how well it fits into the entire context in which they are using it.	(Alben, 1996)
Every aspect of the user's interaction with a product, service, or company that make up the user's perceptions of the whole.	(UPA, 2010)
A consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organisational/ social setting, meaningfulness of the activity, voluntariness of use, etc.).	(Hassenzahl & Tractinsky, 2006)
All aspects of the interaction of a user with a service and its products in a specific environment of product use.	(Nielsen Norman Group, 2007)
Subjective emotions, feelings and attitudes of the user(s) developed before, during and or after their interaction with a system / product to perform a specific task in a specified context of use.	(Mashapa & van Greunen, 2010)

Table 3.1: A variety of UX definitions proposed by different authors

In all the above definitions, the building blocks have been taken into account, which is a good thing. Even though these authors have different interpretations of UX, their definitions show that they agree that UX goes beyond the usability of the product. However, understanding UX requires more than just understanding the high level components that it is made of. It is equally essential to understand the phases of UX. All

but one of the above definitions, are missing an important aspect of UX, its phases. The phases of UX play a significant role in the overall UX (Mashapa & van Greunen, 2010; Obrist & Tscheligi, Alexander Meschtscherjakov, 2010). For this reason, this research adopts the UX definition by Mashapa and van Greunen (2010):

Subjective emotions, feelings and attitudes of the user(s) developed before, during and or after their interaction with a system / product to perform a specific task in a specified context of use.

The levels or phases of UX include: (1) pre-experience, visceral, behavioural and reflective levels. Figure 3.3 outlines the levels of UX over time.

Figure 3.3: Levels of UX over time (Obrist & Tscheligi, Alexander Meschtscherjakov, 2010)

User experience does not necessarily happen only during interaction as many people think. This view is supported by Mashapa and van Greunen (2010); Obrist and Tscheligi, Alexander Meschtscherjakov (2010); and Roto (2007). When users first lay their eyes on a product, they tend to have expectations of it and they expect it to meet these expectations. If, however, these expectations are not met during the interaction, then the user will not be satisfied. One of the goals of UX experience is to provide user satisfaction, and in this situation that goal is not accomplished. Therefore it is vitally important to look beyond the high-level UX components when approaching UX, as it is comprised of a variety of intertwined disciplines, as shown in Figure 3.2.

Moreover, people tend to blur the distinction between usability, which is one of the disciplines of UX, and user experience itself. Consequently, the researchers have made it their goal to emphasize the differences between these two concepts. The following section outlines the key differences between usability and user experience.

3.2.3 UX and usability

The perspective of the quality of an interactive product is rapidly expanding from usability to a broader user experience (Jumisko-Pyykkö et al., 2008). In response to the confusion many people have, regarding the differences between user experience and usability, Hassenzahl (2004) suggests that user experience, in contrast with usability, put emphasis on positive human factors (such as positive emotions) as an outcome of interaction with the system. In addition, Hassenzahl, Law and Hvannberg (2006) have identified three primary aspects that distinguish between usability and user experience, as illustrated in Table 3.2.

	Usability	**User experience**
Aspects		
Holistic	Focuses on task-related (pragmatic) aspects and their accomplishment.	Takes more holistic approach including non-task related (hedonic) aspects of product possession and use such as beauty, challenge, stimulation or self-expression.
Subjective	Having its origin in psychology and human factors, usability evaluation with *objective* measurement methods (e.g. eye-tracking) and rests primarily on observation.	Stresses the importance of *subjectivity*, it is explicitly interested in the way people experience and judge products they use. It may not matter how good a product is objectively, it must also be experienced to have an impact.
Positive	While usability focuses on problems, barriers, frustration or stress and how they can be overcome.	Stresses the importance of positive outcomes of technology use or possession, e.g. positive emotions such as joy, pride, and excitement or simply value.

Table 3.2: Three aspects where UX goes beyond usability adapted from: (Hassenzahl et al., 2006)

Table 3.2 certainly highlights the significance of going beyond the traditional usability to an extensive user experience. This, however, does not imply that usability is not important. Usability is necessary and plays an essential role in the success of a product; however, it is insufficient on its own. Therefore, usability should be dealt with as part of user experience not independently implies Bevan (2009). Harrison (2008) proposes that usability be viewed as a foundation on which UX be built. This implies that usability has to be established first,

with pleasure elements of design added later. In this way, positive results on the overall UX can be expected. Adding pleasure elements to a system that has poor usability does not guarantee positive UX even though Tractinsky, Katz and Ikar (2000) state that people tend to see beautiful things as more usable. It seems, however, logical that when a system has usability problems, users are more likely to get frustrated, leading to unpleasant feelings which, in turn, negatively affect the overall user experience. Figure 3.2 illustrates the various fields that UX entails. Figure 3.4 illustrates the attributes associated with UX including usability attributes and how usability fits into the world of UX.

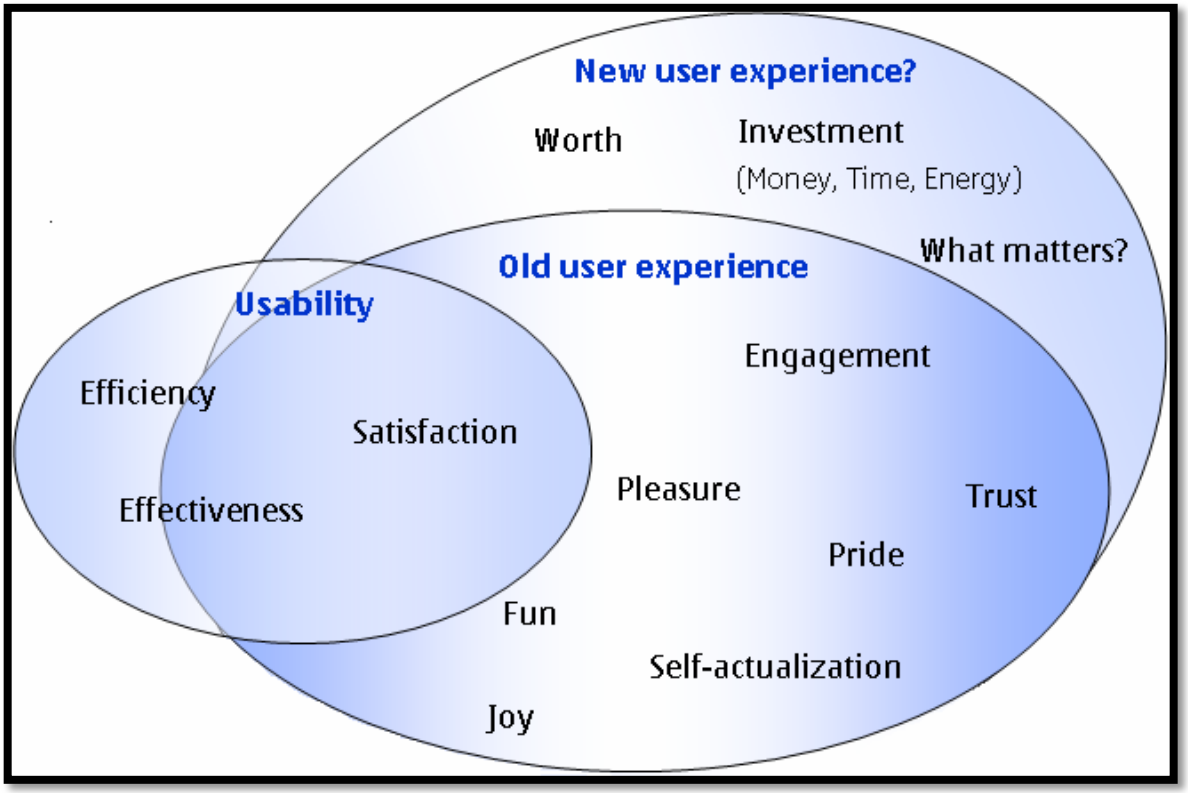


Figure 3.4: The scope for UX (Roto, 2007)

As it can be seen in the diagram above, usability consists of three aspects: efficiency, effectiveness and satisfaction (Roto, 2007). UX, on the other hand, focuses on positive emotional aspects such as engagement, pleasure, trust, pride, fun, self-actualization and joy, leaving the usability aspect in charge of the effectiveness and efficiency of the product. User satisfaction, on the other hand, is one of the anticipated outcomes after the interaction with the system; therefore, it forms a bigger part of the user experience community.

Today's users measure the value of the system by their level of satisfaction and experience when using it. This view is supported by Hassenzahl and Tractinsky (2006) who claim that the perception of a system is based on the user's state, "which in turns affects the experience and user's state". The following section discusses the importance of UX.

3.2.4 Significance of UX

The sudden attention to UX and its facets increases the level of success of a product as UX is increasingly becoming a competitive factor. For the success of any interactive product and enhanced UX, the product should be aesthetically appealing so that users do not only have great expectations but also great curiosity about it.

The overall goal of UX, from a developer's perspective, is to design products that support a user's needs, values and expectations as this, in turn, increases the market success of the product. Given the importance of positive emotional responses to the product, effectiveness and efficiency of the product might not be sufficient to produce positive emotions (Väänänen-Vainio-Mattila, Roto, & Hassenzahl, 2008). This implies that in order to establish positive user experience, designers need to design products with human factors and users' needs in mind.

From the users' viewpoint, products should be user-friendly, engaging, fun, enjoyable, reliable, learnable and useful in a specific context of use (Microsoft, 1999). In response to that, designers should make human-aspect and user needs the centre of their design: only in that way they can achieve positive UX. According to Väänänen-Vainio-Mattila et al. (2008), user experience should be the major concern in product development. The product development team could use the user experience honeycomb to guide them towards a pleasing user experience without overlooking any UX facet. Figure 3.5 illustrates the facets of UX by Morville (2004) to emphasize the need to go beyond usability.

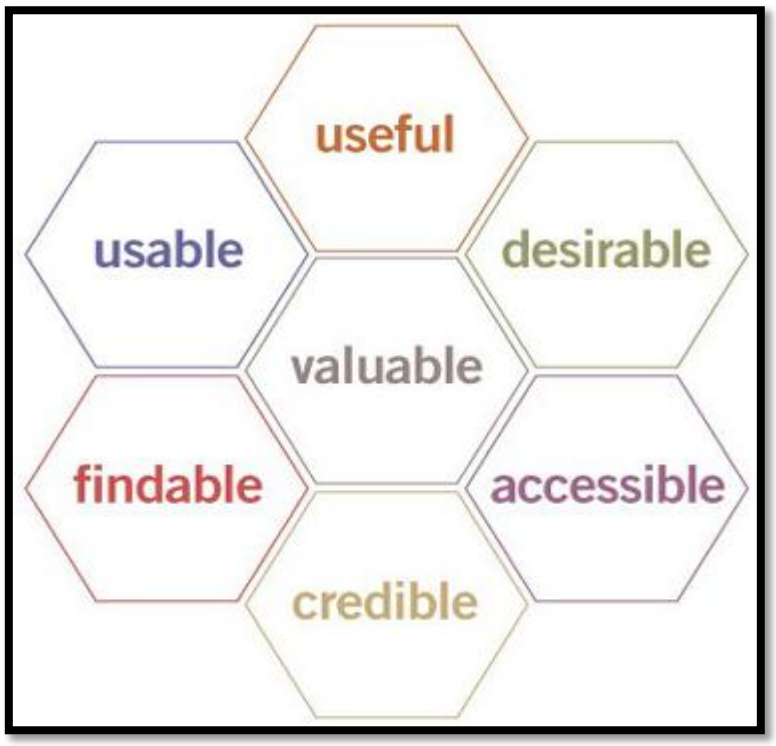


Figure 3.5: The user experience honeycomb (Morville, 2004)

These facets can serve as criteria to evaluate UX of a product. For example, if users perceive a product to be usable, useful and credible, that could create in them a desire to use or possess that product. Additionally, to make it more valuable, it must be accessible and findable. If all these cells are satisfied, from the users' perspectives, they will grow to trust and value it. In that way, the chances for users to accept the product, and their willingness to use it is maximized. The next section discusses the building blocks of UX.

3.2.5 Building blocks of UX

It is suggested that understanding UX building blocks is a critical step towards designing a positive user experience (Roto, 2006). The multi-disciplinary nature of UX has imposed a barrier for designers to identify the appropriate level of abstraction for the user experience components and their attributes (Roto, 2006). Several authors proposed a list of components that they perceive make up UX. Arhippainen and Tähti (2003) proposed five components namely: user; social factors; cultural factors; context of use; and product, along with a list of attributes for each component. Hassenzahl and Tractinsky (2006), on the other

hand, have a different perspective on UX; consequently they proposed three high level UX components (context, system, and user) (Väänänen-Vainio-Mattila, Roto and Hassenzahl, 2008). Figure 3.6 shows the building blocks of UX.

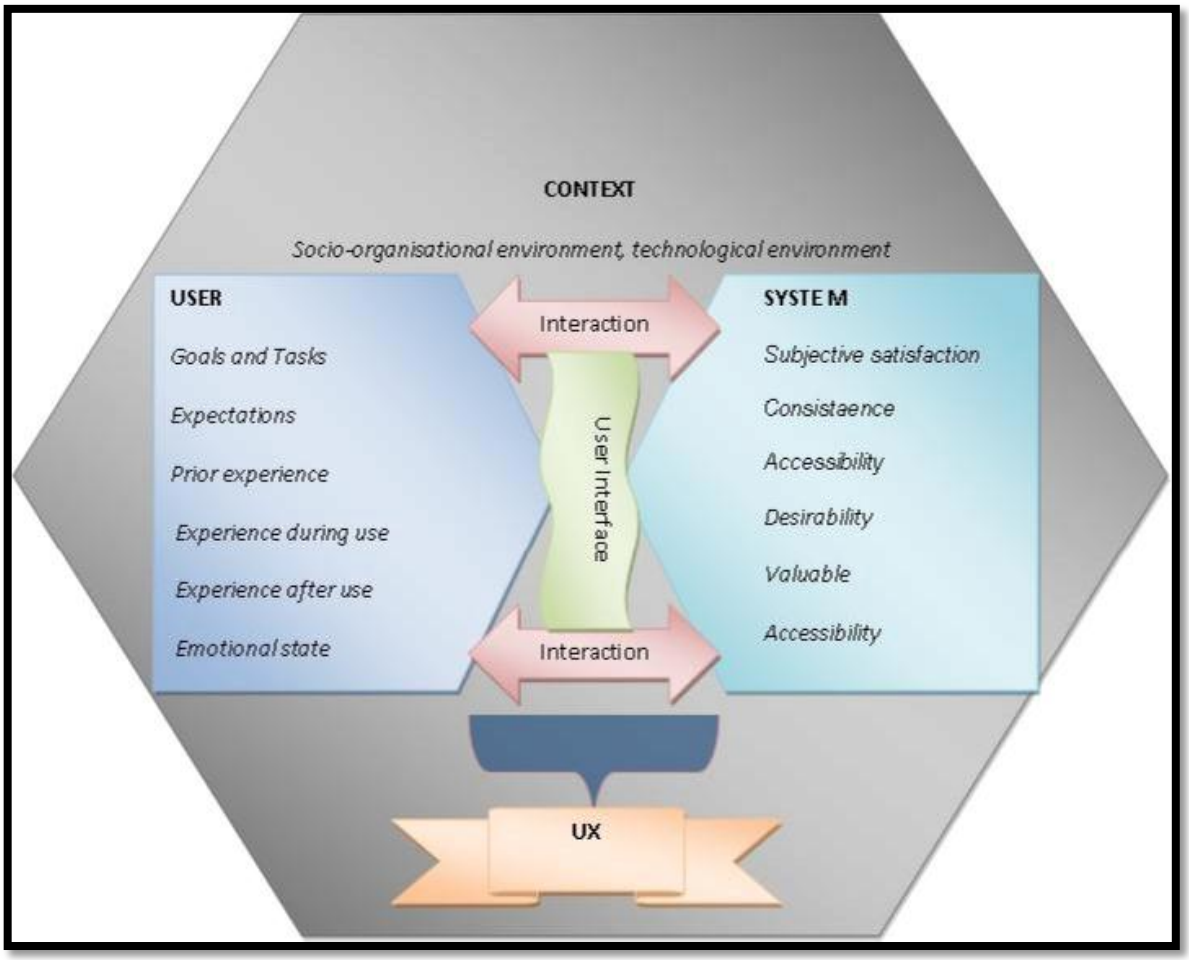


Figure 3.6: UX building blocks source: (Mashapa & van Greunen, 2010) adapted from Roto (2006)

The three building blocks illustrated in Figure 3.6 summarize what the UX definition should comprise. Many researchers stress the necessity for designers to understand the UX building blocks. It is equally important that the evaluators coherently understand UX components and the associated attributes as these components are of great value to the evaluation phase (Roto, 2006). According to Roto (2007), a *system* can only provide the best UX if it "adjusts to the current *context* and the *user*'s current needs and expectations".

According to Hassenzahl and Tractinsky (2006) it is very rare, if not impossible, for distinct products or systems to share a set of attributes. Thus, literature suggests that the product development team identifies the appropriate attributes for a specific product as the attributes are greatly determined by the nature of the product (Avouris, Fiotakis, & Raptis, 2008; Hassenzahl & Tractinsky, 2006). The developers, because they know their product best, are best suited for the job. Even for the product development team it is essential that they identify these attributes with a specific product in mind. A brief description of each component is given below.

Context

This component refers to the context in which interaction takes place (Roto, 2006). It involves quite a number of attributes such as physical, social, temporal and task context, which is optional but recommended, to also examine (Roto, 2006). The context of use for the mobile environment is relatively dynamic and continuously changing. Therefore, environmental context parameters should be measured as frequently as possible (Obrist & Tscheligi, Alexander Meschtscherjakov, 2010).

System

The system component refers to the system / product with which the user interacts and the other products, services, infrastructures and human beings that affect the evaluated system (Roto, 2006).

User

This component refers to the mental and physical state of the person who interacts with the investigated system (Roto, 2006). The overall user experience is strongly affected by personal experiences and expectations of the user (Taina & Tarja, 2010).

3.3 Evaluating UX

Evaluation is as important as the product itself. It is an integral part of the design process and therefore, it must be given a due consideration (Jones & Marsden, 2006). Because UX is

multi-disciplinary and depends not only on the system being studied but also on the user and environmental context in which the interaction takes place, its evaluation is rather challenging. For example, experience with the same system varies depending on the current context of use and, of course, other temporary aspects of UX such as current emotions of the user. The challenge becomes more with mobile context, since environmental context is constantly changing. The key is to select the most appropriate method for a given situation. Section 3.3.1 provides a brief overview of the existing UX evaluation methods.

3.3.1 UX evaluation methods

According to Obrist, Roto and Väänänen-Vainio-Mattila (2009), most of the existing UX evaluation methods, were originally designed to measure usability. Until recently, it was unclear whether these methods can be adapted to UX evaluation without explicit changes, as these concepts are completely different. In an attempt to address this issue, According to All about UX blog (n d) provides a set of verified and well-referenced UX evaluation methods together with typical situations in which they can be used, strengths, weaknesses, requirements and more. This information helps the evaluating team make informed choices, enabling them to choose methods that are most applicable to the situation at hand. The methods are classified according the following categories: field studies; lab studies; online studies; and questionnaire studies (All about UX blog, n d). According to it the types of methods are defined as follows:

- Field studies are conducted in natural settings, in the real- life context where the behaviour is really natural.
- Lab studies, on the other hand are conducted in a controlled environment, which is not the same as the real world. In this environment, it is hard, if not impossible, to find participants in their natural behaviour. Given its characteristics, this environment would be more ideal to test the functionality of the product, especially in the mobile context where environmental context seems to have a significant impact.

Specifically, this research study adopted, experience clip technique principles. This technique is used in field studies to evaluate the UX of mobile application users in the real-life contexts including physical, social, temporal and task ones (Roto, 2006). Based on

Isomursu, Kuutti and Väinämö's (2004) description of experience clip technique, it was chosen as the most proper technique for evaluating the UX of Dr Math® users (pupils) using logged conversation between them and Dr Math®. The major difference is that with this study, there are no video clips. However, in both cases, the evaluation is conducted with real users in a real mobile usage environment (Isomursu et al., 2004). The Dr Math® log files are recorded in the real-world and everyday contexts of real life. Furthermore, participants are not even aware of their research participation; therefore, their behaviour is truly natural.

3.4 Mobile application UX

When designing for UX, be it in mobile or stationary context, it is important to understand the components that comprise UX. It is equally important to understand the factors affecting UX such as context of use; user expectations; experiences of the user; user profile and user interface design. User interface design (UI) is an essential element of user experience as the users interact with the product through it. It therefore, becomes the most significant element to focus on. Section 3.4.1 provides a brief overview of UI design in the mobile context.

3.4.1 UI design

Until recently, a few user interface design guidelines for mobile devices existed; however, this field is still relatively unexplored. Gong and Tarasewich (2004) have made it clear that mobile applications can adopt some of the Golden Rules. According to these authors, the following set of guidelines in Table 3.3 can carry over to mobile devices.

Enable frequent users to use shortcuts
Offer informative feedback
Design dialogs to yield closure
Support internal locus of control

Table 3.3: Guidelines that carry over to mobile devices (Gong & Tarasewich, 2004)

On top of these guidelines, there exist a few that are specifically created for the mobile context. The next section presents the characteristics of a positive UX.

3.5 Characteristics of a positive UX

The characteristics of a positive, as shown in Table 3.4, are described under two major dimensions of UX namely, pragmatic and hedonic. These dimensions were discovered by Hassenzahl (2003) along with respective attributes that could serve as a criteria for evaluating UX. Furthermore, he proposed that people view interactive products along these two dimensions. Thus, the characteristics of a positive UX are categorized as such. Table 3.4 summarizes the characteristics of a positive UX.

Category	**Sub-category**	**Attribute**	**Description**
Pragmatic	Utility	Usefulness	Refers to the ability of the system to enhance job performance from the user's perspective

			(Davis, 1989).
		Reliability	Refers to the constancy to which the product or system operates acceptably (Chuang & Cheng, 2010).
	Usability	Ease of use	Refers to the degree to which individuals believe they can use the product with no physical and mental effort (Davis, 1989).
		Efficiency	Promotes effective use of resources such as time effort and cost, thus, enabling the users to complete tasks quicker and cost effectively (Petrie & Bevan, 2009).
		Accessibility	Refers to the degree to which the product is usable and inclusive to all, including old people and people with disabilities (Bevan, Petrie, & Claridge, 2007).
Hedonic	Social aspect	Identification	Relates to the need to express important personal values through objects (Hassenzahl, 2004).
	Enjoyment	Pleasure	Refers to getting satisfaction that is coupled with pleasant emotional reactions from the product (Norman, 2004).
		Stimulating	Relates to human need of being stimulated and grow in their knowledge and skills, which are normally influenced by the novelty and challenges posed by the system (Hassenzahl & Tractinsky, 2006).

Table 3.4: Characteristics of a positive UX

Furthermore, Hassenzahl, Schobel and Trautmann (2008) affirm that pragmatic aspect of the product relates to the user's needs to achieve "do-goals" such as sending an email. The users judge pragmatic quality of the product based on the degree to which they perceive the product to fulfil "do-goals" (Hassenzahl et al., 2008). The pragmatic aspect, as depicted in the table,

covers usability and utility requirements such as usefulness and ease of use which, according to Davis, 1989; Nah, Zhao and Zhu (2003) largely influence product acceptance. However, Hassenzahl (2004) and Nah et al. (2003) also classify the enjoyment factor as one of the major determinants of the product's acceptance and the user's intentions to use it. Nah et al. (2003) further argue that this is especially the case with mobile IT systems. This argument leads to a discussion of the hedonic aspect of the product, another dimension of UX.

In contrast with pragmatic aspect of the product, which primarily focuses on satisfying the instrumental needs of users, hedonic aspect focuses on the non-instrumental needs. Particularly, hedonic aspect of a product focuses on the fulfilment of "be-goals" such as being emotionally satisfied or happy (Hassenzahl et al., 2008). Furthermore, Hassenzahl et al. (2008) declare that the hedonic aspect puts emphasis on personal, psychological well-being, thereby, inducing pleasurable emotional reactions.

Therefore, in order for the designers to design a product that promotes a positive UX, they need to balance pragmatic and hedonic requirements of the product. In other words, they must produce a product that is not merely usable but also pleasurable. In addition, according to (Hassenzahl, 2003), a pleasurable product normally fulfils hedonic goals such as stimulation, identification and evocation. Figure 3.7 summarizes the user needs from a product.

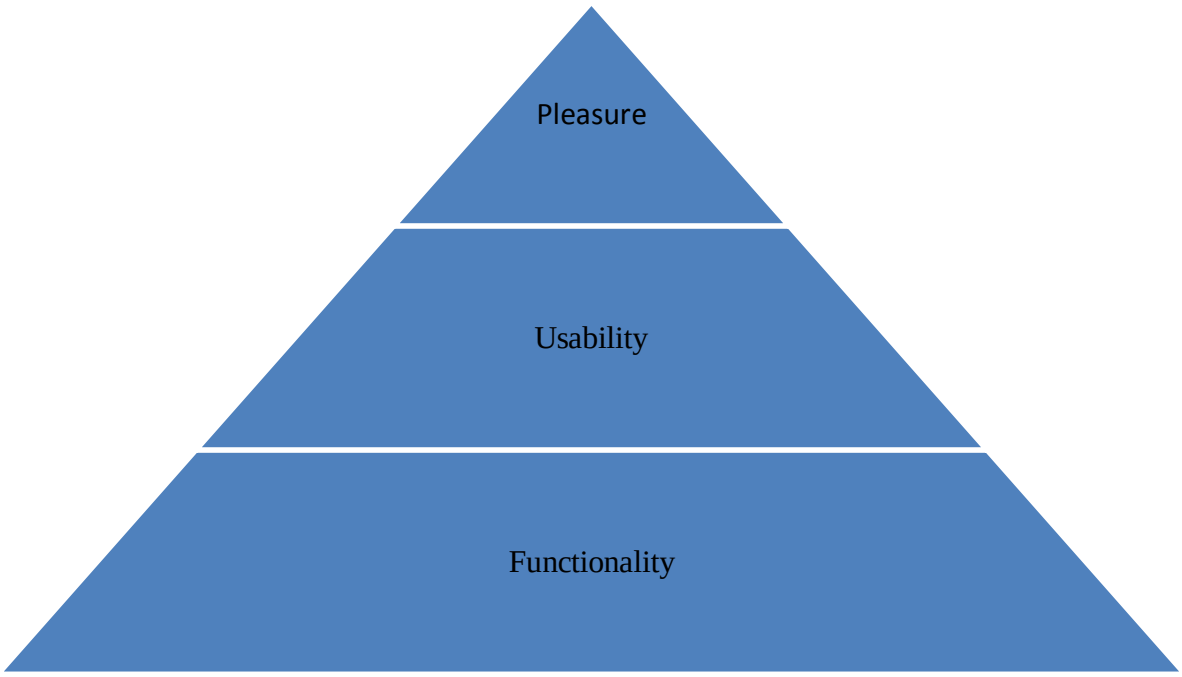


Figure 3.7: Fixed hierarchy of customer needs (Jordan, 2000)

The customer needs illustrated in Figure 3.7 are major determinants of acceptance of the product by the users and their intentions to use it. If all these needs are fulfilled from the user's perspective, a positive UX is achieved. It is, therefore, crucially important that the designers understand the needs of their users. The next sub-section explains what designing for a positive UX entails.

3.5.1 Designing for a positive UX

In order to designing a positive UX entails having an in-depth understanding of the target users, their needs and emotional expectations, and integrating these factors into the design process. This will enable designers to design products that completely satisfy user's instrumental needs and non-instrumental requirements, such as pleasure, identification and stimulation.

In essence, a positive UX is achieved when the product fulfils more than just pragmatic (instrumental) needs and requirements of the user but also hedonic (non-instrumental) requirements. In other words, for the product to produce a positive UX, it must fulfil functional, usability and pleasure or emotional expectations of the user Jordan (2000) and Karapanos, Hassenzahl, and Martens (2008), thereby, maximizing user satisfaction and

loyalty of users to the product. In addition, the level of user satisfaction determines how positive the UX of users with the product is. Moreover, a positive UX increases the acceptance of the product by users. The next section presents the factors that impact on mobile UX.

3.6 Typical factors that impact mobile UX

Mobile technology has a fair share of limitations. These limitations normally impact on the UX of mobile devices and applications. Here are some of these factors:

Connectivity – Connection, be it making a call or connecting to the internet using either GPRS, 3G or infrared, requires a certain amount of airtime. The amount depends on the service provider rates. In other words, without airtime, the connection fails, which can also happen in locations where there is no or poorly covered reception.

Display size – Mobile devices have relatively small screens for output, leading to unpleasant navigation, especially through massive text.

Memory – Mobile devices have limited memory, which sometimes affect the devices' performance.

Input entry – Originally, cell phones were designed for communication. Thus, the key pads were limited to alpha-numeric.

Multi-task – Most of the entry level mobile devices such as cell phones do not support multi-tasking or background execution, forcing users to terminate current tasks when the need to access a different task arises.

The next section provides a summary of the chapter.

3.7 Summary

In this chapter, I described UX as a concept and highlighted its dynamic and subjective nature. This chapter indicated the importance of going beyond usability, thus maximizing the market success of the product. In contrast with usability, UX takes a holistic approach that includes non-task related requirements, stresses the significance of subjectivity and emphasizes the significance of a positive outcome of technology use. The chapter also revealed the multidisciplinary nature of UX, by depicting a multitude of interrelated disciplines such as:

Information Architecture, Interaction Designing, Usability, Human Factors Engineering and HCI and UI design, which is the heart of UX.

Although there is still a lack of unified UX definition, there are agreed-upon UX building blocks (context, system and user), which should serve as a foundation on which to build a unique UX definition. Nevertheless, it was noted that many authors in their definitions of UX left out a very critical aspect of UX: its phases, namely, before, during and after the interaction with the product. This study, however, adopted a UX definition by Mashapa and van Greunen (2010):

Subjective emotions, feelings and attitudes of the user(s) developed before, during and or after their interaction with a system / product to perform a specific task in a specified context of use.

However, the complexities of UX, coupled with the uncertainties about a universal definition of UX, make it difficult for designers to design for a positive UX. Nevertheless, the two dimensions, namely pragmatic and hedonic aspects of the product from which to view the UX of the product and their respective attributes by Hassenzahl (2003) can contribute in facilitating the process of designing for a positive UX. Another issue that needs to be considered when designing for a positive UX is the significance of understanding exactly what is it that the users need from a product. Jordan (2000) outlined customers' needs in a hierarchy in this order (bottom-top): Functionality, Usability and Pleasure. The designers need not to merely understand the user needs but to integrate them in the design.

Basically, to achieve a positive UX, the product needs satisfy both pragmatic (functionality and usability) and hedonic needs such as pleasure, identification and stimulation. In that way, the designers will have happy users. Additionally, their intentions to use the product and loyalty will be maximized.

Chapter 4: Research Design and Methodology

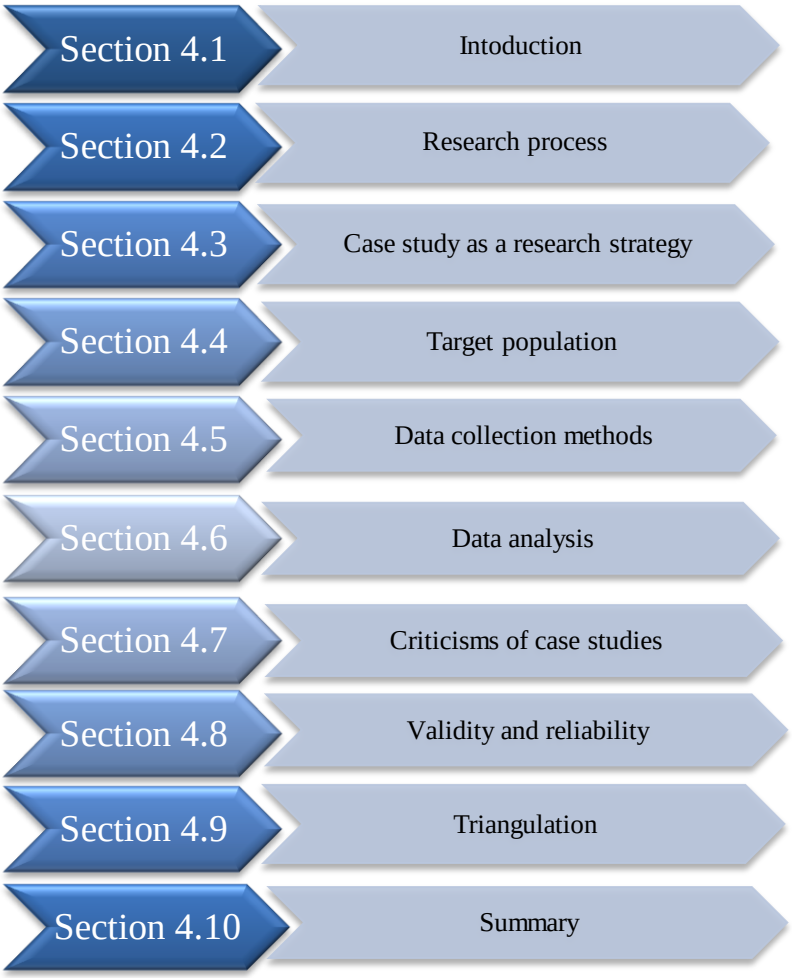


Figure 4.1: Chapter 4 layout

4.1 Introduction

Chapter 1 identified the research problem along with research questions to be addressed in this study. Chapter 4 outlines the research process and methodology used in this research study along with justification of the choices of methodology and methods used. This chapter begins with a brief discussion of the research process with reference to Saunders, Lewis and Thornhill's (2003) research process 'onion'. This is then followed by a discussion of a case study as a research strategy within which case study types; designs; and case selection are discussed. The chapter also examines the target population followed by a discussion of the sampling technique used in this study. Following this is a discussion on data collection

methods followed by one on data analysis. The latter part of this chapter outlines a few criticisms of case studies, followed by a discussion on the validity and reliability issues in research. The chapter ends with a discussion of triangulation and its different types.

4.2 The research process

Saunders, Lewis and Thornhill (2007) define research as: "the systematic collection and interpretation of information with a clear purpose, to find out things". Saunders et al. (2003) proposed a research process 'onion' to illustrate the typical elements of the research process. The layers of the 'onion' include the research philosophy, which is the outermost layer through to the data collection methods layer, the innermost layer. A brief description on the layers relevant to this research will be provided. Figure 4.2 presents the research process 'onion' by Saunders et al. (2003).

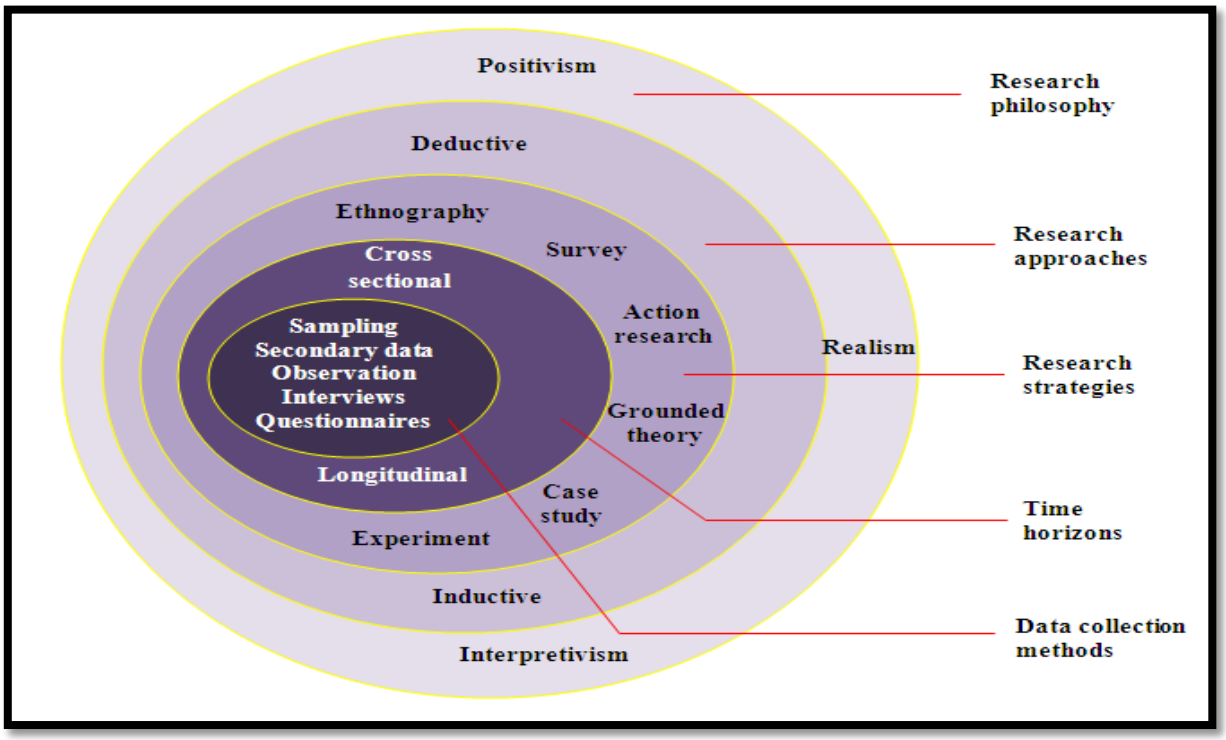


Figure 4.2: The research 'onion' (Saunders et al., 2003)

4.2.1 Research philosophy

Bryant and Charmaz (2007) and Easterby-Smith, Thorpe and Lowe (2001) put emphasis on the importance of understanding the philosophical position of the research. Easterby-Smith

et al. (2001) argue that this practice helps the researcher find alternative designs and methods for a particular research and identify the more appropriate ones for his/her study. Several philosophical approaches for conducting research exist. However, only two philosophical approaches pertaining to this study, namely positivism and interpretivism, are discussed (Amaratunga & Baldry, 2001). The sub-section below provides a brief overview of the two philosophies.

Positivism vs. interpretivism

Positivists believe that the reality can be observed and described using objective methods, whereas interpretivists believe that the subject under study needs to be measured using subjective methods (Noor, 2008). Interpretivists believe that the subject under study and the researcher can never be separated as the researcher usually has to interpret what was observed. The positivism approach is all about accepting the given facts about the subject being studied and ignoring everything else (Noor, 2008). The interpretivism approach, on the other hand, goes beyond facts to the meaning (Noor, 2008). Positivism was originally a natural science approach whilst interpretivism is traditionally a social science approach (Noor, 2008).

This research study is neither purely social science nor natural science research; therefore, it lies somewhere between positivism and interpretivism. Contextual influences on the subject being studied are of significance to this research. Positivists, however, tend to disconnect the subject from its context by conducting the research in a controlled environment. They also focus on the given facts, unlike interpretivists, who seek to obtain a deep understanding of the phenomenon under study by going beyond given facts to the factors that are capable of rendering the meaning. Hence, this research lies more towards the interpretivism philosophical approach.

The nature of any research study, regardless of its philosophical position, based on the methods it employs, is described as either qualitative or quantitative. The positivism approach is generally associated with quantitative research while interpretivism is often

associated with qualitative research. Further elaboration on these two concepts is presented below.

Qualitative vs. quantitative

Research is said to be quantitative when it seeks to calculate, measure and aggregate collected data. Quantitative studies focus on numbers rather than words. Creswell (1996) defines quantitative study as "an inquiry into social or human problems, based on testing a theory composed of variables, measured with numbers and analyzed with statistic procedures in order to determine whether predictive generalizations of the theory hold true".

In contrast, qualitative research seeks to go beyond quantitative statistic results into the meaning behind the given facts. The aim of qualitative research is to fully investigate the phenomenon in order to shed a deeper insight into it. In addition, Creswell (1996) defines a qualitative study as "an inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in natural settings".

Based on the above discussion, this study adopts mainly the qualitative approach. It is, however, not limited to the qualitative evidence. Quantitative evidence and analysis will be exploited too, to supplement the qualitative evidence on which this research study mainly relies. The qualitative approach entails describing and understanding human problems from the participants' viewpoints. The research, whether it is of a qualitative or quantitative nature, can follow one of the main two approaches to theory, namely inductive and deductive, as discussed below.

4.2.2 Research approach

As described above, research may follow a deductive or inductive approach to theory. With a deductive approach, the researcher is expected to formulate the hypotheses first based on assumption, and then collect data so that he/she can test that assumption against the collected data. With the inductive approach, on the other hand, the researcher first gathers

some data and then formulates a hypothesis, based on the gathered data. Figure 4.3 below further illustrates how the two approaches differ from each other with respect to theory formulation.

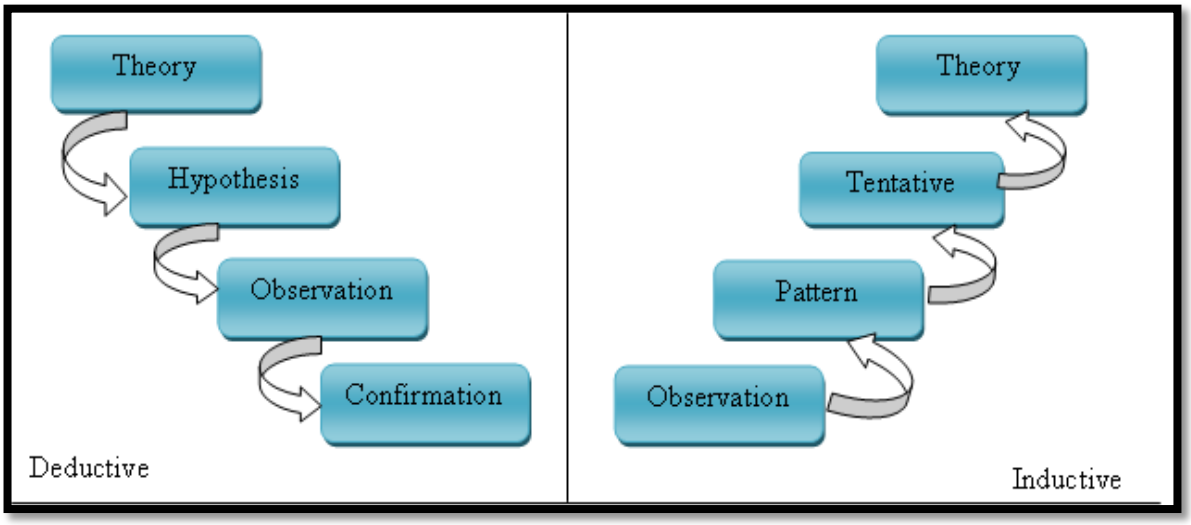


Figure 4.3: Inductive vs. deductive adapted from Trochim (2001)

The deductive approach confirms theory while the inductive one extends it. Qualitative researchers argue that is it rather difficult to devise meaningful hypotheses with an inadequate understanding about the participants' viewpoints and circumstances within the studied context. They base this on the assumption that as a qualitative researcher, one cannot have enough of an understanding about the phenomena prior to any data collection. For this reason, they instead develop and test hypotheses during or after the gathering of data process. This study exploits the advantages of both inductive and deductive approaches to theory. For instance, during the analysis of data, some themes and categories emerged deductively, based on the literature review, and some emerged inductively during the actual analysis of Dr Math® log files. Any research has to adopt one or a combination of the pre-existing research strategies to facilitate the research process. In the following section, the strategies for conducting research are discussed together with a list of a few strategies that one can choose from.

4.2.3 Research strategy

There exist various research strategies including the ones presented in layer three of Saunders et al.'s (2003) research process 'onion' in Figure 4.2. In addition, Yin (2009)

identified five major research strategies along with three conditions that are meant to help one find a suitable strategy for a particular research. These conditions are as follows: 1) type of research question to be addressed (how, why or what), 2) the degree of control a researcher has over the behavioural events and 3) whether the focus is more on contemporary rather than historical events. Table 4.1 illustrates how these conditions relate to each of the five major research strategies.

Strategy	Form of Research Question	Requires Control of Behavioural Events?	Focuses on Contemporary Events?
Experiment	How, Why?	Yes	Yes
Survey	Who, What, Where How Many/Much?	No	Yes
Archive Analysis	Who, What, Where How Many/Much?	No	Yes/No
History	How, Why	No	No
Case Study	How, Why	No	Yes

Table 4.1: Different research strategies (Yin, 2009)

According to Yin (2009), who is one of the well-known experts in case study research, this research study conforms to the three conditions namely:

- Many *how(s) and why(s)* things happened the way they did emerged during the analysis of data and during the discussion of results with the panel of experts*;*
- Focuses on the *contemporary phenomenon* (m-learning); and
- I, as an investigator, *have no control over the behaviour of those being studied*,

Thus, a case study is selected as the most appropriate research strategy for this research study. In addition, the nature and the purpose of the study support this decision. This study aimed at exploring the Dr Math®'s users' expectations, experiences, behaviour and perceptions (overall user experience) regarding their interaction with the Dr Math® program. According to Runeson and Höst (2009), "the analytical research paradigm is not sufficient for investigating complex real-life issues, involving humans and their interactions with technology". They further suggest that a case study is the most appropriate

methodology for software engineering research as it focuses on the contemporary phenomena in its natural context. The next section outlines the methodological choice for this study.

4.3 A case study as a research strategy

A case study is one of the many ways of conducting research. It is recognized as a powerful strategy for conducting qualitative research. Consequently, it is the most widely used research strategies among social scientists. Yin (1994) adds that case studies excel at studying social complex phenomena, especially when the study requires a comprehensive and deep investigation. In addition, Yin (2009) defines a case study as an empirical inquiry that:

1. *investigates a contemporary phenomenon within its real-life context;*
2. *when the boundaries between phenomenon and context are not clearly evident; and*
3. *in which multiple sources of evidence are used.*

In contrast with other research strategies, scientific methods in particular, case studies have support for a large number of variables of interest and multiple sources of evidence (Yin, 1994). In addition to that, case studies add on the ability to combine qualitative and quantitative evidence. In contrast with ethnography and other qualitative research strategies, case studies can adopt either a qualitative or a quantitative approach or both (Stake, 2000; Stoecker, 1991; Yin, 1994). They can also follow either an inductive or deductive approach to theory. Furthermore, depending on the purpose they are used for (Kohn, 1997), case studies are categorized into three types (Yin, 2009). A further discussion on the types of case studies is provided the sub-section below.

4.3.1 Case study types

As mentioned in the previous section, case studies can be used for various purposes including *exploring* new areas where little or no theory exists; *explaining* complex phenomena; and *describing* complex events or interventions (Kohn, 1997), and they can adopt either a single or multiple case design (Yin, 2009). Table 4.2 shows different types of case studies along with a published example of each type.

Type	Definition	Example
Explanatory	Explanatory case study is typically used for complex investigation that entails explaining causal links in real-life interventions, which due to its complexity cannot be accomplished through survey or experimental strategies (Yin, 2003).	Joia (2002). Analysing a web-based e-commerce learning community: A case study in Brazil. *Internet Research, 12,* 305-317.
Exploratory	Exploratory case study deals with situations where no particular outcome on the intervention being studied exists (Yin, 2003).	Lotzkar & Bottorff (2001). An observational study of the development of a nurse-patient relationship. *Clinical Nursing Research, 10,* 275-294.
Descriptive	This type of case study is best suited when one seeks to describe an intervention and the real-life context within which the intervention has occurred (Yin, 2003).	Tolson, Fleming, & Schartau (2002). Coping with menstruation: Understanding the needs of women with Parkinson's desease. *Journal of Advanced Nursing, 40,* 513-521.

Table 4.2: Type of case studies and their examples, adapted from Baxter and Jack (2008)

A common perspective of case studies is that they are more appropriate for exploratory studies (Yin, 2009). In addition to that, the hierarchical view of research suggested that a case study's usefulness is limited to the exploratory phase of research; while surveys and histories are suitable for descriptive phase and experiments are well-suited for explanatory research (Yin, 2009).

Although there are still some researchers who limit their case study research to exploratory studies, there are also those who take full advantage of case study capabilities. Given the case study's ability to answer the *how* and *why* questions, as noted by Yin, a case study can

be an effective tool for exploratory research. Additionally, Yin (2009) noted that all five of strategies discussed in Table 4.1 can be used for all three purposes. This, therefore, proves that the hierarchical view is poorly founded and most probably based on some misunderstandings about case studies.

Nevertheless, exploratory case study is judged as an ideal approach for this study, as it is particularly useful when the researcher's aim is to find out what is going on; obtain new insights; inquire about and assess the phenomena in a new perspective in order to formulate new hypotheses (Robson, 2002). In addition, this research also seeks to answer the "what" question: "*What are the user experience metrics that impact on a positive user experience for pupils when using Dr Math®?"* making an exploratory approach even more appropriate for this research. This view is supported by Yin (2009), when he noted that "what" questions are often best answered through an exploratory study.

However, since user experience is a very complex aspect of Human Centred Interaction, a need for some explanation is evident. Additionally, studying UX for a contemporary phenomenon such as learning mathematics through mobile devices could add more complexity to this research study. Without an in-depth understanding of how good and bad UX affects the system, the proposed key consideration for providing a positive UX for Dr Math®, which will be the contribution of this study, might not be used. Therefore, besides exploring, this study tends to also explain where necessary.

4.3.2 Case study design

Yin (2009) identified four types of case study designs based on the 2x2 matrix. Firstly, the matrix depicts that any design entails analysis contextual conditions in connection with the case (Yin, 2009). The dotted lines between the case and context indicate the blurred boundaries between the two (Yin, 2009). The matrix also shows that a case study research can be based on single or multiple cases. Within a case, analysis can be based on single or multiple units. Figure 4.4 shows the four types of case studies based on the 2x2 matrix.

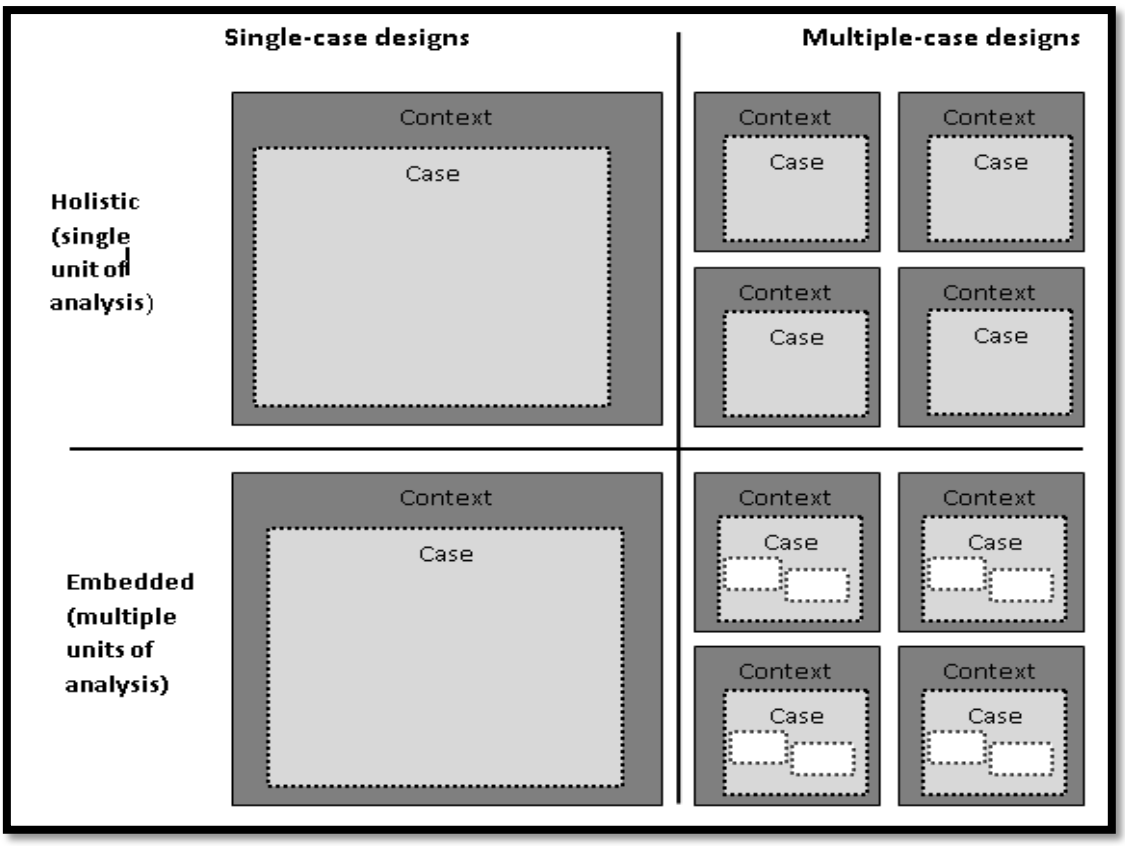


Figure 4.4: Basic types of case study design (Yin, 2009)

4.3.3 Case selection

Case selection is recognized as an integral part of case study research (Seawright & Gerring, 2008). In support to this view, Foster (2002) asserts that a proper case selection enhances the quality of the case study analysis. Case studies, especially when based on a single case, are criticized for the lack of generalizability (Flyvbjerg, 2006; Yin, 1994). Having reviewed Flyvbjerg's (2006) study on misunderstandings about case studies, it is clear that most of the common criticisms of case studies are based on some misunderstanding. Flyvbjerg (2006) identified five misunderstandings about case studies that lead to the various criticisms about case studies in general. One of these misunderstandings says that one cannot generalize from a single case. Based on Flyvbjerg's (2006) answer to this misunderstanding, it is actually possible to generalize from a single case, more especially when a single case is appropriate and adequate for the research being conducted. Despite the various criticisms towards single case studies, this research focuses on a single case.

"Dr Math® on Mxit" program is selected as the case on which this study focuses. Within Dr Math®, multiple units of analysis exist which are Dr Math® users and the logged conversations between students and tutors. This is, in Yin's terms, a single-embedded case design. Dr Math® users, like many other tutoring system users, are divided into two groups: the students and the tutors. In this research, the tutors are not the main concern. As with many other UX-related practices, the clients always receive the bulk of the attention. The rationale for this is that the clients are the ones who determine the quality of the product or system based on their user experience.

Yin (1994) defines the unit of analysis as the "actual source of information: individual, organisation document, artefact...". The selection of unit of analysis for this study, which are the Dr Math® users with their logged conversations as sub-units, is based on the premise that "a case study should only ask questions about the units of analysis and any sub-units" (Rowley, 2002). This study will analyse the logged conversations for the selected users with the aim to investigate their UX. For the purpose of this study, the focus and depth obtained through a single case designs outweigh the diversity and breadth that the multiple case designs provide.

4.4 Target population

A research population is, typically, a very large group of people or objects of interest to the researcher. A target population, for example, could be South African youth; secondary school children in the Eastern Cape or people living with HIV in South Africa. Due to the large size of the population, it is seldom feasible to study the whole population.

The target population in this study is Dr Math® users, of whom the majority is secondary school learners. With the fast growing number of Dr Math® users, as pointed out in Chapter 2, it was rather impractical to study every single user of Dr Math®. For this reason, it is only sensible to use a convenient portion that represents the target population. Further discussion on sampling follows.

4.4.1 Sampling

As to be explained in the next section, for this research study, Dr Math® log files were selected as the source of data. Therefore, the unit of analysis became the logged conversations between Dr Math® users (pupils) and tutors. The rationale behind this was to analyse these conversations to determine the user experience of pupils when using Dr Math®. The large size of these log files necessitated a selection: a representative portion on which the study is based. This process is referred to as sampling (Marshall, 1996). In addition, Abrams (2010) stresses the significance of sampling, as he argues that the integrity of the social science research lies in sampling. Furthermore, inferences about the population are based on the data obtained from the sample (Saunders et al., 2007). Therefore, a careful selection of the sampling method is strongly recommended.

4.4.1.1 Sampling methods

According to Denscombe (2007), there are mainly two types of sampling techniques: probability and non-probability. Further discussion of probability and non-probability sampling methods is presented below, starting with the probability method. Table 4.3 illustrates some of the characteristics of these two techniques.

Probability	**Non-probability**
Every member of the population has an equal probability of being selected (Marshall, 1996).	Focuses on the objects that have certain characteristics which are of interest to the researcher (Abrams, 2010; Mays & Pope, 1995).
Fair and highly representative (King, 2009; Robson, 2002) making it easy to generalize the results.	Prone to a great deal of subjectivity resulting in sampling bias and low representativeness of the sample.
Its methods include: simple random, systematic random, stratified, clustered, and Multi-stage	Its methods include: Quota Purposive Convenience Snowball Judgmental

Table 4.3: Probability vs. non-probability

Random sampling, which is one of the probability methods, is based on fairness, integrity and rigour (Marshall, 1996). These factors are hardly ever found in any of the non-probability methods. In addition, random sampling is generally used, based on the assumption that parameters are normally distributed among the population (Marshall, 1996). This, however, is hardly the case in qualitative research. This view is supported by Abrams (2010) and Marshall (1996) who noted that qualitative researchers have no grounds to assume that variables such as experiences, behaivour, beliefs and attitudes are normally distributed. This is where the purposive sampling technique comes handy.

The purposive technique, however, is the most commonly used technique in qualitative research (Marshall, 1996). Many researchers argue that purposive sampling is better suited for qualitative research as it gives the researcher the freedom to select the sample based on the needs of the research (Coyne, 1997; Curtis, Gesler, Smith, & Washburn, 2000; Denscombe, 2007; Marshall, 1996).

Based on the above discussion, it is clear that a combination of probability and non-probability methods will strengthen the overall sampling technique as the drawbacks of each method will be compensated by the strengths of the other.

For the purpose of this study, and since the literature does not forbid the combination of probability and non-probability sampling methods, simple random and purposive techniques are used. To avoid going through the long list of text files in Dr Math® log files, and reading through each of them, which could be very time consuming, simple random sampling technique is employed. Within each text file there is a single conversation between a student and Dr Math® tutor. Every time a pupil logs in and chats with a tutor, a new text file is created. With the fast growing number of Dr Math® users, this resulted in a large number of conversations. The purposive sampling technique is used to set criteria for inclusion of the population members into the representative sample. In essence, for this study, the sample is selected randomly with a purpose in mind, meaning that every member of the population that meets the criteria has an equal chance of being included in the sample. Any randomly selected member that does not meet the criteria is discarded.

4.5 Data collection methods

There are several methods that can be used to collect data in a research study including interviews, questionnaires, observations, surveys, documentation and more. The selection of the appropriate data collection methods is largely determined by the nature of the research being conducted. For example, it is very much likely that a quantitative study will use mainly quantitative methods. The same applies for many qualitative studies. However, case study research, since it is not strictly qualitative (Yin, 2003), can exploit both qualitative and quantitative methods.

Lindsay (2007) stresses the significance of choosing the most appropriate methods for the research, thereby enhancing the rigour and validity of the research results. In agreement with Lindsay's viewpoint, the case study data collection method, documentation, is used as this

research study employed a case study strategy. Of the six well-known case study sources of data identified by Yin (2009), the documentation method, with Dr Math® log files as a source of data, was found to be the best method for this research. However, documentation is not the only source of data in this study. The other methods used to obtain data are literature and expert reviews. The other ways that could have been used to gather data in this research study are interviews and questionnaires. A brief description of each of these methods and the explanation justifying why documentation was selected over them is presented below.

4.5.1 Interviews

There are basically three types of interviews: structured, unstructured and semi-structured. Structured interviews entail a predetermined list of questions. Conversely, with unstructured interviews, there are no predetermined questions, meaning that questions can be asked in an unstructured manner. Lastly, semi-structured interviews are a combination of structured and unstructured interviews. Essentially, interviews and questionnaires entail personally, telephonically or electronically interacting with the participants. Particularly, the use of questionnaires in this research study, which according to Saunders et al. (2007) are some form of structured interviews, may introduce incompleteness and inconsistency issues (Oppenheim, 1992). Additionally, in contrast with other two types of interviews, this method lacks the ability to produce rich data (Opie, 2004) as the researcher cannot probe the respondents for more details. However, with both these methods, in comparison with documentation, there is a strong potential of interviewer bias. Additionally, these methods cover a relatively small audience. Therefore, the documentary source was selected over these alternative methods. A detailed description of documentation, as a data collection method is presented in the next section.

4.5.2 Documentation

Documentation as a data collection method entails reviewing existing documents. These documents can be in a printed or an electronic form and may include but are not limited to the following:

- personal documents such as letters, notes and diaries, committee minutes;

- internal records such as administrative documents, reports and individual file records;
- written reports of events; and
- articles and formal studies.

Based on the list of typical examples of documentary sources adopted from Denscombe (2007); Noor (2008) and Yin (2009), it is justifiable to declare log files are a documentary source.

Basically, the log files present first-hand data and would reach a wider audience of the users compared to the alternative methods. Gathered data was analysed and turned into meaningful information using qualitative content analysis, which will be discussed in the next section. The next section discusses the data analysis techniques used in this research study.

4.6 Data analysis

The data gathered during the data collection phase of research needs to be analysed and often interpreted into meaningful results. This is especially the case in qualitative research, where the researcher deals with a lot of open-ended questions in interviews or questionnaires or large amount of data from documents. Various methods are used to facilitate the data analysis process. This study will adopt qualitative content analysis. The next section gives a brief description of content analysis.

4.6.1 Content analysis

Content analysis has been identified as the longest method of text analysis when compared to other methods of social empirical inquiry (Titscher, Meyer, Wodak, & Vetter, 2000). Kohlbacher (2006) noted that there is no uniform understanding of content analysis. Titscher et al. (2000) argue that although content analysis was originally rooted in quantitative inquiry aspects, it has, however, extended to qualitative approach of text analysis.

4.6.1.1 Qualitative content analysis

Based on wide range of researchers, qualitative content analysis entails evaluating and organizing raw data into meaningful themes and categories (Babbie, 2001;

Kohlbacher, 2006; MacQueen, McLellan, Kay, & Milstein, 1998; Mayring, 2000; Zhang & Wildemuth, 2009). Further, it refers to the process of organizing gathered data into themes and categories as coding. Coding entails identifying units of meaning which, according to Henning, van Rensburg and Smit (2004), are the pieces of text that convey information that would help in answering the research question. The researcher is supposed to group these pieces of text and label them based on what they mean. The labels that are given to these pieces of text are referred to as codes (Henning et al., 2004). Once all these segments of text are coded, further segmentation into categories is recommended (Henning et al., 2004). In this stage, data can still be further analyzed to identify relationships among categories. The themes, which are the highest level of abstraction of data in this study, are constructed from the relationships among categories (Henning et al., 2004). A focus group with eight experts in user experience was conducted to identify and finalize major themes, categories and respective codes, thereby avoiding subjective bias. The selection of this method as a way to obtain expert review was based on Anderson and Arsenault's (1998) argument that a focus group is more than just a data collection method, but also a way to evaluate a program. However, in this case, it was used to evaluate theory. Additionally, it shares commonalities with brainstorming techniques, promoting deep and insightful findings (Anderson & Arsenault, 1998).

This research study adopted the process of data coding explained above. Two of three types of coding identified by Nemerowicz (2010), namely descriptive and analytical coding, were used in this study. Particularly, descriptive coding was mainly used to clearly distinguish between different groups of data and relate groups of data that share semantic meaning; thereby, making the data more meaningful (Richards, 2005). Given the qualitative and exploratory nature of this study, descriptive coding which, according to Richards (2005), has characteristics of a quantitative approach on its own was clearly insufficient. Consequently, analytical coding was used in conjunction with descriptive coding, as it was impractical to develop some codes merely from the manifest and obvious meaning of the text (Richards, 2005). In addition, analytical coding also allows the researcher to make assumptions (Richards,

2005). Once again, this study has exploited the advantages of both quantitative and qualitative approaches. In essence, due to the nature of this study, the need to discover and interpret the latent (hidden) meaning became a necessity. In other words, some pieces of text were analytically coded.

In essence, this study uses qualitative content analysis by Mayring. The main aim for the development of this approach was to conserve quantitative content analysis benefits while enhancing qualitative text interpretation (Mayring, 2000). It is clear that this method has a virtue, compared to other content analysis methods, as it exploits both quantitative and qualitative advantages. Moreover, given its characteristics, this approach has a potential of addressing some of the criticisms of qualitative analysis and, perhaps, case studies. The next section discusses some of the case study criticisms.

4.7 Criticisms of case studies

As powerful as they can be, especially for conducting qualitative research, case studies have been heavily criticized by many researchers for various reasons. They are often criticized for a lack of scientific rigour and reliability. This is mainly due to the fact that case studies have no strict rules to enforce formality and rigour. Another one of the most frequent criticisms of case study research is that it is subject to bias. This criticism is based on the perception that it is impossible to separate the qualitative researcher from the subject under study. In addition, Yin (1994) reveals and corrects some of the typical criticisms towards case studies. Table 4.4 shows the criticisms along with correcting answers to each criticism.

Criticism	**Correcting answer**
Shortfall of systematic data handling.	Evidence must be systematically reported.
Lack of scientific generalizability.	Analytic instead of statistic generalizing must be used.
Time consuming and may lead to data overload and unreadable documents.	The researcher decides on the writing format and limits.

Table 4.4: Typical criticisms of case studies and correcting answers (Yin, 1994)

The above table evidently conveys that these criticisms are poorly constructed since they can easily be cleared. This, therefore, concludes that these are merely misunderstandings.

These criticisms can influence the way researchers judge the quality of the study. Additionally, they, somehow, impact on the critical factors that are perceived as the determining factors in the quality of the research. Consequently, the next section explores these factors further, from both qualitative and quantitative viewpoints. The rationale behind this is to highlight the different views that qualitative and quantitative researchers have when it comes to judging the quality of research.

4.8 Validity and reliability

The previous section has discussed the criticisms of case studies, which affect the perceived validity and reliability of the research results. Having reviewed a lot of published works on validity and reliability, it is clear that the quality of quantitative research relies heavily on validity and reliability of the results (Bashir, Afzal, & Azeem, 2008; Carcary, 2009; Golafshani, 2003; Onwuegbuzie & Johnson, 2006). Until recently, the importance of these factors has also been realized in qualitative research (Bashir et al., 2008; Golafshani, 2003; Onwuegbuzie & Johnson, 2006). However, since these factors are founded in the quantitative approach, they cannot be adopted in the qualitative approach without explicit changes (Golafshani, 2003).

To prove that the quality of research in qualitative inquiry is as important as it is in the quantitative approach, a wide range of researchers have proposed different terms as criteria for judging the quality of qualitative research. These terms include: truth value (YS Lincoln & E. Guba, 1985; Onwuegbuzie & Johnson, 2006), credibility (Bashir et al., 2008; Golafshani, 2003; YS Lincoln & E. Guba, 1985; Onwuegbuzie & Johnson, 2006), trustworthiness (Bashir et al., 2008; Golafshani, 2003; Onwuegbuzie & Johnson, 2006), authenticity (E. G. Guba & Y Lincoln, 1989), goodness (Emden & Sandelowski, 1998; Marshall, 1990) and plausibility (Bashir et al., 2008; Whittemore, Chase, & Mandle, 2001).

Furthermore, Morse, Barrett, Mayan, Olson and Spiers (2002) argue that quantitative and qualitative researchers have different perspectives on how to judge the quality of the research

outcome (Morse et al., 2002). In support to this view, Bashir et al., (2008); Carcary, (2009) noted that the frameworks for measuring the quality of quantitative research are not necessarily relevant to qualitative research.

In qualitative research, there is a lack of strict rules on how to conduct the research, which results in the uniqueness of each study. Due to the inevitable uniqueness of each qualitative study, there is no point in trying to develop a framework on how to judge the quality of research (Rolfe, 2006). Once the researchers acknowledge this, they will understand that the quality of the research is in their own hands (Bashir et al., 2008; Golafshani, 2003). This research study selected the methods and techniques that were best suitable for the nature of the study, regardless of the effort and time exerted. This was done with the aim to accomplish the acceptable degree of quality of the research, which would increase the credibility of the results and support generalization. The next section discusses triangulation, one of the powerful ways to address validity and reliability issues.

4.9 Triangulation

Denzin (1970) defines triangulation as a combination of several research methodologies to investigate the same phenomenon. Additionally, (Creswell, 2003) defines triangulation as a technique that entails "using different data sources of information by examining evidence from the sources and using it to build a coherent justification for themes". Creswell and Miller (2000), define triangulation as "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study".

Different methods and methodologies have their own strengths and weaknesses (Rowley, 2002). Thus, using several methodologies to examine one particular phenomenon strengthens the validity and reliability of the results of the study. The weaknesses in each method are compensated by the strengths of the others. According to Bryman (2006), triangulation can be applied at any stage of the research process including during the formulation of the research question, sampling, data collection, data analysis or interpretation stages of the research. In this research study, triangulation is applied during the data analysis and interpretation stages of the research process.

Denzin (1978) identified four basic types of triangulation: data source triangulation, investigator triangulation, theory triangulation, methodological triangulation. Each type of triangulation is determined by the stage in the research process in which it takes place. A brief description on each of triangulation types is presented below.

Data triangulation – this type of triangulation involves the use of various data sources in a study to obtain a comprehensive view of the examined phenomenon (Denzin, 1978). The documentary source is the main, but not the only, source of data on which this research study is based. In this study, data triangulation was accomplished by using multiple sources of data such as documentation, a literature review, an expert review and different participants (end users and experts).

Investigator triangulation – this type involves the use of multiple investigators or observers in the field to collect and interpret data (Denzin, 1970). Investigator triangulation increases the credibility to the observation; it may also lead to less biased findings (Denzin, 1970). This study employed the principles of this approach during data analysis and interpretation. The emerged themes and categories were taken to an expert focus group for discussion and finalization of the themes and categories. The experts shared their views on the themes and categories discovered by the researcher. Also during the group discussion more themes and categories emerged. The focus group was conducted to avoid the possibility of one investigator overlooking crucial factors and to validate the themes and categories. For instance, during the expert focus group, it became clear that researcher overlooked some of the important factors, which were then detected by the experts.

Theory triangulation – this type entails using multiple perspectives to interpret data (Denzin, 1978). This study also employed this type of triangulation through a focus group of experts, where the experts shared their views on the analysis and interpretation of data. One of the greatest benefits of this triangulation, as identified by Banik (1993), is that it provides a broader and deeper analysis of findings.

Methodological triangulation – this type involves making use of more than one research methodology, multiple qualitative and quantitative methods in a study (Denzin, 1970). This triangulation involves the integration of qualitative and quantitative research in a single study with the aim of providing a better understanding of the research problem (John W Creswell & Garrett, 2008).

Based on the above descussion, triangulation refers to the use of various methododologies, data sources, analysis and theories in a study to verify the validity of the findings.

Any kind of triangulation allows in-depth understanding of the phenomena, adds rigour to the investigation and it is likely to increase validity and reliability of the results. The logic of triangulation rests on the basis that no single method is sufficient to adequately solve a research problem (Patton, 1999). Triangulation is used to counterbalance each method's strengths and weaknesses (Jick, 1979). Therefore, triangulation technique reduces the vulnerabilities associated with single data sources, methodologies, theory approaches and investigators. A summary of this chapter is presented in the next section. Specifically, in the next section, a brief recap of the methodology used in this study is presented.

4.10 Summary

This chapter has discussed the methodological choices used in the study and the rationales justifying these choices. This study adopts an exploratory case study design of a qualitative approach within an interpretivism paradigm. A single case with multiple embedded units of analysis was selected as an appropriate design for this study. Data was collected through documentation with Dr Math® log files as a documentary source. Data collected through the analysis of log files was supplemented by a literature review and an expert review. Qualitative content data analysis was used to analyze the data. Figure 4.5 outlines the overview of the research design employed in this study.

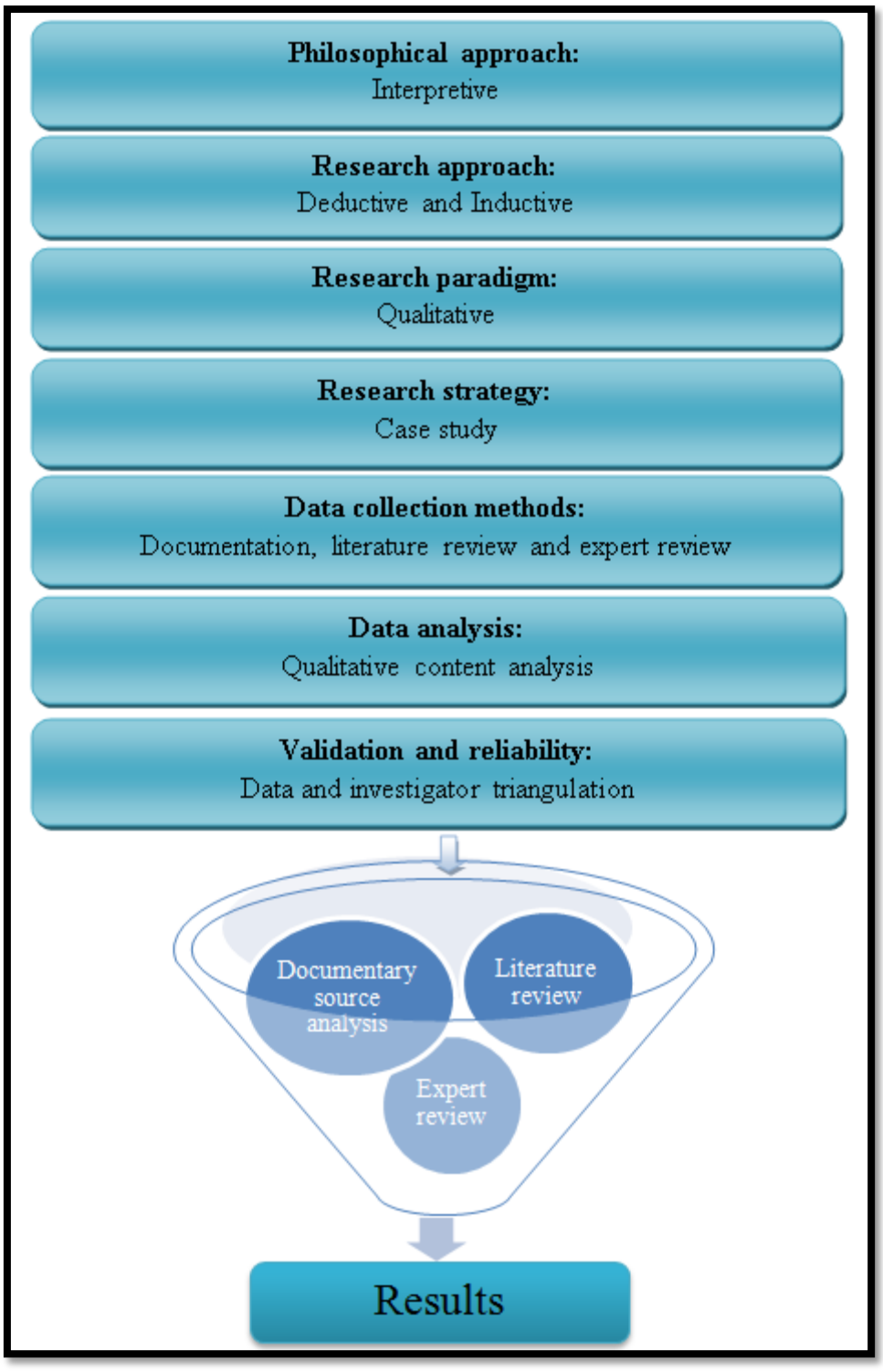


Figure 4.5: Research design overview

Case studies are associated with various criticisms that are mainly based on the misunderstandings that can easily be cleared up, as shown in Section 4.7. It was also determined that although validity and reliability are rooted in quantitative research, they are

equally important in qualitative research. Because qualitative and quantitative researchers have different views on how to judge the quality of research, a need for a set of generic criteria for judging the quality of qualitative research was evident. In response to this view, several researchers have proposed various criteria for evaluating the quality of qualitative research. Qualitative researchers agree that the quality of the research is the responsibility of the researcher.

Thus, a documentary source was analysed as opposed to conducting interviews and questionnaires to reduce possibility of bias, one of the popular case study criticism. Another reason why documentation was selected over interviews was so that the researcher could reach a wider audience and to find them at their natural behaviour as they are not aware of their participation. To increase the rigour of the results and to make the results generalizable to the entire population, simple random sampling was selected as a principal sampling method. Additionally, for credibility of the sample, simple random sampling was not adequate on its own due to the fact that parameters are seldom normally distributed among the population, especially when dealing with subjective concepts like user experience. Therefore, this research exploited the advantages of both simple random sampling and purposive sampling. The flaws of each method are compensated for by the counter-balancing strengths of the other method. Moreover, the obtained results were discussed and finalized with a panel of user experience experts in order to increase the credibility of the results. The same panel of experts reconvened to review the proposed guidelines. The next chapter presents the results and the analysis of findings.

Chapter 5: Results and Findings Analysis

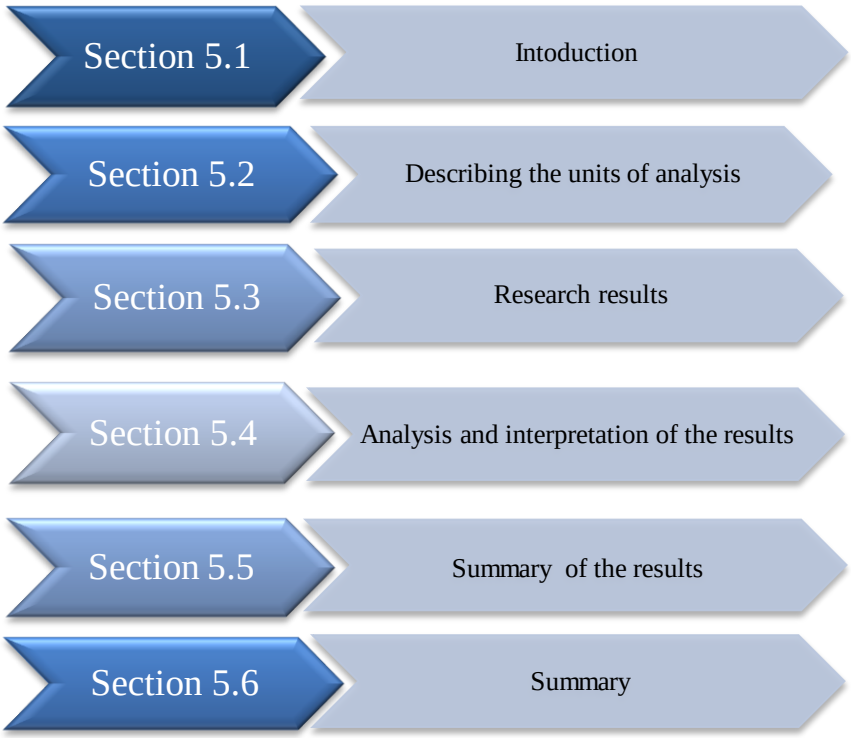


Figure 5.1: Chapter 5 layout

5.1 Introduction

The research design and methodology described in Chapter 4 serves as an overall plan for data collection, analysis and interpretation. The purpose of this chapter is to present the research results and also to analyze and interpret the findings obtained from the Dr Math® case study. The current chapter begins by describing the data-coding techniques and units of analysis employed in the research. Thereafter, a discussion of research results follows. This chapter ends with the analysis and interpretation of findings.

5.2 Describing the units of analysis

This study employed a case study approach to collect data. Dr Math®, a mathematics tutoring system available through Mxit platform, was selected as a case study for this research. This is mainly due to its popularity among South Africa pupils. Furthermore, of all the popular

sources of evidence associated with a case study approach including observations, interviews, and questionnaires, documentation was the most appropriate method for this research. Dr Math® log files from January 2010 up through the end of May 2010 were used as the documentary source. In other words, Dr Math® files are the unit of analysis for this study. Each file, as explained in Chapter 4, contains a single conversation between a tutor and a pupil. The anonymity of the users (pupils) was preserved throughout.

Observations and face-to-face interviews would have limited the scope of the study as the researcher would have been forced to select participants in a geographically convenient location to collect the data that could be easily obtained using Dr Math® log files. The use of Dr Math® log files, on the other hand, enabled the researcher to reach Dr Math® users from different provinces, with different backgrounds, which may not have been achieved through interviews or questionnaires. The regions from which the conversations with selected pupils reside was unknown to the researcher. In this way, the researcher was prevented from influencing participants' responses. In addition to this, the participants were not even aware of the study being conducted; therefore, the possibility of catching them in their normal behavior was maximized. Otherwise, the participants may have wanted to impress the researcher and provided dishonest answers. Additionally, in the Eastern Cape where I, the researcher resides, Dr Math® adoption rate is relatively low. For all the above reasons, Dr Math® log files were found to be the most appropriate unit of analysis from which data was gathered.

These log files were received from CSIR, Meraka Institute in June 2011 and, therefore, contained conversations only from January up through May 2011. Although these log files contained conversations of approximately five months, they formed a large and diverse research population and necessitated sampling. Two different sampling methods, namely random and purposive, as stated in Chapter 4, were used. These two complementary methods, however, have sustained the diversity of the population in the studied sample. Figure 5.1 illustrates the size of the entire population and the resulting sample.

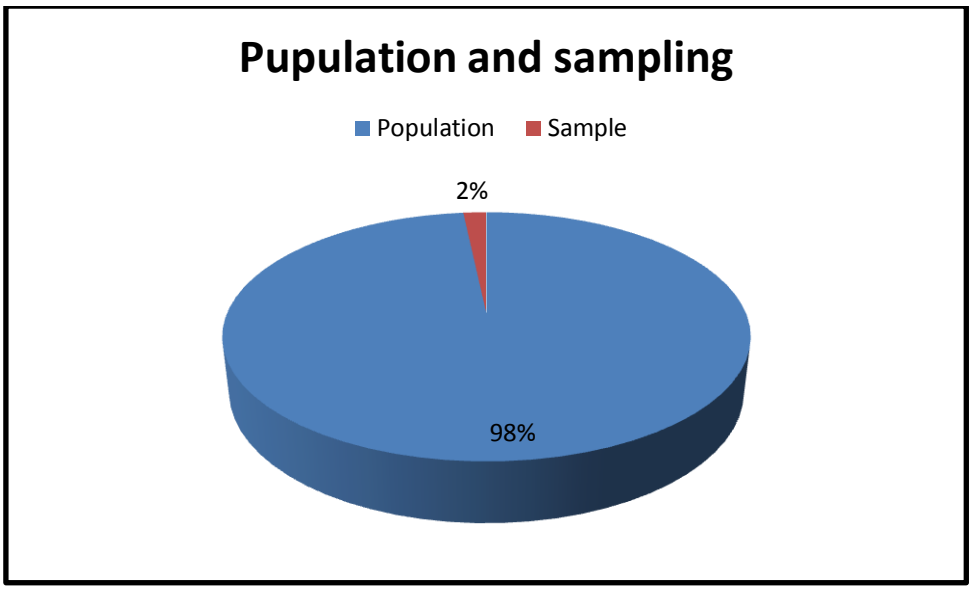


Figure 5.2: Sample vs. population

According to Nielsen (2000), a large sample does not necessarily mean that the research produces reliable results. In support to this view, Faulkner (2003) states that it is all about selecting a proper sample or the right participants; thus, in this study, 50 conversations were found to be fairly representative of all 2904. Additionally, the selected conversations were of convenient size thereby enabling a comprehensive evaluation of the pupils' UX when interacting Dr Math®.

The 50 conversations were selected using random sampling, which as mentioned in Chapter 3, is known to be relatively representative. This technique allows the researcher to make generalization about the targeted population. During the sampling process, it was discovered that some conversations contain a single word or line, which would add little value to this research study. Those one-word or one-line conversation included merely "Hi" or "Do you have any math question today?". These conversations provide vague information, which would have led to vague conclusions. Therefore, this problem necessitated the use of purposive sampling, which was employed mainly to discard such conversations. After these conversations were discarded from the selected sample, random sampling was conducted again to replace discarded conversations. Thereafter, the reviewing process commenced again to look for more of these unwanted conversations. This process recurred until 50

conversations, each with more than one line or word, were reached. Figure 5.3 shows a snapshot of Dr Math log files.

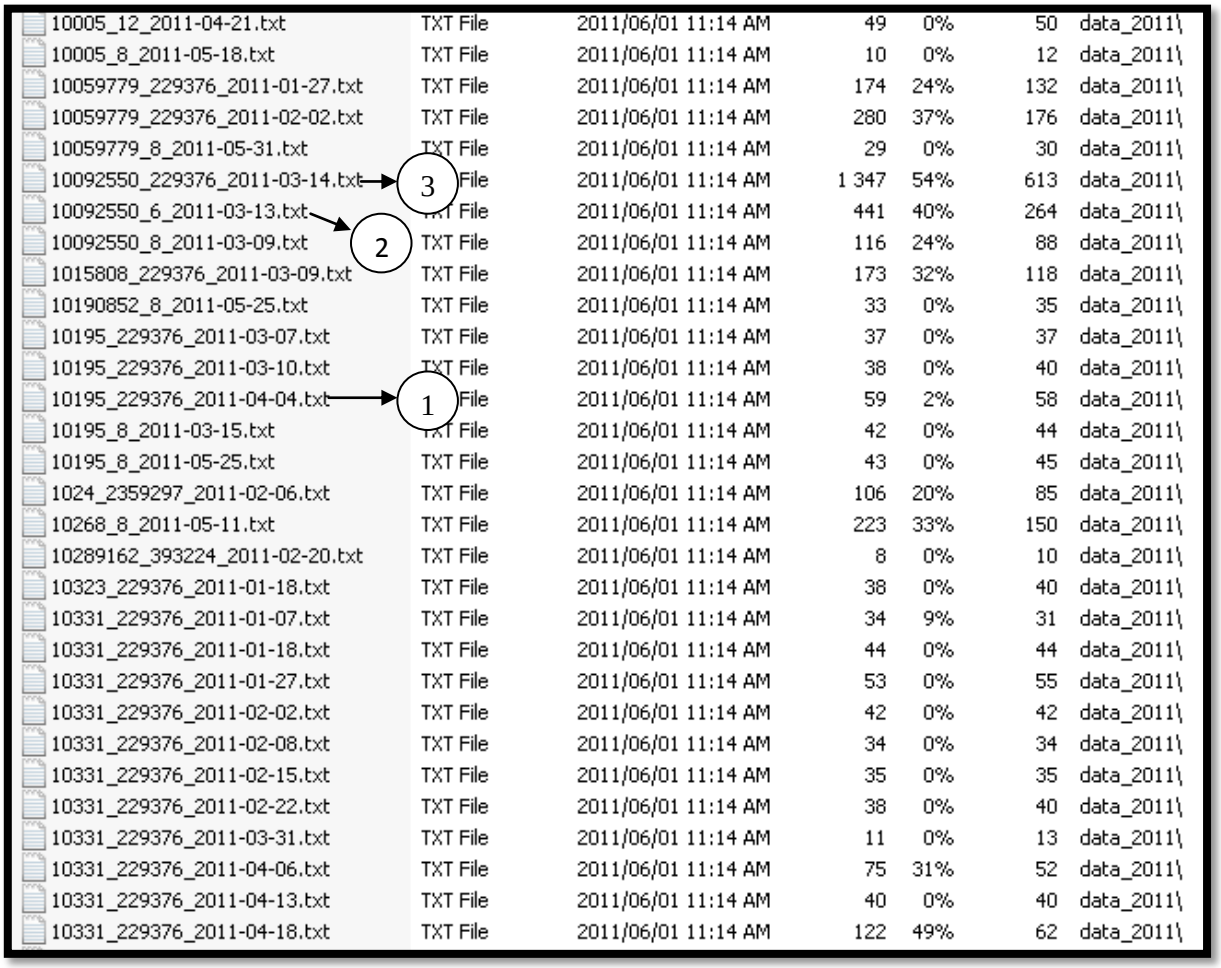


Figure 5.3: Snapshot of Dr Math® log files

Each line represents a single file, which contains a single conversation between the pupil and the tutor. Every time the pupil interacts with Dr Math®, a new file containing new conversation is created. The snapshot in Figure 5.4 shows the file labelled "1" in Figure 5.3 as an example of a single line conversation.

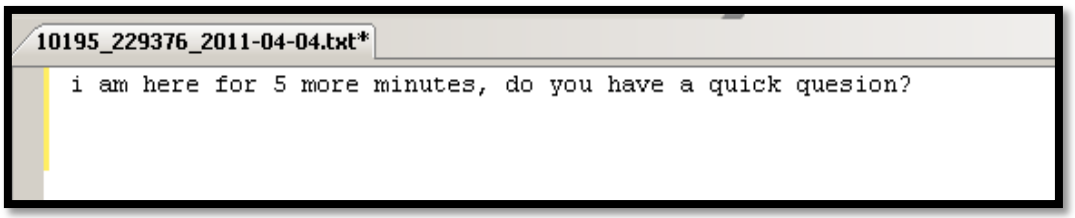


Figure 5.4: Single-line conversation

With all single-line conversations, as can be seen above, there is normally no task done. In other words, a two-way communication must occur otherwise no assistance is offered. Figure 5.5 shows a snapshot of an average conversation taken from the file labelled "2" in Figure 5.3.

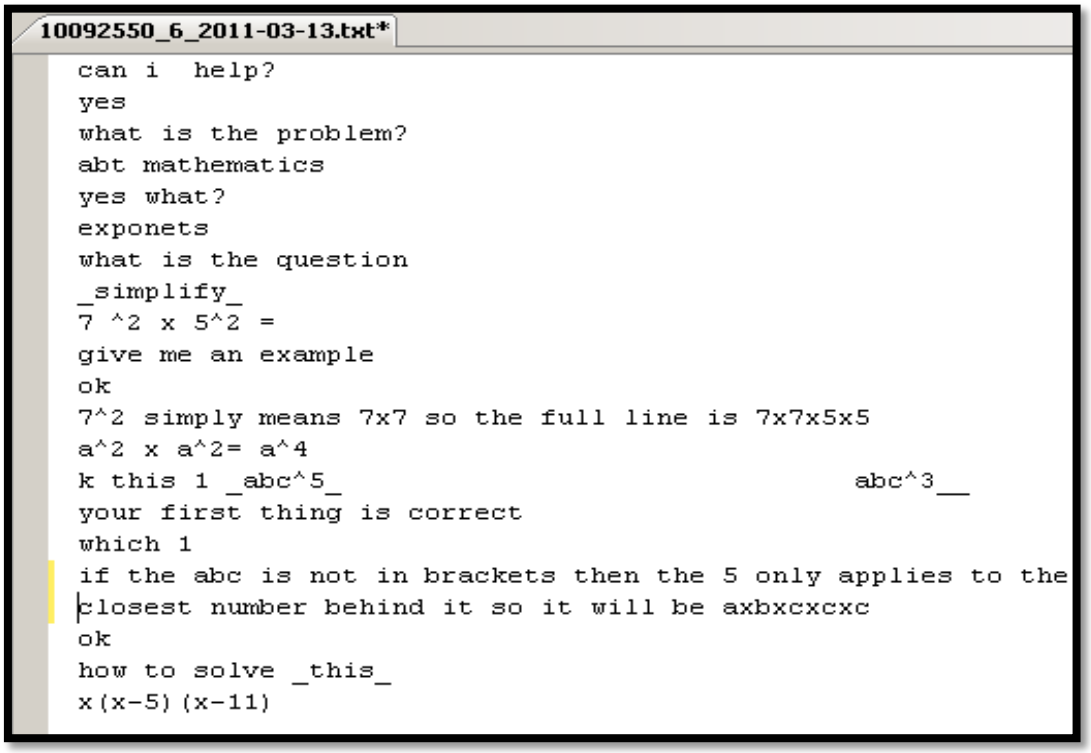
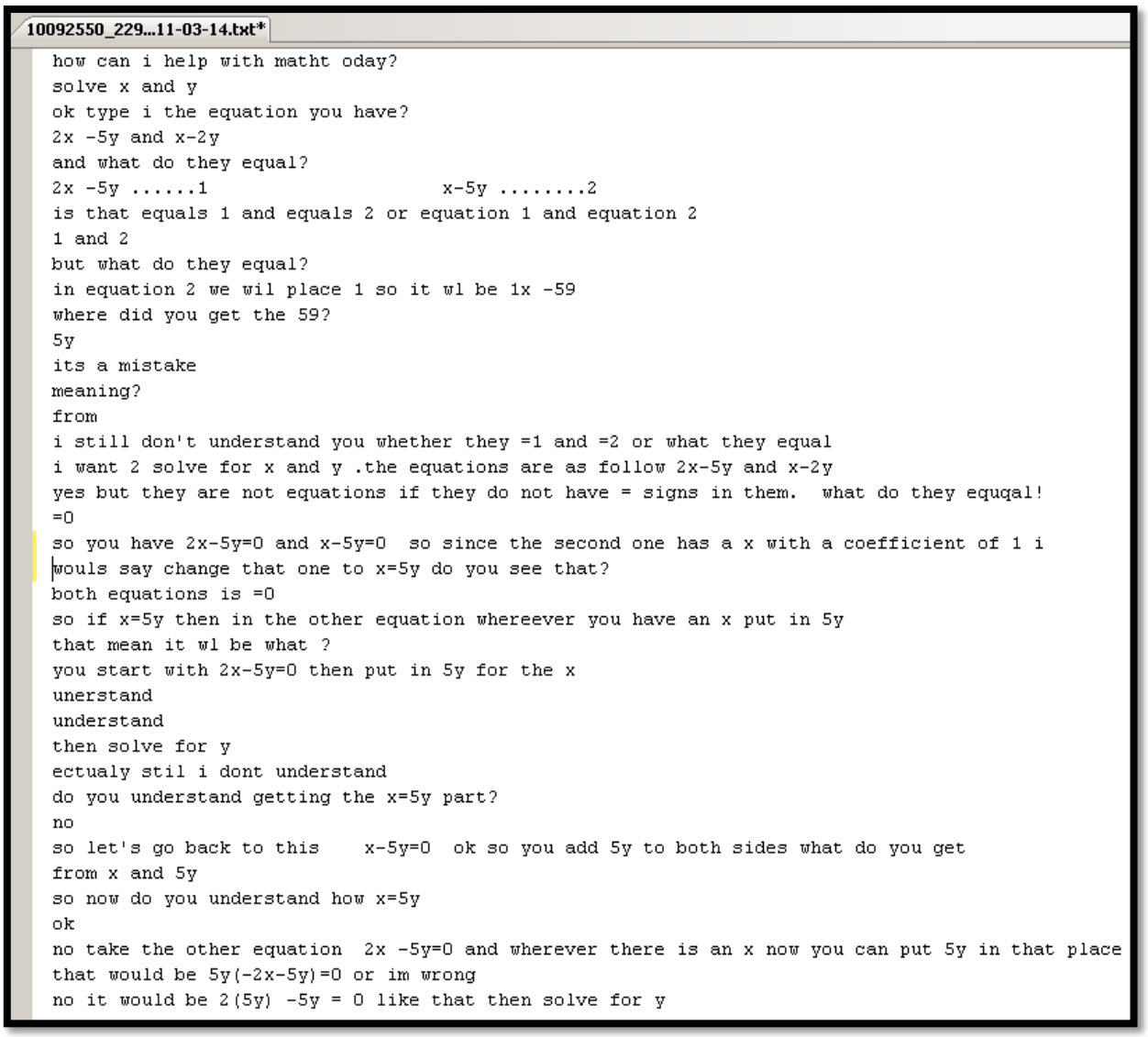


Figure 5.5: Average length conversation

Figure 5.6 shows one of the long conversations between Dr Math® tutors and pupils. There are many conversations of this size. This is partly due to the fact that Dr Math® refuses to supply the pupils with straight answers as it believes in the "learning by doing" theory.



10092550_229...11-03-14.txt*

how can i help with matht oday?
solve x and y
ok type i the equation you have?
2x -5y and x-2y
and what do they equal?
2x -5y 1 x-5y 2
is that equals 1 and equals 2 or equation 1 and equation 2
1 and 2
but what do they equal?
in equation 2 we wil place 1 so it wl be 1x -59
where did you get the 59?
5y
its a mistake
meaning?
from
i still don't understand you whether they =1 and =2 or what they equal
i want 2 solve for x and y .the equations are as follow 2x-5y and x-2y
yes but they are not equations if they do not have = signs in them. what do they equqal!
=0
so you have 2x-5y=0 and x-5y=0 so since the second one has a x with a coefficient of 1 i
wouls say change that one to x=5y do you see that?
both equations is =0
so if x=5y then in the other equation whereever you have an x put in 5y
that mean it wl be what ?
you start with 2x-5y=0 then put in 5y for the x
unerstand
understand
then solve for y
ectualy stil i dont understand
do you understand getting the x=5y part?
no
so let's go back to this x-5y=0 ok so you add 5y to both sides what do you get
from x and 5y
so now do you understand how x=5y
ok
no take the other equation 2x -5y=0 and wherever there is an x now you can put 5y in that place
that would be 5y(-2x-5y)=0 or im wrong
no it would be 2(5y) -5y = 0 like that then solve for y

Figure 5.6: One of the long conversations

The next section presents the results obtained during the analysis of Dr Math® log files.

5.3 Research results

As mentioned in Chapter 4, this research study adopted a qualitative content analysis. According to qualitative content analysis methodology, the results must be organized in terms of themes and categories. As discussed in Chapter 4, the process of organizing data into themes and categories is called coding.

5.3.1 Analysis process resulting in themes and categories

Firstly data was copied onto a spreadsheet and the columns were used to write notes and facilitate labelling of data. While quickly skimming through the text to get the general idea of content, the significant pieces of text, referred to as units of meaning, as explained in Chapter 4, were identified. These pieces of text were then grouped labelled into codes. This process continued until all the significant segments of data were coded. Thereafter, a further segmentation of data into categories was done. Further analysis of the information within categories led to development of themes. The emerged themes, categories and codes were discussed with a panel of UX experts, thus avoiding subjective bias.

The content was sent to the individual experts with the list of the emerged themes and categories from the researcher's perspective prior the meeting. During the discussion, experts shared their views on the existing themes and categories and shared additional categories that they had identified and which had been overlooked by the researcher. Table 5.1 presents a summary of demographic profile of the experts participated in the focus group.

Expert 1	
Name	Darelle van Greunen
Email address	Darelle.vanGreunen@nmmu.ac.za
Gender	Female
Field	UX, Usability and UI design
Expert 2	
Name	Alida Veldsman
Email address	Alidav@telkomsa.net
Gender	Female
Field	Change Management, Impact Assessment
Expert 3	
Name	Godwin Thomas
Email address	Godwinthomas@gmil.com
Gender	Male
Field	Mobile computing, End-to-end service design
Expert 4	
Name	Job Mashapa
Email address	mashapaj@gmail.com
Gender	Male
Field	UX, Usability and UI design
Expert 5	
Name	Calvin Nangue
Email address	calvainraoul.nangue@nmmu.ac.za
Gender	Male
Field	ICT in education

Table 5.1 to continue.

Expert 6	
Name	Alexandros Yeratziotis
Email address	Alexandros.Yeratziotis@nmmu.ac.za
Gender	Male
Field	UX, Usability and UI design

Table 5.1: Demographic profile of the experts

Table 5.2 illustrates the first draft of themes, categories and sub-categories identified by the researcher in comparison with the ones identified by the experts in a focus group discussion.

Researcher	**Experts**

Theme 1: Dr Math® system
• Connectivity
• Login
  o Airtime
• Network availability
• Device battery
• Technical delay
• Communication
• Input limitations
  o No math symbols
  o No graphing support
	Theme 1: Dr Math® Application
	• Technical
	• Login
	  o Connectivity
	  o Access
	• Design
	• Lack of user groups – in terms of grade, topic or language.
	• Input limitations
	• Functionality
	• Capability

Theme 2: Dr Math® tutors • Availability • Tutors • Time • Skill • Language restriction • Language of instruction • Mxit lingo	Theme 2: Users (tutors) • Tutor availability • Response delay • Offline • Resource availability • Time • Skill • Communication • Language • Jargon

Table 5.2: Comparison between themes and categories identified by the researcher and those identified by experts

As can be seen in Table 5.2, there are various commonalities between the researcher's and the experts' interpretations of data. A revision of the identified themes and categories was done. The final themes and categories were cross-checked by the same panel of experts and are summarized in the Table 5.3.

Theme 1: Dr Math® application	Theme 2: Dr Math® tutor
Accessibility • Login • Connectivity System functions and capabilities • Input limitations • Recovery capability • Embedded calculator	Tutor Availability • Availability to offer service • Responsiveness of online tutors Effective communication • Official language of communication • Mxit lingo Resource availability • Operating time • Skill of tutors

Table 5.3: Final themes and categories

The next section presents the results in themes and categories.

5.3.2 Presentation of themes and categories

As highlighted above, data was coded into the themes and categories shown in Table 5.4. During the coding process, five levels of abstraction were obtained. These levels of abstraction, as explained in Chapter 4, starting from the lowest level are: 1) units of meaning; 2) codes; 3) sub-categories; 4) categories; and 5) themes. The results of this study are organized into two themes, five categories and 11 sub-categories, as shown in Table 5.4.

Some categories derived from the factors discovered in Chapter 3, which were found to impact mobile UX. The rest emerged during the analysis of Dr Math® log files, as they are application related. For instance, "*Tutor availability*" specifically relates to Dr Math® as a tutoring system. *Connectivity* and *Input limitations*, on the other hand, are typical problems for mobile applications. Thus, they are also revealed in the literature, as shown in Chapter 3.

Additionally, the characteristics of a positive UX, which are presented in Chapter 3, were taken into consideration during the analysis of the log files. For example, in Chapter 3, *Accessibility* is listed as one of the characteristics of a positive UX. Consequently, due to its

proven impact on UX, it became one of the categories that emerged from data, which represent the factors impacting on UX. Table 5.4 presents an overview of the major themes, categories and sub-categories: the top three levels of data abstraction.

Section	Themes and categories
5.3.3.1	**Theme 1: Dr Math® application**
	Category 1.1. Accessibility
	Sub-category 1.1.1. Login
	Sub-category 1.1.2. Connectivity
	Category 1.2. System functions and capabilities
	Sub-category 1.2.1. Input limitations
	Sub-category 1.2.2. Recovery capability
	Sub-category 1.2.3. Embedded calculator
5.3.3.2	**Theme 2: Dr Math® tutor**
	Category 2.1. Tutor availability
	Sub-category 2.1.1. Available to offer service
	Sub-category 2.1.2. Responsiveness of online tutors
	Category 2.2. Effective communication
	Sub-category 2.2.1. Official language of communication
	Sub-category 2.2.2. Mxit lingo
	Category 2.3 Resource availability
	Sub-category 2.3.1. Operating time
	Sub-category 2.3.2. Skill of tutors

Table 5.4: The overview of the major themes; categories; and sub-categories

The two themes shown in the table, namely Dr Math® application and Dr Math® tutor, together form a major part of Dr Math®'s tutoring system, particularly, a part that offers the services. The user (pupil) utilizes services provided by Dr Math® program as a whole, including tutors. These three aspects (application, tutor and pupil) are the essential parts of Dr Math® tutoring system; however, the user is the most valuable part of this system. As a result, data was evaluated mainly from the user expectations. During the interpretation of data, a variety of user expectations of Dr Math® were identified. These user expectations

began to fall into sub-categories and categories. Further relationships between categories emerged, allowing better organization and presentation of data. This is how the highest level of data abstraction, the theme, came to the fore. In essence, both Dr Math® application and tutors themes determine the fulfilment of user expectations and overall UX of the user; therefore, UX of the pupils is measured from their interaction with both the application and tutors.

The next section provides a detailed discussion on of each category. Additionally, as described in Chapter 4, categories are comprised of codes and units of meaning, the lower levels of abstraction. Therefore, each category is presented with codes and units of meaning that it is comprised of.

5.3.3 Results on category-by-category basis

As mentioned earlier, Dr Math® program, as a tutoring system, comprises of two aspects namely, Dr Math® application and Dr Math® tutor. That is how the two major themes were derived, which are the highest level of abstraction. This level of abstraction has contributed in making data more meaningful and easy to conceptualize.

This section presents all the categories that comprise the identified themes. Each category is discussed under the theme in which it belongs. In other words, all categories that are application-related will be discussed under theme 1 (Dr Math® application), and the tutor-related under theme 2 (Dr Math® tutor).

These categories determine the user experience and the overly usage of Dr Math® program as a tutoring system. Thus, Tables 5.5-5.9 represent a summarized extract of themes and categories. These categories are the factors that were found to negatively affect the UX of Dr Math® program. Each table presents sub-categories, codes, units of meaning and one instance per problem.

5.3.3.1 Theme 1: The Dr Math® application

Theme 1, the Dr Math® application, is comprised of the following categories: *accessibility* and *system functions and capabilities*. Table 5.5 presents the results on the perceived accessibility of Dr Math®.

Category 1.1: Accessibility

Sub-category	Code	Meaning	Extract
Login	No air time	No air time, no access to Dr Math.	**Tutor**: type it in **Pupil**: cn i type it l8r am out of air nw.
Connectivity	Battery running out of power	If the battery dies, the connection will be terminated.	**Pupil**: be3 low.later lovely p3rs.
	Connectivity issues	Pupils experience inconsistent interactions due to technical issues.	**Pupil**: i g0t dc
	Technical delays	Due to technical issues some delays have been experienced.	**Tutor**: we seem to be experiencing a delay. we are swapping you to another tutor. please send another message to us.

Table 5.5: Category 1.1: Accessibility

As evident in the results presented in the Table 5.5, the accessibility of Dr Math® is not entirely satisfying to the pupils. The root causes for this undesired level of accessibility are shown in column 2 and 3 in the table. In one example, without sufficient amount of airtime, pupils cannot have access to the system. However, obtaining access to the system does not necessarily guarantee access to the required assistance. Other accessibility variables include inevitable interruptions arising from connection failure, as shown in the table. The analysis revealed that Dr Math® lacks

some essential capabilities that would make the use of Dr Math® much easier and less stressful. These capabilities, however, are mainly inherent problems as depicted in Table 5.6. Table 5.6 summarizes the results regarding the shortfalls associated with the built-in functions and the capabilities of Dr Math®.

Category 1.2: System functions and capabilities

Sub-category	Code	Meaning	Extract
Input limitations	Lack of mathematical symbols.	Dr Math provides no math symbols, making it difficult for pupils to express math problems.	**Tutor**: type in the expression you need to simplify. **Pupil**: cnt gt da square sign. … **Pupil**: i wnt a square sign like in 5 square **Tutor**: i use ^ for exponent like 5^2 meaning five times five.
	Lack of graphing capability	Due to the lack of graphing capability pupils struggle to express geometry questions.	**Tutor**: please tell more about your parabola question.do you have an equation? **Pupil**: x^2+2x-3 **Pupil**: i think it will be hard because we hve no graphs **Tutor**: do you want to draw the parabola? **Pupil**: lets do completing the square instead.

Table 5.6 to continue.

Recovery capability	No recovery capability	If the connection fails in the middle of the conversation the pupil has to start over	**Tutor**: sorry got dc what is your question
Embedded calculator	Too technical	Hidden functionality	**Pupil**: i dont have a calucator **Tutor**: use ours type in .c 400^50 **Pupil**: where is it? **Tutor**: send me a dot c then the expression. use ^ for exponet **Pupil**: what? **Tutor**: the calulator starts with dot c like this .c 3+2

Table 5.6: Category 1.2: System functions and capabilities

Satisfactory and effective communication between Dr Math® and pupils is hardly achieved due to input limitation problems of the Mxit platform. The Mxit platform does not provide mathematical symbols and graphical support that are used to express mathematical problems. This limitation makes Dr Math® not ideal for geometry. The following extract supports this statement and also shows that tutors acknowledge the fact that it is hard to deal with geometry questions in Dr Math®.

Pupil: x^2+2x-3 **Tutor**: i think it will be hard because we hve no graphs **Tutor**: do you want to draw the parabola?

In addition, the input limitations also make it difficult for pupils to express mathematical problems generally, not only geometry problems, as they are required to write out mathematical symbols in words.

Moreover, Dr Math® offers a calculator as an additional function that can be useful to the pupils when interacting with Dr Math®. Dr Math® pupils are required to

access additional functions such as embedded calculator using commands. However, in the Mxit platform, users (including Dr Math® users) merely follow links and paths in order to access additional functions. Specifically, having to do similar tasks in different ways within the same platform could be confusing and add an unnecessary burden of having to learn new ways. Based on the obtained results, pupils seem to be struggling to access this calculator. The results show that the way in which they are required to access the calculator is one of the root causes of this obstruction. Moreover, Mxit lacks the recovery capability, and, therefore. as shown in the table, Dr Math®, inevitably, inherits this shortcoming. This inheritance forces pupils to restart the conversation when, for some reason, they get disconnected from the system.

5.3.3.2 Theme 2: The Dr Math® tutor

As highlighted before, the Dr Math® program is comprised of two aspects, therefore, its success does not solely depend on the categories of theme 1 (Dr Math® application), but also includes theme 2 (Dr Math® tutors). Theme 2 is comprises of categories such as: *Tutor availability*, *Effective communication*, and *Resource availability*. The following table presents the results regarding the availability of tutors.

Category 2.1: Tutor availability

Sub-category	Code	Meaning	Extract
Available to offer service	No response	There are cases whereby pupils need help and tutors are not there to offer the service.	**Pupil**: how can i multiply a polynomial by a monomial **Pupil**: how can i dr math **Pupil**: dr are you there i realy need help.
Responsiveness online of tutors	Response delay	For various reasons tutors sometimes take time to respond to the pupils.	Pupil: kwl Pupil: ? **Pupil**: any1 da? **Pupil**: dr maths **Tutor**: hi. what is your math question?

Table 5.7: Category 2.1: Tutor availability

Table 5.7 reveals that the unavailability of Dr Math® tutors is sometimes due high pupil-tutor ratio. As mentioned in Chapter 2, Dr Math® has been used by over 30,000 users since its inception. These pupils were assisted by approximately 100 tutors. In line with this point, the results confirm that some pupils do not get the required help or experience response delays because the online tutor(s) is helping many other pupils at the same time. In addition to this issue, Dr Math® has fixed, communicated operating times, which tutors admit that they do not really follow. This results in irregular operating times, which will be further discussed under the *resource availability* category. Table 5.8 depicts the results on the issues hindering effective communication between the tutors and the pupils.

Category 2.2: Effective communication

Sub-category	Code	Meaning	Extract
Official language of communication	Language restriction	Pupils can only use English or Afrikaans to communicate with Dr Math tutors.	**Pupil**: ohk, the two roots is mos the value of b and c ne **Tutor**: what do you mean "mos the value" **Pupil**: it is the value of b and c.
		Tutors who can speak Afrikaans are hard to get.	**Pupil**: hehe thats okay, do you speak afrikaans? **Tutor**: no but we do have a few dr wisk tutors. type in .o to get the contact details and check their hours **Pupil**: okay thank you. its not that i cant speak english, i just think the math terms might be somewhat different?
Mxit lingo	Varying knowledge of Mxit lingo among tutors	Pupil gets different tutors with different level of understanding of Mxit lingo on different logins.	**Pupil:** not today **Tutor**: ok chat l8r **Pupil**: k,i wsnt aware dat u knw da shrt cuts **Tutor**: i'm learning lol **Pupil**: k,dats vry nyc of u:)

Table 5.8: Category 2.2: Effective communication

With Dr Math® program, pupils can only communicate with tutors in English or Afrikaans, as is evident in the above results table. Furthermore, table 5.8 also reveals that although English and Afrikaans have both been selected as languages of

communication in the Dr Math® program, there are relatively few tutors who are able to provide help in Afrikaans. Besides the official language restriction issue, pupils use Mxit lingo (language that Mxit users, including pupils, use to communicate with one another) to communicate with tutors. This has been identified to be a barrier to effective communication. Table 5.9 presents the results on the identified significant resources of Dr Math®.

Category 2.3: Resource availability

Sub-category	Code	Meaning	Extract
Operating time	Time constraints	Pupils have limited time to access Dr Math®.	**Tutor**: i'm leaving now sorry **Pupil**: cn u hlp wt sumthn b4 u leav **Tutor**: i'm leaving now chat tomrrow **Pupil**: k,thnx **Tutor**: i'm leaving at 15:45 so we must be quick type in the two equations you have.
		Pupils are concerned with their irregular operating hours	**Pupil**: please list ur tutor timetable days one afta the other coz its confusing **Tutor**: sorry just started tutoring today, need any help? **Pupil**: wat time are u leaving 1st? **Tutor**: well? **Pupil**: its jst nt worth it!!!!!!!!!!!!!! *leave*
Skills of tutors	Limited conceptual knowledge among tutors	Tutor on duty is not conversant with the topic in question.	**Pupil**: cn u hlp me wt derevitives **Tutor**: no, sorry. i do not help with calculus. maybe you can find an instructor who will help you. good luck.

Table 5.9: Category 2.3: Resource availability

As is evident in the table above, pupils have limited time to access Dr Math®. In addition, as mentioned earlier, Dr Math® has a fixed time schedule that tutors hardly follow. The following extract supports this statement:

> "**pupil**: lol ok wil u b on l8r?
> **tutor**: dy really dnt follow tyms well the tutors are all volunteers. and they are usually students with homework also. the hours are just guidelines of when they are going to try to be online".

In addition to the limited time issue, the results table reveals that sometimes pupils are denied help because the online tutors are not conversant with the topic in question. The following is an extract from Dr Math® log files supporting this claim:

> "**tutor**: what are you trying to find out? is this a calculus question?
> **pupil**: yes am trying 2 solv it, but dont knw how itz done
> **tutor**: ok. i'm sorry but i do not help with calculus. maybe you can get some help from your instruction. good luck. ".

The next sub-section provide a brief summary of the findings on themes and categories.

5.3.4 Summary of findings on the themes and categories

The analysis of the log files revealed a number of factors that impact on the user interaction with Dr Math®. These factors were categorized into themes and categories. Essentially, they were found to have a negative impact on the overall UX of Dr Math®. The next section reviews these factors and looks at how they impact on UX.

5.4 Analysis and interpretation of the results

This section presents the findings as derived from the obtained results. In this study, I make a distinction between results and findings. Findings are the inferences obtained from the results, in this case, the factors identified in the results section to impact on the user experience. An

analysis and interpretation of the results yields to findings. The goal of this research study is to propose guidelines for a positive UX for pupils when using Dr Math®. To accomplish this goal, the factors that impact on satisfactory user interaction with Dr Math® have to be identified. The next sub-section presents a background to the findings.

5.4.1 Background to the findings

As mentioned in Chapter 3, the fulfilment of user expectations is a fundamental pre-requisite to the attainment of a positive UX. In accordance with this statement and the purpose of this study, it is, therefore, imperative to evaluate data from the user expectations' perspective.

Although both tutor and pupils are the users of Dr Math®, this study focuses on the factors that impact on the user experience of pupils. The rationale behind this was based on the fact that pupils are the consumers of Dr Math® services that are offered by its tutors. Additionally, as explained in Chapter 3, users always determine the market success of the system. Moreover, they are the ones who judge the quality of the system. Their judgment is normally based on their user experience regarding the system, which is largely determined by the fulfilment of their *expectations*. Hence, the data is analyzed mainly from the user expectations' point of view.

Particularly, user expectation is one phase, normally the first, of three UX phases. These phases, as discussed in Chapter 3, are: before, during and after the interaction with the product. Also, as stated in Chapter 3, UX entails the emotions, feelings and attitudes resulting from any one or all of these phases. For example, if the pupil does not have enough airtime to log onto Mxit, he or she definitely will not gain access to the system; or if the user runs out of airtime while consulting Dr Math®, the conversation would be interrupted and the pupil might still not get the help he/she wanted. Both these experiences lead to a collection of negative emotions, feelings and will definitely change the attitudes of the users. For example, before pupils interact with Dr Math®, they expect to finish the task with ease (perceived UX), during the interaction the pupil gets to test their perceived UX, the results of this contribute in the overall UX of the product. Figure 5.7 further illustrates

this point by demonstrating one example of how the overall UX of an interactive product is formed.

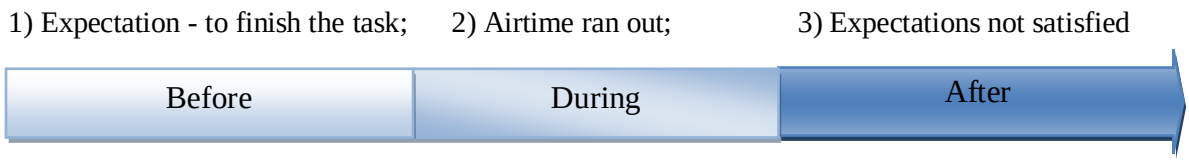


Figure 5.7: phases of UX in context of accessibility of Dr Math®

After interaction with the product, the resulting UX becomes a memory from which the new perspective of the product is based. Figure 5.8 depicts the users' major expectations of Dr Math®.

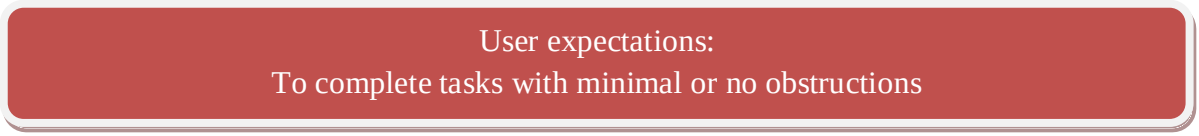


Figure 5.8: The users' major expectations of Dr Math®

It is logical that no one in his/her right mind would expect not to complete the tasks they have started or to complete them with difficulties. This explains the perceived user expectations, which entail completing tasks with little or no obstructions, as stated in Figure 5.8. Basically, user expectations represent the angle from which data was analyzed. The next section discusses the factors impacting on the user interaction with Dr Math® that emerged during the analysis of data.

5.4.2 Factors that impact on user interaction with Dr Math®

As depicted from the results, the factors shown in Figure 5.9, impact on the user interaction with Dr Math®. Identification of these factors has been substantiated from the themes and categories identified during data coding. Figure 5.9 depicts the identified factors impacting on the user interaction with Dr Math® and the overall UX.

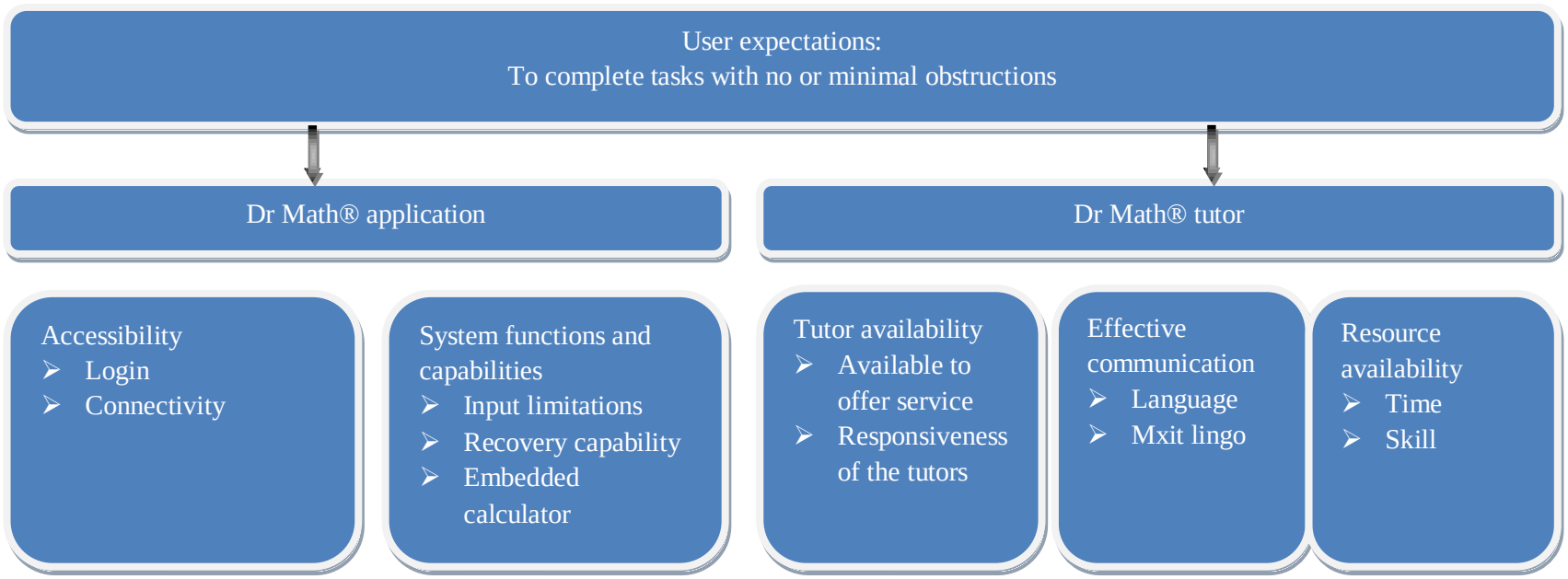


Figure 5.9: Factors impacting on user interaction with Dr Math® and the overall UX

As mentioned before, all the identified categories are major determinants of the quality of UX of Dr Math®. Furthermore, based on the impact they have on the task completion, it is justifiable to state that they are the Critical Success Factors (CSFs) for task completion. In the next section, the impact of these factors on the task completion, user expectations and the overall UX is discussed.

5.4.3 The impact of the identified factors on the overall UX of Dr Math®

These factors do not only impact on the task completion but also on the fulfilment of user expectations, as this is determined by the task completion status. For example, if the task completion status is "incomplete" or "problems but complete", one can say that user expectations have not been met. See other possible task completion statuses in Figure 5.10 below. Figure 5.10 shows a set of identified possible statuses for task completion.

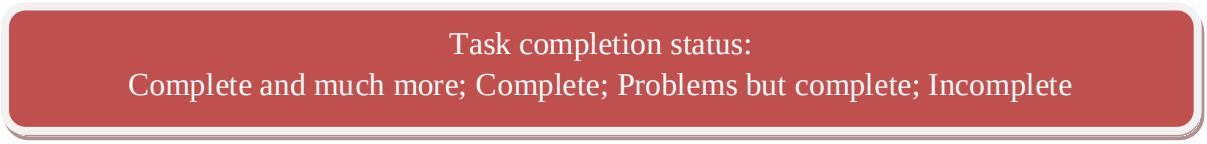


Figure 5.10: Possible task completion statuses

Task completion refers to the fulfilment of the ultimate goal of pupils, which is to get the required help. The degree to which this goal is fulfilled is measured and categorized into four major aspects, as depicted in the figure.

- Complete and much more: many pupils are happy with just an answer and so, when they are presented with more than just an answer, to them that is a bonus; also when pupils experienced pleasant feeling during and after the interaction, on top of getting the required assistance.
- Complete: the pupils' ultimate goal is fulfilled, or at least the tutor presented a set of instruction on how to solve the problem. The pupils, however, tend to want to be supplied with answers, which is against the principles of Dr Math®. It would be unfair to say the task is incomplete when the tutor did what is required of him/her, just because the pupil is not happy.
- Problems but complete – the ultimate goal was fulfilled; however, the interaction was not smooth, meaning that the pupils encountered difficulties while interacting with Dr Math®.
- Incomplete – when the pupil did not get the required help, which could be due to many reasons including provision of inadequate content and explanation that prevents pupils from solving the problem.

Figure 5.11 below displays the distribution of categories of task completion status that a task may have.

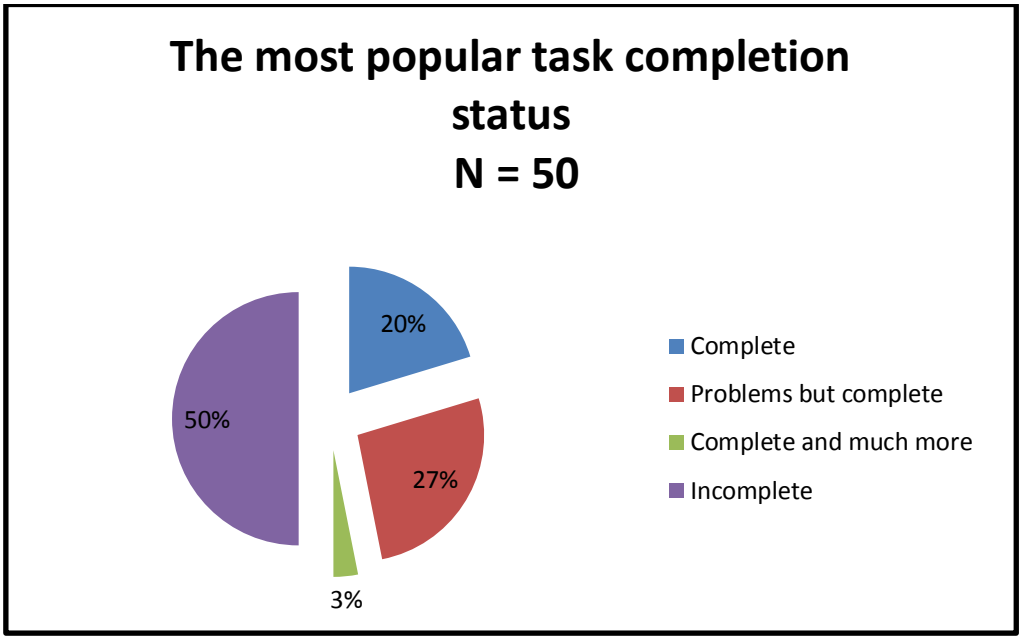


Figure 5.11: Distribution of the categories of task completion status

As displayed in the above pie chart, 50% of the tasks were incomplete. The other 50% of the tasks were complete; however, only 23% of the completed tasks were completed with no difficulties. Of that 23%, only 3% of the tasks were completed with much more, meaning that pupils' expectations were exceeded. The remaining 20% of the tasks were completed with nothing more and nothing less. Essentially, the high percentage of incomplete tasks is not a good sign for a positive UX. This is due to the factors that will be discussed shortly and the problems associated with these factors that pupils encounter while interacting with Dr Math®.

The impact of these factors on UX is broken down into three aspects: the impact on the pupil's emotional state; status of task completion; and subsequent pupil's perspective of Dr Math®. The next tables report on the identified factors and their impact on the user interaction with Dr Math®, and in turn, on the overall UX. Each table presents sub-factors; possible barriers; result for the product; result for the task; and the resulting UX.

Factor 1.1: Accessibility

The scope of accessibility, in this case, is limited to cost-related issues and network or other technical issues that determine access to Dr Math® program. As highlighted in Section 5.3.2, accessibility, like many other emerged categories, is a major determinant in the success of Dr Math®. For example, if pupils cannot access Dr Math® when they need to, whether it is due to connectivity issues such as network coverage or airtime-related issues, the perceived effectiveness and usefulness of Dr Math® will decline. Furthermore, as mentioned earlier in the Chapter, the fulfilment of user expectations impacts on the overall UX of the system. For example, if pupils are not entirely satisfied with the accessibility of Dr Math®, which is the case in this study, their expectations are not fulfilled. This, in turn, negatively impacts on the overall user experience of the system. Some of the possible barriers to effective accessibility, which have emerged from the data, are presented in the column labelled "barriers" in the table below. Table 5.10 summarizes the impact of accessibility issues on the pupils' emotions, task and Dr Math® as a product. Most of the words used to describe the results for product in all the following tables were selected from the set of 118 product reaction cards developed by the Microsoft Corporation (Benedek & Miner, 2002), presented in Appendix C.

Component 1: Dr Math® application				
Factor 1.1: Accessibility				
Sub-factor	Barriers	Result for product	Result for task	Resulting UX
Login	No of air time	Inaccessible Ineffective Frustrating Stressful	Incomplete	Frustrated Stressed
Connectivity	Battery running out of power	Unpredictable Frustrating	Incomplete	Frustrated Annoyed
	Running out of air time	Ineffective Frustrating Stressful Disruptive	Incomplete	Frustrated Stressed
	Technical failure	Ineffective Unpredictable Frustrating Stressful Disruptive Unreliable	Problems but complete Incomplete	Frustrated Stressed
	Technical delay	Annoying	Problems but complete Incomplete	Annoyed

Table 5.10: Factor 1.1: Accessibility

Having adequate airtime is one of the major requirements for obtaining access to Dr Math® system: no airtime means no access to the system. However, gaining access to the system does not guarantee access to the services that Dr Math® offers. In other words, pupils can have enough airtime to access the system and not get the required assistance. This is likely due to connectivity issues, which contribute in denial of access to Dr Math® services.

All the mentioned accessibility barriers, as seen in the table, can either deny pupils access to Dr Math® or interrupt the interaction between Dr Math® and the pupil. This depends in which of the three phases of UX the problem materialized. In other words, it could happen before the actual interaction (no airtime) or during interaction (running out of airtime). Nevertheless, pupils' UX will be affected as both situations lead to an unpleasant experience. This explains why the "results for task" column has only "problems but complete" and "incomplete" as task completion statuses. Based on the above discussion, it is logical to conclude that these accessibility issues deprive pupils the opportunity to get the help they need.

Note: Unfinished conversations were not included in the results since it is not known whether the termination was caused by the tutor or technical issues, which would affect the pupil's UX, or, perhaps, the pupil decided to log off.

Factor 1.2: System functions and capabilities

Dr Math® has some inherited limitations that contribute in depriving the pupils of an opportunity to receive maximum assistance. These inherent limitations include the following: input limitations and lack of recovery capability in Mxit platform. These limitations are some of the major causes of the difficulties that pupils encounter when interacting with Dr Math®. Specifically, since mathematics is a symbolic language in which mathematical problems are expressed, the lack of mathematics symbols and graphing support makes it difficult for pupils to express their problems.

Moreover, the results also indicate that when a disconnection occurs, the conversation between the tutor and the pupils is lost. Due to loss of the whole conversation, pupils have to restart the conversation and this results in time wastage and an array of negative feelings and emotions. Furthermore, Dr Math® has incorporated a calculator for pupils to use when interacting with Dr Math®. However, the results proved that the calculator is not easily accessible from the perspective of pupils. As shown in the results, several pupils were given instructions on how to access it and they did not succeed. Even though the calculator is an additional function, it should be accessible, functional and easy to use; otherwise it

can jeopardize the perceived usefulness and UX of the entire system. This discussion is supported by the obtained results regarding the functions and capabilities of Dr Math®. Table 5.11 summarizes the impact that this issue has on the pupils' UX regarding Dr Math®.

Component 1: Dr Math® application				
Factor 1.2: System functions and capabilities				
Sub-factor	Barriers	Result for product	Result for task	Resulting UX
Input limitations	Lack of math symbols	Ineffective Frustrating Stressful Difficult Time-consuming	Problems but complete Incomplete	Frustrated Stressed
	Lack of graphing capability	Unpredictable Frustrating	Incomplete	No assistance Frustrated
Recovery capability	Lack of recovery capability	Unpredictable Frustrating	Problems but complete. Incomplete	Frustrated Angry
Embedded calculator	Hidden functionality	Too technical Frustrating	Problems but complete Incomplete	Frustrated Intimidated Angry

Table 5.11: Factor 1.2: System functions and capabilities

The barriers to effective communication, as illustrated in the table, result in negative UX such as misunderstandings, misinterpretations and confusion between tutors and pupils. The sub-category, limited input entry, encourages improvising of symbols and shortcuts. It is highly possible that some pupils' needs will not be satisfied as some of mathematical symbols cannot be translated into words. Examples of such is the difficulty of expression of graphical and algebra questions. It has been noted in the results that pupils struggle to explain graphs in natural words. With algebra, help is not guaranteed due to the lack of symbols contributing in depriving pupils the necessary assistance relating to mathematics

problems. This limits the scope of help offered by Dr Math® to non-algebraic and non-graphical mathematical expressions. This is especially the case if neither of the languages of communication is the pupil's mother tongue. The following extract provides further explanation to this statement.

Tutor: oic, unless it is really easy, i can't do those in my head. i would use the quadratic formula or completing the square to find the roots then generate the factors from the roots.
Pupil: okay uhm can u repeat that please? sory im actualy afrikaans so i dont get all the english terms. what is the quadratic formula? and how do u use the roots then?

How is this pupil expected to describe difficult mathematics problems, which involve translating some mathematical symbols and graphs into words using English, if he or she cannot even understand English instructions from the tutor?

It is difficult to explain difficult problems, without mathematical symbols and graphs, let alone having to use a language in which you have a limited vocabulary. In other words, it would be much easier when using a language that you are comfortable with and fluent in. Additionally, as shown in the following extract, pupils tend to rather spare themselves the hardships of expressing their problems without the help of graphs and symbols and quit. The following example supports this statement.

Tutor: i think it will be hard because we hve no graphs
Tutor: do you want to draw the parabola?
Pupil: lets do completing the square instead

As revealed in the results, Dr Math® calculator is not easy to access as some of its users are not aware that it is available or the way in which the pupils can access it. Accessing the calculator is too technical for pupils. In support with this statement, the results show that, of all the pupils who were given instructions for obtaining access to the calculator, none of them seemed to have succeeded. Both the complexities associated with accessing the

embedded calculator, and having to restart the whole conversation after an interruption, result in user frustration, anger and intimidation, thus, creating a negative UX.

Factor 2.1: Tutor availability

Dr Math® system can be accessible and entirely functional; however, without tutors, the system is rather useless. In order for pupils to get assistance, they have to chat with online tutors. If there are no tutors online, pupils will be unable to get the assistance they need. Even when there are tutor(s) online, as illustrated in the results, that does not guarantee that pupils will get the help they need, when they need it. This is likely due to high pupil-tutor ratio, as supported by the results.

The reasons why tutors delay and not are always online, as identified from the results, are summarized in the table below. Table 5.12 illustrates the barriers to the availability of tutors, along with their impact on pupils, tasks and Dr Math® as a product.

Component 2: Dr Math® tutor				
Factor 2.1: Tutor availability				
Sub-factor	Barriers	Result for product	Result for task	Resulting UX
Available to offer service	Offline	Inaccessible Ineffective Frustrating Stressful Unreliable	Incomplete	Frustrated Stressed Angry Hopeless
Responsiveness online of tutors	High pupil-tutor ratio	Inconsistence Frustrating Annoying	Problems but complete Incomplete	Frustrated Annoyed

Table 5.12: Factor 2.1: Tutor availability

Although Dr Math® tutors justify their level of availability, it does not change the fact that some pupils' needs are hardly met, resulting in them losing hope and becoming frustrated and angry. As evident in the results, pupils show aversion when they do not find tutors online when they need them or have to wait while the tutor is helping many other pupils,

hence the emotional reactions in the column labelled "Result for pupil". Furthermore, some pupils quit without getting the help they wanted, which may lead to late submission of assignments or even no submission at all.

Factor 2.2: Effective communication

Effective communication between tutors and pupils is also one of the key factors that determine the success of Dr Math®. Table 5.13 outlines the barriers to effective communication between Dr Math® tutors and pupils and their impact on the overall UX of Dr Math®, which is broken down into emotional reactions of the pupil, task completion status and the reaction to Dr Math® as a product.

Component 2: Dr Math® tutor				
Factor 2.2: Effective communication				
Sub-factor	Barriers	Result for product	Result for task	Resulting UX
Language	Restrictions in language of communication	Ineffective Frustrating	Problems but complete Incomplete	Frustrated
Mxit lingo	Limited knowledge	Frustrating	Problems but complete Incomplete	Frustrated

Table 5.13: Factor 2.2: Effective communication

As shown in the results, pupils can only use English or Afrikaans to communicate with tutors. However, for pupils for whom neither English nor Afrikaans is their mother tongue, it can be hard to express a difficult subject like mathematics, which is more of a language itself, using a second language. Additionally, the results revealed that some pupils' expectations of finding tutors who can speak Afrikaans are hardly met. This language restriction issue can strongly deprive pupils the opportunity to obtain a deep understanding of the subject area, since they have to learn mathematics using a second language, particularly, pupils for whom neither of these languages is their mother tongue.

Another issue concerning communication between tutor and pupil, which is apparent from the obtained results, is the use of Mxit lingo by pupils. Since Dr Math® becomes one of the pupils' Mxit contacts, pupils tend to treat it as such and communicate with it using the language they use with their other contacts. Unfortunately, as seen in the results, not all Dr Math® tutors are familiar with Mixt lingo. The varying knowledge, as reported in the results, leads to inconsistency problems as pupils may be able to write shortcuts (Mxit lingo) now and later be required to write in full words because the tutor on duty is not conversant with this language. This inconsistency can result in frustrations and other undesired emotions, as seen in Table 5.13.

Factor 2.3: Resource availability

Time and skill are found to be the most important resources for the fulfilment of the user expectations and, in turn, determining the success of Dr Math®. When these resources are not managed well, they can strongly deprive pupils the opportunity to learn. The table below shows the impact of the limited consultation times and varying conceptual knowledge of different mathematical topics among tutors, for pupils, tasks and Dr Math®.

Component 2: Dr Math® tutor				
Factor 2.3: Resource availability				
Sub-factor	Barriers	Result for product	Result for task	Resulting UX
Access time	Time constraints	Ineffective Frustrating Stressful	Problems but complete Incomplete	Frustrated Stressed Angry
Conceptual knowledge	Limited conceptual knowledge among tutors	Frustrating Stressful	Problems but complete Incomplete	Frustrated Stressed Hopeless

Table 5.14: Factor 2.3: Resource availability

As highlighted in the results, Dr Math® has a list of operating times that tutors hardly follow. Pupils seem to show aversion to and concern with this problem. Consequently, some pupils tend to ask when the online tutor will be leaving before they can ask

mathematics-related questions. This concern may have been triggered by the pupils' previous experiences regarding this issue. Perhaps the pupil was once left hanging by the tutor because his/her time to go home had come. In essence, during these limited time periods Dr Math® is available, not all pupils in need of help will be assisted.

Tutors, on the other hand, can be there at all times; however, if the online tutors are not conversant with the topic in question, the pupils will still not get the required help. As shown in the results, pupils get different tutors with different levels of understanding of different topics. For example, a pupil might log in now and find a tutor who can help with calculus and log back in later and ask another question pertaining to the same topic and get a tutor who is not familiar with the topic. Furthermore, finding a tutor online can raise pupils' hopes of getting the required assistance. However, finding out that the online tutor is not familiar with the topic in question, after the pupil has stated his/her problem, could turn their high hopes into frustration and stress as this may lead to late submission of assignments.

5.5 Summary of the results

The perspective from which data was evaluated; the factors that determine the success of Dr Math®; and the impact of the identified factors on user expectations and UX of Dr Math® were discussed earlier in this chapter. Now this section ends the chapter with the pattern that these aspects together compose. Figure 5.12 below illustrates how these aspects fit together.

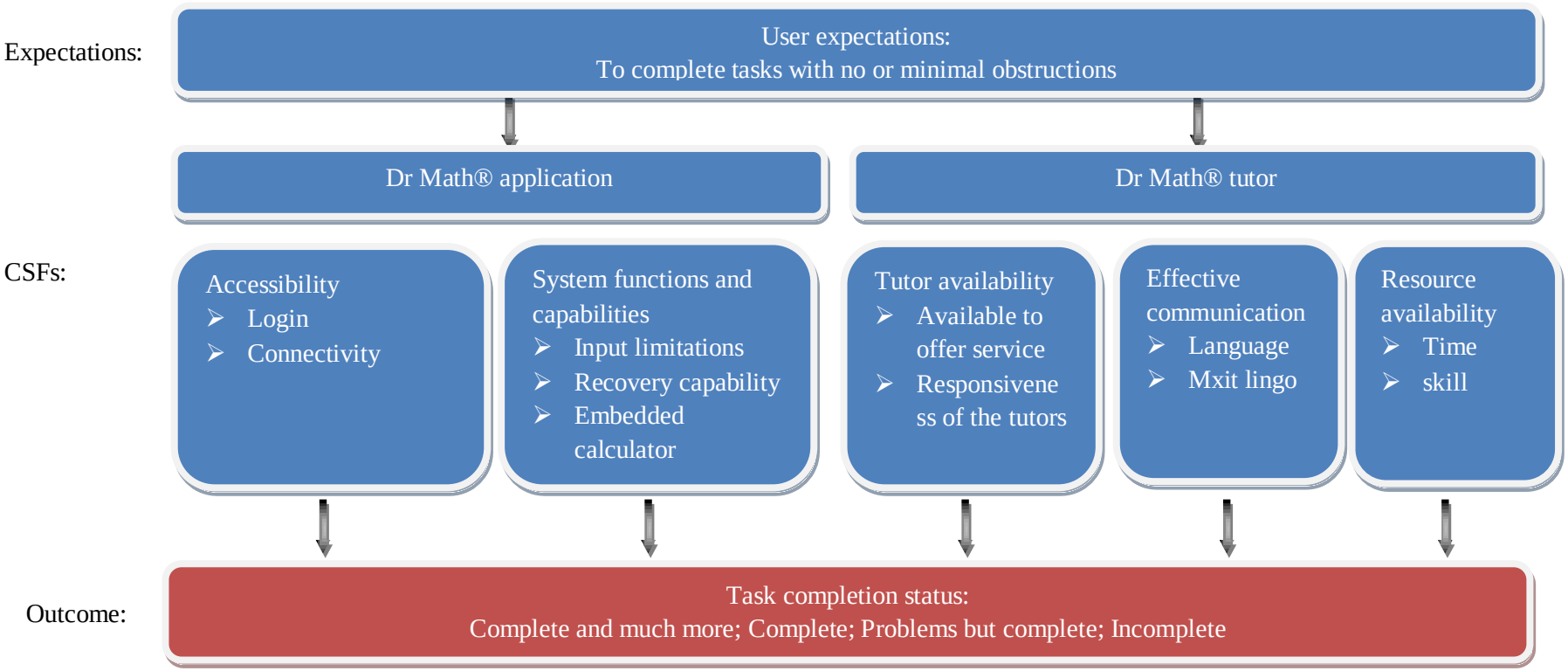


Figure 5.12: The overall pattern as emerged from data

The emerged pattern, as seen in Figure 5.12, consists of three major layers: *Expectations*, *CSF* and *Outcome*. Layer 1 (Expectations) illustrates the angle from which data was evaluated. Additionally, this layer refers to the expectations of the pupils from Dr Math®.

Dr Math® users (pupils) expect to get the assistance they need with ease, in other words, they expect to complete tasks with minimal or no obstructions.

Layer 2 (CSFs) illustrates the factors that need to be in place and well-managed for the user expectations to be fulfilled. These factors impact on task completion, fulfilment of user expectations and, in turn, the overall user experience of Dr Math®.

Layer 3 (Outcome) refers to the outcome of the consultation process, which is the task completion status. Based on the achieved status, one can conclude whether user expectations were fulfilled or not. As mentioned before, users do not normally wish to complete tasks with difficulties or do not complete them at all. In essence, the identified factors determine the outcome of the task which, in turn, determines the fulfilment of the user expectations.

5.6 Summary

In this chapter, data from a documentary source, Dr Math® log files were analyzed using a qualitative content analysis method. Findings that emerged from the analysis of Dr Math® log files were interpreted and presented. Data was analyzed from a user expectations' point of view. Also factors that impact on the user interaction with Dr Math® and their impact on the user expectations, task completion and the overall UX of the pupils were discussed. The identified factors are as follows:

- Accessibility
- Effective communication
- System capabilities
- Tutor availability and
- Resource availability.

All the above factors are found to have a major impact on pupils' interaction with Dr Math® and, in turn, the UX of Dr Math®. These factors can also impact on the use of Dr Math® as well as its market success through word-of-mouth. Specifically, as highlighted in Chapter 3, UX can lead to a positive or a negative word-of-mouth and influence potential users. For example, a positive UX encourages a positive word-of-mouth; negative UX, on the other hand, encourages a negative word-of-mouth. Based on both theoretical and empirical findings, the researcher concludes that it is essentially important that Dr Math® designers endeavour to design for a positive UX. In an effort to provide assistance in this, a number of guidelines for improving the UX of Dr Math® have been developed.

The next chapter proposes recommendations, based on the identified factors impacting on the UX of Dr Math® as an e-learning instant-messaging application. The recommendations serve as guidelines for providing a positive UX for pupils when using Dr Math®.

Chapter 6: Guidelines for Providing Positive UX for Pupils using Dr Math®

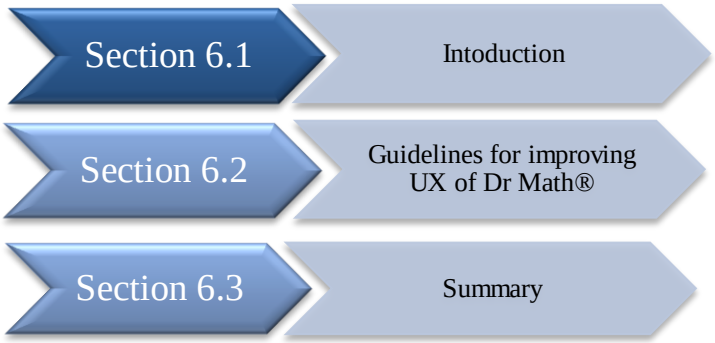


Figure 6.1: Chapter 6 layout

6.1 Introduction

The purpose of this chapter is to provide detailed guidelines to guide the Dr Math® development team towards a positive UX. These guidelines are derived from the findings obtained from the results of this study. This chapter also provides detailed suggestions on how these guidelines can be implemented.

6.2 Guidelines for improving UX of Dr Math®

The guidelines are categorized into five major categories: accessibility, system functions, system capabilities, tutor availability and resource availability. The way in which these guidelines are grouped is very similar to how the factors identified in Chapter 5 were categorized. However, during the analysis of the findings from which these guidelines are based, new relationships between the identified factors emerged. For this reason, the guidelines are presented under five major categories, which, however, are somewhat different from the five categories that were identified during the analysis of the log file. Essentially, a strong bond between the factors, *system functions* and *capabilities*, and *effective communication* emerged, thereby forming two new categories, namely, *system functions* and *system capabilities*. Additionally, the *system capabilities* category is further segmented into two sub-categories: *input limitations* and *recovery issues*.

6.2.1 Accessibility

Currently, it seems rather futile for Dr Math® to be exploiting Mxit, the most popular Instant Messaging (IM) system among South African pupils, while the availability of tutors to provide assistance is as low as shown in the results. This means that Mxit is not utilized to its full potential. Otherwise, Mxit could boost the accessibility of Dr Math® as a tutoring system. However, due to the low availability of tutors, exploiting Mxit is not as effective as it could be. Furthermore, Mxit is not only accessible anywhere and anytime, it is also cost effective. The cost-effectiveness of Mxit is another advantage that Dr Math® has exploited. This, therefore, means that Dr Math® is delivering the required assistance with minimal costs using a ubiquitous IM system.

Moreover, because Mxit is available anywhere, anytime, pupils may expect to find Dr Math® anywhere, anytime too. They may expect to find tutors online whenever they need them. In line with this, the following guidelines were developed to contribute in resolving Dr Math® accessibility issues.

- **Enhance Dr Math® to enable remote access to the Dr Math® server**. Given the fact that many tutors are also students, as highlighted in the results, it is understandable that they cannot always be online, especially now that they are restricted to using a desktop PC at the office. Enabling remote access may not only enhance the accessibility of Dr Math®, but also the consultation time and the level of tutor availability, as tutors would be able to provide assistance in transit and at home.
- **Minimize costs associated with accessing Dr Math®**. Although Dr Math® has utilized a cost-effective means of delivering assistance to the pupils, in order for pupils to gain access to Dr Math®, they need to have a certain amount of airtime. However, it must be noted that not all pupils will have airtime every time they have a mathematics homework that they need help on. This means that Dr Math® may still not be accessible to all, although the required amount of airtime is

relatively low. Dr Math® designers should strive to keep the costs of accessing Dr Math® to a minimum.

- **Warn pupils and tutors when airtime is about to run out**. This would help tutors to speed up the process of providing assistance to the pupil. Besides, given the level of availability of Dr Math® tutors, it is not guaranteed that by the time the pupil gets airtime, tutors will still be there. Therefore, it seems critically important that both tutor and pupil are pre-warned of such an event as it could negatively impact task completion.
- **Warn pupils about any other foreseen interruptions where possible.** Pupils and tutors should be notified of any other issues such as technical problems that may lead to interruptions and the time that the system would be stable again. This would contribute in making users feel valued.

6.2.2 System functions and capabilities

6.2.2.1 Capabilities

Input limitations

Dr Math® inherently provides a real-time, two-way communication between tutors and pupils. Additionally, it is by this type of communication that pupils get the required assistance. Pupils are normally the ones who initiate the communication by asking a question. Then the available tutor can help the pupil to solve the problem or inform the pupil that he or she cannot help. This process requires an effective communication between tutors and pupils. However, it must be noted that the language of communication is not the only hindrance to an effective communication between Dr Math® and the pupil. The inherent input limitations of Dr Math® also affect the communication between the tutors and pupils. For instance, due to the lack of mathematical symbols and graphs that are used to express mathematical statements, it becomes difficult for pupils to express their mathematics problems. The following is an explanation of a communication process that commonly occurs between the pupil and the tutor during consultation period.

- Pupil: asks for help (communication using language).

- Tutor: reads and interprets the pupil's request (communication using language).
- Tutor: tells the pupil to state the problem (communication using language).
- Pupil: reads and interprets tutor's response (communication using language).
- Pupil: states the problem (communication using mainly mathematical symbols and graphs).
- Tutor: reads and interprets the problem (communication using mainly mathematical symbols and graphs).
- Tutor: communicates the solution with the pupil (communication using both language and mathematical symbols and graphs).

Based on the above communication process example, it is logical to say effective communication between tutors and pupils is critically important. Therefore, a need for improving communication issues associated with Dr Math® becomes a necessity. The following guidelines provide specific recommendations for facilitating communication between the tutors and pupils.

- **Provide pupils with a wide variety of languages to choose from**. Currently, pupils are forced to communicate with tutors using only English and Afrikaans. In addition, pupils do not need to merely understand the languages but to be fluent enough to be able to describe their mathematical problems using one of the two languages. This problem is made even worse by the absence of mathematical symbols and graphing support as it adds the burden of having to translate mathematics symbols and graphs into words. Having a wide choice of languages of communication would definitely contribute in reducing communication issues and invite more users. For example, pupils who are not fluent in either of the two languages are likely to be reluctant to engage in programs that force them into communicating using languages that they are not conversant with.
- **Provide pupils with the list of languages that the online tutors are familiar with**. In line with the previous guideline, pupils need to be kept constantly informed of the languages that the available tutors are conversant with. This is to avoid the time-consuming process of probing for such information, while it

can be made available through a status message for all pupils to see when they log in.

- **Encourage tutors to familiarize themselves with Mxit lingo.** Tutors can see Mxit lingo as an improper language; however, in order for them to be able to provide maximum assistance to the pupils, they need to learn it. Mxit lingo is a language that is used in the Mxit platform, which Dr Math® exploits. Given that Dr Math® has exploited this platform, it seems only appropriate that they are prepared to comply with what the Mxit users, pupils in particular, are already familiar with. Furthermore, considering the way users are so conservative about what they are already familiar with, especially with user interface, as confirmed by Constantine (2004), pupils would be reluctant to the idea of shifting from Mxit lingo to proper language when interacting with Dr Math® tutors. Dr Math® is a Mxit contact and pupils tend to treat it as such.
- **Enhance Dr Math® to include mathematical symbols and graphing support**. As highlighted earlier, this would make the process of expressing and interpreting mathematical problems much easier. Moreover, regardless of the pupils' background and home language, this would improve their communication with the tutors as they would all be using mainly one language, which is mathematics. This can be done by introducing new special symbols like the existing Mxit emoticons. In contrast to the existing emoticons (emotional icons), these symbols should represent mathematical symbols and can be termed "mathicons", meaning mathematical icons.

Recovery issues

- **Enhance Dr Math® to have recovery capabilities.** This way the users will not have to restart the conversations they had before an interruption, instead they can simply resume from where they were before they were interrupted. This will not only save them time, but also effort, frustration and other unpleasant feelings.

6.2.2.2 Functionalities

Dr Math® provides a calculator as an additional function, which, evidently, is very hard to access. This contributes in the overall declining perceived usefulness of Dr Math® as the perceived usefulness of the calculator, which is part of the Dr Math, will decline. In addition to this, knowing that Dr Math® offers a calculator, pupils will consult Dr Math® without their calculators in the expectation that they will successfully be able to use Dr Math®'s calculator. When this expectation is not met, which, according to the results, is hardly ever, pupils' perceived usefulness of the entire system will decrease. Moreover, every additional function should contribute in augmenting the usefulness of the system rather than decreasing it. In addition to this, Dr Math® lacks a recovery support, which is a very crucial capability that any system should have. Here are a few guidelines that can be of great help regarding Dr Math® capability issues.

- **Know your users**. Knowing your users as a developer or designer means that you know what your users are already familiar with. And knowing this information makes it easy for the developers or designers to keep their users happy. This is supported by Constantine (2004), who affirms that it is rather impossible for the designers to produce a good design without knowing anything about their users. For instance, Mxit users, including Dr Math® users (pupils), are used to accessing additional functions or services through links instead of commands. However, with Dr Math®, pupils are forced to use a command in order to access the Dr Math® calculator. This is completely different to what the pupils as Mxit users are familiar with. With Mxit, users just need to click on links to access an additional function or service.
- **Avoid unnecessary complexities**. In line with the previous guideline, if the designers know their users well, they would know the level of complexity their users can comprehend. In support with this statement, users are generally reluctant to learn new things (Brenningmeyer & Franck, 2009; Constantine, 2004).

6.2.3 Tutor availability

It has been highlighted before that allowing tutors to remotely access the Dr Math® server and be able to help pupils while in transit or sitting at home would improve the level of their availability to provide assistance to the pupils. In addition, although they are not expected to always be online, something needs to be done to enhance their availability. Here are some of the proposed guidelines to help mitigate this problem.

- **Notify the pupils when there are no tutors online.** This would save pupils time and effort of having to ask if there is any tutor available to help. This could be stated in a status message for all pupils to see as they log in.
- **Specify the approximate amount of time that the tutors will try to stay online.** Pupils do not only need to know that there are some tutors available but also how long they are planning to stay online. Knowing this information would help pupils choose the time that is best suitable for them to interact with Dr Math®. For example, some pupils have chores to do after school; some might want to take a break from school work for a while and decide to interact with Dr Math® later. For pupils to decide on when to start their mathematics homework, which they might need Dr Math®'s help on, they need to know the time the online tutors will be leaving.
- **Add a feature that would allow pupils to leave questions when there are no tutors online.** Tutors would be required to answer those questions so that when the pupil logs back in later, he or she can finds step-by-step instructions on how to go about solving the problem. If the pupil is still not happy with the provided information, they must be able to probe for clarity, either by leaving a probing question or asking a currently available tutor. This would not only benefit the pupil who asked the question but other pupils who have similar problems as they should be able to view the questions and answers in the "box". By doing this, the unavailability of tutors may have a less adverse impact on the fulfilment of pupils' needs.

6.2.4 Resource availability

As mentioned earlier, consultation time would be extended if tutors are granted remote access to the Dr Math® server. However, time is not the only important resource required in order for

the pupils to get the assistance they need. Skill is another resource that without, pupils' needs would be unmet. As shown in the results, pupils show aversion to the experience of being left hanging because the tutor has to go. It is also an adverse experience to have to find a tutor online and then, only when you have asked a question, that tutor tells you that he or she is not conversant with the topic in question. To avoid this, specific guidelines were developed as depicted below.

- **Specify the times the tutor will try to be online.** This information needs to be provided so that the pupils can draw up timetables and decide whether to start with mathematics homework or other subjects. Dr Math® should provide this information through a status message and in a farewell message of the last tutor to log out.
- **Specify the topics that the online tutors are conversant with.** It would be good for pupils to know from the onset that they may or may not get help on a specific topic. This information can be provided in a status message.

6.3 Summary

As mentioned in Chapter 3, UX does not start during the user interaction with the product. It, however, starts as user expectations, which are normally based on what the user has heard about the product; his or her previous experiences with the previous versions of the product or similar products; and the needs, goals and values of the user.

As highlighted in Chapter 5, pupils have a number of expectations which are summarized to form one major expectation: that is to get the required assistance with no or minimal obstructions. This expectation depends on many factors, which were also discussed in Chapter 5, including Accessibility; System functions and capabilities; Tutor availability; Effective communication; and Resource availability. If anything goes wrong with these factors, then the pupil's expectations would be unmet, resulting in negative UX. All these factors impact on the UX of Dr Math® and in order to for Dr Math® to produce an improved UX, these factors need to be well managed. The proposed guidelines serve as a starting point for Dr Math® development to provide Dr Math® users with a more pleasant UX when interacting with Dr Math®.

With the use of the above guidelines, Dr Math® can even turn situations that pupils would interpret as negative experience into a positive thing. For example, if Dr Math® applies the following guideline: *Notify the pupils when there are no tutors online* and remind them about the available games and competitions, pupils would feel valued and perhaps, keep themselves busy playing games while waiting for the tutors to be available. However, this can still result in a bad UX, as the pupils are not informed of the time in which the tutors will be online. Knowing this information gives the pupils a chance to decide whether log out and do something else in the meantime, or to participate in games and competitions to pass time. To address this issue, the following guideline should be applied hand-in-hand with the previous one. *Specify the times the tutor will try to be online*.

Chapter 7: Conclusions and Recommendations

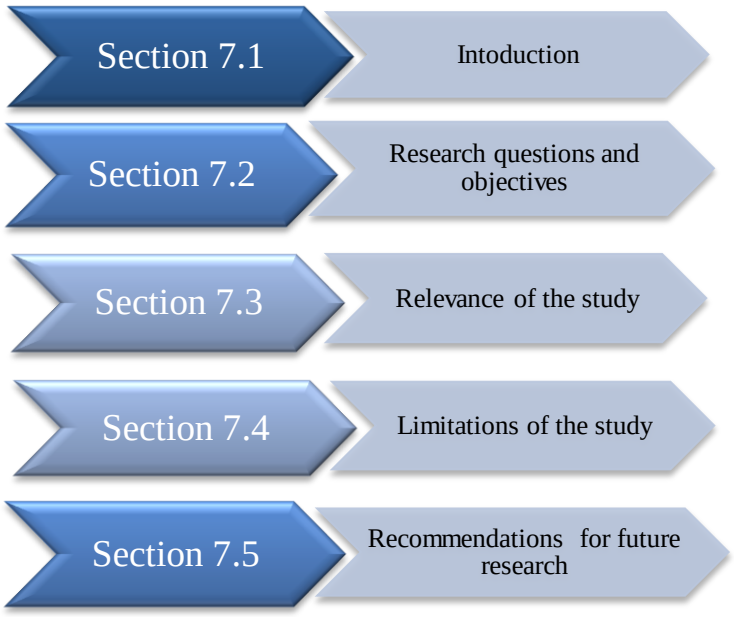


Figure 7.1: Chapter 7 layout

7.1 Introduction

There are several m-learning applications specializing in mathematics in the South African market. At first, there were uncertainties on which m-learning application to investigate as it was impossible to investigate all of them in this study. The aim was to select the most accessible, affordable and popular application among the target population. In the results of the preliminary survey, Dr Math® came out to be the only one meeting these requirements. It is available through Mxit platform, technology that is already at hand. Thus, it was selected as a case for this study.

Dr Math® has been reported to improve mathematics performance and enhance levels of mathematics understanding among pupils. However, the results of a preliminary survey, as discussed in Chapter 1, indicated that Dr Math® is not as widespread as it could be. This motivated the researcher to investigate the reasons why this is the case. Consequently, the goal of this research study was to assist Dr Math® designers in designing for a positive UX so that they can keep and attract new users. Subsequently, this goal resulted in the research questions and objectives outlined in Section 7.2.

This chapter begins by re-stating the research questions and objectives. Thereafter, it summarizes the findings based on the research questions and objectives. Based on the findings, a few recommendations are made. The limitations of the study as well as the relevance of the study are discussed. The chapter culminates the research by suggesting recommendations for future research.

7.2 Research questions and objectives

The primary research question for this study is:

What are the user experience metrics that impact on a positive user experience for pupils when using Dr Math®?

To answer this research question the following secondary research questions were explored:

- What is the Dr Math® program?
- What are the characteristics of a positive user experience?
- Which factors impact on user interaction with Dr Math®?

These research questions were answered through the fulfilment of the following objectives.

The main objective of this study is:

To define the user experience metrics that impact on a positive user experience for pupils when using Dr Math®.

The sub-objectives of this study are as follows:

1) To describe Dr Math® as an m-learning tool specializing in mathematics education in the context of South Africa.
2) To describe the characteristics of a positive user experience.
3) To determine the factors that impact on user interaction with Dr Math®.

7.2.1 Research question 1

What is the Dr Math® program?

Dr Math® is a mobile-based mathematics tutoring system available through Mxit platform, the most ubiquitous MIM among South African teenagers. Dr Math® affords pupils from different backgrounds an opportunity to interact with mathematically skilled tutors. Pupils normally use their GPRS-enabled cell phones and their own airtime to consult Dr Math®, making mathematics learning time and location independent. In other words, Dr Math® promotes a conducive, personalized learning environment. Additionally, it promotes on-demand learning, enabling pupils to be in control of their learning.

Dr Math® is rapidly gaining ground among South African pupils. It has gathered over 30,000 users since its inception. These numbers have been confirmed with the Meraka Institute. Dr Math®'s growing popularity means that there is indeed a gap in mathematics education in South Africa and that pupils really need assistance in the subject. Due to the benefits that Dr Math® offers, as highlighted in Chapter 2, including affordability, it can be the best mathematics learning tool in South Africa. It can effectively counteract the challenges facing South African mathematics education such as shortage of mathematically qualified teachers; lack of basic equipment and infrastructure; and the lack of access to traditional ICT, as reported in Chapter 2. However, one of the observed problems with Dr Math® is that the users do not seem to know exactly what the purpose of Dr Math® really is. The following extracts further illustrate this point.

Tutor: well you just said (2c-3y)(2c+2y) that's all you can do with it

Pupil: *i want the answer*

Tutor: *i am not going to just give you the answer. sorry. you have to do the dirty work yourself.*

Tutor: so combine like terms

Pupil: *no terms i need answers*

Tutor: *no i am not going to just give you answers. that would be useless*

Pupil: so what? **Tutor:** i can help you solve this problem but i'm not going to just give you the answer

Finding: Based on the empirical results, Dr Math® tutors and pupils have different perspectives on the purpose of Dr Math®. The results revealed that pupils expect to be supplied with answers. However, this is in contrast with the purpose of Dr Math®, which is to acquaint pupils with in-depth understanding of the subject, thus developing their problem-solving skills. As the tutors are supposed to stick to Dr Math®'s principles, this means that the pupils are not getting what they expect from Dr Math®. In other words, their expectations are not fulfilled.

Recommendation: Dr Math® must clearly communicate its purpose to the users (pupils). When they know the purpose of Dr Math®, they can set their expectations with regard to the communicated purpose of Dr Math®.

Through answering research question 1, the following objective was met.
To describe Dr Math® as an m-learning tool specializing in mathematics education in the context of South Africa.

7.2.2 Research question 2

What are the characteristics of a positive user experience?

As mentioned in Chapter 3, a product that satisfies both instrumental and non-instrumental needs and requirements of the user promotes a positive UX. Morville (2004) summarizes typical characteristics of a positive UX diagrammatically. Figure 7.2 illustrates these characteristics.

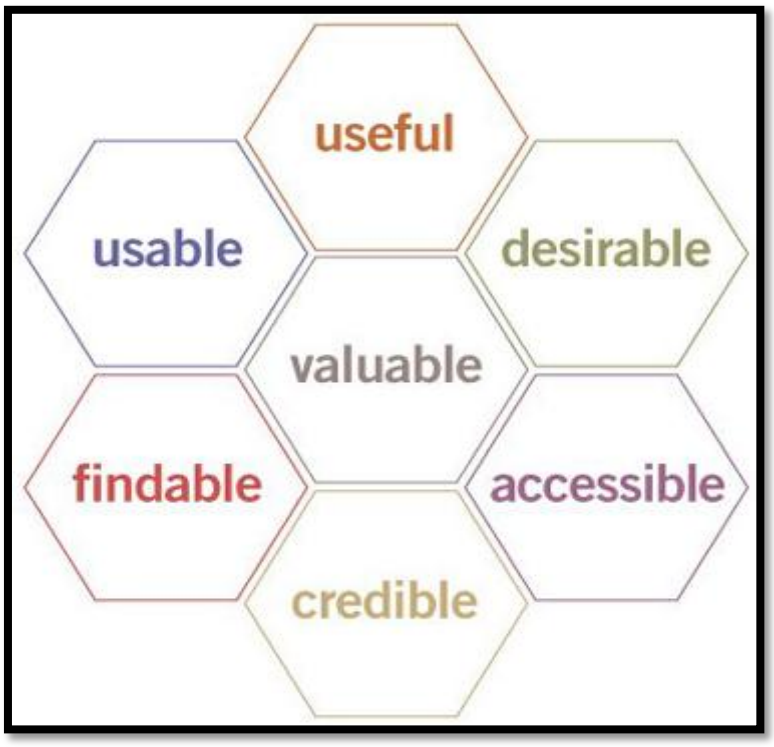


Figure 7.2: The user experience honeycomb (Morville, 2004)

Any product that satisfies all the cells of this UX honeycomb, coupled with a pleasurable experience, promotes a positive UX. A pleasurable experience is mainly achieved through satisfying the hedonic-related attributes such as joy, pride, status, trust, stimulation and more. In Chapter 3, this figure is used to put emphasis on the significance of UX and how it can be used as audit criteria to evaluate whether the product promotes a positive or a negative UX. In this context, however, it is used to illustrate some of the typical characteristics of a positive UX.

Finding: Looking at the theoretical findings on the characteristics of a positive UX and the results obtained in this study, it is clear that Dr Math® is not providing a positive UX for many users. Additionally, as highlighted in literature, a negative UX can become a barrier to the adoption and use of Dr Math®. This could be an explanation of the fact that Dr Math® is not as widespread as it could be. The preliminary survey showed that only five out of 33 pupils from different backgrounds have used Dr Math®.

Recommendation: Designing for a positive UX entails understanding the users' needs and integrating them in the design process. According to Jordan (2000), there are three basic user needs: *functionality*, *usability* and *pleasure*. Additionally, according to Hassenzahl (2003, 2004); Hassenzahl, Schobel and Trautmann (2008) and Karapanos, Hassenzahl, and Martens (2008), in order to produce a product with a positive UX, designers should strive to maintain a balance between pragmatic and hedonic qualities of the product.

By answering research question 2, the following research objective was fulfilled.
To describe the characteristics of a positive user experience.

7.2.3 Research question 3

Which factors impact on user interaction with Dr Math®?

The identified factors were grouped into themes and categories. These themes and categories were discussed and finalized through a focus group of eight experts. The identified factors are presented under the two major categories as follows.

System related

- Accessibility
- System functions and capabilities.

Tutor related

- Tutor availability
- Effective communication
- Resource availability.

Finding: The impact of the identified factors on UX were evaluated from three different perspectives: the impact on the pupil's new perspective of Dr Math® as a product (result for product); status of task completion (result for task); and the subsequent pupil's emotional state and the overall UX (resulting UX), as outlined in Chapter 5. In essence, the empirical findings indicate that the above factors impact on the overall UX of Dr Math® and, therefore, need constant attention.

Recommendation: The Dr Math® team should manage these factors and keep looking out for more factors that impact on the user interaction with Dr Math®, thereby inducing a positive UX. As highlighted in Chapter 3, a positive UX results in happy and loyal users. This would generate a positive word-of-mouth which, in turn, would help them attract potential users.

Through answering research question 3, the following research objective was met.
To determine the factors that impact on user interaction with Dr Math®.

7.3 Limitations of the study

There are several m-learning applications specializing in mathematics in the South African market. However, the focus of this study is limited to Dr Math®, which according to the results of the preliminary survey was the most popular application.

At first, the plan was to analyse the log files and then conduct follow-up interviews. However, since Dr Math® preserves user anonymity and the fact that its users are scattered all over the country, such interviews could not be conducted. This necessitated the use of documentation as the principal method for collecting data.

Due to the size and common problems that were found in various conversations, the findings of this study are based on 50 out of 2904 conversations. The log files that the researcher had access to, were logged within the period of five months: from January 2011 to the end of May 2011.

Due to the time constraints involved in conducting a research, this study investigated the user experience of pupils using Dr Math®. However, it was noted that Dr Math® users are not merely the pupils who utilise Dr Math® services but also the tutors who provide the services to the pupils. However, it would be irrational to expect unhappy employees or service providers to provide good services that promote a positive UX. Nevertheless, limiting the study to focus only on the UX of pupils promoted an in-depth, comprehensive investigation that the users deserve, which would otherwise not have been achieved. This choice was based on the significant role that users have on the success of the product.

7.4 Relevance of the study

Apart from the limitations discussed in Section 7.3, this study is significant for several reasons.

Firstly, previous work in this area focused on promoting the idea of learning mathematics through Mxit, making this study the first of its kind. This study examined UX of pupils when using Dr Math®, as it impacts on the overall adoption and usage of Dr Math®. This was done by identifying the factors impacting on the user interaction with Dr Math®, from which guidelines were suggested.

Secondly, the identified factors serve as the Critical Success Factors for Dr Math® team to produce a desired user experience. This will help Dr Math® keep current users happy and loyal and possibly attract new ones. The guidelines, on the other hand, were developed to guide the designers towards producing a positive UX for Dr Math® users (pupils).

Thirdly, this study contributes to answering the big question that many designers may have: why user experience?, by emphasizing its significance in the market success and acceptance of a product or service.

Fourthly, this study contributes to the limited amount of literature regarding user experience in mobile educational applications. Specifically, this study shows that user experience of educational applications and services is as crucial as it is in their industrial counterparts.

7.5 Recommendations for future research

To date, not much research has been done in this area, leaving a lot of room for future research.

Firstly, the present study focussed on the user experience of the pupils when using Dr Math®. Future research focusing on the user experience of the tutors is needed.

Secondly, although this research found the factors impacting on UX and suggested guidelines for improving pupil's UX when using Dr Math®, a deeper dive into this aspect would add more value and credibility. For instance, this could be done through follow-up interviews and empirical evaluation of the proposed guidelines.

Thirdly, future work could conduct similar research using multiple cases. Specifically, in contrast with the current study, future research exploring m-learning mathematics applications should focus on multiple applications to improve generalizability.

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APPENDIX A: PRELIMINARY SURVEY RESULTS

1. Personal information

Q1-1 Age	Q1-2 Gender	Q1-4 Where did you matriculate (town)?	Q1-5 Did you have electricity at school?	Q1-6 Did your school have computers?
18	1	port elizabeth	Y	Y
21	2	Uitenhage	N	N
23	2	lady frere	Y	N
21	2	Dubai	Y	Y
18	2	Durban	Y	Y
19	1	Port Elizabeth	Y	Y
20	2	2010	Y	Y
21	2	Port Elizabeth	Y	Y
20	2	uitenhage	Y	Y
17	2	idutywa	Y	Y
19	2	Queenstown	Y	Y
19	2	Uitenhage	Y	Y
17	1	Cofimvaba	Y	Y
20	2	Stutterheim	Y	Y
18	1	Klerksdorp	Y	Y
21	1	pe	Y	Y
19	2	DUTYWA	Y	Y
20	2	tabankulu	Y	Y
21	2	Pretoria	Y	N

20	1	Umthatha	Y	N
19	2	Port Elizabeth	Y	Y
18	2	George	Y	Y
19	2	cradock	Y	Y
19	1	Somerset East	Y	Y
20	2	P.E	Y	Y
21	2	NEW BRIGHTON	Y	Y
19	2	Uitenhage;Kwa-Nobuhle	Y	N
18	2	Port Elizabeth	Y	Y
18	2	ngcobo	Y	Y
19	2	Cradock	Y	Y
19	2	Port Elizabeth	Y	Y
19	2	Graaff Reinet	Y	Y
19	2	port elizabeth	Y	Y

2. Cell phone usage

Q2-2 What was the model of the phone you had access to? e.g. Sumsang E 250	**Q2-3 Could you access internet from that phone?**	**Q2-4 Which chat networks did you have on your phone?**	**Q2-5 If you have selected 'other' in the previous question, please specify**	**Q2-6 I used to chat**	**Q2-7 I used chat networks for**	**Q2-8 If you have selected 'other' in the previous question, please specify**
samsung m620	Y	6,4,3	-	5	1	-
Sumsung	N	6	-	3	1	-

SGH B100M						
sumsang j 750	Y	6	google.com	2	3	-
Samsung D600	N	1	-	5	1	-
nokia 5130	Y	6,4,3	-	5	1	-
i-mate JAM	Y	6,3	-	5	1	-
sumsang GT-C3303	Y	6	-	1	1	-
Nokia N73	Y	6,3	-	5	1,2,3,4	Getting girls
samsung b100	Y	6,3	-	4	1,2,3	-
samsung J750	Y	6,3	-	1	1	-
Nokia	Y	6,4,3,2	badoo,operamini	5	1,2	-
Nokia N70	Y	6,4,3	-	2	1	-
Sumsung M 620	Y	6,3,2	tweeter and My space	5	1,3	-
Motorolor v360	Y	6,3	-	5	1,3	-
Nokia C5	Y	6,3	-	1	1,3	-
nokia	N	6	-	4	1	-
N/A	N	6	-	3	1	-
sumsang d900	N	6	-	5	1,3	-
Motorrola V3	Y	1	.	1	4	.
sumsung D900i	Y	6,4,3	-	4	1,3	-

E250, M3200 beatbox	Y	6,3	-	2	1	-
Nokia Classic 6303	Y	6,3	-	3	1	-
samsung e250	Y	6,4,3	-	5	1,2	-
Nokia N95	Y	6,3	-	4	1,2	-
Sony Ericsson W810i	Y	6	-	4	1,2,3	-
N/A	N	1	N/A	2	1,2,3	-
Samsung E250	Y	6	-	2	1,2,3	-
Sony erricson w810i	Y	6,5,4,3	-	5	1,2	-
sumsang E 250	Y	6,4,3	-	5	1,2,3	-
Nokia 5320	Y	6,4,3	-	4	1	-
Samsung M620	Y	6	-	3	1	-
Nokia 6730	Y	6,4,3	-	5	1,2	-
nokia n70	Y	6,3	-	3	1,3	-

Cell phone usage continues

Q2-9 I used my phone mainly for:	**Q2-10 I used to charge my phone:**	**Q2-11 If you have selected 'other' in the previous question, please specify**	**Q2-12 Were mobile phones allowed in your school premises**	**Q2-13 I used my phone**	**Q2-14 Please rate the importance a cell phone**

3,2,1	6,5	-	Y	5,4,3,2,1	5
3	6	-	Y	4	5
1	5	-	Y	4	5
3	6	-	Y	3	4
3,2,1	6	-	N	5,4,3,2,1	4
3,2	6	-	N	2,1	4
3	4	-	Y	1	4
3,2,1	6	-	N	2,1	5
3,2	6,5,3	-	N	4,2	5
3,1	6	-	N	4,3,2	3
3,2,1	6	-	N	5,4,3,2,1	5
1	6	-	N	2,1	3
3,2,1	6	-	N	3,2,1	5
3,2	6	-	N	3	4
1	6	-	N	5,4,3,2,1	5
3,2	6	-	Y	4,3,2,1	4
1	6	-	DK	1	5
2,1	6,5,2	-	N	4,3,2,1	4
3	6	-	N	2	4
3	6	-	N	4,3	5
3	6	-	Y	2,1	4
3	6	-	N	2	4
3,2,1	6,1	in the hostel	Y	5,4,3,2,1	5
3,2,1	6	-	N	5,4,3,2,1	5
3,2	6	-	N	4,2	5
3	6	-	Y	2,1	5

3,2	6	-	N	2,1	5
3,1	6,5	-	Y	5,4,3,2,1	5
3,2,1	6	-	DK	3,2	5
3,2,1	6	-	DK	4,2,1	4
3,2	6	-	Y	4,2,1	2
2,1	6	-	Y	5,4,3,2,1	5
3,2,1	6	-	N	4	4

3. Mobile Mathematics Applications awareness

Q3-1 I have:	**Q3-2 I have used:**	**Q3-3 if you have selected 'other' in the previous question, please specify**	**Q3-4 How did you hear about mobile mathematics applications?**
5	1	-	2
5	1	-	3
3	1	-	3
5	1	-	5
5	1	-	2
5	1	-	5
5	1	-	5
5	1	-	5
5	1	-	4
5	1	-	2
5	1	-	5
5	1	-	5
2	1	-	1
5	1	-	5

5	5	-	3
5	1	-	5
5	1	-	5
5	1	-	3
5	1	-	5
2	4	-	5
5	1	-	2
5	1	-	5
5	1	-	5
4	1	-	3,4
5	1	-	5
5	1	-	5
5	1	DVDs from school incubator project sponsered by Sasol at Misson Vale Campus.	5
5	1	-	5
1	1	-	3
3	1	-	1,3
5	1	-	5
4	5	-	3
3	1	-	2,3

Question types and description

Key to Questions	Description	Question Type	Choice List Description (value)
Q1-1	Age	Open Question (short	

		answer)	
Q1-2	Gender	Radio buttons: (one choice from a list of radio buttons)	Female (1), Male (2)
Q1-4	Where did you matriculate (town)?	Open Question (short answer)	
Q1-5	Did you have electricity at school?	Radio buttons (yes/no)	
Q1-6	Did your school have computers?	Radio buttons (yes/no)	
Q1-7	Did your teachers use computers in the classroom?	Radio buttons (yes/no)	
Q2-1	Did you have access to a cell phone in high school?	Radio buttons: (one choice from a list of radio buttons)	Yes. My own (1), Yes. Someone else's (2), No access at all (3)
Q2-2	What was the model of the phone you had access to? e.g. Sumsang E 250	Open Question (short answer)	
Q2-3	Could you access internet from that phone?	Radio buttons (yes/no)	
Q2-4	Which chat networks did you have on your phone?	Multiple Choice (select multiple options from a list of check boxes)	Mxit (6), Knock Knock (5), 2 go (4), Facebook (3), Other (please specify below) (2), None (1)
Q2-5	If you have selected 'other' in the previous question, please specify	Open Question (short answer)	
Q2-6	I used to chat	Radio buttons: (one choice from a list of radio buttons)	More than once a day everyday (5), Once everyday (4), 2 to 5 times a week (3), Once a week (2), Once in a while (1)
Q2-7	I used chat networks for	Multiple Choice (select multiple options from a list of check boxes)	Friend socializing (1), Family socializing (2), Educational purposes (3),

			Other (4)
Q2-8	If you have selected 'other' in the previous question, please specify	Open Question (short answer)	
Q2-9	I used my phone mainly for:	Multiple Choice (select multiple options from a list of check boxes)	Receiving and making calls (3), Text messaging (2), Entertainment e.g. radio, camera, social networking, music and more (1)
Q2-10	I used to charge my phone:	Multiple Choice (select multiple options from a list of check boxes)	At home (6), At school (5), Next door (4), Near by location with electricity (3), In town (2), Other (please specify below) (1)
Q2-11	If you have selected 'other' in the previous question, please specify	Open Question (short answer)	
Q2-12	Were mobile phones allowed in your school premises	Radio buttons (yes/no/don't know)	
Q2-13	I used my phone	Multiple Choice (select multiple options from a list of check boxes)	During class (5), At school during break times (4), On the way to or from school (3), At home after school (2), During weekends (1)
Q2-14	Please rate the importance a cell phone	Scale type J (1 not important to 5 very important)	

Q3-1	I have:	Radio buttons: (one choice from a list of radio buttons)	heard about Mobile Mathematics Applications (1), heard about and used Mobile Mathematics Applications (2), heard about computer-based mathematics applications (3), heard about and used computer-based mathematics applications (4), Never heard about Mobile Mathematics Applications (5)
Q3-2	I have used:	Multiple Choice (select multiple options from a list of check boxes)	Dr Math® (5), Mobi Math (4), MobileMath (3), Other (please specify below) (2), None (1)
Q3-3	if you have selected 'other' in the previous question, please specify	Open Question (short answer)	
Q3-4	How did you hear about mobile mathematics applications?	Multiple Choice (select multiple options from a list of check boxes)	Friend (2), Family (1), Teacher (3), Used at school (4), Media (5)

APPENDIX B: DR MATH® LOG FILES - THE CONTENT

Analysed conversations

dr maths plz hlp me 522 m kaskas

what ?

when de prise of digital camera is r899,95 including vat. wat is

de prise of digital camera excluding vat?

the answer is 899,95/1.14 = r789.43

k! thnks dr maths C

i need ur help.matshola 323

hw does dis work?

you aks me a math qeustion and i try to answer it for you

cn i start

sure

hw do i calculate 4 angles withou knwing da sum of da sites

what shape

triangle.

do you have 2 of the angels?

na only one angle

i'm leaving now chat tomrrow N

how can i help with matht oday?

trigonometri

ok ask your question

trigonometry

ask me your qeustio

what is 400 to the exponent 50?

use our calucator send me .c 400^50

i dont have a calucator

use ours type in .c 400^50

where is it?

send me a dot c then the expression. use ^ for exponet

what?

the calulator starts with dot c like this .c 3+2 N

can you say asin,acos and atan in full please?

arcsine arccosine arctangent

okay thank you

C

plsr

whats your name?

dr math

where are you from?

dr math doens't answer personal qeustions

okay

good bye

how can i help with math today?

gve m typz of angls

like acute, right, and obtuse?

ja

do you know what those words mean?

n0

acute is an angle between 0 and 90

0btuse is 90 akr

is between 90 and 180. what is right?

no right is 90 degrees

s0 watz 180
straight line
C

0hk.tnx.a u a male

how can i multiply a polynomial by a monomial

how can i dr math
dr are you there i realy need help
N

rozzy 531

kwl

?

any1 da?

dr maths

hi. what is your math question?

a(-3;3) b(7;-3) c(3;5) prove dat angle abc is an isosceles triangle

?

you'll use the distance between the points and see if two points have an equal distance between them.

k thnx
C

a(-1;-3) b(1;7) and c(x;2) are points in the cartesian plane calculate x in each case 1. bc=squareroot of 2 units

doc?

how does x relate to the 3 points? not quite sure what you're asking.

they are the p0intz in the cartesian plane i mean in da x-axis n y-axis

lyf is a rolla coasta nd it dropz bitch.so i drop u 2.am owt myb 4 now peace!!!

i g0t dc
N

elw 324

sorry got dc what is your quesiton

wht is sigma

it is the sum of a series of numbers

k
C

wht abt square root

what grade u in?

a sqwuare root is a number which when mulitpilied by itself gives the original number. so the square root of 25 is 5 beacuase 5 times 5 is 25
k
C

cn u tel me more abt simultenious equation

do you have two to work out

jah
type it in
N

hi. what is your math question?
i need help with simultaneous equations
ok. please show me an example of an simultaneous equation that you want help with.
y=-6x+58 and y=5x-63
first, substitute one of the values for y in one equation into the other equation. such as: y=-6x+58 and y=5x-63 becomes -6x+58=5x-63 now solve for x.
step 2
my answer is: x=11
that's correct. now put your x value into one of the equations and solve for x
are you still there?
i got disconnected but im still working on it
im stuck i dont know where to put da x value i just got
use one of the given equations. for example, y=-6x+58 becomes y = -6(11)+58 because x=11. now solve for y.
i got the answer as y=-8
einstein is logging off...
your answer is correct. bye.
C

we seem to be experiencing a delay. we are swapping you to another tutor. please send another message to us.
N

hi can i help with math today?
yes plz.
ask me
finasiele wiskunde
so i don't speak afr very well. we may get dr wisk tutor later. type in .o to find dr wisk but ask me your question i will try to understond
its ok il log io ltr
N
ok
thx alot
gr8 chat another day

how can i help with math today?
i need the meaning of a foil
?
i wonder why you don't answer me
foil menas first outer inner last do you have some polynoms to mutlipply
C
upto so far i don't want to ask you ques,because last time i did u just talk n talk and i didn't understand

ok so tell the tutor to slow down when that happens. do you need help with foil?

no,i am pregnant with the information

what do you mean?

i am fed up

with what

info

please ask me a math qeustion?

not today

ok chat l8r

k,i wsnt aware dat u knw da shrt cuts

i'm learning lol

k,dats vry nyc of u:)

thx ;-)

is der any dr accounting?

a u a (m)?

type in .o to see btw, i'm leaving at 7 if ther eis another tutor on you will get automatically swapped

531 crazy gal

how can ihelp with math today?

i need help with algebra

ask me your quesiotn

2x-7x2+x3-4=

when you type 7x2 what do you mean

x squate

i will use ^ for exponent so you have 2x - 7x^2 +3x -4 = what?

yes

so combine like terms

no terms i need answers

no i am not going to just give you answers. that would be useless

so what?

i can help you solve this problem but i'm not going to just give you the answer

fine

$531 miss cronic$

cool

hi.. what is your math question?

wat is 1 plus 1

?

ok....give me a real question or i need to answer harder questions.

solve for x 3plus2equals to x

not sure of your equation> is it... x^3 + 2 = x

yah so the answer is?

?

modify it to x(x^2 -1 +2/x) = 0 then solve that.

ok thnk u

C

wat is da decimal fraction of 4

531 miss cronic

a

N

shtng dwn
hi. can i help you solve a math problem? if you need help, just tell me what the problem is.

x-x2

not quite sure what your question is. please give me more info.

factorisatn. .(xsqrd-x2)(x5+6x)

does x2 mean 2x or x^2?

wt duz this mean? duz it mean squrd?^
N

hello

ho can i help with math today?

how do you find the turning point of a parabolar by using the solving the square method

find the two roots and then half way between the roots is the turning point

i don't understand

find the two roots of the parabola first. then half way between the roots is the tp

ohk, the two roots is mos the value of b and c ne

what do you mean "mos the value"

it is the value of b and c.

well it's not b and c of the form ax^2 +bx +c

if eg) you get x'2 - 9x + 20 then the roots wil be -4 and - 5 ryt?

close the factors will be x-4 and x-5 but the roots will be 4 and 5
C

can i help?

yes! i have a problem with factorization

n

i struggle with 3 terms like: x2 - 6x + 9

ok the trick is to first write out two brackets with an x on each side ie. (x)(x)

okay? but how do i go from there?

step two is you look at the sign in front of the constant term which is 9 in this case and the sign is positive
okay...
C

hey cori how can i help with math today?

hey there. uhm i struggle with factorisation of threeterms when a isnt 1

i will use ^ for exponent. do you mean something like x^2 +5x +6 ?
yes but when there is a numer before the x^2

oic, unless it is really easy, i can't do those in my head. i would use the quadratic formula or completing the square to find the roots then generate the factors from the roots.

okay uhm can u repeat that please? sory im actualy afrikaans so i dont get all the english terms. what is the quadratic formula? and how do u use the roots then?

x = (-b +- sqrt(b^2 - 4ac)) /2a

oooh okay...i forgot about that one hehe

so that will give you two roots because of the +- then you can make the factors from that

okay thank u so much.

C

plsr

can u quickly tell me under what in tradepost u find the tutors cus i cant remember and i want a science one hehe

type in .o right here. but we don't have any sciecne tutors yet but you can get thei numbers at .o

okay thank u so much! hope u have a fantastic day!

u2

thanks. bye

do you have another quiont?

not atm but thank u

39 i have a problem solving by completing the square,then leaving it in surd form

sure typein the equation you have

x-square minus 2x minus 1=0

i will use ^ for expnent so you have x^2 - 2x - 1 = 0 so add the constant value to the other side so you have x^2 -2x = 1 ok so far

ok,go on

now take the coefficient of the x term (-2) in this case, divided it by two and then square it. add that value to both sides. so on the left we now have x^2 -2x +1 and on the right 1+1 = 2

ok,please go on

now the left side is now a perfect square. can you factor it?

(x-1)(x-1)

right and on the right is 2 and if you take sqrt of both sides you have x-1 = +- sqrt(2) where +- means plus or minus

is the reason why you square both sides the fact that the 2 brackets =(x-1)^2
i square rooted both sides but yest that is the reason

C

hell

hello

hey bobby how can i help with math today?

what is 2x2-2 < 3x

is that 2 times 2 minus 2 or 2x?

2x

2xsquared?

yes

i will use ^ for exponent so you have 2x^2 -2 < 3x now solve it as if it were a normal equality but never never never mulitply or divide by a negative number. so the next step is 2x^2 -3x -2 < 0 agreed?

yes

now can you factor that?

yes

what factors do you get?

(x-1) (x-2)

no that doesn't mulitply out to 2x^2 -3x -2

what do u do?

help kids with math homework

i mean the question?

oh <blush> i get (2x+1) and (x-2)

help

yes i got (2x+1) and (x-2)

wow thanks

but can you see how i did that

yes

C

ok

simplifying 322

type in the expression you need to simplify

cnt gt da square sign

i use ^ for exponent. do you x^2

no

what is your quesiton

simplify wthout the use of a calculator.

type in the expression

^3-^6+7^6

i'm not sure i understand your notation. is that x^3

because ^3 all by itself doesn't make sense

i wnt a square sign like in 5 square

i use ^ for exponent like 5^2 meaning five times five

its nt a perfect square

what is it

be3 low.later lovely p3rs

N

do you have a math question for me today?

what are rational number nd their examples

a rational number can be represented as the fraction of 2 integers.

C

hw 2 simplify surd expressions?

N

do you have one to simplify? set your name by typing in .n joe or .n sue

ï¿½n mandy

dot n mandy like this .n mandy

hw 2 complete squares?

do you have a polynom to solve we can do it tog

cn u pls cum up wth it so dat we cn solve it 2geda bcouz

mi fone does nt hv maths symbols

i will use ^ for exponet. how about x^2 + 4x -6 = 0 so you add the 6 to the other side so you have x^2 +4x = 6 are we gotegether?

yes

ok now take half of the coefficient of x and square it. what do you get

6+4

and the left is x^2 +4x+4 = 10 now factor the left. you see it is pefect square

ï¿½jah i c,thnx 4 ur hlp

wait so take the sqrt of both sides,

k

cn u help me plz dr math

sure whats ur quesiton?

actaully id lyk u to give sudy tip for n3 engeneering mathematics.bcoz i simply can nt put into detail my prob over mxit.trigonometry

try. are you doing trig graphs, trig equations, what

trigonometric equation

can you type it in

thats the prob.my frnd is tryin it on his phone for the symbols that my phone doesnt have

oh, simbols like theta and phi? just write them out

sir or mam i wil cum to u when im mre prepared about wat i want.cuz this wil confusing and u are kinda doin wat ma teacher does.try to have a little patience with me sir/mam please

not a prob.

thank you for your i wil be back when im ready :)

ok

N

hae 531

how can i help with matht oday?

hw du i chnge n exponent to a numba

do yo have an example we can work out together?

59 to da exponent 3

so that is 59 times 59 times 59

ok tnx

C

plsr

wat du u advse me to du wen i gt a questn paper n frk owt

close your eyes, take a few deep breaths, and then tackle it

i wnt ta be a dcter bt i dnt knw wat subjcts to du wat du suggst i du

you must look at the website for the university where you want to study

bt wat subjcts shld i du wen i gt ta hgh skul

probably math and biology at least
k

hey
how can i help with math today?
im busy with algebra
ok what is your qeustion
i dnt understand when we have to simplify or wen we hve 2 group it or wen 2 factorise
do you have a specific problem to solve
yep
type it in
yes i do
k...give me a sec.
(2x to the power2,minus 3x plus 1)3x plus 5)minus
(2x powe2 minus 3x plus1)(xplus5)
so you need to first mutilply through all the parenthese.
yes...
i'm not going to do it for you. you must do that then combine like terms
y cnt u do it 4 me as an e.g and then i can do the otherz
i'm not going to **do** your homework. that would be useless. i am here to help you do your own homework.
but i need it as an example please
so mutiply the 3x times 2x^2 and times -3x and times +1

yes..,i think i got the pattern now thank you very much ill be back l8er,thanks
C

numbers, exponents and sequences. 26
rational exponents. 26
hello
hey
i need some help in rational exponents
okay. do you have a specific problem?
yes.
can you state it for me?
[(a to the exponent 2/3 x b to the exponent negetive 4/3) to the exponent negetive 1/2 x (a to the exponent negetive 1/2 x b to the exponent 1/4) tho the exponent 4/3] tho the exponent -1
N

hi
we seem to be experiencing a delay. we are swapping you to another tutor. please send another message to us.
hi can i help with math today
yes .. (square root of 7 over th sqaure root of 3 +1)
how cn i do it
you can't do that by hand. do yo uhave a calculator

no

we have one you can use. type in .c sqrt(7) to get the sqroot of 7 or type in .c sqrt(7) / sqrt(3) to get that value

bt i must show steps

so do it one calc at a time .c sqrt(7) and write down the answer and then .c sqrt(3) and write down the answer then .c 8/2 or whatever those numbers were and write down that answer.

cn u pls ryt ths down cos we nt supposd ta use a calculator ..open bracket squar root of 7 over squar root of plus 1 close bracket

you must do it, not me

thanx 4 your help!

ok

i thought dr.math was made ta help us

we help but we don't do homework.

i ddnt say u should do it askd u hw i should go abt doing it

C

maths 420

k

logs 420

k

yes what do you need to know about logs

change of base n hw 2 solve thm

log base b of x = log base k of x / log base k of b

C

k, help me wth ths arithmetc series the 2nd term of an arithmetc is 9 x the 5th term n the sum of the 8th term is 56 find: common diff list numbr of ap whch mst b taken for the sum 2 b negative

geez that's an ugly question. what is ap?

arithmetic series/sequenc

p? for sequnce? lol where di you learn to spell lol

frm the lady tht teaches me maths aftr school

lol ok. so do you know the formula for the nth term in an as

yes

so the 2nd term is 9 times the 5th term right?

yes

so a + (2-1)d = 9(a+(5-1)d) right

ja

ok and the other clue was sum to the 8th term is 56 right? what is the formula for the sum to the nth term?

sn=n/2[a+(n-1)d]

ok so 56 = 8/2(a + 7d) right?

yes

so now you have two equations and two unknowns (a and d) use normal simultaneous equation techniques to solve for a and d

thnx
C

519 obakeng

i hve hmewrk 2 do so it hard i wnt your help please

sure what is your quesiton

12 to the power 12 divid by 8 to the power of2

so u will my quation

i won't **do** your homework. i will help you with it

ohkey
N

so ask me your question

wat is the 8 to the power of 16 divid by 12 to the power 102 comvet   to 50

we have a calucator you can use. use * for mutliply and ^ for exponent type in dot c followed by the experssion liket his .c 8 ^ 16

ya

did you get the answer

n i dnt hve calculate

use the one we have installed in mxit type in .c 8^16

c8-16 :[

dot c then the expression on a line by itself

8ta
C

how can i help with math today?

what is a proper fraction

where the numerator is smaller than the denometator
C

x to the power 2 -y to the power 2,factorise please

so whenever you have a square minus a squre there is a special rule it is x^2-y^2 = (x+y) * (x-y) where * means times

i don't get you

i use ^ for exponent so x^2 means x to the power 2

k,could you please solve the equation for me,3(2x-1) +5(1+7x)=16(2x-4)

no exponents at all?

yes,solve the equation

so you must first multiply the 3 times 2x and times -1 write that down

k,continue

then multiply 5 times 1 and 5 times 7x and add that to twhat you already wrote down

k,covered

now do the same for the right side of the =

k

?

dfo it for the right side

i just did

so now combine like terms on both sides

7x and 2x

what happened to the constants

i need help in simplifying surd form problems

ok. what is your problem that you want to solve?

parabolla

please tell more about your parabola question. do you have an equation?

x^2+2x-3

i think it will be hard because we hve no graphs

do you want to draw the parabola?

lets do completing the square instead

einstein is logging off...

ok. bye.

N

i am struggling

with what?

maths

sure what is your qeuionst?

on geometry am in grade 9

sure what is the question

hw do u calculate it?

calculate what?

angles

sure what is your question

thanks alot

you must ask me a specific question

i am trying

ok i'm waiting ;-)

do you know geometry?

yes you must ask me a queston about it

how do u calculate them. and the verticall opposites

calculate what? angles? given what data?

yes. lyk when do you add? and when do u subract?

it depends on the situation. don't you have a specific homework problem to work out. we can do it tog.

N

yho i am writting maths

when?

wednesday.

so you must ask me a specific quesiton. i am not a teacher. i just help with homework.

ohk how about products?

as in multiplication

its lyk dis (2c-3y)(2c+2y)

ok so do you know foil?

nhe:?

when you have two binomials and need to mulitply foil means first outer inner last the odrder of the mulitplications

okay

and after that?

well you just said (2c-3y)(2c+2y) that's all you can do with it

i want the answer

i am not going to just give you the answer. sorry. you have to do the dirty work yourself.

C

my friend is asking for your mxit c0ntacts

what provice are you in?

kwazulunatal

drmath_kzn

wat

the contact for kids in kzn is drmath_kzn just add us a s a mxit contact

okay

323 m

how can i help with maht today

help

sure how can i help today

geometry

sure - a bit hard using mxit but we can try. what is your question

theorems

whr r u frm?

do you have a math qeustions

N

418 mieke

how do i send you an math problem?

you just type it in

1 on cos x - cosx on 1+ sinx=tanx

did you mean (1/cos(x)) - (cos(x)/1) + sin(x) = tan(x)?

yes, y the kisses?

oh so you don't see my simbols. mxit changed it to kisses lol

hehe thats okay, do you speak afrikaans?

no but we do have a few dr wisk tutors. type in .o to get the contact details and check their hours

okay thank you. its not that i cant speak english, i just think the math terms might be somewhat different?

okay thank you *

N

ohk

how can i help with math but i am leaving at 15:45

N

hi i am leaving in about 10 minutes. so let's be

quick and ask your quesiton

0kay. so is the answer 0 if the equati0n is 3 to the power of 0?

no the answer is 1 anything to the power 0 (*except 0) is one

0kay thanks. and what is it going to be if it waz negative 2 in a squareroot?

that is 1 divided by the square

C

i'm leaving now sorry
cn u hlp wt sumthn b4 u leav
i'm leaving now chat tomrrow
k,thnx
N

hi there pato can i help with math today?
ohk
whats ur question?
jah
ask me
how do u calculate th arthmetic progresshon?
do you have one to work out?
jah
type it in
cn i type it l8r am out of air nw
sorry
l8r plz
i leave at 15;45 but may tomorrow
ohk 2mrw thn
ok
bye
N

n ace 525
how can i help with maht today
itz difficult to understnd about surds
do you have one to work out
yes
type it in
square root of 20 + square root of 45 divide by square ro
divide by square root of 5
sqrt(20) + sqrt(45) divided by what?
by sqrt (5)
and is that all over sqrt(5) or only the sqrt(45)
only (5)
what is on top of sqrt(5)
sqrt(20)+sqrt(45)
ok so you need to factor the 20 and 45 i am leaving soon so i will do that for you so you have sqrt(4*5) + sqrt(5*9) all over sqrt(5) so the sqrt(5)s cancel
C
531 what is a value . dj gift
ey
how can i help with math today?
what are the charectaristics of a right angle triangle
well pythagorus theorum is true for right triangels
C
what is a trigomatry maths
basically the study of right triangles and their relationships
C
what are whole number

0, 1, 2, 3, 4, 5 etc
C
what is the answer of 2 - 0
what is maths
type in .w mathematics for a complete answer
angel ao tlhe
what is the meide point of y(8,2) and x(4,6)
i am leaving really soon. take the average of the x components and the avare of the y componts.
how
N

hy
how can i help with math today?
i do not understand the trigonometry
do yo uhave a homework problem to do
no but we are starting 2 write the exams tomorrow & i'm still struggling
you should have come and talk to me weeks ago. if your exam is tomrrow that is really close
we going to write maths next week....& i've been trying so hard 2 talk 2 u but u were always offline
i did 2 many times,bt there were no tutors
:-(the tutors are volunteers. and alas they are usually university students and yhave their own exams coming up.
are u also a university student?
no but i am leaving at 15:30 which is 15 minutes away :-(
y?
i'm a volunteer i have other things to do
jst stay 4 a few mo minutes plz:(
dr maths
yes ask your math quesiton
i've got alot of questions so we wont finish cause u are about 2 leave
:-(
i think its time for us to say our goodbyes
we will chat a lot before end of year exams though ok?
i hope we will....goodbye i wish u all the best in life
N

silmutanious equation523
i'm leaving at 15:45 so we must be quick type in the two equations you have
2y_x=3 nd x plus 2y plus yx
so take the first equation 2y-x=3 and manipulate it so you ahve x=something what do you get
x=3minus 2y
right now take the second equation x plus 2y plus yx uh what does it equal?
3minus 2y plus 2y plus 3minus 2y plus y
but what does the second equation equal. you haven't written an = sign

6x to the power 2

where is the equal sign i'm leaving in 5 minutes
N

hi can i help with math today?
helo
hi there can i help u
analytical geometry
plss
sure - what's the quesiont?
i wna knw basics 1st
well it is using algebra to define shapes.
yea
but you must ask a qeustion. we don't have the text books. you drive the conversation
lol ok wil u b on l8r?
dy really dnt follow tyms
well the tutors are all volunteers. and they are usually students with homework also. the hours are just guidelines of when they are going to try to be online
i knw
N

please list ur tutor timetable days one afta the other coz its confusing
sorry just started tutoring today, need any help?
wat time are u leaving 1st?

well?
its jst nt worth it!!!!!!!!!!!!!! *leave*
NT

hey
k
hi. what is your math question?
wat tym u gng to log out
are you asking when i am going to log out?
that's in about
one hour.
NT

hy
hi dr math
hi. what is your math question?
what cn u deduce 4rm folwn correlation coeficients?1.r=0 2.r=-0.95 3.r=0.6
a u ther dr math

yes, i'm here. i am helping lots of people right now. is this the correlation that you mean? the correlation is one of the most common and most useful statistics. a correlation is a single number that describes the degree of relationship between two variables
ohk.so wht i do in dat situation cause it costs 6 marks
what are your two variables? they are included in the definition.

wht cn u deduce

what costs 6 marks? what does that have to do with correlation?
rid up da question i askd
N

Mxm
y dnt u help mf

i would be glad you. what is your math question?

wats da main thng u hav 2 knw wen factorising

you should look for a number and/or variable that is in all of the expressions.

if u r given xsquard(a+b)+xy(b+a) wats da ansa
xsquard(a+b)+xy(b+a) is (b+ a) an exponent?
no

ok. is it x^2 (a + b) + xy (b + a) ? i want to make sure i have the correct question.

yes

r u wrkn on it

fuck da bitch hu snd me mxit vibez
that's it. good bye. i don't respond to dirty language.
N

financial maths tutor

hmmm, i'm the only one here and that is not my strong

poitn but ask your quesstion

an investment 0n da st0ck exchange pr0vided pr0fit 0f r53500 fr0m r75000 only in 3yrs n0w h0w d0 u calc ur interest rate p.a if its c0mp0unded

ok so how much interest did it earn?

dats wat im n0t clear wit

wait i misread so the profie is 53500. that will be the interest. so i would use fv=pv(1+i)^n where pv is 75000 and fv is 53500 + 75000

cn u elab0rate m0re

the profit plus the orignal deposit is the fv - future value of the investment

w0w n0w its quite clear thanx
C

plsr

cn u explain 4 me h0w d0 da n0minal and effective f0rmulae being calculated
ah, now sorry i can' do that one sorry
N

0key, thanks anyway

Plsr

calculas?525

hi dr maths

cn u hlp me wt derevitives

no, sorry. i do not help with calculus. maybe you can find an instructor who will help you. good luck.
u hlp wt wat?
N

cal 426

hello how may i help you ?

cal

if you are referring to calculus then i'm sorry i only deal with maths lit and it

rate

ok bye

rate ? rate what ?

i luv people hu hate me 4 nothing but not trust dem n i wish long life 2 dem so dat dy c my progress

that sounds great

N

424sot

hi

do you need help with maths lit or it?

mathematics

so that's higher grade maths then !

yep

bliev me nw see me der i'll be der nd i say taa

sorry i won't be able to sufficiently help you ! i'm out of practice

ok

N

hi. what is your math question?

have a problm about porting a graph, so just want 2 knw hw is it done

i'm not sure what you mean about "porting" a graph. please tell me more.

i waz given a problm 2 solv dat go's like this draw th graphs of th followin axes, use the table method.include both positive nd negative values for th independent variable 1) g(x)=x/2 2) f(x)=2/x 3) h(x)8%x

1) g(x)=x/2 2 f(x)=2x 3) h(x)=8%x

what are you trying to find out? is this a calculus question?

yes am trying 2 solv it, but dont knw how itz done

ok. i'm sorry but i do not help with calculus. maybe you can get some help from your instruction. good luck.

ok, want kind of problem do u deal with

i help with problems up to and including trigonometry.

N

APPENDIX C: PRODUCT REACTION CARDS

The complete set of 118 Product Reaction Cards				
Accessible	Creative	Fast	Meaningful	Slow
Advanced	Customizable	Flexible	Motivating	Sophisticated
Annoying	Cutting edge	Fragile	Not Secure	Stable
Appealing	Dated	Fresh	Not Valuable	Sterile
Approachable	Desirable	Friendly	Novel	Stimulating
Attractive	Difficult	Frustrating	Old	Straight Forward
Boring	Disconnected	Fun	Optimistic	Stressful
Business-like	Disruptive	Gets in the way	Ordinary	Time-consuming
Busy	Distracting	Hard to Use	Organized	Time-Saving
Calm	Dull	Helpful	Overbearing	Too Technical
Clean	Easy to use	High quality	Overwhelming	Trustworthy
Clear	Effective	Impersonal	Patronizing	Unapproachable
Collaborative	Efficient	Impressive	Personal	Unattractive
Comfortable	Effortless	Incomprehensible	Poor quality	Uncontrollable
Compatible	Empowering	Inconsistent	Powerful	Unconventional
Compelling	Energetic	Ineffective	Predictable	Understandable
Complex	Engaging	Innovative	Professional	Undesirable
Comprehensive	Entertaining	Inspiring	Relevant	Unpredictable
Confident	Enthusiastic	Integrated	Reliable	Unrefined
Confusing	Essential	Intimidating	Responsive	Usable

Connected	Exceptional	Intuitive	Rigid	Useful
Consistent	Exciting	Inviting	Satisfying	Valuable
Controllable	Expected	Irrelevant	Secure	
Convenient	Familiar	Low Maintenance	Simplistic	

APPENDIX D: CONFERENCE PAPER 1 (UNDER REVIEW)

Biased Expectations: User Experience of Pupils Using Mobile-Learning Applications

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Abstract: The pervasive proliferation of mobile technologies has resulted in the adoption of mobile devices and applications in a variety of disciplines. To date, mobile devices have been successfully used in various domains and in a number of contexts. One such example is the use of the mobile platform to enhance on-line learning and tutoring (mobile-learning). Mobile-Learning (m-learning) systems are tools used to provide learners with access to learning guidance and tutoring facilities beyond the classroom or computer laboratory learning environment. M-learning applications designers are faced with the challenge of developing their products to meet the requirements, expectations and mental models of the users. A product which satisfies the expectations and needs of the users in completing a specific task promotes a positive User Experience (UX). The purpose of this paper is to report on the factors which impact on the user experience of learners interacting with m-learning systems. A mobile instant messaging (IM) mathematics learning application called Dr Math® was selected as a case for the study. Dr Math® conversation log files were analyzed to determine the factors that impact on the user experiences of the learners. This

paper reports on the findings and results of the analysis and makes some recommendations as to how the user experience can be improved.

Keywords: Mobile-Learning; Instant Messaging; User Experience; Usability; Human Computer Interaction

1) Introduction

It is evidently established that the proliferation of mobile computing is opening a new paradigm contributing to the increase in electronic learning implementation [1; 2]. Mobile technologies provide people with the facility to have access to services without restrictions of time and location. The versatility of mobile services such as the ability to make voice calls, transfer textual data and instant messaging has propagated the use of mobile technologies as tools to enhance learning and present online tutoring.

Mobile learning promises the benefits of providing educational resources in a manner which complements the way learners think and meets their expectations for fun while developing academically [2; 3; 4]. While there is rapid growth in mobile-learning initiatives, there are a variety of factors hindering the successful implementation and acceptance of the new means of learning. This paper aims at determining the features of the mobile-learning applications that influence the feelings and experiences of the users interacting with the applications. Such feelings and opinions resulting from their anticipated interaction and or actual interaction are referred to as user experience [5]. Following the discussed premise, this paper addresses the following research question:

What factors have an impact on the user experience of the people using mobile-learning applications?

In building the conceptual framework, a brief background on mobile-learning also a description of the Dr Math® application and user experience is introduced in sections 2 and 3 respectively. Section 4 presents a discussion on the research methodology used. Results of the empirical study are presented and analysed in section 5. The paper culminates by a report on the factors found to impact on the user experience of the learners using Dr Math® and future work to improve on the user experience of the mobile-learning applications.

2) Mobile- Learning

The objective of this section is to describe what mobile-learning is and its benefits. A definition of mobile-learning depends on the dimension through which an individual views it [6; 7]. The prevalent perspectives to defining mobile-learning are technological perspective [6; 8] and as a tool for enhancing learning outside the classroom and computer laboratory setting [2; 6]. Thus in this paper we define mobile-learning as a means of providing learners with opportunities to access online tutoring facilities, review course content and communicate with their tutors and other students "anywhere," "anytime" without the restrictions of fixed-location computer technology [2; 9]. This form of education suit the lifestyle of the learners as technology is now part of their lives [4; 10; 11].

The ubiquitous use of cell phones in society has led to delivery and access of learning resources without time bound or location restrictions. Clarke, Flaherty and Madison, [12] posits portable devices to provide the benefits of mobility, ubiquity, convenience, localisation and

personalisation. Online tutors can guide students with their homework and exam preparation anywhere, anytime [13]. The younger generations (often referred to as generations Y and Z) often use the mobile devices and applications for fun, games and social networking [2; 14; 15]. This has resulted in competition between learners studying school books and seeking fun from cell phones and mp3 players [16]. Based on such it justifiably makes it beneficial for mobile designers to develop mobile-learning applications providing fun running along the social networking platform to provide tutoring services to the learners [14].

For the purpose of our study we selected Dr Math® as the case of study. Dr Math® is a mobile-based mathematics tutoring system available through the Mxit platform, the most popular Mobile Instant Messaging application (MIM), among South African pupils [17]. Dr Math® links primary and secondary school pupils with mathematically skilled tutors, which are mainly students from the University of Pretoria [18]. The pupils communicate with Dr Math® tutors via Mxit, using their GPRS-enabled cell phones [16] and their own air time. Dr Math® has grown from being just a tutoring system into being an edutainment system. Particularly, Dr Math® deployed competitions and games not only to keep the pupils busy when there are no tutors online but most importantly to make mathematics learning more engaging [18; 19]. Furthermore, Dr Math® has an embedded calculator for the pupils to utilize when interacting with Dr Math® [19].

Our aim is to determine which factors affect the user experience of the learners interacting with the Dr Math® application. A discussion on user experience is presented in section 3.

3) User Experience

User experience is defined as the subjective judgement, opinions and feelings of the quality, effectiveness and usefulness of a product based on the expectations and interaction experience of the user with the product [5; 20]. An analysis of literature on user experience positions the following characteristics of user experience; it is determined by the expectations of the users prior to interaction with the product, it results from long or short term interaction, and an evaluation of the user expectations against how they feel as a result of the interaction [5; 20; 21]. The perceived usefulness and ease of use of products determines whether its users will accept it or reject it [23].

User experience can be positive or negative. Most importantly, user experience is determined by how well a product satisfies the expectations of the user. A product exceeding the expectations of the user promotes a positive user experience [20; 21]. Negative user experience is when users find a product to be boring; difficult to interact with during usage or not fit for the intended use. A positive user experience is developed when the user finds the product to be usable with pleasure and satisfaction [22].

The pupils using Dr Math® have expectations to get help on mathematical homework or examination preparation. Thus the pupils expect to have access to the system by being able to logon. After they have had access they expect to find a tutor online. Subsequently they expect to have effective communication with the tutor and get help on solving the questions they will be having. Thus failure to have any of the expectations satisfied results in a negative user experience. The purpose of this study is to report on the factors influencing the user experience of the pupils seeking help on the Dr Math® application. Section 4 presents a discussion on the research method employed to determine the factors impacting on the user experience of the users of the application.

4) Research Methodology

Dr Math®, an online instant messaging mathematics tutoring system was selected as a case for study. A variety of other m-learning applications were considered for investigation but Dr Math® was chosen because of its wide usage among learners and the availability of data to the researcher. We preferred determining the factors that influence the user experience based on analysis of log files conversation over interviews, questionnaires or user observations. The rationale justifying opting for log files is the fact that they present first hand data and would reach a greater audience of the users compared to the other methods.

A total of 2904 Dr Math® conversations log files were obtained. Out of these log files we randomly selected 50 conversations for analysis. The log file conversations were analysed using conventional qualitative content analysis [24]. The Atlas.ti application was used to electronically code the data for analysis. The themes and categories were determined from existing literature on user experience and through a discussion panel with eight experts in user experience. Themes and categories for coding the data were identified as the conversations were analysed. The data was grouped into themes and respective categories using an in-vivo coding technique. The themes and categories are presented in Table 1.

Table 15: Themes and Categories from log files

Themes	Categories
Accessibility	Login, Connectivity
Effective communication	Official language of communication, Mxit lingo
System capabilities	Input entry, Embedded calculator, Recovery capability, Lack of mathematic symbols, Lack of graphing capabilities
Availability to offer service	Tutor availability, Tutor response time, Skills of tutors,

Accessibility

Accessibility relates to whether the user is able to log in and access the system. Any issues identified to be hindering the users from accessing the system were grouped into the theme accessibility. Log in and connectivity issues were categorised under the theme accessibility.

Effective communication

The success of any conversation based application is dependent on its usefulness in terms of effective communication. The language used by the communicating parties should be understood by all the parties without any ambiguities for communication to be effective.

System capabilities

The system must be capable of providing effective mediation between pupil and tutor conversation. Useful and easy to use functionality must be present to support the tasks of the users. Input entry issues, embedded calculator, recovery capabilities, lack of mathematical symbols and graphing capabilities categories were identified as system capability features.

Availability of resources

Dr Math® employs a synchronous means of communication. Thus the pupils expect to find tutors online; they expect the tutors to have the expertise to help them solve the mathematical problems they may have in a response rate convenient to the pupils. Thus tutor availability, skilled tutors and the response time are the categories classified under the theme availability of resources.

5) Results Presentation and Analysis

Fifty randomly selected Dr Math® conversation log files were studied to determine the factors impacting on the user experience of the pupils. The purpose of this section is to present the results and report on how such findings impact on user experience. The log files were analysed based on the identified themes and categories. Extracts from the conversation logs are used to illustrate typical examples of issues noted to hinder a positive user experience. The issues are rated on a severity scale of high, medium or low and were defined as follows [25]:

Low issues*:* Disturbs the user, result in unsatisfactory interaction, user confusion but do not contribute to task failure. Medium issues*:* Those issues that slows task completion and reaching solution to the problems. High: The issues that cause the pupils to fail to get the help they need. The results and respective severity ratings per theme are presented in Tables 2 – 6.

Table 16: Accessibility Issues

ACCESSIBILITY				
	Description	Frequency count	Extract	Severity rating
Login	The pupils fail to log in due to lack of airtime and network related problems	7	**Pupil** *"made t gdness ntwrk hs bn bd"* **Pupil** *"ddt 've 8tym de past wk"*	High
Connectivity	These issues results in termination of an active conversation.	33	**Pupil***: "cn i type it l8r am out of air nw".* **Pupil**: "*be3 low.later lovely p3rs*". **Pupil**: *"i g0t dcnct".* **Tutor***: "we seem to be experiencing a delay. we are swapping you to another tutor. please send another message to us."*	High

The results in Table 2 show that at times the pupils are denied access to the system due to network related problems, also without airtime they cannot log on to the system. This shatters the expectations of the pupils when they need to get help. Log in denial issues have been rated to have a high severity rate on user experience as the pupils have failed to access the system.

Loss of connectivity resulting in termination of a conversation is a high severity rate issue of user experience. The pupils get frustrated when their session hangs without getting the help they expected. Examples of such issues include a pupil's mobile phone running out of battery during the conversation, running shot of airtime, network related problems and technical delays in sending and receiving messages.

Issues affecting effective communication are presented in Table 3.

Table 17: Communication Issues

Effective Communication				
	Description	Frequency count	Extract	Rating
Official language of communication,	At times communication fails due to pupils using their first languages, The official languages used in Dr Math® are English and Afrikaans	17	**Pupil**: "*ohk, the two roots is mos the value of b and c ne*" **Tutor**: *"what do you mean "mos the value""* **Tutor**: *"no I don't speak Afrikaans but we do have a few dr wisk tutors. type in .o to get the contact details and check their hours"*	Low
Mxit lingo	Pupils use Mxit shortcuts which the tutors are not conversant with.	38	**Pupil**: *"k,dats vry nyc of u:)"* **Pupil** : "*hw cman i 5yd beta if cos 2 beta = -0,5"*	Low

The major barriers to effective communication are linguistic problems. The pupils have difficulties to explain themselves in the Dr Math® official languages (English and Afrikaans). They end up using their first languages and this impedes effective communication. It has been noted that there are few tutors who can answer in Afrikaans. The pupils use shortcuts which they are familiar with in Mxit chats. Some tutors do not understand the shortcuts and this brings confusions, and misunderstandings leading to the pupils having to rephrase their questions. Effective communication problems were rated as issues of low user experience severity.

Table 4 presents system capability user experience issues.

Table 18: System Capability Issues

System capabilities				
	Description	Frequency count	Extract	Rating
Input entry	The interaction style on the mobile is not easy to use	3	**Pupil** *"sorry 4 de delay 'm using a touch screen"*	Medium
Embedded calculator	The embedded calculator on Dr Math® is difficult to access	8	**Pupil**: *"i dont have a calucator"* **Tutor**: "*use ours type in .c 400^50".* **Pupil**: *"where is it?".* **Tutor**: "*send me a dot c then the expression. use ^ for exponent"*	Medium

Recovery capability	If the connection fails in the middle of the conversation the pupil has to start over	5	**Tutor**: *:sorry got dc what is your question"*	Medium
Lack of graphing capabilities	Dr Math® application lacks the capability to draw graphs	11	**Tutor**: "*do you want to draw the parabola?"* **Pupil**: *"i think it will be hard because we hve no graphs"*.	High
Lack of mathematical symbols	Dr Math® does not provide math symbols	14	**Pupil**: "*cnt gt da square sign*"	High

Users expect a system to be useful and usable providing the required functionality to complete a task. Some devices like touch screens and devices with multi-tap keypads make for difficult input entry. Dr Math® has an embedded calculator with a large number of the pupils struggling to use its calculator function. Calculator accessibility and limited input styles have been rated to be issues of medium priority as they slow the pupils down in completing their tasks. Once a pupil mistakenly disconnects from the system they will retype their question as the conversations do not carry over from where they had left. This frustrates the pupils and was rated to be a medium severity user experience issue.

Dr Math® lacks mathematical symbols and graphing capabilities. This may result in pupils not asking questions which relate to the problems requiring graphical presentation or other mathematical symbols not expressed in the application. Since these inhibit the pupils from completing their tasks, the issues are therefore high severity issues as depicted in Table 5.

Table 19: Availability of Service Issues

Availability to offer service				
	Description	Frequency count	Extract	Rating
Tutor availability	Tutors might leave before the pupil is satisfactorily answered.	19	**Pupil**: "*please list ur tutor timetable days one afta the other coz its confusing*" **Tutor**: *"i'm leaving now chat tomorrow"*. **Pupil**: *"its jst nt worth it!!!!!!!!!!! *leave*"*	High
Tutor response time	At times tutors are slow to respond to the pupils	28	**Pupil**: "*dr are you there i realy need help.*	Medium
Skills of tutors	Some of the tutors do not have the expertise in certain subject areas.	9	**Tutor**: *"no, sorry. i do not help with calculus. maybe you can find an instructor who will help you. good luck"*	High

Once the pupils manage to get connected to the system they expect to find tutors online. They expect response from tutors with the expertise to solve their questions. At times the pupils log on and they do not find any tutor online and in some instances the tutors logs off leaving the pupil not helped. This result in a negative user experience thus we have rated unavailability of tutors to be a high severity issue impacting on user experience. A tutor's delay in responding to the pupils leaves the pupil wondering if there is anyone to help them. We have rated delays in tutors responding to pupil's problem as a medium severity user experience issue. At times the available tutors will not have the expertise to help the pupil in a subject area. When a pupil is not helped he or she feels neglected thus a negative user experience. We have rated lack of tutor skills as a high severity rating user experience issue because the expectations of the pupil will not be met. Table 6 presents a summarised severity rating on the issues impacting on the user experience of the pupils using Dr Math® system.

Table 20: Summarized Severity Rating on User Experience Issues

Severity Rate	Issues
High	Login , Connectivity, Lack of graphing capabilities, Lack of mathematical symbols, Lack of graphing capabilities, Tutor availability, Skills of tutors
Medium	Input entry, Embedded calculator, Recovery capability, Tutor response time
Low	Official language of communication, Mxit lingo

6) Conclusion

It can be concluded that accessibility is an important factors in instant messaging mobile-learning applications. The pupils expect to log on to the system with ease and anticipate strong connectivity with undisrupted sessions. Failure to log in and unexpected termination of a session leads to a negative user experience. It is vital that the communication must be effective; the language used must compliment the linguistic capabilities of the pupils using the m-learning application. Failure to match the capabilities of the users results in confusion and unpleasant communication, thus a negative user experience. The system should be both useful and usable providing functionalities needed by the user to complete their task. As noted Dr Math® system lacks graphing and mathematical symbol capabilities and its calculator facility is not easy to find. Such attributes result in user frustrations and overall negative user experience. Other factors noted to impact on the user experience of pupils using Dr Math® system are under the theme "Availability to offer service". When the pupils log on they expect to have tutors to help them within a reasonable time period. Unavailability of tutors or delays in response results in negative user experience.

The factors reported have a negative influence on the user experience of the pupils using Dr Math® system. Understanding such factors is important for designers; it provides summative feedback to the mobile-learning designers to know how they have to improve on the design of the applications and design for positive user experience.

7) Future work

This study investigated factors impacting on the Dr Math® m-learning application based on the conversation log files. The following has to be done to improve on the credibility and applicability of the findings. The future work is both methodological and implementation of the findings. To improve on the methodology we suggest increasing the sample size of the log files analysed, using user inquiry methods and expert based evaluations to determine the factors that impact on the user experience of the pupils. Another dimension to improve the credibility of the results will be investigating the user experience of at least two more m-learning applications. The findings will then be triangulated. The findings report has to be formulated into recommendations and developers will make alterations to the design. The new versions will have to be evaluated to validate the applicability recommendations.

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APPENDIX E: CONFERENCE PAPER 2

Purpose of Paper

To determine and report on the user experience metrics that impact on a positive user experience for pupils when using Dr Math®

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Introduction

- South Africa - Mathematics issue at school level
  - Worrying factor for several decades.
  - 3rd International Mathematics and Science Study conducted in 1995 revealed that South African pupils came last – participated with 41 other countries.
  - Repeats conducted in 1999 and 2003 showed no improvement in the performance of South African pupils
  - Only 7% of South African pupils manage to cope with university-level mathematics.

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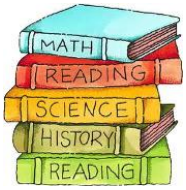
Background to the problem

Lack of access to:



Basic equipment

Basic infrastructure

Traditional ICT tools

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Results from Survey (2009)

- National Education Infrastructure Management System (NEIMS) survey
  - 28 742 schools in SA participated in the survey
  - 72% had electricity
  - 40% had landline telephones and
  - Only 23% had computer centres
    - Of the 23% only 13% had access to the internet

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How to solve current problem?

- Use of ICT tools in Maths teaching and learning
- Use of mobile technology/devices in Maths teaching in learning
  - According to Kreutzer (2009)
    - 97% cell phone adoption rate among South African youth
    - However, its use in the educational context is still in its infancy stage.
  - Typical devices include cell phones, laptops, tablets, etc

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Why Mobile Technology?

- To excel in Maths one needs
  - A strong support system
  - Extended learning time
  - An environment where they can practice math skills
  - Access the necessary material anywhere, anytime

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Dr Math®

- Mobile tutoring system
  - Additional content – definitions, formulae
- Links pupils with mathematically qualified tutors
- Available through Mxit (most popular Mobile Instant Messaging system)
- Edutainment system
  - Games
  - Competitions
  - Quizzes

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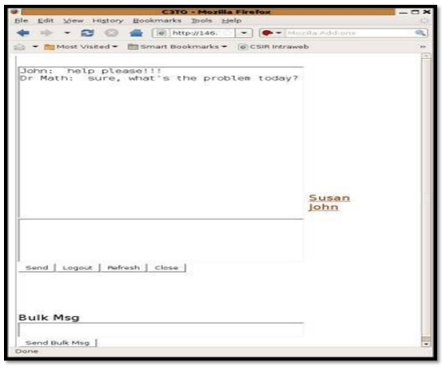
How does it work?

Pupil – connects using

- GPRS-enabled cell phone via Mxit
- Own airtime

Tutor – interacts with pupil

Computer with internet access



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Purpose of Dr Math®

- Original objective was to help secondary school learners with their mathematics homework using technology.
- It aims at acquainting pupils with the necessary problem solving skills while they are guiding them towards the answers as opposed to supplying them with straight answers.
- The general rationale behind the development of Dr Math® project was to contribute in mitigating the mathematics crisis in South Africa.

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Example conversation

Speedster: whats the answer of: (10-x) To the power of 2= 9x?

Dr.math: are u taking a cycle test or something and needing an answer?

Speedster: its good to take regular breaks..

Dr.math: do you know how to do (10 -x) power 2?

Speedster: no, its just a test of yesterday and im not sure about the answer..

Dr.math: the rule is first, outer, inner, last. Have you heard of that?

Speedster: yeah (100-x power 2)..

Dr.math: u forgot the inner and the outer parts. you only have the first and the last

Dr.math: the inner and outter are -10x and -10x

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Aim of study

- To determine what the specific factors are that impact on the user experience of Dr Math®.
- To make recommendations as to how Dr Math® should be designed to address these challenges.

Process followed:

- Desktop literature study
- Analysis of log files containing pupil-tutor conversations
- Expert review of issues identified
- Formulation of specific guidelines based on categories of challenges/issues

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Defining User Experience

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Challenges in Dr Math®

- Accessibility
  - Login
  - Connectivity
- System functions and capabilities
  - Input limitations
  - Recovery capability
  - Embedded calculator
- Tutor availability
  - Available to offer service
  - Responsiveness of online tutors

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Challenges in Dr Math® cont.

- Communication
  - Language of instruction
  - Mxit lingo
- Resource availability
  - Operating time
  - Skill of tutors

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Proposed Solutions to Challenges (1)

- Accessibility
  - Enhance Dr Math® to enable remote access to the Dr Math® server.
  - Minimize costs associated with accessing Dr Math®.
  - Warn pupils and tutors when airtime is about to run out.
  - Warn pupils about any other foreseen interruptions where possible.

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Proposed Solutions to Challenges (2)

- System functions and capabilities
  - Functionalities
    - Know your users.
    - Avoid unnecessary complexities

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Proposed Solutions to Challenges (3)

- Capabilities
  - Provide pupils with a wide variety of languages to choose from.
  - Provide pupils with the list of languages that the online tutors are familiar with.
  - Encourage tutors to familiarize themselves with Mxit lingo.
  - Enhance Dr Math® to include mathematical symbols and graphing support.
  - Enhance Dr Math® to have recovery capabilities.

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Proposed Solutions to Challenges (4)

- Tutor Availability
  - Notify the pupils when there are no tutors online.
  - Specify the approximate amount of time that the tutors will try to stay online.
  - Add a feature that would allow pupils to leave questions when there are no tutors online.

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Proposed Solutions to Challenges (5)

- Resource availability
  - Specify the times the tutor will try to be online.
  - Specify the topics that the online tutors are conversant with.

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In summary

- Categories of factors that impact on using Dr Math® include accessibility and availability.
- The factors reported have a negative influence on the user experience of the pupils using Dr Math®.
- Understanding such factors is important for designers.
- It provides summative feedback to the mobile-learning designers to know how they have to improve on the design of the applications and design for positive user experience.

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Conclusion

Positive UX → Learning and smiling

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