Using mobile learning applications to encourage active classroom participation: Technical and pedagogical considerations

By

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Dissertation submitted in accordance with the requirements for the degree

MAGISTER SCIENTIAE

(Computer Information Systems)

In the Faculty of Natural and Agricultural Sciences

Department of Computer Science and Informatics

UNIVERSITY OF THE **FREE STATE**
UNIVERSITEIT VAN DIE **VRYSTAAT**
YUNIVESITHI YA **FREISTATA**

Bloemfontein - South Africa

May 2011

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Declaration

I hereby declare that the work which is submitted here is the result of my own independent investigation and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references. I further declare that the work is submitted for the first time at this university/faculty towards the ***Magister Scientiae degree in Computer Information Systems*** and that it has never been submitted to any other university/faculty for the purpose to obtain a degree.

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Acknowledgments

"No one walks alone, and when one is walking on the journey of life just where do you start to thank those that joined you, walked beside you, and helped you along the way"

David H. Hooker

I would like to express my deepest appreciation to my highly esteemed supervisor, Dr L Nel, who possesses not only the attitude, but the sufficient substance of a genius. She continually and convincingly conveys a spirit of adventure in research. She never stopped to give constructive advice whenever necessary, even during the holidays. Her mentorship facilitates constructive thinking, development of ideas through challenge and engagement as well as preparation to defend one's opinions and conclusions. Without her duly guidance and persistent help, this dissertation would not have been possible. It was indeed a privilege to be her Masters student.

I owe a great debt of exceptional gratitude to Telkom South Africa for its grant, named Centre of Excellence (COE), extended to me via the University of the Free State. This grant would not have realised had it not been for the Department of Computer Science and Informatics at the University of the Free State. My sincere and heartfelt thanks to the Department of Computer Science and Informatics, not only for their efforts to make the grant possible, but also for all the resources they afforded me while I conducted this research study.

It would be unjust not to thank the Government of Lesotho for sponsoring my Master's program. I doubt if I could have afforded to pay for all that was needed to complete my degree if it was not for them. I say to the Government of Lesotho: "**Keep up that financial muscle and strengthen it in order to lift all the Basotho who are in need**".

A special thank you goes to my wife, 'Me 'Mamohato Josephine Khomokhoana who walked this road with me and supported me during difficult and trying times in a journey to complete this research work. I say to 'Me 'Mamohato "*You are and shall always be very special to me – You acted as a catalyst for me to have completed this research project*".

My parents deserve to be thanked for their immense spiritual and social support. They indeed are special parents. I also have to extremely thank Mr Darren Fry for the work he did to develop the MobiLearn application used in this study. He indeed proved to be a hard worker when my supervisor, myself and him discussed the requirements of the MobiLearn application. I say to him "*Keep up the hardworking spirit, and the entire world, not only South Africa will one day reap the good fruits of your hard work*". My thanks are further willingly expressed to Ms Danila Liebenberg who has edited the entire dissertation and translated the summary of this study into Afrikaans. She is thanked for devoting her time and efforts into this work and her determination to do it.

Last, but not least, I acknowledge the contributions of the students and instructors who were of great help to collect data for this research project as well as all the people who helped with the technical advice of this manuscript. Their respective contributions culminated in the completion of this dissertation. Finally, saving the best for last, I would like to thank **Our Almighty Father** without whom none of this would be possible. Thank you Father for blessing me, loving me, giving me strength, wisdom and intelligence, as well as for the grace you poured on me to have endured this difficult journey.

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Summary

Higher education institutions are experiencing burgeoning growth in student enrolment. The subsequent increase in undergraduate class sizes means that the needs of individual students are no longer effectively addressed. Students are also less likely to actively participate in these large classes. There is a high probability that such students are less likely to be successful in their studies. In order to support the learning needs of the student population, there are various strategies and tools that can be used to encourage active classroom participation. This study investigated how mobile learning applications can be used to encourage active participation in large undergraduate Computer Science classes.

The study identified the four main teaching and learning challenges that are experienced by lecturers and students in large undergraduate courses. They are lack of resources, facilitation of student assessment and feedback, pressure to increase student throughput and the academic under preparedness of students. In this study, the researcher established that it is not easy to address these challenges if a traditional teacher-centred approach is used. The main reason is that this approach is ineffective to support the construction of conceptual understanding by students.

Upon consideration of various teaching and learning issues, a student-centred approach was identified as being a more promising approach for quality teaching and successful learning in the 21st century. In a teaching and learning environment where a student-centred approach is practiced, active classroom participation was identified as one viable solution that has the potential to lower the intensity of the four stated challenges. The researcher demonstrated how active classroom participation could mitigate the effects of these challenges. Some of the active participation strategies identified from contemporary literature were also implemented by the lecturer in her classes.

On realisation that it is not easy to implement active classroom participation strategies, especially in large classes, the researcher opted for applications that could automate some of these strategies. He specifically decided to use mobile learning applications because in this era, most of the students own cellular phones.

The researcher believed that the existing applications could not help him to address the research questions and objectives of this study. He opted for a custom developed application, called MobiLearn. Technical and pedagogical usability of this application were then evaluated in terms of the metrics established from literature. Technical usability was evaluated in terms of 12 metrics and pedagogical usability was evaluated in terms of nine metrics.

The study employed the mixed methods design, and the approach was mainly qualitative with some quantitative enhancements. Data was collected through focus group discussions held with voluntary participants from the selected population; questionnaire survey; extracting it from the application (usage data); a face-to-face interview with the lecturer who used the MobiLearn application in her classes as well as class attendance records. Qualitative data was analysed according to qualitative content analysis principles, while quantitative data was analysed by means of statistical analysis. The application was evaluated as both technically and pedagogically usable. It was also evident to have potential to encourage active classroom participation for students who use it.

Some students indicated that they experienced some technical problems to access the MobiLearn application. They indicated that they were not motivated to use the application. To address the last (third) objective of this study to mitigate problems such as these experienced by MobiLearn users, the study compiled a set of technical and pedagogical guidelines for best practices in the use of mobile learning applications to encourage active participation in similar contexts.

Keywords: Large class teaching, mobile learning, active classroom participation, usability metrics, technical usability, pedagogical usability.

Opsomming

Hoër onderwys instansies ondervind ontluikende groei in studente registrasies. Die gevolglike toename in voorgraadse klasgroottes beteken dat die behoeftes van individuele studente nie langer meer effektief aangespreek word nie. Studente is ook minder geneig om aktief in hierdie groot klasse deel te neem. Daarom is daar ’n laer waarskynlikheid vir hulle om suksesvol te wees. Om die studente se leerbehoeftes te ondersteun, kan verskeie strategieë en hulpmiddels gebruik word om aktiewe klasdeelname te bevorder. Die studie ondersoek hoe mobiele leer toepassings gebruik kan word om aktiewe klasdeelname in groot, voorgraadse Rekenaarwetenskap klasse te bevorder.

Hierdie studie het vier leer en onderrig hindernisse geïdentifiseer wat deur studente en dosente in groot, voorgraadse klasse ervaar word. Hierdie hindernisse is ’n gebrek aan hulpbronne, die fasilitering van studente assessering en terugvoer, druk om studente se deurvloeikoers te verhoog en akademiese onvoorbereidheid van studente. In die studie het die navorser vasgestel dat dit nie maklik is om die hindernisse aan te spreek met ’n tradisionele dosentgesentreerde benadering nie. Die hoofrede is dat die benadering oneffektief is om die konstruksie van konsepsuele begrip van studente te ondersteun.

Na oorweging van verskeie onderrig en leergegewe is ’n studentgesentreerde benadering geïdentifiseer as die mees belowende vir kwaliteit-onderrig en leer in die 21ste eeu. In ’n onderrig en leer omgewing, waar ’n studentgesentreerde benadering gevolg word, is aktiewe klasdeelname geïdentifiseer as die een werkbare oplossing wat die potensiaal het om die intensiteit van die vier genoemde hindernisste, te verlaag. Die navorser demonstreer hoe aktiewe klasdeelname die effek van die hindernisse kan versag. Sekere van die aktiewe klasdeelname strategieë wat uit kontemporêre literatuur geïdentifiseer is, is ook deur die dosent in haar klas geïmplementeer.

Met die besef dat dit nie maklik is om aktiewe klasdeelname strategieë te implementeer nie, veral in groot klasse, het die navorser toepassings gekies wat

sekere van die strategieë kon outomatiseer. Hy het spesifiek op mobiele leertoepassings besluit omdat die meeste studente in die era selfone gebruik. Die navorser is van mening dat die huidige toepassings nie kan help om die navorsingsvrae en doelwitte van die studie aan te spreek nie. Daarom is ’n doelgerigte toepassing, genaamd MobiLearn ontwikkel. Tegniese en pedagogiese bruikbaarheid van die toepassing is geëvalueer in terme van maatstawwe wat uit die literatuur geïdentifiseer is. Tegniese bruikbaarheid is geëvalueer in terme van 12 maatstawwe terwyl pedagogiese bruikbaarheid 9 maatstawwe in ag geneem het.

Die studie gebruik ’n gemengde metode ontwerp en die benadering wat gevolg word, is hoofsaaklik kwalitatief met kwantitatiewe verbeteringe. Data is ingesamel deur fokusgroep besprekings wat gehou is met vrywillige deelnemers van die geselekteerde populasie; vraelyste, uittreksels uit die toepassing (gebruikersdata); ’n aangesig-tot-aangesig onderhoud met ’n dosent wat die MobiLearn toepassing in haar klasse gebruik en klasbywoningsrekords. Kwalitatiewe data is geanaliseer volgens kwalitatiewe inhoudsanalise beginsels. Die toepassing is geëvalueer as tegnies en pedagogies bruikbaar. Dit is ook duidelik dat die toepassing wel aktiewe klasdeelname bevorder.

Sekere studente het aangedui dat hulle tegniese probleme ervaar het om toegang tot die MobiLearn toepassing te verky. Hulle het aangedui dat hulle nie gemotiveerd was om die toepassing te gebruik nie. Om die laaste (derde) doel van die studie aan te spreek en die problem wat deur MobiLearn gebruikers ervaar word, te versag, is ’n stel tegniese en pedagogiese riglyne vir beste praktyk saamgestel vir die gebruik van mobiele leertoepassings om aktiewe deelname in soortgelyke situasies te bevorder.

Sleutelwoorde: Onderrig in groot klasse, mobiele leer, aktiewe klasdeelname, bruikbaarheidsmaatstawwe, tegniese bruikbaarheid en pedagogiese bruikbaarheid

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Chapter One:
Introduction

1.1 Background to the study

In a global economy, education is the single most important key to success for individuals and the entire nation (The Council of Chief State School Officers, 2010, p. 3). Education is a priority, not only for governments, but for all the members of society. The private sector, in particular, has a vested interest in an effective education system. This system is critical to economic growth, builds a skilled labour force, increases purchasing power and boosts productivity (World Economic Forum, 2007). Education is further regarded as one entity that can contribute to build a democratic country (Leibowits, 2000, p. 1). Any contemporary analysis of development and growth prospects in South Africa (a democratic country since 1994) promptly moves to draw attention to the lower standards of education and critical skills shortage amongst the population (Kruss, 2009, p. 1). The results of this analysis led to education and skills development in South Africa to be at the centre of government's policies (Zuma, 2010). South Africans put a major emphasis on their education to become responsible, participatory and reflective citizens who contribute to an emerging democracy (Leibowits, 2000, p. 1).

In order for South Africa to put its present democracy in a continuity state, it has to ensure that education continues as well. Education not only has to continue, but lower standards have to be improved and skills amongst the population have to be enhanced. To maintain education continuity, improve education standards, develop the necessary skills and address the global need to meet the growing demand for higher education (King, 2004), countries such as South Africa are faced with several challenges, especially with regard to higher education.

Some of these challenges include decline of financial support from states and endowments (Glidden, 2009; Saint-Germain, 2008, p. 4), greater levels of diversity of the student population (O'Neill, Singh & O'Donoghue, 2004, p. 315; Stumpf, 2001), massification of higher education (Hutchison, 1996; Klemencic & Fried, 2007; Saint-Germain, 2008, p. 1), escalation of higher education cost (Hayward & Amiryar, 2004;

Hutchison, 1996), competition for students, funding, research and recognition within the wider society (O'Neill et al., 2004, p. 314), pressure to increase student throughput (Bettinger & Long, 2005) and the academic under preparedness of new students who enter the higher education world (Bharuthram, 2006; Nzimande, 2009; Paras, 2001). The corporate stakeholders in higher education, namely lecturers and students, also experience some challenges as a result of the general challenges faced by higher education.

Lecturers are faced with challenges such as to design a curriculum that prepares students for actual careers (Clark, 1994), to use new technologies in their teaching (Marten, 2009), to deal with students who are academically under prepared for higher education (Miller & Murray, 2005), to balance research with teaching (Marten, 2009), to design effective teaching methods which engage students in their learning experiences (DeBourgh, 2008, p. 76), to provide quality and flexible education to meet the diverse needs of students (O`Neill et al., 2004, p. 313) and to teach large classes (Haddad, 2006). Students are faced with challenges such as high failure rates, particularly for the first year students (Nzimande, 2009), higher cost of education (Hayward & Amiryar, 2004) and large class sizes (Jaffer, Ng'ambi & Czerniewicz, 2007; Pundak, Herscovitz, Shacham & Weizer-Biton, 2009).

In the face of these challenges, lecturers need to find and implement ways to best meet the needs of the diverse student population. In a large class, students vary in abilities and background (Gibbs & Jenkins, 1992). It is not a best practice for students to learn in a large class, because a lecturer may neglect some of them unconsciously. In the long run, this lack of attention may become a negative stimulus and cause students to lose their interest and be unwilling to corporate with the lecturers in class (Xiufen, 2009). Moreover, students may lose their individuality and be afraid to ask questions in class. One student describes an experience of learning in a large class as to be "like numbers at the end of a computer print-out" (Gibbs & Jenkins, 1992, p. 23).

Teaching a large class makes it difficult for lecturers to know the individual students (Roberts, 1997, p. 2) and it reinforces the lecturer's feeling to perform rather than to teach. There is more stress for dedicated and determined lecturers, because they worry about the situation and at the same time they just cannot cope (Gibbs & Jenkins, 1992). Large classes result from the large numbers of students who enrol at educational institutions. This increase in enrolments can, in part, be attributed to rapid population growth trends and global initiatives for universal education, especially in developing countries. The world's population doubled in the past four decades between 1959 and 1999 (Benbow, Mizrachi, Oliver & Said-Moshiro, 2007). In South Africa, the population increased from 45.4 million in 2001 to 46.7 million in 2004 (Steenkamp, 2004, p. 1). At the University of the Free State (UFS), the student population increased from 14,167 in 2001 (Steyn, 2001) to 25,351 in 2004 (Steyn, 2004).

1.2 Problem statement

In large class environments, students are less likely to actively participate and their individual needs may not be addressed effectively. This implies that students are not actively involved in their own learning experiences and are less likely to be successful in their studies. It follows that for successful learning to take place, some sort of intervention is needed to encourage students to participate more actively in class so that their learning needs can be met.

Several strategies including the one minute paper (Paulson & Faust, 2002), think-pair-share (McTighe & Lyman, 1988) and ConcepTest (Mazur, 1997) have been used to encourage active classroom participation (more details on these strategies are given in Section 2.6). It is not easy to implement these strategies in large classes. Student response systems have been suggested as the best alternative (DeBourgh, 2008; Draper & Brown, 2004; Meedzan & Fisher, 2009; Sciandria, 2007; Simpson & Oliver, 2007). The main drawback of this strategy is that it is expensive. There is a need to find more readily available technology that can be used to encourage active classroom participation. As most South African higher education students already own a cellular phone, the use of a mobile learning application might be a more feasible alternative. Hence the overarching research question for this study is as follows:

> *How usable are mobile learning applications in encouraging active participation in large undergraduate Computer Science classes?*

1.3 Aim and objectives of the study

The aim of this study is to determine how usable mobile learning applications can be in encouraging active participation in large undergraduate Computer Science classes. To achieve this aim, the following objectives were pursued:

1. To undertake a comprehensive literature review in which the following aspects are studied:
    - The global shift from the traditional teacher-centred teaching and learning approach towards a more student-centred approach.
    - The teaching and learning challenges associated with the implementation of a student-centred approach in large undergraduate classes in general, as well as in the South African context.
    - The strategies which can be employed to implement a student-centred teaching and learning approach.
    - The strategies that may be used to address the lack of participation in large undergraduate classes.
    - Existing mobile learning applications and the role they can play to address the lack of active classroom participation in large undergraduate classes.
    - Usability quality criteria categories and metrics used to measure both technical and pedagogical usability of educational applications.

2. To evaluate both the technical and pedagogical usability of a selected mobile learning application by means of an interview, a questionnaire survey and focus group discussions in order to determine the overall usability and effectiveness of this application to encourage active classroom participation.

3. To compile a set of technical and pedagogical guidelines for best practices in using mobile learning applications to encourage active classroom participation in large undergraduate classes in similar contexts.

1.4 Scope of research

The research focused on the use of mobile learning applications to encourage active classroom participation in large undergraduate Computer Science classes. The research was based on the use of a customised mobile learning application which was developed with the objective to encourage students to participate actively in class through its use in combination with cellular phones. The application was tested with a group of first year Computer Science students at the UFS who were registered for a specific course (RIS164). This course introduced them to the Internet and website development. The RIS164 students were the principal source of data (questionnaire survey data and focus group discussions). The lecturer for this course provided secondary data. Supplemental data was the usage data gathered from the application and the class attendance records for the selected course. Usability of the selected mobile learning application (MobiLearn) was measured from both technical and pedagogical perspectives.

1.5 Limitations of the study

There were several limitations experienced in this study. They include:

Firstly, the number of students who were able to access the selected mobile learning application was less than expected. This was because a survey conducted by the Division: E-learning at UFS in 2007 showed that 96 per cent of all the first-year students on the UFS main campus own a cellular phone, and of these, 97.1 per cent were WAP-enabled (Blanche, 2009). It turned out, although most of the students did own a cellular phone, most of these phones were not WAP-enabled (which is a feature required to access the selected mobile learning application).

Secondly, the students were expected to have their cellular phones with ample airtime to use the selected mobile learning application. While some students were not willing to use their airtime units for academic activities, others did not have the financial means to buy additional airtime for their phones.

Finally, to measure the pedagogical usability of the selected mobile learning application, there were some measures, identified from literature, which were not possible to measure due to the nature of the selected application. Such measures were promotion of self-monitored learning, self-directed learning and self-regulated learning (see Section 3.8.3). For the *ease of use* pedagogical usability metric, it was not possible to measure whether the interface of the MobiLearn application had an intuitive interface to satisfy the natural curiosity of students to explore the unknown. Even if students were curious to explore the MobiLearn application further, the purposefully set limitations did not allow any exploration.

1.6 Clarification of concepts

The main concepts in this study are large class teaching, mobile learning applications, active classroom participation, technical usability and pedagogical usability. In the following sub-sections, these concepts are defined in the context in which they are used in this study.

1.6.1 Large class teaching

There seems to be a lot of different interpretations from literature on when a class should be considered as large. Benbow et al. (2007) define an overcrowded or a large class in a developing world as a class where the ratio of students to lecturers exceeds 40:1 (meaning more than 40 students per class). Pundak et al. (2009, p. 216) have a similar definition as they consider a class to be large when it includes fifty or more students. In their definition of a large class, Buchanan and Rogers (1990) tried to move away from linking “large” to a numbered size by stating that a class can be considered as large when the traditional techniques such as finger signals and round robin are no longer workable and new ones must be tried. They did indicate that traditional techniques are no longer workable when the class size exceeds 80. Conn, Boyer, Hu and Wilkinson (2010, p. 5) provide a completely different viewpoint by defining a large class as one which involves 500 or more students.

Both Gibbs and Jenkins (1992, p. 16) and Haddad (2006, p. 1) are of the opinion that there is no rigid interpretation of a large class. They believe there are several issues which need to be taken into account before a class can be labelled as “large”. These include issues, such as what is being taught and what resources, accommodation and facilities are available. The typical example Gibbs and Jenkins (1992, p. 16) provide is: “we have seen teachers struggling to meet the needs of 40 students in a design studio which has work spaces for 18 [students]”. It becomes evident that a large class is not determined by a numbered size. Instead it is determined by context. For the purpose of this study, a class with 40 or more students was regarded as a large class.

1.6.2 Mobile learning applications

Traxler (2005, p. 262) defines mobile learning as “any educational provision where the sole or dominant technologies are handheld or palmtop devices”. He believes that mobile learning can include mobile phones, smart phones, personal digital assistants (PDAs) and their peripherals. Not deviating much from Traxler’s view, Hunsinger (2005) defines mobile learning as “a new way to learn using small, portable computers such as PDAs, handheld computers, two-way messaging pagers, Internet-enabled cell phones, as well as hybrid devices that combine two or more of these devices into one”. Mobile learning can also be defined as “any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that occurs when the learner takes advantage of the learning opportunities offered by mobile technologies” (O’Malley et al., 2003, p. 6).

This study aims to investigate how students can take advantage of the learning opportunities that mobile learning applications offer to encourage active classroom participation. In this context, the term mobile learning application was used to specifically refer to an application which allows users to interact with it through some mobile device such as a cellular phone.

1.6.3 Active classroom participation

Active classroom participation entails to get everyone involved in a productive and inclusive way in tasks or activities in question (The University of Queensland, 2007). For the purpose of this study, productive and inclusive ways can imply that students would be expected to show positive emotions during a lecture and willingness to fully participate in class. Students are not expected to participate for the sake of it. Instead they should benefit academically from the lecture through their active participation.

The World Health Organisation (1999, p. 9) defines active participation as “a process by which people are enabled to become actively and genuinely involved in defining the issues of concern to them, in making decisions about factors that affect their lives, formulating and implementing policies, planning, developing and delivering services and in taking action to achieve change”. In the case of students, the methods of teaching and the activities carried out in the lecture should encourage students to participate in class. These methods and activities should also allow students to directly and, without any fear, ask questions in class to clarify issues which directly relate to the learning content. This makes it possible for students to be wholly aware of most issues which surround their entire learning experiences.

In the view of Biggs and Tang (2007, p. 144), actively participating students are involved in the design of their learning experience, the identification of their learning needs, their ways to fulfil those needs and how they will be assessed. This implies that the responsibility of learning is shared between students and lecturers. The responsibility of learning is a subset of active learning as Wilson (2008, p. 1) defines it as “an umbrella term that refers to several models of instruction that focus on the responsibility of learning on learners”. It is based on the idea that students who actively engage with the learning material are more inclined to recall information at a later stage (Bruner, 1961). Active learning is further defined as anything that students do in a classroom other than to merely passively listen to the lecturer. This includes everything from listening practices which help the students to absorb what they hear, to short writing exercises in which students react to material delivered in the lecture, to complex exercises done in teams wherein students apply course material to real life situations and/or new problems (Paulson & Faust, 2002). For the purpose of this study, the definition provided by Paulson and Faust (2002) was used.

1.6.4 Technical usability

Kukulska-Hulme and Shield (2004) define technically usable computer applications to address issues such as broken links, server reliability, download times, appropriateness of plug-ins and accurate HyperText Mark-up Language. They aim to ensure trouble free interaction with the application or system (Melis, Weber & Andres, 2003, p. 282). According to Nokelainen (2006, p. 178), certain assumptions are made when technical usability of a software application is evaluated. The first assumption is that the application should be easy to learn, to use its central functions and such functions should be efficient and convenient in use. Another assumption is that error responses to incorrect operation of the software should help to teach the user how to use the system as intended so that the error will not be repeated. In this study, technical usability was mostly concerned with the components that constituted the user interface for the entire system or application to be easy to use, efficient and convenient to most users. The components considered in this study are referred to as technical usability metrics.

1.6.5 Pedagogical usability

Pedagogical usability refers to the evaluation of aspects of an educational application (such as tools, content and interface) and how it supports various students in their learning process (Silius & Tervakari, 2003, p. 3). According to Nokelainen (2006, p. 180), pedagogical usability is dependent on the dialogue between a user and a system, as well as the goals set for a learning situation by the student and lecturer. He further asserts that when this type of usability is evaluated, the assumption is that the designers of the learning platform or unit are guided by either a conscious or subconscious idea of how the functions of the system facilitate the learning of the material that it delivers. Melis, Weber and Andres (2003) assert that pedagogical usability ensures that an e-learning system is usable. They state that it aims to support the learning process. As these assertions all touch on the support of students in their learning process, Silius and Tervakari's (2003) definition was adopted in this study. The pedagogical aspects considered in this study are referred to as pedagogical usability metrics.

1.7 Research Design

To address the stated research question and objectives of this study, the researcher employed a qualitative research design with some quantitative enhancements. According to Creswell (2005, p. 39), qualitative research tends to collect data consisting largely of words or text from participants. The meanings of this text are expressed in context rather than in numerical measures (Anderson & Poole, 1998, p. 26). The researcher believes that to fully obtain the overall usability and effectiveness of mobile learning applications to encourage active classroom participation, the qualitative design could not suffice in isolation of the quantitative elements, hence the quantitative enhancement.

The mode of inquiry in this study involves a single case study. A case study is a “strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence” (Robson, 2002, p. 178). In addition to the researcher being the instrument, students and lecturers were mainly involved in this study. These participants used the MobiLearn application and their views were solicited afterwards. The students who participated were a group of students who were registered for RIS164 course. The involved lecturer is from the department of Computer Science and Informatics at UFS. The study was conducted over a period of a semester when the concerned lecturer and the students used the MobiLearn application. The necessary permission to use the students was obtained from the concerned lecturer for the course.

The sample selected for this study was both purposeful and convenient. It was purposeful, because students in the selected course were representative of a large undergraduate Computer Science class as well as of the diverse student population of the UFS. The sample was convenient, because the lecturer who facilitated the selected course, was interested to test out the MobiLearn application in her classes.

The data first available to the researcher was usage data. This was the data retrieved from the MobiLearn application (the application that was used in this study). Usage data indicated responses which were entered by the students on the application as well as the time in seconds that students took to make their entries. A questionnaire survey was also used to gather data. Focus group discussions were used as a follow up to issues that needed to be clarified further from the questionnaire. Face-to-face interview with the lecturer who used the MobiLearn application in her classes was held. The class records of the selected group were also used to provide useful data. Analysis of the collected data helped to investigate the objectives of this study.

1.8 Outline of the dissertation

This introductory chapter is followed by the following five chapters:

Chapter 2:	A pedagogical shift towards a more student-centred approach in a technology enhanced teaching and learning environment (Literature review).
Chapter 3:	Technical and pedagogical considerations to evaluate mobile learning applications (Literature review).
Chapter 4:	Research methodology.
Chapter 5:	Data analysis and interpretation of findings.
Chapter 6:	Conclusions and recommendations.

The following appendices are also included at the end of this document:

Appendix A:	MobiLearn questionnaire.
Appendix B:	Informed consent form for focus group discussions.
Appendix C:	Questions for the focus group discussions.
Appendix D:	Questions for the interview with the lecturer.

1.9 Conclusion

In this chapter, a brief introduction of the research study discussed in this dissertation was provided. The discussion indicates the preliminary literature upon which this study is grounded. This literature indicates the theoretical direction that this study takes. The following two chapters provide a more in-depth discussion of the existent literature.

Chapter Two:

A pedagogical shift towards a more student-centred approach in a technology enhanced teaching & learning environment

2.1 Introduction

This chapter comprises of a comprehensive literature review that aims to provide perspectives on the following issues:

- The global shift from the traditional teacher-centred teaching and learning approach towards a more student-centred approach.
- The teaching and learning challenges associated with implementing a student-centred approach in large undergraduate classes in general, as well as in the South African context.
- The strategies which can be employed to implement a student-centred teaching and learning approach.
- The strategies that may be used to address the lack of participation in large undergraduate classes.
- Existing mobile learning applications and the role they can play to address the lack of active classroom participation in large undergraduate classes.

This chapter commences by illustrating the need for a pedagogical shift towards a more student-centred approach, especially in 21st century classrooms. From the discussion, it becomes apparent that both students and lecturers are faced with numerous challenges that complicate the implementation of a student-centred approach, especially in large undergraduate classes. These challenges are mainly related to issues regarding working with limited resources, ensuring that student assessment is effective and students receive constructive feedback, increasing student throughput rates and ensuring that academically under prepared students receive required attention. Active classroom participation is regarded as one viable solution that could potentially mitigate the intensity of the stated challenges. Various strategies to encourage active classroom participation are identified and discussed.

However, the realities of large undergraduate classes seem to complicate the implementation of these strategies. As a result, some technologies that may ease the implementation of these strategies to facilitate active classroom participation are considered. One type of technological innovation, in particular, that shows great potential in this regard are cellular phones. The advantages thereof are optimised when used in combination with educational software applications.

2.2 Traditional teacher-centred approach

A traditional teacher-centred approach has been the dominant approach at higher education institutions for many years and was used by most lecturers. This approach is characterised by passiveness of students in their learning (Ayele, Schippers & Ramos, 2007, p.120; Raine & Collett, 2003, p. 41) where the locus of control in terms of learning remains with the lecturer (O`Neill & McMahon, 2005, p. 29). In this approach, the material is delivered to students by means of a lecture-based format (Carpenter, 2006, p. 14). But, these traditional lectures are considered to be ineffective for many students when conceptual understandings are constructed (Bonwell & Eison, 1991). Research on the promotion and effectiveness of quality learning by students exposed to lecture-based teaching is not encouraging (Bonwell & Eison, 1991; Johnson, Johnson & Smith, 1991; Meyers & Jones, 1993).

In a class environment where a traditional teacher-centred approach is followed, most students tend to unquestioningly write down what the lecturer writes on the board, says verbally or shows on PowerPoint slides. These students are not actively processing the information (Gibbs & Jenkins, 1992). Moreover, the lecturer is deemed as *the sage on the stage* since s/he is regarded as the only one who has the knowledge and needs to transmit it to the students (King, 1993, p. 30; Saulnier, 2009, p. 9). As a result, students tend to simply memorise information to reproduce it at a later stage in a test or an examination. This can be regarded as one of the main reasons why the practices of a traditional teacher-centred approach often result in surface learning (Xiaoyan, 2003, p. 54).

With surface learning, students accept new facts and ideas uncritically and attempt to store them as isolated and unconnected items (Biggs & Tang, 2007, p. 23;

Entwistle, 2000, p. 3). Characteristics exhibited by students who only keep to surface learning include the following:

- Focus on the most important topics or elements with the intention to memorise without understanding. This is also referred to as rote learning. (Biggs, 1988, p. 129; Kembler, 1996, p. 343);
- Passive absorption of information or learning material and failure to distinguish principles from examples (Biggs & Tang, 2007, p. 22-23; Greyling, Kara, Makka & van Niekerk, 2008, p. 179);
- Goal of learning is to pass the examination (McAllister, Lincoln, McLeod & Maloney, 1997, p. 8; Xiaoyan, 2003, p. 54);
- New material is not recognised as building on previous work (Shuell, 1993, p. 296);
- Knowledge is not retained long beyond the end of the term or course (Udovic, Morris, Dickman, Postlethwait & Wetherwax, 2002, p. 272);
- Mere recording of the learning material and no construction of own mental representation of the material to be learned (Shuell, 1993, p. 296);
- Perception of learning as a reproductive, rather than a constructive, process (Leung, Wang & Olomolaiye, 2008, p. 51). Students just memorise what they receive from a lecturer and do not try to make sense of information to create knowledge; and
- Acquired information is not interpreted based on existing knowledge and current needs. This often results in low level outcomes (Shuell, 1993, p. 296).

The teacher-centred approach also makes it difficult for individual students (especially in large entry-level undergraduate classes) to interact with a lecturer. This format also diminishes the importance of human interaction (Jungic, Kent & Menz, 2006, p. 2). As entry-level courses are normally content-heavy, fast-paced and impersonal, students are more likely to sit stone-faced in class and just take down notes on what the lecturer says (Gibbs & Jenkins, 1992, p. 28). In such large classes, students may also become demotivated to attend class, seek help in class or communicate with other students and the lecturer (Jungic et al., 2006, p. 2). This lack of interaction causes students to miss out on an important aspect of their learning. They do not get the opportunity to ask questions throughout the lecture, which could have helped them to grasp concepts under discussion. They forfeit the chance to keep up with the material being presented.

Efforts to reform education increasingly emphasise that the traditional transmission of knowledge from lecturer to student is no longer sufficient for the 21st century educated citizen (Magolda & Terenzini, 2010). The 21st century students are typically characterised by a willingness to engage in extra-curricular activities and a preference to work in teams. They also tend to prefer a structured learning environment that affords a fair amount of flexibility and are mostly comfortable in interacting with different racial and ethnic groups (Rodgers, Runyon, Starrett & Holzen, 2006, p. 3). Furthermore, the majority of students currently enrolled at higher education institutions were born after 1982 and are, therefore, regarded as being part of the *Net* generation (Tapscott, 1998). This generation demonstrates an enhanced use and familiarity with computer technology and new media (Wessels & Steenkamp, 2009, p. 1040). The abilities, expectations, preferences and learning styles of this generation not only reflect the environment in which they were raised, but also the environment in which they expect to learn. The 21st century curriculum uses the computer as the conduit for teaching and learning (Marold, 2002, p. 114) and hence compels students to use information and communication technology in their learning. Characteristics possessed by the Net generation coupled with the needs of the 21st century necessitate a change in the way teaching and learning was conducted for previous generations.

It becomes clear that a traditional teacher-centred approach is no longer the best paradigm to successfully meet the educational needs of 21st century students. There is a need to seek alternative teaching approaches that can help students to be more successful in their learning. One such an alternative is a student-centred approach.

2.3 Student-centred approach

A student-centred approach seems to be a promising teaching and learning approach that could potentially ensure quality teaching and successful learning for the 21st century generation. It is a broad orientation in teaching whereby knowledge is constructed by students and where the lecturer is a facilitator of learning rather than a presenter of information (O'Neill & McMahon, 2005, p. 28). Central to this approach is the notion that students are the centre of attention (Di Napoli, 2004, p. 3; Estes, 2004, p. 247).

There are several outcomes that transpire from implementing a student-centred approach:

- Students are allowed to be more open and more efficient in making decisions of their own (Darling, 1994, p. 116);
- Natural interactions between students and lecturers are ensured. This will break the psychological barrier of seeing lecturers as experts (Darling, 1994, p. 116);
- The social nature of learning is honoured (Johnson et al., 1991);
- Students become actively engaged in the process of their learning (Ayele et al., 2007, p. 120; Bonwell & Eison, 1991; Brown, 2008, p. 30) and
- Meaningful and timely feedback because of the focus on the explicit needs of students (Van Houten, 1980).

Since a student-centred approach promotes high student participation, it is most likely that this approach will also encourage students to become more actively involved in their own learning processes.

While a traditional teacher-centred approach often encourages surface learning, a student-centred approach is inclined to encourage deep learning. Higher quality learning outcomes may transpire as a result of being involved in deep learning (Xiaoyan, 2003, p. 53). When students are involved in deep learning, they exhibit several characteristics, such as:

- Effective involvement in searching for meaning and deeper understanding of the learning material (McAllister et al., 1997, p. 8);

- Tendency to approach knowledge and learning by relating new knowledge to previous knowledge (Entwistle, 2000, p. 3). In order to discover new knowledge, students explore new ideas and experiment with those ideas. This is also referred to as knowledge transformation;
- Active involvement and participation in the learning process (Brandes & Ginnis, 1986; Zhiming, 2004, p. 95);
- Increased knowledge retention and positive attitude towards the subject being presented (Johnson et al., 1991; Meyers & Jones, 1993);
- Vigorous and critical interaction with the learning content (Hartley, 1995, p. 150);
- Ability to relate knowledge between different courses or modules (Ramsden, 2003, p. 28);
- Capacity to link learning material to the real world (Slack, Beer, Armitt & Green, 2003, p. 307);
- Ability to understand learning expectations and perform self-assessment (Griffiths, Oates & Lockyer, 2007, p. 459); and
- Use of personal experience to make sense of new ideas and experiences and relating evidence to conclusions (McAllister et al., 1997, p. 8).

As deep learning encourages students to critically examine new facts and ideas, tie them into existing cognitive structures and make numerous links between them (Biggs & Tang, 2007, p. 24; Entwistle, 2000, p. 3; Ramsden, 2003, p. 28), it is invaluable to prepare students for the contemporary work place after graduation. However, it is not easy to implement a student-centred approach by which they attain these characteristics.

2.4 Challenges in implementing a student-centred approach

Both students and lecturers are faced with numerous challenges that complicate the implementation of a student-centred approach. These include limited resources, facilitating student assessment and feedback, increasing student throughput and dealing with academic under preparedness of students. This section focuses on how each of these challenges complicates the introduction of a student-centred approach in the 21st century classroom.

2.4.1 Limited resources

A student-centred approach creates opportunities for students to use the available resources effectively (De la Harpe, Kulski & Radloff, 1999). Effective resource utilisation may help students to perform well even though it may be limited. Lecturers also need to adapt their teaching approaches to the environment in which they are working because it is often expected from them to perform to the best of their abilities with limited resources. Although scarce means are a concern for all class sizes, it can become particularly serious for large class environments where a student-centred approach is employed. In the context of this study, resources refer to qualified lecturers, classroom space and funds needed to purchase sufficient equipment. The latter include desktop computers, classroom furniture, data projectors and whiteboards.

Over the years, the increase in the numbers of students to lecturers at higher education institutions was not proportional (Ballantyne, Hughes & Mylonas, 2002, p. 427). This is also evident in the student to lecturer ratio at the Department of Computer Science and Informatics at the UFS (Main Campus) from 2007 to 2009. The number of students increased from 1607 to 1984, while the number of lecturers rose from 12 to 14 (Van Biljon, 2010, p. 1). The implication is that the ratio of student to lecturer increase for this time period was approximately 189:1. As a result of such disproportional increases in the student-lecturer ratio, many fear that this will ultimately lead to a decline in the quality of higher education (Gibbs & Jenkins, 1992, p. 11; Jenkins & Daniel, 1993, p. 150). The decrease is more likely to happen, viewed from a teacher-centred approach and not from a student-centred approach. In the latter approach, students have clear learning goals and take responsibility for their own learning (De la Harpe et al., 1999), which is not the case in the former approach.

The existing infrastructure at most higher education institutions seems to be the main contributor to the limited resources. This can have further adverse effect, namely on the implementation of technology in the classroom. Some erected structures at higher education institutions were built a long time ago and were not designed with information technology in mind (Akbaba-Altun, 2006). In the 21st century, information technology has become pervasive in most peoples' daily lives (Lavin, Korte & Davies, 2008, p. 2). Students have a need to study in an environment that provides real life connections. For example, they need modern technology used at home for play, communication, etc. to also be conducive for learning purposes. Therefore, if lecturers are to teach using new technologies, it would be expected from higher education institutions to invest in the necessary hardware and software (Casey, 1995; MacNeil & Delafield, 1998, p. 297). This includes the installation of network points in classrooms, expansion of physical classroom space and the set-up of desktop or laptop computers in classrooms. Unfortunately, the lack of financial and planning resources is in many cases regarded as the main inhibitor to implement technology in the classroom (MacNeil & Delafield, 1998).

Furthermore, resource problems associated with large classes have been found to vary across disciplines. For courses with rapidly changing content such as Computer Science, it is difficult for libraries to have enough up-to-date resource books for all students, and this causes high competition for limited books. Large classes also pose problems in courses (like Computer Science, Nursing, Chemistry, Geography, Physics and Biology) where students are required to complete practical components in laboratories. Most of the time, student overcrowding is experienced in the laboratories. Such courses coupled with large classes, therefore, necessitate organised and systematic ways of administration (The University of Queensland, 2001). According to Ayele et al. (2007, p. 120), it is more difficult to implement a student-centred approach with large numbers of students than when a teacher-centred approach is followed. It is, therefore, necessary for lecturers to seek ways in which the resources problem, coupled with large numbers of students, can be mitigated.

It is clear that the shortage of resources poses a huge challenge to the successful implementation of a student-centred approach. The lack of adequate resources makes it almost impossible for lecturers to focus effectively on the needs of individual students. It is, therefore, indispensable that lecturers should adapt their teaching to the environment in which they are working, amidst the limited resources. To still equip students with high quality skills and knowledge under such circumstances will be difficult, but needs to be sought.

2.4.2 Student assessment and feedback

Assessment is defined broadly to include all activities that lecturers and students undertake to obtain information that can be used diagnostically to alter teaching and learning (Black & Wiliam, 1998, p. 140). It includes observations made by a lecturer, class discussions and the analysis of student work (including assignments and tests) (Boston, 2002). Valid and effective assessment of student learning is a complex and challenging task (Harris et al., 2007; The University of Queensland, 2001). Although the challenge of assessing students is prevalent with lecturers irrespective of the size of a class, the intensity of this challenge increases significantly in large classes where a student-centred approach is employed. It then becomes necessary for lecturers to seek more effective ways in which student assessment can be facilitated in a student-centred environment. The facilitation of assessment in such environments may be easy or challenging depending on the motives of a lecturer.

If a lecturer tries to give as few assignments and tests as possible and s/he does not care how the overall assessment grade of the course accumulates, then assessment may be easy, but insufficient. In an attempt to make assessment easier, such a lecturer might revert to asking multiple choice questions, which are less time consuming to set and mark (Chan, 2008; Harris et al., 2007; Merritt, 2006; Simkin & Kuechler, 2005), instead of essay type questions. If students have to reason in essay format, understanding of the content needs to be present and this forms the basis to engage in this type of assessment. On the contrary, if they have to choose an answer (as with multiple choice questions), they can simply memorise the information without thinking about it or they may even guess a correct answer. This, according to Ayele et al. (2007, p.119), is to employ quick and easy assessment methods and favours a traditional teacher-centred approach which is likely to lead to surface learning.

On the other hand, a passionate lecturer who is aware of the profile of his/her students (e.g. slow, average or fast learners) and wants to lift students to more or less the same level will be more concerned to give a decent number of assignments and tests within the possible timeframe. This type of lecturer is likely to ensure that all the assessment tasks are systematically aligned with the learning outcomes of the course (Biggs & Tang, 2007, p. 7). S/he will ask questions that require students to apply concepts, learned in class, in a way that reflects the students' understanding of the concepts. The students may also be asked questions that require them to critically analyse problems. In this way, students do not just use cramming as a study technique because they need to affirm that they understand the content as well. For students to understand the content adequately, they need to seek meaning and deeper understanding of the learning material. In that way, they will be able to apply their knowledge and understanding which will result in deep learning. As questions that require critical analysis are not easy to formulate and difficult to mark (Reiner, Bothell, Sudweeks & Wood, 2002, p. 11), assessment is likely to be a much more challenging task for a passionate lecturer.

Assessment is further complicated by the fact that for students to learn better, they must be given feedback in a timely manner (Mehvar, 1999, p. 352). Students also need to receive realistic feedback (Boyapati, 2000, p. 365) that will help them achieve the critical and other cognitive outcomes that characterise deep learning. But to give detailed feedback is highly time consuming and often regarded as almost impossible for classes with large numbers of students (Hauske, Aschoff & Schwabe, 2007, p. 1571; The University of Queensland, 2001). As a result, some lecturers do not give feedback in such a way as they are supposed to or they try to limit the time they spend on feedback by giving as few assignments and tests as possible. This practice encourages surface learning because students are not exhaustively examined and are not given enough opportunity to apply their knowledge.

Moreover, when class sizes become larger, there is a tendency to move away from the extensive use of written assignments and efficient, effective forms of feedback towards various other forms of assessment (The University of Queensland, 2001). Provision of multiple forms of assessment is regarded as one of the advantages of the student-centred approach (Ayele et al., 2007, p. 120). One of these alternative assessment strategies is self-assessment. This form of assessment is regarded as the key element in empowering students. Not only does it give students an opportunity to reflect on their own progress towards instructional objectives, but it also helps them to determine the learning strategies that are most effective for them. This will assist them to develop plans for their future learning (O'Malley & Pierce, 1996, p. 3). In a student-centred approach, students understand the learning expectations and are encouraged to use self-assessment measures (Griffiths et al., 2007, p. 459).

When a large class is comprised of a diverse group of students, assessment is further complicated. A study conducted by Harris et al. (2007) identified three key challenges that lecturers commonly encounter when they assess a diverse student group. They experience challenges when assessing:

- students with diversified knowledge backgrounds and interests relating to the field of study;
- international students and those from language backgrounds other than English; and
- students with different levels of motivation and engagement when it comes to learning.

In an attempt to overcome these challenges, a lecturer has to put in additional effort to assist all the students and advise them accordingly on the entire higher education learning process.

Issues raised in this sub-section coupled with the fact that student-centred learning focuses on the actions of the individual student (O`Neill & McMahon, 2005, p. 33), illustrate why assessment is often regarded as difficult in such an environment. To overcome these challenges, lecturers need to look at innovative ways in which they can facilitate student assessment and feedback. In such a way, the results of this process are more likely to help students perform well academically and lead to high quality education.

2.4.3 Student throughput

Student throughput has long been a critical issue for higher education institutions. The increase of student throughput at undergraduate level was listed as one of the priorities in a five-year national plan for higher education in South Africa. This plan was introduced in 2001 by the Department of Education (2001a). Integral herein is the notion to increase undergraduate output (also known as undergraduate throughput) in order for more of the students to successfully complete their studies within the prescribed time. An increase in student throughput will not only help to reduce class sizes (especially on first-year level), but will also ensure that the current demand for high-level managerial and professional skills is met (Department of Education, 2001a).

Since the implementation of a new funding formula in 2004 by the South African Department of Education, higher education institutions have been under even more pressure to increase student throughput (Council on Higher Education, 2010, p. 3; Jaffer et al., 2007, p. 132). According to this formula, undergraduate throughput is regarded as a main factor when the funding of an institution to be received from government is determined (Department of Education, 2001a, 2001b). Despite various initiatives from institutions to increase undergraduate throughput, the problem of large classes (especially on first-year level) still remains a reality. According to Ayele at al. (2007, p. 120), it is more difficult to implement a student-centred approach with large numbers of students. Nevertheless, lecturers at higher education institutions are expected to increase student throughput irrespective of the type of approach employed in teaching or the numbers of students they are dealing with.

There is an on-going debate on the effect that class size has on the academic performance of students. According to Toth and Montagna (2002), studies on the relationship between class size and student performance have identified conflicting results. Some studies (Hancock, 1996; Kennedy & Siegfried, 1997) maintain that there is no relationship between class size and student performance, while other studies (Arias & Walker, 2004; Borden & Burton, 1999; Gibbs, Lucas & Simonite, 1996; McKeachie, 1980, p. 27) favour small class environments. These mixed results may be attributed to the varying criteria used to gauge student performance and class sizes.

Kennedy and Siegfried (1997) assert that small classes provide no advantage over large classes when traditional achievement tests are used. However, it appears that small classes hold an advantage when additional performance criteria such as long-term retention and problem-solving skills are used (Arias & Walker, 2004, p. 311-314; Gibbs, Lucas & Simonite, 1996). In a large class environment, students are more likely to perform badly due to a lack of student engagement and lecturer-student interaction in the learning process. This contributes to reduced student throughput (Greyling et al., 2008, p. 182).

The South African government`s efforts to reward higher education institutions for satisfactory student performance should be regarded as an incentive for institutions to increase student throughput. But, before institutions can reap these benefits, lecturers will have to seek more innovative ways in which student throughput can be increased. This is especially true for large groups of students in a student-centred environment.

2.4.4 Academic under preparedness

One of the main factors that attribute to the unsatisfactory levels of student throughput at higher education institutions are the academic under preparedness of students (Nzimande, 2009). Under prepared students can be regarded as those who have some areas of academic skill deficit or whose higher education readiness skills do not adequately prepare them to be successful in their higher education studies (Dzubak, 2005, p. 2; Dzubak, 2009). According to Dzubak (2009), many under prepared students often overestimate their academic readiness and are unaware of the areas in which they need to strengthen their skills. For these students, lecturers often have to put in extra hours to guide them to identify their weaknesses and help them to improve their inadequate skills.

The challenge of dealing with under prepared students is further complicated when combined with a student-centred approach in a large class situation. When a student-centred approach is followed, the lecturer already has to focus on the needs and abilities of individual students by examining how they learn, what they experience and how they engage with their learning (Murphy & Rodriguez-Manzanares, 2009). These are all very time consuming tasks which may lead to lecturers not having additional time in large classes to attend to the needs of the under prepared students.

In the current education environment, where different institutions (in both basic and higher education) subscribe to different educational standards, this challenge is unlikely to go away soon. In the meantime, lecturers need to seek and implement innovative strategies that will enable underprepared students to also interact with the learning material on the same level as their peers.

2.5 Addressing challenges in implementing a student-centred approach

The four challenges discussed in Section 2.4 are likely to result in a deterioration of the quality of higher education which will ultimately affect students in a negative way. Therefore, a feasible solution that creates more opportunities for deeper learning needs to be found within the given frameset. Hauske et al. (2007, p. 1571) assert that these challenges cannot be counter-acted with personnel intensive solutions. Examples of these solutions include splitting up classes (Li, 1993, p. 89). These solutions are not viable, because they would require additional financial and human resources which are likely to be unavailable at most higher education institutions. One of the possible ways in which the stated challenges could be mitigated would be through encouraging students to become actively involved in their own learning processes. This may require the creation of a conducive learning environment that permits students to interact vigorously and critically with the learning material. Such an environment may also encourage students to construct their own body of knowledge and retain it for longer. These are some of the characteristics of the student-centred approach that may ultimately lead to increased successful learning.

For students to be successful in their learning, there are several principles of good practice that need to be incorporated in the courses that students are enrolled for.

Chickering and Gamson (1991, p. 63) suggest seven such principles. They determined these good practices as contact that is encouraged between students and lecturers; reciprocity and cooperation that develop among students; active learning being promoted; prompt feedback been given; time on task being emphasised; high expectations communicated and diverse talents and ways of learning respected. Although all of these principles are important, this study mainly focuses on the attainment of successful student learning based on the principle that encourages students to engage in active learning.

Active learning is defined as "an umbrella term that refers to several models of instruction that focus on the responsibility of learning on learners" (Wilson, 2008, p. 1). It is based on the idea that students who actively engage with the learning material are more likely to recall information at a later stage (Bruner, 1961). University education increasingly requires students to engage actively in their own learning experiences in order to be successful in their studies (Hillyard, Gillespie & Littig, 2010, p. 9). Extensive research reveals that active learning encourages learners to develop skills to solve problems; think critically through debate teams and critical incidents; manipulate learning materials; analyse, synthesise and evaluate the information in an effective way; seek solutions to case studies or dilemmas; respond to simulations and make informed decisions (Egan & Gibb, 2002, p. 37; Felder & Brent, 1996; Hankin, 1997; Jones & Safrit, 1994). These aspects lead students to acquire a body of knowledge that is retained long beyond the completion of a course.

Various authors (Gelisli, 2009; Hillyard et al., 2010; Ransdell & Gaillard-Kenney, 2009) regard active classroom participation as a vital element to ensure successful student learning experiences. The environment in which active classroom participation is enforced may encourage students to be involved in most activities in class. This may lead students to perform well. Nevertheless, active classroom participation is not easy to practically enforce in a large class environment. One challenge in this regard is that most students who enter into higher education today are principally used to passive learning (Dzubak, 2009). Many of these students assume that the same passive learning methods they followed with success during their high school education (Dzubak, 2009) will also be sufficient to ensure success in their higher education studies.

In the face of the four challenges discussed in Section 2.4, the effective implementation of active classroom participation plays an important role to mitigate their effects on both students and lecturers. The sub-sections that follow provide a discussion of how active classroom participation can be used to lower the intensity of each of these challenges. This may help lecturers to meet students' individual needs and create opportunities for deeper learning, resulting in increased successful student learning.

2.5.1 Coping with limited resources

By participating actively in class, students are more likely to engage in higher-order thinking tasks such as analysis, synthesis and evaluation of the learning material (Bonwell & Eison, 1991). Considerable knowledge may be shared if the lecturer encourages these students to work in teams. Team work will enable students to share the resources necessary to complete class activities. For example, if students have to use their cellular phones or text books to do class activities, the group members owning cellular phones or text books may share with the other members who do not have phones/books.

According to Egan and Gibb (2002, p. 34), to achieve clarity through organisation and planning is one of the student learning variables that contribute to effective and meaningful learning. They assert that one way to achieve clarity is by lecturers segmenting their sessions into manageable and interesting sections. These have often been referred to as lecturettes (Cyrs & Smith, 1992). Lecturettes are a mix of explanations; illustrations and questions; and are generally followed by student tasks which are activity-oriented. If a lecturer resigns, and students stay for some period without a lecturer, they may regularly interact with these lecturettes (by analysing, synthesising and evaluating the learning material contained in the lecturettes) if they are active participants in their learning. They will still ultimately perform well.

If students participate actively in class and are encouraged to work in teams, a lot of knowledge may be shared. Furthermore, by being exposed to the lecturettes, actively participating students will be able to continue with the class work even when there is a shortage of lecturers.

2.5.2 Facilitating student assessment and feedback

Active classroom participation may lead to mitigation of the intensity of the challenge to facilitate student assessment and feedback. Students can be given as many assignments (that require them to reflect on the concepts learned in class) as possible. They are then compelled to work on the assignments and submit them. A lecturer may not necessarily mark the assignments, but may give a "1" to students who submitted, and a "0" to students who did not submit the assignment. Both Gibbs (1992) and McKeachie (1999) argue that formal assessment can be minimised by replacing it with informal assessment methods. Examples are non-graded assignments and tests; provided they address the course objectives. The amount of time that a lecturer has to spend to work through each student's assignment is reduced and students simultaneously exercise their critical and analytical skills in the assignments. The lecturer has to adapt and simplify the learning material or assignments as necessary. The material can be aligned to the goals and objectives of the course in question.

Active classroom participation encourages an open culture that helps students to be transparent, even to a lecturer. Egan and Gibb (2002, p. 37) identified some variables that can help students in their learning process. They entail *inter alia* to use feedback to promote learning and to employ teacher immediacy behaviour which fosters interaction. Feedback is important to students as it indicates how well they understood the topic and presented their assignment (McDowell, 2007, p. 240). It also helps students to create meaning from what they have learned (Egan & Gibb, 2002, p. 37). Appropriate feedback that reflects on the accuracy of students' work and deters them from learning facts that may have to be unlearned later helps them to develop in their learning experiences (Angelo, 1993; Van Houten, 1980). Lecture immediacy behaviours (Sanders & Wiseman, 1994) are also necessary in the instruction of a course. These behaviours are interaction encouraged by lecturer's approachability and positive affective outcomes fostered in students (Egan & Gibb, 2002, p. 37). Open culture may help a lecturer to get verbal feedback from students about their attitudes on his/her mark allocation.

If students participate actively in class, they are likely to adopt the practice to do as many assignments as possible. Students are encouraged to be as open as possible to both their peers and lecturers in an open classroom.

2.5.3 Increasing student throughput

Various authors (Biggs, 2003; Gibbs & Jenkins, 1992, p. 17; Hauske et al., 2007, p. 1571) agree that students are more likely to perform well if they participate actively in class. Quality education is more likely to transpire when the chosen teaching and learning approach effectively encourages active classroom participation. This statement is further supported by French and Coppage (2000, p. 69) who believe that any innovative teaching and learning approach requires complete student classroom participation. Various researchers (Ayele at al., 2007, p. 120; Brandes & Ginnis, 1986; Zhiming, 2004, p. 95) regard active involvement and participation in the learning process as the main characteristic of a student-centred approach that fosters deep learning.

Moreover, actively engaged students do more than to listen to a lecture, be alert or pay attention in class (Egan & Gibb, 2002, p. 37). Instead they ask questions, engage in group discussions, share personal experiences in relation to the topic, volunteer to demonstrate some activity and do assignments. Tewksbury and Macdonald (2005) believe that actively engaged students should observe, speak, write, listen, think, draw and do. By actively participating in asking questions (speaking), group discussions (listening, thinking and speaking), sharing of experiences (speaking), demonstrating class activities (speaking and doing) and working on assignments (thinking and doing), students can enhance their critical thinking and learning abilities (Ayele et al., 2007, p. 120). Students who engaged in these tasks will most probably perform well. This could result in increased student throughput.

Effective implementation of active classroom participation requires learning experiences that promote engagement rather than passivity. One form of student-centred teaching that encourages active participation is based on the principles of constructivism (Ayele et al., 2007, p. 120). In constructivism (which is regarded as a more modern view of learning), students are expected to play an active role in constructing their own knowledge (Hein, 1991; Jonassen, 1995a; Krause, Bochner & Duchesne, 2003; Schauble, 1990). Students who acquire the body of knowledge when they construct it by themselves are more likely to do well in their assessments. This could ultimately lead to increased student throughput.

According to Carpenter (2006, p. 14), studies concerning the effectiveness of teaching methods favour constructivist active learning strategies. De Caprariis, Barman and Magee (2001, p. 10) also suggest that while a lecture leads to the ability to recall facts, a discussion is likely to lead to a higher level of comprehension. If students understand the learning material, they should be able to critically apply the knowledge they gained during their studies to solve real life problems.

2.5.4 Dealing with academic under preparedness

In an attempt to address the problem of under preparedness, various South African higher education institutions offer support programmes to selected students. One challenge associated with support programmes is that they are very resource intensive (Jaffer et al., 2007, p. 134). If active classroom participation is effectively implemented in support programmes, the classes could be facilitated by the lecturer and managed by students who better understand the work. This practice is referred to as *developing learning communities*. This is a variable that contributes to student learning (Egan & Gibb, 2002, p. 36).

Learning communities are groups of students who meet face to face or through electronic means. These groups provide students with opportunities to teach one another, clarify course-related questions and assignments, receive academic and social support and develop relationships that extend beyond the duration of the course (Egan & Gibb, 2002, p. 36). Due to the necessity of continuing interaction between lecturers and students to clarify information, it is vital that lecturers facilitate the organisation of such learning communities (Verduin & Clark, 1991). In this way, under prepared students can get a lot of assistance from their peers through interaction in learning communities. This can create more time for lecturers which they can use to assist other under prepared students.

Learning communities and support programmes can help students, especially those who are under prepared, to have a broader perspective on learning issues. Exposure to learning communities may encourage students to share their ideas or problems with the participants in the community instead of a lecturer, as the only source of information. If the support programmes are run by their peers, students may feel free to expose their skill deficiencies or areas where they have problems. The handling thereof will be more flexible (sociable and friendly).

2.6 Active classroom participation – Implementation strategies

There is a myriad of instructional strategies that can be used to encourage active classroom participation. Such strategies include think-pair-share, one minute paper, affective response, ConcepTest, the fish bowl, finger signals and send-a-problem.

2.6.1 Think-Pair-Share

According to the think-pair-share strategy, a lecturer assigns a question or a problem to students. S/he then instructs students to first think silently and independently about the question and to individually write down their answer. The time that individual students spend working alone is important, because it encourages students to be actively involved with the question and it helps students to develop their own answers. When the lecturer signals, each individual student pairs with a neighbour to discuss the answer. Depending on the type of prompt, students may compare their two answers and justify or rationalise the differences in their solutions. After allowing students to discuss their answers with one another, the lecturer may call on a few pairs to share their opinions or answers with the entire class (Carss, 2007, p.32; McTighe & Lyman, 1988, p.19).

2.6.2 One Minute Paper

The one minute paper is a highly effective strategy for checking student progress, to see if they understand the key concepts and how they react to the course material. This is done to ensure that learning objectives are met. According to this strategy, the lecturer asks students to take a blank piece of paper. S/he then poses either a specific or open-ended question and gives the students one minute to respond (Angelo & Cross, 1993, p. 5-7; Chizmar & Ostrosky, 1998, p. 3-4; Ludwig, 1995; Stead, 2005). Although the responses to a one minute paper are normally not marked (Northern Illinois University, 2004, p. 1), they provide the lecturer with an opportunity to obtain regular feedback from students that can help him/her to improve his teaching (Chizmar & Ostrosky, 1998, p. 3). It rests upon the discretion of the lecturer to give students perhaps two minutes, but not much longer is recommended (Paulson & Faust, 2002).

2.6.3 Affective response

Though not very different from the one minute paper strategy, affective response is a strategy where students are asked to report their reactions to some facet of the course material. An emotional response to, or value judgement of, the material has to be given (Paulson & Faust, 2002). Examples of value judgements (also known as affective states) include interest, boredom, break taking, arousal, frustration and quitting (Burleson, 2006, p. 16). This strategy can help a lecturer to identify the type of course material that students like as well as dislike. Based on this knowledge, the lecturer can seek innovative and interesting ways in which such material can be presented in future.

2.6.4 ConcepTest

The ConcepTest strategy was developed by a Harvard physics professor (Mazur, 1997) to provide a mechanism to introduce effective pedagogy into large undergraduate physics teaching without acute changes to course content or organisation. Following this strategy, students vote for answers to multiple-choice questions. These questions are asked after the lecturer presents a short lecture. Typically, the duration varies from 5 to 15 minutes. The questions focus on one key concept from the learning goals for a class (Crouch, Watkins, Fagen & Mazur, 2007,

p. 9-11; Mazur, 1997; Mestre, Gerace, Dufresne & Leonard, 1997; McConnell, n.d.). The voting gives the lecturer an opportunity to examine student knowledge before s/he proceeds with subsequent tasks. The lecturer asks questions that are intended to challenge students. Students are then prompted to confront the critical concepts that they need to understand in order to succeed with their studies (McConnell, Steer & Owens, 2003, p. 208). Figure 2.1 provides a schematic representation of the ConcepTest strategy.

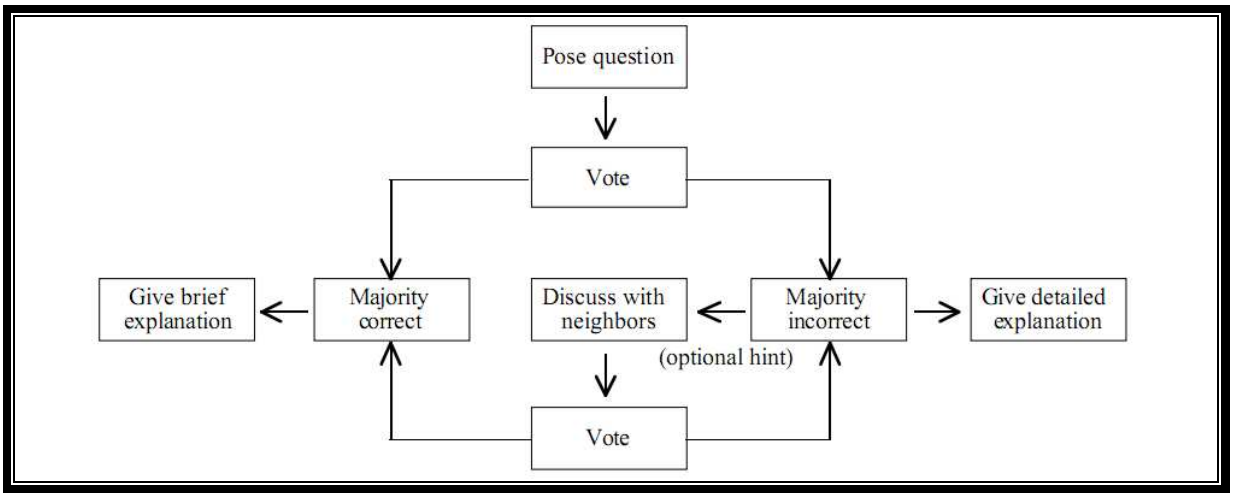

Figure 2.1:

Figure 2.1: ConcepTest Process *[Source: Ellis, Landis & Meeker (n.d.)]*

According to Ellis, Landis and Meeker (n.d.), if the majority of the students voted for a correct answer, the lecturer provides a brief explanation on the concept in question. Otherwise, the lecturer provides a detailed explanation of the concept. If the majority of the answers are incorrect, it is optional for the lecturer to ask students to discuss the answer with their neighbours. They then vote again and the same process is repeated. This strategy helps the lecturer to obtain immediate feedback on the level of class understanding.

2.6.5 The Fish Bowl

By means of the fish bowl strategy, a lecturer issues index cards to students and asks them to write down one question. These questions should typically seek clarification on an aspect of the learning material which students do not fully understand or the practical application of course material. At the end of the lecture, or at the beginning of the next lecture (if the question is assigned as homework), students deposit their questions into a fish bowl. The lecturer then draws several questions out of the bowl and answers them or asks the class to answer them (Kennedy, 2007, p. 186-187; Paulson & Faust, 2002).

2.6.6 Finger signals

The finger signals strategy provides lecturers with the means to test student comprehension without the waiting period (or the grading time required) associated with written quizzes. The lecturer asks the students a series of questions and instructs them to signal their answers by immediately holding up an appropriate number of fingers related to their selected answer in front of their torsos. This makes it impossible for students to reproduce the same answer as their peers and obliges them to answer each question on their own.

The lecturer, for example, may say: *one finger for true, two fingers for false*, and then ask questions such as: *A recursive data structure is an object or class that contains an abstraction of itself. True or false?* Alternatively, the lecturer may have multiple choice questions incorporated in PowerPoint slides with numbered answers (for example from 1 to 7). S/he then asks students to answer with finger signals. In very large classes, students can use a set of large cardboard signs with numbers written on them. This method allows lecturers to assess student knowledge literally at a glance (Paulson & Faust, 2002).

2.6.7 Send-a-Problem

According to the send-a-problem strategy, students work in groups and each group is given a different problem to solve. Each group then writes down the solution to their problem and places it in a file folder. On the cue of the lecturer, each group passes the file folder together with their problem to the next group. Each group then works on the solution of the new problem without looking at the previous group's solution, records their solution and places it in the same file folder. Until time is called by the lecturer, they again pass the problem to the next and new group. Students in the final group will review and evaluate all the solutions. As a closure activity, groups conclude and report the best solution to each problem to the entire class (Barkley, Cross & Major, 2005; Boon, Hong & Swee, 2006; Millis and Cottell, 1998). As a result of this strategy, students have an opportunity to enhance teamwork and communication skills. These skills may ultimately result in enhanced student performance.

Although all the active learning strategies discussed in Section 2.6 are designed to encourage active classroom participation, large class sizes may complicate the implementation thereof. There is also the added challenge that students may show some resistance towards these strategies (Cooper, MacGregor, Smith & Robinson, 2000, p. 68-69; Svinicki, 2006). According to Moore, Fowler and Watson (2007, p. 51), one way in which students' resistance to accept responsibility for learning can be mitigated is to actively guide them to understand why a particular approach to pedagogy underpins a learning experience. They further assert that an explanation given to students that interactivity in class will help them develop the skills needed to apply knowledge in real-world settings often enhances participation. It also encourages a basic understanding of the process.

Lecturers need to seek innovative ways in which these strategies can be successfully implemented in large classes. One possible solution is to make use of technological tools to assist with the implementation of the strategies.

2.7 Nature and role of technological tools to implement active classroom participation strategies

There are various existing technological tools that can help to manage the implementation of active classroom participation strategies in large classes. For this discussion, the types of tools are grouped into three categories, namely student response systems, web-based student response systems and mobile phones.

2.7.1 Student response systems

A student response system can be described as “technology that allows an instructor to present a question or problem to the class, allows students to enter their answers into some kind of device and instantly aggregates and summarises students’ answers for the instructor” (Beatty, 2004, p. 2). Normally, students purchase a portable, wireless, handheld response pad (a TV-remote-sized gadget also known as a *clicker*) as part of the required study resources for the course. In class, a lecturer can pose a question verbally or through a computer onto a projector or television screen. Students respond by entering their answers on the clicker. In most cases, the infra-red clicker response is read by a receiver in the classroom. There are some student response systems that require a network connection in order for the students' responses to be sent back to the lecturer's computer (Dufresne, Gerace, Leonard, Mestre & Wenk, 1996; Koppel & Berenson, 2009, p. 4-5). The results are then formatted into digital graphics that are integrated into PowerPoint presentations. Lecturers then share the results with the class (Beatty, 2004; "Clicking for scholars", 2005; Draper & Brown, 2004; Sciandria, 2007; Simpson & Oliver, 2007).

Student response systems enable students to actively participate (DeBourgh, 2008, p. 76) in an anonymous way in class (Martyn, 2007, p. 75). Behind the cloak of anonymity, students can answer and voice their opinion. They are protected, because it is not possible for peers to pair their fellow-students with strange or foolish ideas or wrong answers. Students can also privately respond to sensitive, ethical, legal and moral questions. It is also argued that student response systems can impact positively on the learning success of students (Jones, Henderson & Sealover, 2009, p. 2; Meedzan & Fisher, 2009). Student response systems create a more dynamic and collaborative atmosphere in the classroom (Boone, 2008). Such an atmosphere is likely to encourage critical thinking, creativity, peer discussion and willingness to actively participate in class. However, the successful implementation of student response systems (unlike websites, PowerPoint or even learning management systems such as Moodle and Blackboard) depends less on the lecturer and more on the student. The intention of the implementation is not just to change the mode of communication between lecturers and students or to make information more readily available. But more does it require a change in the culture of the classroom environment (Trees & Jackson, 2007, p. 37-38).

2.7.2 Web-based student response systems

A web-based student response system is a specific, but exclusive, type of student response system. Within this system, laptops are used in the place of TV-remote-sized clickers. This system was used at Edith Cowan University to provide learning opportunities to students who had to learn in large class environments (Oliver, 2007, p. 791-792). It allows a lecturer to display a web page which presents a question or an activity that requires a response from the students as a group (the audience). Students respond to the question or activity through wireless enabled laptops. When the lecturer refreshes the screen or page, the students' responses are displayed. Web-based student response systems provide several advantages in comparison to the student response systems. While synchronous interactions are key in student response systems, activities performed with the web-based student response system also support asynchronous interactivity. This system has a life beyond the immediate classroom setting and enables students who did not attend the class to participate at a later stage. Large distance, as well as face-to-face classes are supported by this system.

2.7.3 Mobile phones

Applications classified as mobile phones mainly communicate through the use of text messages. These messages are either sent to or received from the application by means of mobile phones. Such applications include Mobile learning tool, StudyTXT and TXT-2-LEARN.

Mobile learning tool (MOLT) is a Windows-based application that was developed by Nadire and Ibrahim (2009). The aim of this development was to determine the potential of mobile phones usage in teaching new technical English language words to first-year undergraduate students. This experimental study was conducted at Near East University in the Department of Computer Information Systems. *MOLT* consists of a single graphical user interface-based display. Prior to use, the start and end dates, as well as the times of the experiment have to be entered to this interface. Once the experiment starts, the application runs throughout the experimental period and terminates at the requested date and time. Before the application is run, a text file (*Messages.dat*) that stores the messages to be sent to all the students, and a file (*Phones.dat*) that stores the mobile numbers of all the students who are participating in the experiment, are created. *MOLT* is configured to read a new message from *Messages.dat* and send this message as a short message (SMS) to all students participating in the experiment. Students are able to read the received messages from anywhere, provided that they have their cellular phones with them. Results obtained from this study were positive and favoured this mobile phone-based teaching system. All study participants expressed their satisfaction and enjoyment to learn outside the classroom with the help of their mobile phones. The drawback of *MOLT*, according to its developers, is that it is uni-directional and student responses, feedback or answers to particular questions cannot be received and processed by the lecturers.

StudyTXT is a mobile phone on-demand study support system that was used at Auckland University of Technology to maximise learning through the use of mobile devices (Mellow, 2005). Students can access SMS knowledge bytes of information about their course and review them in their own time and at any location. These text messages are hosted on a gateway server and directed into the mobile network. It is made available through a short code that students enter into their mobile phones (Apple Corporation, 2006). Key in this educational application is the *study anywhere* feature. Students normally have downtime during their day (e.g. taking a break at work or when they commute on a train to and from their institution, etc.) in which they may not want to engage in traditional study methods (e.g. turning the pages of a text book) due to brevity of the time available. Initially *StudyTXT* was regarded as a content delivery system and a form of rote learning. Since it was developed, ways to make it more interactive have been created to incorporate the principles of constructivism (Mellow, 2005, p. 471-474). A main shortcoming of Mellow's (2005) study was that there is no obvious direct link between improvement in student academic achievement and the use of *StudyTXT*.

TXT-2-LEARN (text-to-learn) is a short-message-services (SMS)-based classroom interaction system that was developed by Scornavacca, Huff and Marshall (2007). This system comprises of a mobile phone that is connected to the lecturer's laptop on which an SMS management tool (SMS Studio) is installed. Its development was based on the assumption that most students have SMS-enabled mobile phones and that they bring them to class. The student users of this system can submit questions or comments to the lecturer's laptop by means of SMSes and submit answers to multiple choice quizzes. The lecturer can read the messages on the screen and decide to respond immediately or wait until later. The lecturer can also provide a quiz to the students and collect results via *TXT-2-LEARN*. Students can view the projector's screen to see real-time graphics which show the results. The feature of *TXT-2-LEARN* that allows students to send an SMS to the lecturer during class is regarded as the most important one because it enables the possibility of instantaneous feedback, as well as adaptive learning and teaching. Through the use of this system, student participation is increased and better quality feedback affirmed. The noted drawbacks of this system are that students have to pay for the costs to send SMSes when they use it and that it may be overwhelming for lecturers to interpret large numbers of text messages during class sessions.

All the technological tools discussed in Section 2.7 are used to encourage active classroom participation in undergraduate classes. Although the implementation platforms differ (desktop-based, web-based and mobile-based), these tools can all be regarded as different types of student response systems. The subsequent section provides two principal challenges when student response systems are used, and it aims to justify why mobile-based technology is the most viable option to use when active classroom participation is to be encouraged.

2.8 Use of mobile-based technology to encourage active classroom participation

Research (Beckert, Fauth & Olsen, 2009; Meedzan & Fisher, 2009; Trees & Jackson, 2007; Watkins & Sabella, 2008) suggests that student response systems can be used in various ways to encourage active classroom participation. As with most technologies, student response systems have challenges associated with time and cost. The time factor relates to the time required to set up and dismantle the hardware (Stuart, Brown & Draper, 2004, p. 100); to learn to use the software (Hatch, Murray & Moore, 2005, p. 39) and for lecturers to design effective questions (DeBourgh, 2008, p. 11). The cost factor is associated with the costs involved to acquire, use and set up this technology (Kenwright, 2009, p. 76). To offset these costs, some institutions make it compulsory for students to buy clickers as part of their required study resources (Immerwahr, 2009).

Of the two challenges, the cost factor seems to be the principal problem that institutions which use a student response system are faced with. In order to avoid additional costs, it may be viable to investigate alternative options that make use of more readily available technologies. The technology device that first comes to mind is a cellular phone (mobile phone). These devices are readily accessible to students as most of them own and actively use them (Corbeil & Valdes-Corbeil, 2007). A survey conducted by the e-Learning Division of the University of the Free State in 2007 indicated that 96 per cent of all first-year students at the UFS main campus own a cellular phone. It is estimated that 97.1 per cent of these cellular phones are WAP-enabled (Blanche, 2009, p. 3).

WAP "is the technology that makes it possible to link wireless devices (such as mobile phones) to the Internet by translating Internet information so [that] it can be displayed on the display screen of a mobile telephone or other portable device" (Benmoussa, 2005, p. 98). This relates to students that log onto websites using their cellular phones and mobile web pages that are transferred to those phones. These pages are then displayed on the small screens of the cellular phones. These phones with a certain mobile application can replace clickers. Students can access this application from their cellular phones. The question is not if such applications will be incorporated into teaching and learning, but rather how effectively they can be used to encourage active classroom participation in 21st century classrooms. The use of such applications to achieve this goal is inevitable. An added benefit is that they are already in existence in a variety of forms (as discussed in Section 2.7).

To investigate the suitability of such applications to achieve the goals for which they were developed, they need to undergo usability evaluation. User-based methods such as questionnaires and interviews are examples of the existing usability evaluation methods (Adebesin, de Villiers & Ssemugabi, 2009, p. 6). According to Adebesin et al. (2009), conventional software is frequently used by professionals and business people in the work place, while educational applications are used by students who should be able to use the application before they can start to learn with it. This affirms that educational applications should be easily usable to support the student learning process. Consequently, when usability of an educational application is evaluated, pedagogical usability is also exceptionally important to consider.

Pedagogical usability refers to the evaluation of aspects of an educational application (such as tools, content and interface) and how it supports various students in their learning process (Silius & Tervakari, 2003, p. 1-9).

It emerges from the above discussion that there are some technologies that can be used in combination with customised applications to encourage active classroom participation. When a combination is considered, one has to be aware of the time and cost factors prior to implementation. These factors should be reduced to the minimum. There is also a need for such technologies/applications to be evaluated to ascertain whether they achieved the aim for which they were developed.

2.9 Conclusion

The chapter aimed to illustrate the need for a pedagogical shift towards a more student-centred approach in a technologically enhanced teaching and learning environment. It justified why the shift is vital for successful learning of students. Several challenges have been identified that can potentially derail the successful implementation of a student-centred approach, especially when confronted with large classes. Active classroom participation has been identified as a viable solution to address these challenges.

From the discussion in this chapter, it can be deduced that there are specific aspects which should be observable in a classroom environment to encourage active classroom participation. These include: lecturer-student interaction – including the increased asking of questions without fear (see Sections 2.2 to 2.5) or anonymous response conditions (see Section 2.7); student engagement with learning material (see Sections 2.4 and 2.5); better performance (see Section 2.5); increased positive attitude towards the course (see Section 2.3); critical thinking (see Sections 2.3 to 2.7); and the sharing of information/ideas/experiences (hereafter called “knowledge sharing”) (see Sections 2.5 and 2.6).

Although there are several existing strategies that can be used to encourage active classroom participation, these strategies are not easy to implement in large classes. Therefore, an educational application, especially one that involves the use of mobile devices such as cellular phones is recommended to encourage active classroom participation in large classes. It has been illustrated how these mobile devices can be used in combination with educational applications. The use of such technological tools has the potential to create a technology enhanced and conducive teaching and learning environment. It is suggested that the usability of educational applications is evaluated in order to ascertain whether they really support students in their learning process. The usability evaluation of educational applications is discussed in more detail in Chapter 3.

Chapter Three:
Technical and pedagogical considerations in evaluating mobile learning applications

3.1 Introduction

As mentioned in Section 2.8, the usability evaluation of educational applications should not only consider technical usability, but also pedagogical usability (Lim & Lee, 2007, p. 68; Silius, Tervakari & Pohjolainen, 2003, p. 3). Consequently, this chapter comprises of a comprehensive literature review that aims to provide perspectives on the following issues:

- Directives from literature on technical and pedagogical aspects which should be considered when the usability of mobile learning applications and similar applications is evaluated. Special focus is placed on those aspects that aim to encourage active classroom participation.
- Usability quality criteria categories and metrics used to measure both technical and pedagogical usability of mobile and similar learning applications.

The chapter starts off by discussing various usability evaluation methods. The discussion then moves to the general concept of *usability* and identifies three technical usability quality criteria categories, namely effectiveness, efficiency and user satisfaction. The previously identified usability metrics are then classified and discussed under these three categories. The focus shifts subsequently from technical to pedagogical usability and justification of why it is also necessary to consider pedagogical usability in the evaluation of educational applications is provided. Pedagogical usability metrics are then selected and discussed. With the identification of these metrics, more emphasis is put on those that are likely to enhance active classroom participation. This is followed by a discussion of previous usability studies conducted on mobile learning applications. The chapter culminates in a summary of all the usability metrics deemed relevant for this study.

3.2 Usability evaluation methods

In order to determine whether an application or product is usable, usability testing can be conducted (Preece, Rogers & Sharp, 2007, p. 646). Usability testing was a dominant approach in the 1980's (Whiteside, Bennett & Holtzblatt, 1988). It is defined as a "systematic way of observing actual users trying out a product and collecting information about the specific ways in which the product is easy or difficult for them" (Dumas & Redish, 1993, p. 12). In a broader context, Preece et al. (2007, p. 646) refer to usability testing as an approach that examines and emphasises how usable a product is. It determines whether an application or product meets a pre-defined and quantifiable usability level when a specific user performs specific tasks using that application or product (Lee, 1999). To determine the usability of an application, one or more of the following methods can be used:

- *Observing users* – Users are observed directly (direct observation) and very carefully by the investigator as they perform their activities using the software application. The observation can also be conducted indirectly (indirect observation) through recording users' activities and by reviewing them at a later stage (D'Hertefelt, 1999; Krug, 2000, p. 153; Preece et al., 2007, p. 595).
- *Asking users their opinions* – Authors such as Dix, Abowd, Beale and Finlay (2004, p. 348) and Ardito et al. (2004) refer to this method as a query technique. They affirm that this technique is based on the philosophy that the best way to identify usability problems of an application is to ask the user directly. Users are first given an opportunity to use the software application. Thereafter, the investigator asks them for their views on their experiences in using the application. The users' views can be gathered through questionnaires, focus group discussions and interviews (using open and/or closed ended questions) (Preece et al., 2007, p. 595).
- *Asking experts their opinions* – This is also referred to as heuristic evaluation. Nielsen and Molich (1990, p. 249) define heuristic evaluation as "an informal method of usability analysis where a number of evaluators are presented with an interface design and asked to comment on it". They assert that heuristic evaluation aims to identify the usability problems in the design of an application or product. Attention can then be given to these problems in an

iterative design process. According to Dix et al. (2004), a heuristic evaluation allows for a set of questionnaires in which users have to share opinion(s) regarding their experience whilst they interact with the application.

- *Testing users' performance* – Users are given a specific task to perform. Time and quantity are normally the two measures. For example, how long does it take a typical user to find a specific element in the application or how many (quantity) errors does a user make when s/he performs a certain task in the application? (Dumas & Redish, 1993; Preece et al., 2007, p. 595; Rubin, 1994).
- *Modelling user's task performance* – In this method, models such as GOMS (Goals Operators, Methods and Selection rules) and keystroke level are used to predict the efficacy of an interface or compare performance times between different versions of the application (Preece et al., 2007). The GOMS model was first proposed by Card, Moran and Newell (1983), and was developed as an attempt to model the knowledge and cognitive processes involved when users interact with the software application. The keystroke level model is the daughter model of GOMS and it differs from the original model because it is able to provide actual predictions of user performance (Preece et al., 2007).

The first three of these methods normally involve observation studies, questionnaires and interviews (Preece et al., 2007, p. 595). One method or a combination of two or more may be used in the usability evaluation of a software application. Since this study is principally concerned to measure the usability of a software application through the use of appropriate methods, it is necessary to also discuss the general concept of usability.

3.3 Concept of usability

All software applications are developed to accomplish a specific goal. In order to achieve this goal, there are specific tasks that a user needs to perform on the application. The performance level and the extent to which an application is usable are determined when the user performs tasks using that particular application. Of these two measures, usability is regarded to be more important than performance (Cinque, Cacace, Crudele, Lannello & Bernaschi, 2005, p. 115). Usability is a significant factor in the quality of software applications that helps to alleviate difficulties that people encounter when they interact with technology. It plays a fundamental role in the success of software applications (Matera, Rizzo & Carughi, 2006, p. 2). Over the years, various definitions of usability have been proposed. These definitions vary according to the models they stem from (Matera et al., 2006, p. 4). For example, the usability of websites differs from the usability of desktop applications.

The International Standards Organisation (ISO) (1998, p. 2) defines usability generally as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. However, there are many attributes that are associated with usability. Booth (1989) identified four attributes, namely usefulness, effectiveness, learnability and attitude (likeability) while Constantine and Lockwood (1999) identified five attributes. They are satisfaction, learnability, rememberability, reliability and efficiency in use. Preece et al. (2007) expanded the definition with six attributes, namely effectiveness, efficiency, safety, utility, learnability and memorability. A similar perspective is shared by Nielsen (1993) who identified five usability attributes. They are efficiency, memorability, low error rate or easy error recovery, learnability and satisfaction. It is deduced that usability is a multidimensional construct, and may be measured in a variety of ways based on the perspective followed (Jeng, 2005, p. 48).

It is also important to be cognisant of the existing layers of usability. These are the technical, general, academic and context-specific layers (Muir, Shield & Kukulska-Hulme, 2003, p. 191). The technical usability layer is concerned with common functional usability problems. The general usability layer refers to overall human-computer interaction while the academic usability layer implies broad educational issues. The context-specific usability layer is concerned with contexts of specific disciplines and the learning activities undertaken within those disciplines. Research (Kukulska-Hulme & Shield, 2004; Muir et al., 2003) shows that the technical usability layer is the basis on which the other three levels are built. In order to measure usability within each of these layers, various usability metrics have been defined.

3.4 Usability metrics

Usability metrics can be regarded as efficient measures of usability of a certain product or software application. Tullis and Albert (2008, p. 7) define a metric as "a way of measuring or evaluating a particular phenomenon or thing". They assert that all usability metrics must be observable either directly or indirectly. Various usability metrics to develop usability guidelines for different software applications exist. Originally developed in collaboration with Molich in 1990 (Molich & Nielsen, 1990; Nielsen & Molich, 1990), Nielsen (1994a, p. 30) identified a set of usability heuristics that made the development of usability guidelines for user interface design possible. These heuristics are: the visibility of system status; the match between the system and the real world; user control and freedom; consistency and standards; error prevention; flexibility and efficiency of use; aesthetic and minimalist design; assistance to users with recognition, diagnosis and recovery from errors; recognition rather than recall; and support and documentation.

Studies on usability of software applications conducted after the work of Nielsen (1994a, 1994b) used his usability heuristics as a basis to develop new usability guidelines. Based on his experiences and partly on Nielsen's (1994a) set of usability heuristics, Cogdill (as cited in Preece et al., 2007, p. 689-690) identified seven usability heuristics. Guidelines to evaluate websites were developed from these. They are internal consistency, simple dialog, shortcuts, minimising the user's memory load, preventing errors, feedback and internal locus of control. These heuristics are effective usability metrics.

It is evident that there are different sets of usability metrics that researchers may use during a usability study. These metrics have the ability to assist researchers to establish usability guidelines for the development of software applications. Human computer interaction researchers mainly use already established usability metrics and guidelines to evaluate software applications. Based on usability metrics, with specific cognisance of the layers of usability (see Section 3.3) and general usability that does exclude technical usability, the following section discusses technical usability. Thereafter, various technical usability metrics are identified and discussed.

3.5 Technical usability

The concept of technical usability in software application design and usability engineering is very broad (Hadjerrouit, 2005, p. 1139). Technical usability involves methods to ensure that any user interaction with a software system or application is trouble-free (Melis & Weber, 2003, p. 282). This implies that the interaction is free of problems that interfere with users' tasks, cause stress or reduce performance. The interaction occurs at the user interface. The user interface is defined as the part of the system or software application which the user can see, hear, touch, understand or direct (Galitz, 2002, p. 4). Kang and Lee (2003, p. 121) regard the user interface as a "communication tool between man-made machines and humans" as it provides the visual and operational means for interaction between the user and the computer (Redmond-Pyle & Moore, 1995). To most users, the user interface is the entire system (Bankston, 2003, p. 5; Galitz, 2002, p. 1; Mayhew, 1999). Technical usability refers to components that constitute the user interface in order for the system or application to be effective, efficient and satisfactory to most users.

The extent to which each of the usability attributes (effectiveness, efficiency and satisfaction; hereafter referred to as *quality criteria categories*) is accomplished for a particular application can be measured by technical usability metrics.

3.6 Technical usability metrics

A large body of research (Chalmers, 2003; Chin, Diehl & Norman, 1988; Henninger, 2000; Lin, Choong & Salvendy, 1997; Nielsen, 1993; Preece et al., 1994; Preece, Rogers & Sharp, 2002; Shneiderman, 1998; Tognazzini, 2003) recommends a number of usability metrics to evaluate the technical usability of software applications. In the following sub-sections, the various technical usability metrics are grouped and discussed according to the three quality criteria categories (effectiveness, efficiency and satisfaction) in the ISO's (1998) definition of usability.

3.6.1 Effectiveness

Effectiveness refers to the accuracy and completeness with which users are able to achieve certain goals while using a system (ISO, 1998). It is explained as how good a system is at doing what it is supposed to do. It refers to the degree to which such a system provides the right kind of functionality to help users do what they need or want to do (Preece et al., 2007).

It is not easy to directly measure the effectiveness of a software application (Ramezan, 2009, p. 130). Most of the time, this measurement needs to be quantified. Contemporary literature (Mayhew, 1992; Nielsen, 1993; Whiteside et al., 1988) identifies effective measures as percentage of tasks completed, ratio of successes to failures, workload and number of features or commands used to complete a certain task. Talib and Abdullah (2010, p. 184) add extra measures, namely quality of solution and error rates. They regard the quality of a solution as a measure of the user's interaction with the software application.

Effectiveness is normally measured by assigning similar task(s) to all participants involved in a usability test. In a study to test the usability of an e-learning system, Adebesin et al. (2009, p. 10) assigned the task shown in Figure 3.1 to participants.

Task 1:

- From the title page go to **menu**.
- From the main **menu page** go to "**Karnaugh diagrams**" sub menu.
- You are required to study the learning content presented in this section and do the associated exercises.

Figure 3.1: Example of a task list for usability testing

For the task depicted in Figure 3.1, effectiveness was measured by the number of mouse clicks, errors, repeated errors, calls for help and correct answers. Seffah, Donyaee, Kline & Padda (2006, p. 164) believe that effectiveness can be derived from the quantity and quality of task output. They assert that effectiveness measures whether users succeed to achieve their goals when they work on the system. Effectiveness of a system is indicated by its ability to deliver the expected results.

It has already been mentioned that the number of features or commands users use to complete their assigned tasks on the application is one of the measures of effectiveness. It is deduced that a software application that accommodates both novice and experienced users when shortcuts are used is effective. This is the result of experienced users who prefer to use shortcuts and novice users who have a tendency to follow conventional steps when they perform tasks (Brinkmann, 2010). Users who use shortcuts deploy a fewer number of features or commands than users who follow the conventional steps to complete a task. Preece et al. (2007, p. 690) are especially concerned with design, and argue that the interface of any software application should be designed to accommodate both novice and experienced users. Based on this discussion, it is concluded that effectiveness can be measured by the percentage of completion of the assigned task and the frequency of user errors while using a software application.

3.6.2 Efficiency

Efficiency refers to the accuracy and completeness of goals achieved in relation to available resources (ISO, 1998). Preece et al. (2007, p. 21) view efficiency as the way in which an application supports users to carry out their tasks. Indicators of efficiency include time to complete a task, time to learn how to perform a task, time spent on errors, percentage or number of errors, frequency of help or use of supportive documentation and number of repetitions or failed commands (Mayhew, 1992; Nielsen, 1993; Whiteside et al., 1988). In view of the above, efficiency can be measured in terms of the following seven usability metrics:

3.6.2.1 Internal Consistency

In order to quickly complete a task, software applications must be clear and not confusing to the user (Preece et al., 2007, p. 689). The components of the user interface should be placed in a consistent way across the application (Stone, Jarrett, Woodroffe & Minocha, 2005, p. 174). Chalmers (2003) ascertains that high ability students need less organised user interfaces than low ability students. It is further added that applications common to both a desktop and mobile device should appear similar. For example, when synchronising an Excel worksheet on a desktop device, the same type of interface needs to be on a mobile device (Tremlett, 2005, p. 8). One can examine the consistent placement of user interface components of an application under investigation when internal consistency is measured.

3.6.2.2 Error handling and prevention

Designers of a software application should be ultra-careful during the design of a software application to prevent errors from the start. But if errors do occur, users should be provided with clear and explanatory messages. It is important to either eliminate error-prone conditions or to monitor these conditions. Users should be presented with a confirmation option before they commit to an action (Nielsen, 1994a). The error messages should be clear on what is wrong and the possible steps are (if any) to correct the problem (Nielsen, 1990; Shneiderman, 1998). If error prevention is guaranteed, the percentage of errors that users encounter may be low. This could predict high efficiency for such an application. A usability study is thus able to measure whether a software application provides users with the relevant error messages when necessary.

3.6.2.3 Learnability

Learnability refers to how easy an application is to learn to use (Preece et al., 2007, p. 22). An application that is difficult to learn only has value for those users who are willing and are able to spend time to master it. An application that is impossible to learn is worthless to any user (Nokelainen, 2004, p. 3). In order to measure learnability in a usability study, it is vital to determine if it is “possible for users to work out how to use the application by just exploring the interface and trying out certain actions as well as how difficult will it be to learn the whole set of functions in this way” (Preece et al., 2007, p. 22). It becomes obvious, therefore, that in a usability study, learnability can be only be tested over time and can, therefore, produce different results at different times. This is because at first, users evaluating the learnability attribute on an application may not be familiar with it and hence may be negative. When users are more familiar with the application, they may be positive about the learnability attribute.

3.6.2.4 User’s memory load

Users are at their best recognising items, whilst a computer is better suited to remember data (Nielsen, 1993, p. 129). The working memory of humans often contains 7±2 memory slots (Miller, 1956, p. 63). This means that, on average, a human being stores between five and nine items at a time in his/her memory. This has the implication that the user interface is suitable for most users if only the essential features are visible at first level. Nielsen (1993) believes that the more available information is synchronous, the longer it takes for the user to process it and make decisions. Minimising the complexity of a system is an efficient way to prepare for individual differences in information processing (Norman, 1988). An interface should be designed in such a way that users are not required to remember information from one part of the dialog to another (Preece et al., 2007, p. 690). A usability study is able to measure whether an application forces users to use a lot of memory to remember items or data.

3.6.2.5 Display problems

Mobile device users are unable to use a significant part of information when included in the software application, especially if such application is web-based (Harper, 2008). The problem associated with a mobile device when used in combination with web-based applications is that it either cannot display a website at all, or it cannot display the website in a size that fits its screen. In addition, the mobile device might be able to display the website, but it may be difficult for users to interact with that website (Collier & Dahanayake, 2008) due to the limited number of keys or buttons available on the device.

When people acquire mobile devices, they accept a small screen size which allows that the device is portable. With mobile applications, it is important to ensure that the height and width of the display area does not exceed that small screen size (Fetaji, 2008, p. 1396). This guideline is directly linked to Gafni’s (2009) mobile wireless usability metric. It evaluates whether the length and format of the outputs are minimised to fit the screen size of the mobile device. According to Kaikkonen and Laarni (2002, p. 228), the small screen display with short lines, slows down the speed of reading because it disrupts the normal pattern of eye movement. Indirectly, it affects human interaction.

Interface cluttering or overload is a usability metric that can also be measured when a software application of a mobile device is evaluated. Kukulska-Hulme and Traxler (2005) assert that the use of a lot of information on a mobile interface does not follow good practice. The reason is that it does not only confuse novice mobile users, but also slows down expert users. The *less is more* rule is essentially practical to apply in a limited display area. While it is important to only include the most relevant information on a mobile interface, care should be taken not to fragment the intended message. The most important information is normally placed at the top-right corner in order to ease readability. Empty and blank spaces can also mislead and confuse users if not designed with great care (Fetaji, 2008, p. 1396). In a usability study, one can, for example, measure whether users have to scroll either horizontally or vertically in order to view all the text in an application.

3.6.2.6 Data entry and viewing

Most mobile phones are not equipped with a keyboard or a mouse. Users are, instead, required to enter values using a limited 12-button keypad (Wigdor, 2004). Some smartphones and PDAs have touch screens and a stylus that provide higher precision in data entry. Due to the mentioned smaller screens, the display of mobile devices is almost always very small. The result is that it makes data viewing and entry more difficult. The display is further complicated by web pages which are designed for display on conventional desktop size displays because they have large screens for viewing (Jones, Buchanan, Thimbleby & Marsden, 2000; Rabin & McCathieNevile, 2008). Despite the creation of new and innovative input devices for mobile devices (Wu, Chang & Chen, 2009), it is generally easier to work with input devices designed for a desktop computer. In a usability study can, the degree to which it is easy to enter and view data on a mobile device can be measured.

3.6.2.7 Navigation

In the context of this study, navigation refers to the number of clicks to scroll horizontally on a page and the number of clicks required to view a page. Although navigation may be a minute concern for applications that run on desktop computers, it cannot be ignored in applications that run on mobile devices.

In mobile applications, it is important to arrange information in such a way that it reduces page scrolling because of the small screen and input limitation in mobile devices (Hua & Ping, 2007). In a mobile environment, users have limited time and cognitive resources to spare to perform tasks (Chan et al., 2002, p. 190). Mobile users are typically less interested in lengthy documents or browsing (Rabin & McCathieNevile, 2008). The ergonomics of the mobile device is mostly unsuitable to read lengthy documents. Users often only access such information from their mobile devices as a last resort because more convenient access is not available at that moment. Content for web-based mobile applications, therefore, needs to be adapted according to the device used. This implies that text needs to be summarised and text length needs to be limited. But the main idea must not be lost. If a website requires extensive scrolling and several clicks to navigate through its web pages, mobile device users may regard the website user unfriendly or unusable (Collier & Dahanayake, 2008).

Most mobile devices allow access to functions and services through a series of complicated hierarchical menus (Jones et al., 2000, p. 674). It is not possible from a conventional approach to show users a complete list of possible options within the small screen display area of a mobile device. Gafni (2009) recommends that there should be specific menus for each possible operation to ease operations for users. Menus also facilitate users' interactivity with interfaces. Hua and Ping (2007, p. 322) believe that mobile web interfaces should be customised adequately to allow easy interaction for improved efficiency.

Chan et al. (2002, p. 197) indicate that expert and novice users might expect different interface designs and content for mobile devices. It is, therefore, important to allow for variation amongst different users because they have different usage patterns, preferences and skill levels (Gong & Tarasewich, 2004, p. 3755). To allow for variation among different users in an application is important because the application has to be configurable according to the user at any stage (Gafni, 2009). If an experienced user, for example, prefers to use shortcuts rather than to follow the conventional steps to perform tasks, the application should allow that. Gafni (2009) recommends that ease of navigation (an Internet system metric) needs to be measured with a mobile-wireless application. The ease with which users are able to navigate through the application is one way to measure the navigation metric in a usability study.

3.6.3 Satisfaction

Satisfaction refers to the users' comfort with the system and their positive attitudes towards its use (ISO, 1998). User satisfaction can be measured by rating the usefulness of the product or service, the user's satisfaction with functions and features, the number of times a user expresses frustration or anger, task user control versus technological control of that task and the perceived degree to which the technology supports the tasks (Mayhew, 1992; Nielsen, 1993; Whiteside et al., 1988). It can be measured in terms of the following three usability metrics.

3.6.3.1 Internal user control and freedom

The discussion in this sub-section refers specifically to the usability heuristics, namely internal user control and freedom as termed by Nielsen (1994a). Users should have a feeling that the software operates for them when they use an application, and not the other way round (Lin, Choong & Salvendy, 1997; Shneiderman, 1998). Squires and Preece (1996) believe that the application should be so intuitive that no help would be needed when users interact with it. Users should also be free to carry out some tasks without fear that they will break the system or some parts of it. It needs to be easy for users to reverse their actions if they find themselves in an unwanted state. Emergency exits need to be present to move to the desired states. This creates a good opportunity for users to learn how to use the application without any external coaching or training. User control on the tasks performed with an application and the ability of a software application to support tasks as needed by users can both be regarded as indicators of user satisfaction.

It emerges from this discussion that internal user control and freedom can be measured if users are free to use the concerned application or have some fear that the application may crash as they use it. This indicator can also be measured by investigating whether the specific application allows users to perform some tasks or activities at a later stage if they have not completed them within the expected time.

3.6.3.2 Memorability

Another important measure of satisfaction is memorability. This refers to users who can return to the system after a period of non-use without needing to relearn everything (Holzinger, 2005, p. 72). Users should not have to relearn how to carry out tasks when they use the application after an interrupted period. Users should also be helped to remember how to perform tasks. It is necessary to provide meaningful icons, command names and menu options. If options and icons are properly structured and positioned within relevant categories, it helps users to remember where to look for a particular tool in a specific stage of the task (Preece et al., 2007). Software application users may be more satisfied if they are able to locate specific features of an application with ease. The measure whether the interface of the application enables users to easily remember how tasks and activities are performed can be exerted in a usability study.

3.6.3.3 Accessibility

In a study to evaluate the usability of a virtual learning environment, Nokelainen (2004) identified accessibility as one of the components of technical usability. Accessibility can be regarded as a measure of satisfaction because it may frustrate students if they have to use an application, but it is not easily accessible. Nokelainen (2004) asserts that the learning material is of no value to the student if s/he is not able to access and use it. According to Ambler (2001), an application is more likely to be accessible if the needs of real users are priority during design and implementation. Preece et al. (2007, p. 694) stress that various users, such as older users, users with disabilities, non-English speaking users and users with slow Internet connection, must be able to access the basic content of an application. One way in which an application's accessibility can be measured, is to determine the ease with which users access it.

3.6.4 Summary of technical usability metrics

Upon investigating the various technical usability metrics, the researcher identified those metrics that might be relevant to this study. Table 3.1 provides a summary of the selected technical usability metrics, with an indication of how each metric can be measured together with the quality criteria category that it belongs to.

Table 3.1: Usability quality criteria categories, technical usability metrics and measurement

Usability quality criteria category	Metrics	Measurement
Effectiveness	Percentage of tasks completed	The percentage of tasks completed using the application.
	Error rate	The frequency with which users encounter errors when using the application.
Efficiency	Time to complete a task	The time to complete tasks with the application.
	Internal consistency	The extent to which user interface components are positioned in a consistent way across the application.
	Error handling and prevention	The number of errors encountered in using the application.
	Learnability	The extent to which it is possible to use the application by just exploring its interface.
	User's memory load	The extent to which users are not required to remember information from one part of the dialog to another.
	Screen display	The degree to which the length and format of the outputs are optimised to screen size (area).
	Data entry and viewing	The ease or difficulty with which users enter and view data.
	Navigation	The navigation that users have to do to perform their tasks with the application.
Satisfaction	Internal user control and freedom	The control a student has in using the application.
	Memorability	The extent to which features of the application are placed in their relevant categories to help students perform their tasks.
	Accessibility	The degree to which the application is accessible to users.

The other layers of usability (general, academic and context-specific) as discussed earlier (see Section 3.3) are based on technical usability. This implies that these layers may be evaluated independently from technical usability. According to the definitions of Muir et al. (2003), it can be deduced that the academic and context-specific layers are closely related to the pedagogical requirements of the application.

But with the revision of the usability metrics summarised in Table 3.1, it is evident that none of them are specifically considering issues closely related to encourage students to be active participants in their learning process.

It can be concluded that it is insufficient to only consider technical usability when educational software applications are evaluated. Pedagogical usability is suggested to evaluate the extent to which these unique pedagogical requirements are addressed by these applications (Chang & Nguyen, 2006, p. 193; Lim & Lee, 2007, p. 68; Silius, Tervakari & Pohjolainen, 2003, p. 3).

3.7 Pedagogical usability

Pedagogical usability is the investigation of how various aspects of an educational application (e.g. the tools, content, tasks and interface) support different students in their learning process within various learning contexts according to learning objectives (Silius & Tervakari, 2003, p. 3). According to Lim and Lee (2007, p. 68), pedagogical usability should be especially concerned with educational aspects such as the learning process, purposes of learning, user's needs, the learning experience, learning content and learning outcomes. If students, for example, know the purpose of their learning and learning outcomes, they may engage in deep learning. They become aware that the knowledge they gain from their learning will have to be retained and applied at a later stage; even after the examinations.

Pedagogical usability can be divided into several categories. The three main categories identified by Silius, Tervakari and Kaartokallio's study (as cited in Silius, Tervakari & Pohjolainen, 2003, p. 2) are:

- Support for the organisation of teaching and learning;
- Support for learning and tutoring processes, as well as the achievement of learning objectives; and
- Support for the development of learning skills (e.g. interaction with others, growth of students' autonomy and self-direction).

These categories form the elements on which students can build to achieve their pedagogical goals. Previous research identified pedagogical goals in association with various learning applications. Amershi et al. (2005, p. 179) described the following five pedagogical goals which support the design of an interactive environment for computer assisted learning:

- Understand the target area in terms of the student;
- Support the different learning skills and levels of knowledge;
- Motivate and increase interest in the topic under discussion;
- Promote active engagement to use interaction tools; and
- Support the different learning scenarios, including demonstrations in classroom, homework and exploration.

All these goals are likely to result in successful learning for students. An educational application that, for example, supports students with varying learning styles may provide backing for novices and continue to provide support as the expertise of students increase. It also has to provide for individual learning pace. This means that students can learn at their own pace (slow, average or fast) with the use of the application. The concept of learning pace is vital for passionate lecturers who care about student assessment and feedback (see Section 2.4.2).

It is believed that in an educational application, an educational aid may be designed based on effective pedagogical principles. But for the application to be effective in the teaching and learning process, it has to satisfy the usability needs of both educators and students (Naps, Röβling & Working Group, 2003). Amershi et al. (2005) identified usability requirements that they regard as essential for educational applications. They regard such applications as usable if they are easy to learn, understand and use. Together therewith, the lesson must also be integrated into a course. This implies that when an educational application is developed, care should be taken to ensure that these usability requirements are met. An educational application that students struggle to use may discourage them to even start to learn with it. An application that is easy to learn, understand and use may immediately encourage students to engage with it in order to learn. If a lesson is integrated into a course, an educational application should allow for the customisation of lessons according to the plan of the lecturer. Balog, Pribeanu and Lordache (2007, p. 117) assert that an application has educational value if it is attractive, stimulating and exciting for students. They also recommend that tools and interaction techniques are enriched and improved in terms of speed and accuracy.

The above discussion considers most of the tasks which are necessary for students to participate actively in class, to support the organisation of teaching, to motivate students and to support different learning styles. These tasks can be incorporated within the active classroom participation strategies as discussed in Section 2.6. Kukulska-Hulme and Shield (2004) summarise this argument with their statement that pedagogical usability is a set of key considerations that need the buy-in of all those concerned. And the functionality of educational applications needs to be improved to support students in their learning process. The following section discusses a selection of pedagogical usability metrics and has the objective to identify those relevant to this study.

3.8 Pedagogical usability metrics

In order to build on tested pedagogical usability metrics, the need is identified to evaluate previous research on pedagogical usability. This includes research on usability evaluation of educational software applications. It is not easy to identify pedagogical usability metrics. The discussion will, therefore, focus on the usability guidelines from which these metrics are constructed.

3.8.1 Instruction

According to Lim and Lee (2007, p. 71), instruction in an online learning environment should be accurate and clear because students and lecturers are physically separated. This instruction should also be anchored in appropriate learning theories, present clear goals and objectives and learning content according to an appropriate sequence of learning. In a study that utilised wireless polling devices to enhance classroom participation, Heinich, Molenda, Russell and Smaldino (1996, p. 47) raised concerns about this educational application. One such concern was whether the application contains clear and concise language. This emphasises the importance to use simple instruction or language in an application used primarily for educational purposes. The use of such an application in class is likely to increase the interest of students in this application, and this may encourage students to participate actively by virtue of being interested in the application. A usability study is able to measure the language clarity of the application under evaluation.

3.8.2 Learning content

Lim and Lee (2007, p. 71) believe that for educational applications, content should match the purpose of the application. According to Heinich et al. (1996, p. 47), questions need to be asked whether the technology matches the curriculum. This viewpoint is consolidated by Trickel (2005) who mentions that the content of an application should be useful for educational purposes. It serves no purpose to include content in an educational application that is not relevant to the curriculum. Such applications can be regarded as useless because they do not address issues that support students in their learning process, hence discourage active participation in class. Their presence and use only confuse students and waste their time.

Furthermore, consequences are that students may not be effective, efficient and productive and that they may feel scared, frustrated and dissatisfied. Eventually, the understandability and learnability of a subject may suffer. This results from a learning application that has an insufficient design (difficult to use, to learn how to use and to remember how to re-use). A learning application that is not well designed usually also has a messy content structure and a workflow that is difficult to comprehend (Fetaji, 2008, p. 1395). Design is a technical issue, but may have a large impact on pedagogical usability of an educational application. If, for example, students struggle with the interface, it may be difficult for them to learn with the application.

Fetaji (2008, p. 1395) asserts that if the user interface is efficient and easy-to-use, the student will concentrate on the learning goals, content and activities, instead of struggling how to use the application. The content included in the educational application should be relevant to the purpose and student level. Such content should be organised in a clear, consistent and coherent way (Lim & Lee, 2007, p. 73). Relevant content and proper organisation of such content in an educational application are likely to create a conducive learning environment that encourages students to be interested in their learning and will increase willingness to participate actively.

Following from the above discussion, a usability study can measure whether learning content is well organised or structured in a specific application. Learning content relevance can also be measured to streamline the content according to the needs of the students.

3.8.3 Tasks

Tasks need to be designed to reinforce and promote self-directed, self-monitored and self-regulated learning (Lim & Lee, 2007, p. 71). With regard to the intention to use technology in education, Heinich et al. (1996, p. 47) raised the following two questions:

- Will the technology arouse motivation and maintain interest?
- Does the technology provide for student motivation?

These questions imply that the tasks that an educational application asks of students should be relevant to the learning objectives. An application that contains tasks that help students meet their learning goals is likely to stimulate their excitement in those tasks. The inclination of students may increase to engage actively in those tasks to do well in the specific subject. Those tasks may be measured with the objective to establish if their performance helps students to improve their understanding of the course material.

3.8.4 Learner variables

Learner variables is another aspect to be measured in software applications. Lim and Lee (2007, p. 71) define learner variables as personal information about the individual learners, their cognitive, affective and metacognitive domains. They further state that the following should be taken into account when students are encouraged to be more engaged in their learning and motivated: different learner variables such as age, gender, level of capabilities and previous knowledge, different learning styles, personalities, attitudes toward the target course, degree of self-direction, anxiety levels and different learning strategies. If students develop a positive attitude toward the target course through the use of an educational application, they may be encouraged to participate actively in class.

In précis, the content included in the application should be relevant to the target user group. A usability study can evaluate if a certain application is usable, and users will recommend it to their other counterparts with similar age, levels of capabilities, previous knowledge and attitudes towards certain courses at tertiary level.

3.8.5 Collaborative learning

Nokelainen (2004, p. 3) identified collaborative learning as a pedagogical usability component to consider with the evaluation of the usability of a virtual learning environment. The notion of collaborative learning is based on the idea that learning is naturally a social act whereby participants talk among themselves (Gerlach, 1994). Dillenbourg (1999, p. 2) defines collaborative learning as a situation in which two or more students learn, or attempt to learn, something together. The groups formed are each composed of students of different ability levels and use a variety of learning activities to improve the group's common understanding of the course material. Each member of a group is responsible to learn what is taught and to help other group mates to learn. This creates an atmosphere of achievement (Johnson & Johnson, 1993; Johnson, Johnson & Smith, 1998; Kagan, 1994; Shafritz, Koeppe & Soper, 1988).

It has been indicated that collaborative learning can have a positive impact on the academic success of students (Smith, Sheppard, Johnson & Johnson, 2005, p. 88). Academic success also follows if both lecturers and students are active participants in the learning process (Hiltz, 1994, p. 23). If students receive and respond to information acquired in class with collaboration and feedback from other students, they are encouraged to actively participate in class (see Section 2.5.3).

When an educational software application is used, such an application should provide students with tools to communicate and negotiate different approaches to a learning problem (Jonassen, 1995a, 1995b). It is possible to practice collaborative learning with the aid of computer-supported learning material. All students are, for example, connected to each other over distance. Online discussion groups and/or chat forums may be used (Quinn, 1996; Reeves 1994). A usability study can measure whether the activities of the application in question encourage discussion and collaboration amongst users.

3.8.6 Ease of use

Ease of use may also help students to participate more actively in class if it is well incorporated in an educational application. According to Khan (1997, p. 15), ease of use is one of the features associated with web-based instruction learning environments. An e-learning course, well designed with intuitive interfaces, can anticipate students' needs and satisfy their natural curiosity to explore the unknown. This capability can help to reduce the students' frustration levels and facilitate their learning environment. However, delays between an action requested from a student and the response time can contribute to the student's frustration levels. The hypermedia environment in an e-learning course allows students to explore and discover resources which best suit their individual needs. While this form of learning may facilitate the learning process, it should be noted that students may lose interest in a topic due to a wide variety of sources that may be available on an e-learning course. Information may sometimes not be accessible, because of common problems such as network breakdowns (Khan, 1997).

The ease of use of an educational application can also be measured by the extent to which a software application provides clear directions and descriptions of what students should do in their learning process (Khan, 2005, p. 149). Clear directions and descriptions in an application imply that it communicates smoothly to the users. Consequently, if such users are students they may be encouraged to participate more in class as a result of the usage of the specific application.

3.8.7 Learner control

In a study to evaluate the usability of a virtual learning environment, Nokelainen (2004, p. 3) identified learner control as an important pedagogical usability component to consider. Khan (1997, p. 14) also identified learner control as an outstanding feature associated with web-based instruction learning environments. In the context of using a software application, learner control is regarded as a characteristic of a computer program that allows students to make instructional choices (Filipczak, 1996; Schnackenberg & Hilliard, 1998). For example, learner control can be increased when a software application has a multi-option control button that allows students to work through lessons in any way or order that suits them. Or if they may select the level of difficulty of exercises they need to do. Learner control can support students in their learning process. It refers to the opportunity for students to sequence the objectives to be mastered within a particular course according to their own interests and preferences (Mayer & McCann, 1961; Mayer & Clark, 1963). This allows students to choose topics, assignments, project format, communication strategies and flow (or events) of instruction. Mayer and McCann (1961) and Mayer and Clark (1963) showed that if students are allowed sequence control over the objectives of a course, their study time is significantly shortened. At the same time, there is no loss to understand the course material.

When students learn new content, their memory should be stretched to an optimal level due to their limited memory capacity (Miller, 1956; Shneiderman, 1998). Although it is not easy to define a universally optimal level (as explained in Section 3.6.2.4), it is necessary to break down the material to be learned into meaningful chunks (encoding) (Wilson & Myers, 2000). Anderson and Krathwohl (2001, p. 67) refer to “breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organising and attributing” as one of the elements of cognitive process dimension, called analysing.

Other positive influences of learner control include:

- Encouraging critical thinking. Students are given control over their instruction and they are more likely to think about what they do as a result of choices and decisions they have to make along the way (Williams, 1996).
- Helping various students to structure the learning process according to their preference. Adult students may, for example, desire to set their own learning

pace, use their own style of learning, keep the learning strategy flexible and devise their own structure on the learning project (Penland, 1979).

- Increasing the involvement of students in their learning experiences and achievement (Williams, 1996).

It can be deduced from the above discussion that in a usability study, the learner control metric can be measured if these three aspects are evaluated. They make instructional choices possible to students, break the learning material contained in the application down into meaningful units and contribute to the degree to which the learning material in the application is interesting to students. As a result, it will encourage students to participate actively.

3.8.8 Motivation

Nokelainen (2004, p. 3) evaluated the usability of a virtual learning environment and classified motivation as a pedagogical usability component that can be measured independently. Motivation refers to “a student's willingness, need, desire and compulsion to participate in, and be successful in the learning process" (Bomia et al., 1997, p. 1).

Motivation has an enormous influence on the entire learning process and makes students behave the way they do in a given situation (Middleton & Spanias, 1999). Students who are motivated to effectively engage in their learning “select tasks at the border of their competencies, initiate action when given the opportunity and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during on-going action, including enthusiasm, optimism, curiosity and interest” (Skinner & Belmont, 1991, p. 3). Motivation generally contributes positively to the ability of students to solve problems (Yunus & Ali, 2009, p. 94).

There are several important concepts of motivation, which include incentives, self-regulation, expectations, attributes of failure and success, performance or learning goals, as well as intrinsic or extrinsic goal orientation (Reeves, 1994; Ruohotie & Nokelainen, 2003). Students who have an intrinsic goal orientation engage in learning-directed behaviour out of their curiosity and desire to achieve expectation of success and individual goals for learning (Forsyth & McMillan, 1991, p. 34). This behaviour compels students to reach learning goals for their own purpose because the material is interesting in itself. Students with an extrinsic goal orientation engage in behaviour that compels them to achieve better results than others (e.g. become the best student in class) in order to obtain an extrinsic reward (e.g. a scholarship) or to avoid punishment (e.g. repeating a course). Contextual motivation relates to the interest of the topic under study and it varies dynamically while general level motivation is more static. The latter may change according to stages of life (Nokelainen, 2004). A usability study can measure whether users are eager to take part in the activities that the application provides. It has the ability to investigate whether users prefer activities done on the application itself or if they want to do the activities with pen and paper.

3.8.9 Summary of pedagogical usability metrics

After all the pedagogical issues discussed in Section 3.8 were evaluated, the researcher was able to identify a selection of pedagogical usability metrics that are applicable to this study (see Table 3.2). This table also provides a description of what each of the usability metrics measures.

In order to measure the metrics indicated in Table 3.2, it is important to also consider other usability studies, particularly those conducted with the objective to create an environment that supports students in their learning. These studies indicate how mobile applications, similar to the one selected for this study, were evaluated.

3.9 Examples of usability evaluation of mobile learning applications

Literature contains several examples of research studies that evaluated the usability of mobile educational applications. This section examines two of these studies and provides insight on how the respective usability studies were conducted. The selected studies aimed to create an effective student learning environment with emphasis on the encouragement of active classroom participation.

Table 3.2: Pedagogical usability metrics and their measurements

Metric	**Measurement**
Instruction	Whether the application's instruction is clear or if it needs a lecturer's intervention.
Learning content relevance	The extent to which the content of the application supports students in their learning.
Learning content structure	The degree to which the content of the application is organised in a way [clear, consistent and coherent] that supports learning.
Tasks	The extent to which the tasks performed on the application help students to achieve their learning goals.
Learner variables	The degree to which learner variables are considered in the application.
Collaborative learning	The extent to which the application allows students to study in groups.
Ease of use	The provision by the application of clear directions and descriptions of what students should do at every stage when questions to the mobile class activities are answered.
Learner control	• The characteristics possessed by the application that allow students to make instructional choices. • The extent to which the learning material is broken down into meaningful units. • The extent to which the learning material in the application is so interesting to students that it compels them to participate.
Motivation	The degree to which the application motivates students.

3.9.1 Mobile Learning Prototype

Wahab, Osman and Ismail (2010) from *Universiti Teknologi MARA* developed a mobile learning prototype with the objective to engage students in a science subject in Malaysian schools. This prototype contained notes and exercises for one of the chapters in the syllabus. The researchers envisioned that such an application could be used as a revision aid to complement the use of textbooks and workbooks in classroom learning. The prototype allowed students to read notes during their free time. In addition to the *Read Notes* function, this prototype also had an *Exercise* function. Another important feature in this mobile learning prototype was the *Get Help* function which assisted users when they faced problems while using the application. The design of this prototype was based on the technological skill, learning capability and language proficiency of its target users.

Usability testing was used in the evaluation of this prototype. The researchers specifically employed the heuristic evaluation method, because of its flexibility and lower cost. Five usability experts (evaluators) were involved in the evaluation of this mobile learning prototype. The participants were a group of software ergonomics experts from a university (Wahab et al., 2010). The main objective of the researchers was to observe the reaction of participants towards the usability of the mobile learning prototype.

The participants were first required to perform three tasks. The first task was to read notes from the prototype. The researchers made observations on how participants navigated in the *Read Notes* function while they read the notes. The second task was to answer exercise questions based on the notes given previously. The questions were combinations of multiple-choice and fill-in-the blank type of questions. The third task was to read the *Get Help* function from the main menu. After completion of the three tasks, an interview was conducted with each participant. During the interview session, the researchers encouraged participants to give feedback and make suggestions on how to improve the mobile learning prototype.

3.9.2 M-Tik

Ariffin and Muthan (n.d.) developed and evaluated the functionality of a mobile learning application named M-Tik. This application helped students to learn the patterns and motifs of Malaysian traditional batik (as part of an Art and Design course). It was developed to provide an effective learning environment for students and to ensure they engage with mobile learning technology. This application was tested at the University Pendidikan Sultan Idris with 20 undergraduate students. M-Tik was evaluated for consistency. It seems as if query techniques were used in this study, although not stipulated explicitly in the study. For all the questions in the M-Tik' study's questionnaire, students had to use a 4-point Likert scale to indicate if they agreed or disagreed with the statements.

In the M-Tik application, consistency was measured by the following three aspects:

- The main interface's representation of the overall contents of the application;

- The consistency of the shape, size and colour of the letters; and
- The consistency and relevancy of the buttons' design.

Although consistency may be regarded as a technical aspect, M-Tik's consistency played an important role to provide an effective learning environment for students. According to Hadjerrouit (2005, p. 1139), technical and pedagogical usability are closely related to each other. Consequently, if the technical side is a mess, the pedagogical side may be affected adversely. It is important to ensure that the user interface is well designed to encourage students to use it in their learning.

3.9.3 mCLEV-R

Monahan, Bertolotto and McArdle (2009) developed an application called mCLEV-R with the aim to incorporate mobile users into an online learning community with their peers. This application also allowed such users to participate in synchronous learning activities with others and presented the three-dimensional graphical user interfaces for the learning tools to students. This application consisted of the following three components:

- A client-server architecture to support real-time communication technologies;
- An e-learning interface to allow users to connect to the application through desktop computers and laptops; and
- An m-learning interface to allow users to access the learning facilities through their PDAs.

The interface of the mCLEV-R application was presented to users through a series of webpages. The user evaluation examined the usability of mCLEV-R, users' attitudes towards the interface and its effectiveness for m-learning. Four tasks were designed to ensure that users were exposed to all the features of mCLEV-R in a variety of different learning scenarios. These tasks included:

- Social interaction to familiarise users with the communication tools that mCLEV-R uses;

- Online lecture to evaluate mCLEV-R by means of accessing and downloading learning content and exploring participation in synchronous online learning activities;
- Collaboration to allow users to explore the mCLEV-R tools. (These tools provided support for group learning activities such as project meetings or discussion groups); and
- Free session to ensure that users experienced all the different features of mCLEV-R and to observe ways in which users would interact informally within the learning environment.

The *After Scenario Questionnaire* was used for evaluating user satisfaction. In particular, ease of completing the task, time taken to complete the task and support information available when completing the task were evaluated. Other aspects which were evaluated on the application were overall usability, system usefulness, information quality and interface quality. All of these aspects were evaluated positively by the 12 users who were involved in the evaluation. Seventy-five per cent of the participants were university students who represented the target group of the application.

The discussion in Section 3.9 looked at three research studies that evaluated the usability of mobile educational applications. Focus areas of these studies include the aim, the methods employed, the population and setting of each of these studies. This discussion helps to give the researcher an idea on methods to use in this study and to justify research design choices.

3.10 Conclusion

This chapter aimed to identify the various technical and pedagogical aspects that should be considered when the usability of educational applications is evaluated. Specific usability quality criteria categories and metrics to use in measuring these aspects were identified. In an endeavour to address this aim, the chapter discussed topics that led to the identification of various technical and pedagogical usability metrics. These metrics were derived from contemporary literature that is relevant to this study. The discussion also considered a variety of usability evaluation methods to determine the most appropriate methods to be employed in this study.

Table 3.3 provides a summary of the usability metrics that were selected for this study, together with their levels. These levels help to rank the metrics. Level 1 metrics are the highest level metrics and level 3 metrics are the lowest level metrics. In order to effectively measure these metrics, they have to be broken down to the lowest level. The technical usability metrics have been classified into three quality criteria categories, namely effectiveness, efficiency and user satisfaction. For pedagogical usability metrics, there are currently no generally accepted broad classification categories.

Table 3.3: Summary of the selected metrics and their levels

Level 1 Metrics	**Level 2 Metrics**	**Level 3 Metrics**
Technical usability metrics	Effectiveness	• Percentage of tasks' completed • Error rate
	Efficiency	• Internal consistency • Error handling & prevention • Learnability • User's memory load
	User satisfaction	• Internal user control & freedom • Memorability • Accessibility
Pedagogical usability metrics		• Learning content • Learning content structure • Learner control • Instruction • Tasks • Motivation • Collaboration • Ease of use • Learner variables

Chapter Four:
Research methodology

4.1 Introduction

This chapter presents a detailed discussion of the research design that was followed in this study. It also maps the specific methods that were used in the empirical study for data collection and analysis. The chapter also justifies the appropriateness of the procedures used, the fundamental assumptions made and tasks performed, according to the aims and nature of this study. The chapter further describes how issues, related to validity and reliability, were addressed to ensure the trustworthiness of the findings. A reflection on various ethical research issues is also included.

4.2 Research design

A research design, in the most elementary sense, is a logical sequence which links the empirical data to the original research question(s) of the study and eventually to its conclusions (Yin, 1994, p. 19). It can be described as a detailed plan or an exact framework for the research, which deals with at least four problems. They are questions to study, relevant data, the data to collect and how to analyse the data (Yin, 1994, p. 20). The foremost objective of scientific studies is to decide on a research problem. Thereafter, the research focus is narrowed down by means of the formulation of research question(s). The next step is to meticulously decide on the appropriate research design methods (Mouton, 2001, p. 50-51).

4.2.1 Nature of research problem

Research problems are classified according to the unit of analysis as either empirical or non-empirical. This unit is defined as the major phenomenon or object which the researcher investigates and analyses during the course of the research study (Mouton, 2001, p. 51; Trochim, 2006). When this phenomenon or the object under investigation resides in the world of real-life objects, the research problem is regarded as empirical. If the object belongs to the conceptual world, the research problem is considered to be non-empirical (Mouton, 2001, p. 52). The focal points of the research problem in this study are firstly the technical and pedagogical usability of the visual parts of an interface within a software application and secondly, the students and their educational interactions with technology. As both of these focal points can be regarded as real-life objects, it can be concluded that the research problem in this study is empirical.

4.2.2 Nature of research question

Research questions are implicitly or explicitly embodied within the research problem (Mouton, 2001, p. 53). A research question is a specific, measurable and overriding question that a research study seeks to answer and it guides the entire research process. Research questions may also be classified as either empirical or non-empirical and then sub-divided into different categories (Mouton, 2001, p. 53). As already established, the research problem in this study is empirical and the research question is, therefore, also empirical. Empirical questions are subdivided into the following categories, namely exploratory, descriptive, causal, evaluative, predictive and historical (Mouton, 2001, p. 53-54). The main research question for this study is defined as: *How usable are mobile learning applications in encouraging active participation in large undergraduate Computer Science classes?* (see Section 1.1). To address this question, the researcher seeks an in-depth understanding and/or exploration of the phenomenon to use mobile learning applications to encourage active participation in large classes. The research question for this study is, therefore, exploratory.

4.2.3 Nature of research purpose

The main purpose of this study is *to determine how usable mobile learning applications can be in encouraging active participation in large undergraduate Computer Science classes.* This purpose is classified as exploratory because the researcher seeks to explore the overall usability and effectiveness of mobile learning applications to encourage active classroom participation. He investigates what happens when students interact with the application, seeks new insights into the phenomenon to use mobile learning applications to encourage active classroom participation, asks questions and assesses that phenomenon from a new perspective (Robson, 2002, p. 59). This helps him to ultimately establish best practices in this regard.

4.2.4 Nature of research method

Qualitative research is a multi-perspective approach to social interaction that aims to describe, make sense of, interpret or reconstruct the interaction in terms of their meanings (Denzin & Lincoln, 1994, p. 44). It is also perceived as a research method that aims to analyse concrete cases in their local context. It especially starts with the expressions and activities of people in those contexts (Fick, 1995, p. 13). Creswell (2005, p. 39) defines qualitative research as a type of educational research in which the researcher depends on the views of participants, asks broad and general questions, collects data that consists largely of words or text from participants, describes and analyses these words for themes and conducts the inquiry in a subjective and biased manner. Although this study possesses some quantitative elements, it is mainly qualitative because there was a need to understand and to explain the evidence from the data and from the contemporary literature. This aims to answer the salient research question for this study (Henning, Van Rensburg & Smit, 2004).

The inquiry process to understand the phenomenon to use a mobile learning application to encourage active classroom participation was conducted in a natural setting. The process built a complex and holistic picture which was formed by words and by the reported detailed views of informants. The phenomenon was interpreted in terms of the meanings that the participants attached to it (Anderson & Arsenault, 1998, p. 119; Creswell, 1998; Denzin & Lincoln, 1994).

Qualitative research provides the researcher with a choice on how to structure the research design (De Vos, 1998, p. 80). This is achieved if strategies are used that the researcher finds suitable to address the objectives or answer the research question(s) of the study. Based on the research question and purpose of this study, the researcher utilised mainly qualitative research methods with some quantitative enhancements. The qualitative research approach employs an exploratory and contextual focus. It allowed the researcher to conduct an in-depth exploration of the phenomenon to use mobile learning applications in large classes to encourage active classroom participation. This is a combined design to accommodate the participants' opinions at every stage of the investigation. The design is based on both closed-ended and open-ended questions (Cormack, 2000, p. 19; Denzin & Lincoln, 1994).

4.2.5 Research perspective

In order to conduct qualitative research, it is necessary to understand some underlying assumptions on constituents of valid research and appropriate research methods (Myers, 1997, p. 241). These assumptions are normally classified into research perspectives. The research perspective of this study is described as interpretivistic because the researcher attempted to understand the phenomenon to use mobile learning applications to encourage active participation by means of the general meanings which participants assigned to this phenomenon (Boland, 1991; Chua, 1986; Orlikowski & Baroudi, 1991; Saunders, Lewis & Thornhill, 2007, p. 106-107). This perspective is considered as most appropriate for this study, because there are no predefined dependent or independent variables (Kaplan & Maxwell, 1994). The focus broadened as the complexity of human sense making emerged (Walsham, 1993, p. 4-5). An understanding of how participants found the selected application (either as useful or non-useful) to encourage active classroom participation was gained based on the context wherein the application was used. The researcher assumed that the participants would create and associate their own subjective and inter-subjective meanings as they interacted with the selected mobile learning application in their natural setting (Orlikowski & Baroudi, 1991).

4.2.6 Approach to theory

In any field of inquiry, it is vital to be clear about the theory at the beginning of the research to help formulate the research design with ease (Saunders et al., 2007, p. 117). Being clear about the theory will direct whether the researcher should use deductive or inductive reasoning. A deductive approach tests a theoretical proposition and employs a research strategy designed specifically for the purpose of testing. An inductive approach involves the formulation of a theory as a result of the observation of empirical data (Hayes, 2000, p. 5; Saunders et al., 2007). Research (Bass, Dunn, Norton, Steward & Tudiver, 1993, p. 69; Creswell, 1994; De Vos, Strydom, Fouche & Delport, 2002, p. 117) shows that the inductiveness of qualitative research is indicated by research from real life observations, questions and understanding of the phenomenon under study. This study adopted an inductive approach because it aimed to ultimately establish a set of technical and pedagogical guidelines for best practices in the use of mobile learning applications to encourage active classroom participation. The findings from the study, coupled with contemporary literature, are thus presented.

4.3 Mode of enquiry

One of the research strategies which are specifically designed for qualitative research is the case study (Creswell, 1998). A case study is defined as a “strategy for doing research which involves an empirical investigation [or a holistic inquiry] of a particular contemporary phenomenon within its real life context [or natural setting] using multiple sources of evidence” (Robson, 2002, p. 178). The phenomenon is a unit of analysis, as discussed earlier (see Section 4.2.1). The natural setting is the context within which this phenomenon appears. Context is included because contextual conditions are considered to be important to the phenomenon that is evaluated. These conditions are important either because many factors in the setting impinge on the phenomenon or because the separation between the phenomenon and the context is not evident. A holistic inquiry involves the collection of in-depth and detailed data which are content-rich and involve multiple sources of information. These sources include direct observation, participant observations, interviews, audio-visual material, documents, reports and physical artefacts. The multiple sources of information provide a wide array of information needed to sketch an in-depth picture (Harling, 2002, p. 2; Yin, 2003).

This study employed a case study strategy since the researcher wished to gain rich understanding of the research context and the process being enacted. Other reasons for the case study are that it provides extensive detail that helps to understand the complexity of human behaviour (Mark, 1996, p. 218); its environment helps participants to develop a degree of confidence in their judgement, as well as a degree of humility (Edge & Coleman, 1986); it allows a full picture of the actual interaction of variables or events to be obtained (Lubbe, 1999, p. 59-60); it allows the researcher to concentrate on specific instances in an attempt to identify interactive processes that might be crucial, but were not transparent in the large scale survey (Lubbe, 1999, p. 60; Remenyi, Williams, Money & Swartz, 1998, p. 51); it helps to establish the number and variety of properties, qualities and habits combined in a particular instance, because the possible depth of the inquiry through a case study method is higher than for any other research method (Galliers, 1991); and it is not necessary to repeat the case study since it follows the logic of the experiment rather than of the survey (Yin, 1994).

Harling (2002, p. 2) classifies the intrinsic and the instrumental case studies as two forms of a single case study. Instrumental case studies are usually an examination into one element of a population. One department at a university, one programme of study, one research class or one person are all examples of instrumental case studies. This study employs a single instrumental case study, because the focal group represents one group of students who were registered for one specific course.

4.4 Selected mobile learning application

Several factors were considered prior to making a decision regarding the specific mobile learning application that would be used for this study. Firstly, a number of existing mobile tools were identified and evaluated (as explained in Section 2.7). During this evaluation, various problematic issues were detected for each of these tools. These issues included aspects such as costs involved in using clickers (see Section 2.7.1); need for computer servers to host the text messages (see Section 2.7.3); unavailability of laptop computers (see Section 2.7.2); time needed to set up and dismantle the hardware as well as to learn the software (see Section 2.8); and the lack of support for both face-to-face and online instruction (see Section 2.7.2). Considering these aspects and the nature and objectives of this study, it was obvious that the purpose of the study could not be effectively achieved through the use of any one of the reviewed tools. Consequently, the decision was made to develop a custom mobile learning application that could combine the relevant aspects of these tools. The custom-built application was web-based system called MobiLearn. The lecturer could use the web interface to register students on the system and add multiple-choice or open-ended questions to the database. These questions could then be assigned to specific class activities. The lecturer could also control when the activities would be made available to student. Students, on the other hand, were able to access this application through their cellular phones to access and participate in the various class activities. Refer to Section 5.3 for a detailed description of how the MobiLearn application is used for in-class activities as part of this study.

4.5 Population and sampling methods

In every research study, there is a need to indulge in the process to select a number of study units from a defined study population. Population is defined as a large collection of individuals or objects that form the main focus of a scientific enquiry (Castillo, 2009). Populations are normally large in size. It is, therefore, not always possible for researchers to test every individual in the selected population, because it is either too expensive, or time-consuming. This is why researchers rely on sampling techniques (Castillo, 2009). These techniques can be categorised into two types, namely probability (representative) sampling and non-probability (judgemental) sampling.

According to Saunders et al. (2007), non-probability sampling is more frequently used when a case study strategy is adopted. In non-probability samples, the likelihood of each case to be selected from the total population is not known. It is further impossible to answer research questions or to address objectives that require the researcher to make statistical inferences about the characteristics of the population. It is possible to generalise from non-probability samples, but not on statistical grounds.

Non-probability samples are classified into various types. Types such as quota sampling, purposive or judgmental sampling enable the researcher to use his/her judgment to select cases that best answer his/her research question(s) in order to meet the set research objectives. These types of samples are often used with small samples (which is typical of case study research) and when the researcher is interested to choose cases that are particularly information-rich (Neuman, 2000). Other non-probability sample types, such as snowball sampling, self-selection sampling and convenience sampling involve randomly selecting those cases that are the easiest to obtain for the researcher's sample (Nachmias & Nachmias, 1981).

The population that forms the focus of this study was undergraduate Computer Science students at the UFS. As discussed earlier (see Section 4.3), this study employed a case study strategy and, therefore, non-probability sampling was regarded as the most appropriate method. The sample of students that was selected for this study was a large group of first-year students (86 students) registered for one specific course (RIS164 – Introduction to the Internet and web page development). The sample selected for this study was both purposeful and convenient. It was purposeful, because students in the selected course were representative of a large undergraduate Computer Science class as well as of the diverse student population of the UFS. The sample was convenient, because the lecturer of the selected course was interested in using the MobiLearn application in her classes.

4.6 Data collection methods

Data collection is an important aspect of any type of research study. It needs to be planned and executed carefully, because inaccurate data collection can impact on the results of a study and may ultimately lead to invalid results. Saunders et al. (2007, p. 292) identify four issues that need to be considered for a data gathering session to be successful.

Setting goals

> There are many reasons to collect data and prior to embarking on the collection, the specific goals of the particular study should be identified. The set goals influence the nature of the data gathering sessions, techniques to be employed and analysis to be performed.

Relationship with participants

> A relationship between data collector(s) and data provider(s) is a very significant aspect in the collection of data. This relationship should be clear and professional to help clarify the nature of the study. One way in which this can be achieved is through the use of an informed consent form.

Pilot studies

These are small, trial runs of the main study with the objective to ensure that the proposed method is viable. It happens prior to the real study.

Triangulation

This provides for various perspectives and corroboration of research findings across different data collection techniques. It leads to more rigorous and defensible research findings. The data used in this study is from five sources, namely a questionnaire survey, focus group discussions, the face-to-face interview with the lecturer, class attendance records and usage data from the MobiLearn application.

Each of the data collection techniques in this study is described in more detail in the following sub-sections:

4.6.1 Questionnaire

A questionnaire was chosen as the principal data collection method for this study. The main reasons to choose a questionnaire are that it makes it possible to collect a diverse range of answers from a broad section of the target sample in a highly economical way (Saunders et al., 2007, p. 138). The majority of the questions included in the questionnaire are related to the usability metrics (technical and pedagogical) and active classroom participation aspects. The questionnaire also includes a set of open-ended questions to gather data regarding the students' likes and dislikes with regard to the MobiLearn application. The aim of these questions was to get suggestions from the students on possible future improvements in the use of this application.

Before the questionnaire was distributed to the student participants, the researcher first conducted a pilot run of the questionnaire. The aim of the pilot run was to determine if the questions were stated clearly and unambiguously and to obtain general suggestions on how the questionnaire could be improved. The four individuals who were selected for the pilot had either used the MobiLearn application before or were directly involved in the design and development of the application.

The pilot participants made comments and suggestions on several issues related to specific questions (including language use, clarity and relevancy) and the structure of the questionnaire (including grouping of questions and length of the questionnaire). The researcher considered all these comments during the revision of the questionnaire.

The final questionnaire (see Appendix A) was divided into five sections. The questions in Section 1 seek demographic information from the participants. These questions were included to provide the researcher with some basic background information on the participants and to provide a better interpretation of their responses to the rest of the questionnaire. Section 2 contains questions to explore the participants' views on the ease-of-use of the MobiLearn application. The questions in this section mostly focus on the technical usability aspects of the application. Section 3 contains questions to explore the participant's views on the learning support provided by the MobiLearn application. The questions in this section focus mostly on the pedagogical usability aspects of the application. Section 4 contains questions to evaluate whether the application encourages active classroom participation, while Section 5 uses open-ended questions to explore the participants' general experiences of the application. Participants were also asked to identify problems and make suggestions for future improvements.

The questions in Sections 2, 3 and 4 of the questionnaire are based on a 4-point Likert scale. This rating scale was selected, because it avoids neutral answers and forces participants to make a choice (Sclove, 2001). Garland (1991, p. 66) shows that distortions in the obtained results are possible irrespective of the mid-point presence, or not, on a rating scale.

The questionnaire was distributed to all students who were present during a selected RIS164 class session (at the end of the semester). Those students who were able to access and use the MobiLearn application at least once were instructed to complete all five sections of the questionnaire. (From here on this group of students will be referred to as the “Users”). The rest of the students (those who were not able to access the MobiLearn application and, therefore, only observed the in-class use of the application) were instructed to complete only the first and the last sections of the questionnaire (Section 1 and Section 5). (This second group of students will, hereafter, be referred to as the “Observers”). The students were given 15 minutes to complete the questionnaire. Thereafter, all the completed questionnaires were collected by the researcher.

4.6.2 Focus group discussions

The focus group discussions were included as one of the data collection methods, because analysis of the questionnaire survey data revealed that there were some issues that needed further clarification. This type of discussion can be described as a semi-structured data gathering method where a set of participants, selected for the purpose of getting rich information, gather to discuss issues and concerns. These issues are based on key themes established by the researcher (Kumar, 1987). Similarly, Kreuger (1988, p. 18) defines a focus group as a “carefully planned discussion designed to obtain perceptions in a defined area of interest in a permissive [and] non-threatening environment”. As a data collection method, focus group discussions have both advantages and disadvantage.

One of the main advantages of focus group discussions is that the data gathered from this method is very rich (Dürrenberger et al., 1997, p. 15). Some authors (Morgan & Spanish, 1984, p. 267; Rabiee, 2004, p. 656) assert that the focus groups can generate large amounts of data in a relatively short time span. Kitzinger (1995, p. 299) believes that focus group discussions provide a convenient way to collect data from several people simultaneously, encourage participation from people who are reluctant to be interviewed individually and encourage contributions from people who feel they have nothing to say. Other advantages of focus group discussions are that they encourage participants to disclose behaviours and attitudes that they might not consciously reveal in an individual interview. The lively dialogue may activate memories, feelings and experiences similar to the process of free association (Folch-Lyon & Trost, 1981, p. 445). This type of discussions also inhibits the group members from exaggeration (Obeng-Quaidoo, 1987, p. 58) because other members may react against such exaggerations.

One of the disadvantages of focus group discussions is that the transcription of the discussions may be inaccurate (Maynard-Tucker, 2000, p. 397). The observer may miss significant non-verbal interactions that usually give clues to the participants' truthfulness and inner-thoughts about a topic (Maynard-Tucker, 2000, p. 398). According to Folch-Lyon and Trost (1981, p. 445), focus group discussions provide a possibility to obtain erroneous information on sensitive areas. The quality of data collected in a focus group may be compromised because the data is dependent on the skills and motivation of the interviewer (Denzin & Lincoln, 1998, p. 55). Aubel (1994, p. 8) asserts that the information is not necessarily representative of other groups and that the participants have a tendency to agree with the opinions expressed by others in the group rather than to express minority opinions. She further states that the focus group may allow for more articulate group members to dominate the discussion and that the analysis and interpretation of focus group data are more subjective than survey data.

There are several factors that need to be considered by the researcher when s/he plans for focus group discussions. These include the size of the group, the number of groups to involve and the timing of the sessions.

Size of the group

Focus groups are normally composed of a small number of participants. This makes it easier for the moderator/researcher to control the participants and also ensures that all the participants have an opportunity to present their point of view (Folch-Lyon & Trost, 1981, p. 446). According to Maynard-Tucker (2000, p. 400), focus groups should consist of between 4 and 12 participants. She asserts that a group of 6 to 8 participants is recommended for best results. To ensure the presence of 6 to 8 participants, Maynard-Tucker (2000) suggests that at least 10 individuals should be notified. Experience shows that some participants might not attend. With regard to the size of the focus groups, Stewart and Shamdasani (1990) mention that the number of participants depends on the objectives of the study. This implies that smaller groups (about 4-6 people) would be preferable when the participants have a lot to share about the topic or have lengthy experiences in terms of the topic in question (Kreuger, 1988, p. 94).

Number of groups

Research (Debus, 1988; Folch-Lyon & Trost, 1981, p. 446; Morgan, 1988) shows that focus group discussions should not rely on one group only as the researcher may observe the dynamics of that group and little else. However, issues such as available time and budget may also influence the number of groups organised by the researcher.

Timing of the focus group sessions

According to Maynard-Tucker (2000), a focus group discussion should not last for more than 90 to 120 minutes. Longer sessions are regarded as difficult to handle since participants get bored, lose concentration and start to provide repetitive answers.

Based on all the factors discussed above, the researcher decided to organise two focus group sessions. Nine students were invited to the first session and six to the second session. To ensure that the group sizes would be sufficient, the researcher sent out an individual SMS message to each of the invited participants which contained a reminder of the time and venue for his focus group discussion sessions. But, as noted by Maynard-Tucker (2000), not all the invited participants attended the sessions. For the first session, only three students pitched. In an attempt to ensure a better attendance for the second session, the researcher personally called each of the students who were invited to confirm their attendance. Despite all his additional efforts, only four students arrived for the second session. After both focus group discussions were conducted, the researcher noted that all the uncertainties identified from the questionnaire data were addressed. The seven focus group participants were representative of the entire sample and he, therefore, decided that there was no need to schedule any additional focus group discussion sessions.

Each of the focus group discussions were conducted in a pre-determined venue that was free of any disturbances. The researcher acted as moderator for both sessions and an audio recording was made of each discussion session. The researcher structured each discussion with a pattern which welcomed, introduced and briefed participants, as suggested by Kreuger (1988, p. 80). He welcomed all the participants, introduced himself, explained the purpose of his study and established some ground rules for the discussion. He also briefed the participants on the content of the informed consent form (see Appendix B) and gave each participant the choice to decide whether s/he wanted to continue with the discussion or not. Following the suggestion of Stewart and Shamdasani (1990), the focus group participants were then asked to introduce themselves to the rest of the group. After completion of the introductions, the researcher started the discussion. Although the discussions in both sessions were mainly unstructured, the researcher had a pre-compiled list of five main questions (with several probing questions) which he used to direct the discussions (see Appendix C). Both focus group sessions were completed within 50 minutes.

4.6.3 Face-to-face interview with the lecturer

Interviewing is regarded as a predominant mode of data collection in qualitative research (Greeff, 2002, p. 287) and can, therefore, be regarded as relevant to this study. The specific interview type chosen for this study was face-to-face interviews. These are interviews which involve a meeting between one researcher and one informant (Denscombe, 2007, p. 177) and are characterised by synchronous communication in time and place (Opdenakker, 2006). This type of interview has several advantages and disadvantages.

One of the advantages of face-to-face interviews includes the fact that they are flexible, iterative and continuous rather than prepared in advance (Herbert & Rubin, 1995, p. 43). This type of interview is also easy to arrange and control as the researcher has only one person’s ideas to grasp. Only one person is interrogated and needs to be guided through the interview agenda. It provides for a possibility to produce data which deals with topics in depth. The opinions and views expressed throughout the interview come from one source (one voice to recognise and only one person who talks at a time). It makes it easier to transcribe a recorded interview (Denscombe, 2007). Face-to-face interviews also allow the researcher to observe social cues such as voice, intonation and body language (Opdenakker, 2006).

One of the disadvantages of face-to-face interviews is that the use of a recorder (tape and/or audio) and open ended questions can make the interviewee feel vulnerable (Field & Morse, 1994, p. 67-73). Conducting face-to-face interviews can be relatively costly to the researcher in terms of time and cost, especially if the informants are geographically dispersed (Denscombe, 2007, p. 177-204). The time-consuming nature of this type of interview also limits the number of voices that can be heard and the range of views that can be included within a research project. Analysis of data collected through a face-to-face interview can be time consuming (on transcribing) and difficult (on analysis) because the open format often results in non-standard responses. Face-to-face interviews can also be costly if the researcher is not skilled in the art to conduct interviews since there will be a need to recruit experts to help in this regard. The informants in a face-to-face interview may not be willing to share and the researcher may ask questions that do not evoke the desired responses from the informants (Greeff, 2002, p. 299). The effect of some of these disadvantages can be minimised through the use of a trained or skilled interviewer.

In this study, the researcher decided to conduct a face-to-face interview with the RIS164 lecturer because he wanted to gain more insight into the manner she utilised the MobiLearn application in her classes. He also wanted to find out what challenges she experienced in the use of this application and whether she found the application effective to encourage active classroom participation. The researcher also intended to obtain the lecturer's opinion on some of the issues that arose from the analysis of the questionnaire survey data and the focus group discussions. Lastly, suggestions regarding the best way in which the MobiLearn application could be used to encourage active classroom participation were also sought from the lecturer.

The interview was held in the lecturer's office. It was a semi-structured interview guided by five main questions with some probing questions (see Appendix D for interview schedule). The researcher explained the purpose of the interview to the lecturer prior to starting with the questions. The interview lasted for 51 minutes and the entire session was audio recorded.

4.6.4 MobiLearn usage data

The MobiLearn application includes a functionality that records usage data for each user. As part of the usage data, the application records all the text entries made by each user while s/he participated in a MobiLearn class activity. The time (in seconds) that it took the user to make each entry was also recorded. The usage data for a specific class activity could afterwards be downloaded as a comma delimited file. This data was used in the measurement of the percentage of tasks completed and accessibility metrics (as described in Sections 5.3.1.1 and 5.3.3.3 respectively).

4.6.5 Class attendance records

As class attendance was not compulsory for the selected course (RIS164), the number of students who were present during each class session varied. In order to determine the percentage of students who were able to successfully complete each of the MobiLearn class activities (using the usage data described in Section 4.6.4), the researcher also needed to know how many students were present during each of these activities. For this reason, the attendance records for the relevant class sessions were obtained from the RIS164 lecturer. This data were specifically used in the measurement of the accessibility metric (as described in Section 5.3.3.3).

4.7 Data analysis

As explained in Section 4.2.4., this study is mainly qualitative in nature, but with some quantitative enhancements. Therefore, both qualitative and quantitative data were collected.

The analysis of the quantitative data collected through the questionnaire survey was fairly straightforward. The researcher first captured the data from the paper-based questionnaires into an MS Excel spread sheet. Thereafter, the responses were grouped to all the Likert scale statements. For each of these statements, the mean and standard deviation were calculated. The analysis of the qualitative data was more complex.

There are several techniques that may be used to analyse qualitative data. One of these is qualitative content analysis (Nieuwenhuis, 2007, p. 101) which makes inferences through objectively and systematically identifying the particular characteristics of messages (Holsti, 1969). It seeks the theoretical interpretations that may produce new knowledge and usually covers two categories, namely media content and audience content. *Media content* includes printed publications, broadcasted programs, websites or any other types of recording. *Audience content*, which is relevant to this study, refers to feedback that is collected either directly or indirectly from an audience group through various methods such as focus groups, interviews, diaries and observations (Lazar, Feng & Hochheiser, 2010).

Prior to the analysis of the data by means of qualitative content analysis, it is important to consider aspects that can help the researcher to frame the scope of the analysis and the specific techniques to be used for the analysis. These include:

- Specification of a clear definition of the data set that is going to be analysed and definition of the population from which the data set is drawn (Krippendorff, 1980) (as already described in Section 4.5).
- Organisation - close study of the data and removal of any data that does not meet the criteria of the definition (Krippendorff, 1980). In this study, the researcher organised the data into folders. This organisation helped him to quickly identify usable and non-usable data. The folders helped to place material that dealt with the same batch together (Nieuwenhuis, 2007, p. 105).
- Knowledge of the specific context of data that will, during analysis, create meaningful and unbiased findings (Krippendorff, 1980). In order to identify the data that could be meaningful, the researcher first established the technical (see Section 3.6) and pedagogical (see Section 3.8) usability metrics and the active classroom participation measures (see Section 2.9). This helped the researcher to quickly classify and relate identified concepts to the already established metrics and measures.
- Data transcription and saving (Nieuwenhuis, 2007, p. 105). In relation to these issues, the researcher transcribed the audio data verbatim and ensured that he also included the non-verbal cues in the transcript. The researcher then confirmed that the data was properly saved. This was achieved through keeping different versions of every single piece of work on the data on different components (desktop computer, laptop computer, campus network, memory stick, CD/DVD and e-mail inbox).

During qualitative content analysis, the technical process and techniques used to analyse text content is known as coding (Lazar et al., 2010). This involves "interacting with data, making comparisons between data, and so on, and in doing so, deriving concepts to stand for those data, then developing those concepts in terms of their properties and dimensions" (Corbin & Strauss, 2008, p. 66). Some researchers develop these codes as they code the data, and these codes are called inductive codes (Nieuwenhuis, 2007, p. 105). This is also known as the conventional approach to qualitative content analysis. This study, however, followed a directed approach wherein the codes are derived from theory or previous relevant research findings (Hsieh & Shannon, 2005, p. 1278). These codes that are developed before the examination of the current data can also be referred to as *priori codes* (Nieuwenhuis, 2007, p. 105).

There are three different types of coding namely, open coding, axial coding and selective coding. Open coding is an interpretive process that labels and categorises phenomena as indicated by the data. In axial coding, the researcher relates the main categories identified to their sub-categories and those relationships are tested against data. Selective coding involves unification of all the categories around a core category. The categories that need further explication are described thereafter (Corbin & Strauss, 1990, p. 12-14; Pandit, 1996).

In this study, the researcher analysed the qualitative questionnaire data carefully and categorised it under the most appropriate categories. All of the predefined categories are based on the technical and pedagogical usability metrics and the measures of active classroom participation identified from literature. In reading and re-reading of the transcripts from the focus group discussions and the interview with the lecturer, the researcher categorised the projected views and/or experiences under their relevant categories. Any views and/or experiences that did not belong to the existing categories were carefully given other labels. These additional labels helped to recommend and formulate a set of best practices guidelines.

4.8 Reflections on ethical issues

It is inevitable that ethical concerns will emerge as researchers plan their research, seek access to organisations and individuals, collect, analyse and report their data (Saunders et al., 2007, p. 178). Ethics is defined by Blumberg, Cooper and Schindler (2005, p. 92) as the moral principles, norms or standards of behaviour that guide moral choices about the behaviour of the researcher and his/her relationships with others. Saunders et al. (2007) assert that research ethics relates to questions on how researchers formulate and clarify their research topic, design their research and gain access, collect data, process and store their data, analyse collected data and write a report on research findings in a moral and responsible way. This implies that the research design should be morally defensible to all the stakeholders in the research and be scientifically and methodologically sound.

To ensure that ethical issues are taken care of, the researcher firstly ensured that the participants were well-informed about the purpose of the research study they were asked to participate in. This was achieved through the use of an informed consent confirmation, communicated in the introduction of the questionnaire (see Appendix A) and also through an informed consent form that students completed before they participated in the focus group discussions (see Appendix C). According to Lazar et al. (2010, p. 381), *informed* means that the participants in the study understand the reason for the study, the involved procedures, potential risks and how they can obtain information on the study. Without this information, participants are not given a choice to participate in the research or not. The informed consent also formalises interaction between participants and the researcher. The National Cancer Institute (2001) asserts that if potential participants are informed truly, the information in the informed consent should be as comprehensible and clear as possible to the participants. The consent notion emphasises that to take part in a research study should be completely voluntary and free from any implied or implicit coercion.

In this study, participants were informed that there would be no negative consequences if they decided not to participate in the study (Lazar et al., 2010). The researcher also ensured that the ethical principles were considered throughout all phases of planning, data collection and data analysis.

4.9 Trustworthiness

Babbie and Mouton (2001, p. 277) define trustworthiness as issues which the researcher has to consider in his/her research study. These issues should persuade the reader that the findings of this study are worth paying attention to, or taking account of. The well-accepted approach to evaluate the trustworthiness of a qualitative research study is composed of four key criteria namely credibility, transferability, dependability and confirmability.

4.9.1 Credibility

According to Lodico, Spaulding and Voegtle (2006, p. 273), credibility asks if the participants' perceptions of the setting or events match with the way the researcher described them in the research report. They further assert that the question to be answered with credibility is: "Has the researcher accurately represented what the participants think, feel and do and the processes that influence their thoughts, feelings and actions?" To ensure that the above question was addressed, the researcher used multiple sources of data (triangulation) namely a questionnaire survey, a personal interview with the lecturer, two focus group discussions with the students as well as usage data and class attendance records. The hard and soft copies of all the questionnaire responses, usage data and class attendance records have been filed and are available upon request. The audio recordings and transcriptions of the interview and the focus group discussions are also available, if needed.

4.9.2 Transferability

In transferability, the researcher provides background data to establish the context of the study and a detailed description of the phenomenon under investigation with the objective to allow comparisons to be made (Shenton, 2004, p. 73). Thick descriptions and purposive sampling are two strategies that facilitate transferability. Both of these strategies were employed in this study. With regard to the first strategy, the researcher collected sufficiently detailed descriptions of data in context.

He then reported them with sufficient detail and precision to allow the reader to make judgements about transferability. The purposive sampling strategy that was employed in this study, helped to maximise the range of the information obtained, because it was chosen with the purpose to obtain rich data (Erlandson, Harris, Skipper & Allen, 1993, p. 33; Lincoln & Guba, 1985, p. 241).

4.9.3 Dependability

Dependability is defined as the ability of a research study to provide evidence to its audience that, if the study is to be replicated with the same group of participants in a similar context, its findings would be similar (Lincoln & Guba, 1985, p. 290). To ensure dependability with regard to the data collected during the interview, the researcher provided the lecturer with a complete transcript of the interview. She could verify whether the presentation and interpretation were an accurate representation of what she shared with the researcher. All the qualitative data collected as part of this study was analysed according to a direct approach (see Section 4.7.1) where most of the codes were based on themes previously established from the literature. The use of these *priori codes* helped the researcher to stay within predefined boundaries (themes) during the data coding process. The selected quotes were used very cautiously and the researcher ensured that he did not use the participants' words out of context and/or edited quotes in any way to suit what he wanted to say (Nieuwenhuis, 2007, p. 113).

4.9.4 Confirmability

Bradley (1993, p. 437) defines confirmability as "the extent to which the characteristics of the data, as posited by the researcher, can be confirmed by others who read and review the research results". It pertains to whether or not the findings of an inquiry reflect the participants' views and experiences and not just those of the researcher (Larrabee, 2009, p. 98). The researcher followed various strategies to ensure the confirmability of all the data collected during this study. Prior to data collection, he did a pilot questionnaire which was used in this study. In his reporting, the researcher avoided biasness to the extent possible. He also interpreted the data according to what was brought forward and not according to his personal inclination and how he wanted it to address his research question. The objective in this study is to discover new facts/knowledge and not to prove something as right or wrong. This objective also helped the researcher to keep his interpretations as neutral as possible. All the data was carefully analysed and the findings frequently compared with the findings from literature.

4.10 Conclusion

This research study followed a qualitative research design with some quantitative enhancements to compile a set of technical and pedagogical guidelines for best practices in the use of mobile learning applications to encourage active participation in large undergraduate Computer Science classes. In this chapter, the researcher provided justification for the selected research design and the research methods, as well as the strategies used to achieve the objectives. The researcher places this research study in an interpretivist camp, utilising a case study strategy. The chapter also includes detailed descriptions of each of the five data collection methods used and the methods used to analyse this data. The chapter concludes with a discussion on how issues relating to ethics and trustworthiness, are addressed in this study.

The next chapter provides a discussion of how the data was analysed. It also provides interpretations of the findings of this study.

Chapter Five:

Data analysis and interpretation of findings

5.1 Introduction

This chapter is aimed to analyse and interpret the data that was collected in this study. To achieve this aim, the discussion in this chapter is grouped according to the various sections of the questionnaire that was used. The questionnaire survey provided data which helped the researcher to determine the degree to which the MobiLearn application was technically and pedagogically usable. This was determined through the measurement of various usability metrics as established from contemporary literature. In cases where the obtained results did not help the researcher to make inferences about the usability (technical or pedagogical) of the MobiLearn application, further investigations were made. These were done through the focus group discussions with students and the interview conducted with the RIS164 lecturer who uses the MobiLearn application in her teaching. The class attendance records and usage data from the MobiLearn application were also used where necessary. The responses gathered from all the participants provided a unique insight into the functioning of the MobiLearn application to support students in their learning process.

The chapter starts off with a brief description of the student participants. It then focuses on how technical and pedagogical evaluation of the MobiLearn application was respectively carried out to determine its overall usability and effectiveness to encourage active classroom participation. Thereafter, the value added through the use of the MobiLearn application in the learning process is discussed. The added value helped to measure the effectiveness of the MobiLearn application to encourage active classroom participation. The focus then shifts towards a discussion of the personal experiences that students had when they used the MobiLearn application.

5.2 Profile of student participants

Data was collected from student participants through a questionnaire survey and two focus group discussions. The following sub-sections provide an overview of the profile of these participants.

5.2.1 Participants in the questionnaire survey

A total of 41 students completed the questionnaire. These students came from various backgrounds as indicated by their home languages which varied from Chinese, English, Sepedi, Sesotho, Swati, Tswana, Venda to Yoruba. More than 40% of the respondents were Afrikaans speaking (see Figure 5.1).

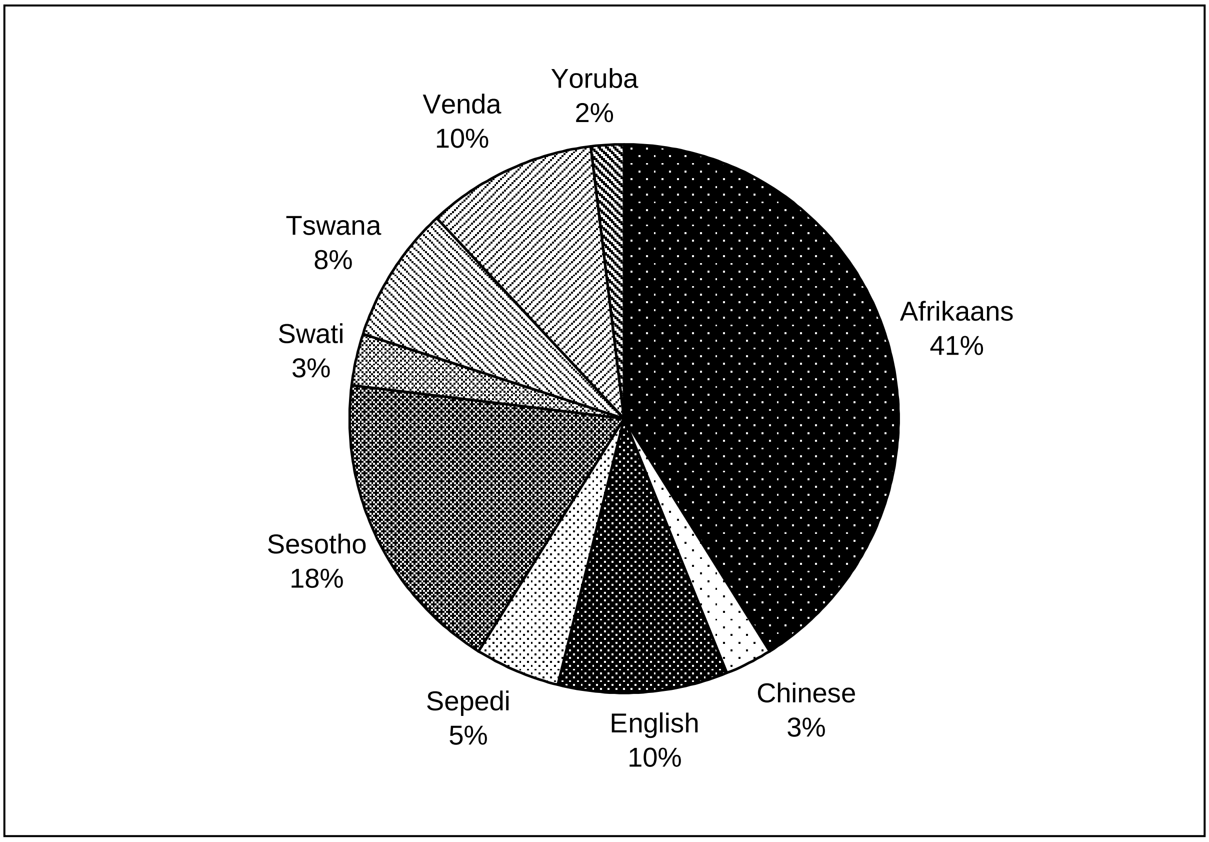

Figure 5.1: Distribution of participants according to home language

The majority of the students (more than 65%) were between 19 and 20 years old. Table 5.1 provides the age distribution of all the questionnaire survey participants.

Of the 41 students who completed the questionnaire, 27 belong to the “Users” group while 14 belong to the “Observers” group (as explained in Section 4.6.1). In this chapter, the discussions in Section 5.3 (technical usability), Section 5.4 (pedagogical usability) and section 5.5 (value added) only considered the responses of the "Users" group. For the discussion of the open ended questions in the final section of the questionnaire (see Section 5.6), the responses from all the students (both "Users" and "Observers") were considered.

Table 5.1: Age distribution of students

	19 years	20 years	21 years	22 years	23+ years
Frequency (n = 41)	16	12	5	3	4
Percentage	39.0%	29.3%	12.2%	7.3%	12.2%

5.2.2 Participants in the focus group discussions

As mentioned in Section 4.6.2, seven students participated in the two focus group discussions (three in the first discussion and four in the second). Of the participants in the first session, two were Afrikaans speaking and one was Venda speaking. These participants were all males between 19 and 21 years old. Two of them belonged to the “User” group and one to the “Observer” group. Three of the four participants in the second session were above 23 years old and one was 19 years of age. Two of these participants were Sotho speaking, one Afrikaans speaking and one Yoruba speaking. One of them was an “Observer”, while the rest were “Users”.

5.3 Technical usability evaluation

The purpose of Section 2 of the questionnaire was to evaluate the technical usability of the MobiLearn application. Each of the statements included on the questionnaire is directly related to one of the technical usability metrics that were identified from the contemporary literature (as summarised in Table 3.1). The responses to all these statements are summarised in Table 5.2.

Table 5.2 indicates the percentage of participants who chose responses in the agree (1), partly agree (2), partly disagree (3) and disagree (4) categories. The second-last column indicates the mean ($\bar{x}$[x-bar]) for the responses and the last column represents the standard deviation (s) in the responses.

Table 5.2: Summary of responses to statements about students' experiences in their usage of the MobiLearn application

Statements	Responses				Mean (n=27)	s
	Agree (%)	Partly Agree (%)	Partly Disagree (%)	Disagree (%)		
1. The user interface components were placed in a consistent way across the MobiLearn application.	33.3	51.9	7.4	7.4	1.89	0.85
2. The interface of the MobiLearn application made it easy for me to remember how to carry out the mobile class activities.	40.7	37.0	18.5	3.7	1.85	0.86
3. It was possible to work out how to use the MobiLearn application by just exploring its interface.	59.3	22.2	11.1	7.4	1.67	0.96
4. While using the MobiLearn application, I sometimes had to remember information from the previous step(s).	29.6	55.6	11.1	3.7	1.89	0.75
5. I was free to carry out all tasks without any fear that the MobiLearn application would crash.	51.9	22.2	7.4	18.5	1.93	1.17
6. The MobiLearn application allowed me to complete activities at a later stage if there was not enough time to complete them in class.	40.7	29.6	22.2	7.4	1.96	0.98
7. The MobiLearn application provided me with an easy way to interact with the lecturer during the class sessions.	33.3	40.7	18.5	7.4	2.00	0.92
8. The MobiLearn application provided me with a fast way to interact with the lecturer during the class sessions.	29.6	37.0	29.6	3.7	2.07	0.87
9. It was easy to navigate through the MobiLearn application.	40.7	37.0	14.8	7.4	1.89	0.93
10. It was easy to enter the answers to the MobiLearn question answers on my cellular phone.	63.0	11.1	14.8	11.1	1.74	1.10
11. It was not easy to view all the MobiLearn text on my cellular phone at once.	25.9	37.0	18.5	18.5	2.30	1.07
12. The MobiLearn application provided meaningful error messages where necessary.	18.5	25.9	37.0	18.5	2.56	1.01
13. I encountered errors for more than 50 per cent of the total number of times I used the MobiLearn application.	14.8	14.8	18.5	51.9	3.07	1.14

In this study, technical usability was evaluated not only through the responses to questions on the questionnaire, but also through usage data that was generated by the MobiLearn application. Some of the issues which needed further investigation were clarified through the use of the focus group discussions with the students and/or the interview with the lecturer. The technical usability metrics to which each of the statements in Table 5.2 relate, were earlier classified (see Section 3.6) into three quality criteria categories (effectiveness, efficiency and user satisfaction). The discussion in the following sub-sections will proceed in the respective order in which the classification was made.

5.3.1 Effectiveness

Effectiveness was measured in terms of two technical usability metrics, namely percentage of tasks completed and error rate.

5.3.1.1 Percentage of tasks completed

With the measurement of the percentage of tasks completed metric, the focus was on usage data that was recorded by the MobiLearn application. This data showed that all the students who had logged in on the MobiLearn application (all students belonging to the "User" group) were able to successfully complete all the MobiLearn tasks/activities given to them. According to the lecturer, the MobiLearn application was used for three class activities during the semester. For the first activity, the students had to individually answer an open-ended question on MobiLearn (as described in Figure 5.2).

Activity 1

- Use your cellular phone to login to the MobiLearn application (http://csi.uovs.ac.za/mobi). Use the password provided by the lecturer.
- Enter any questions that you have about the material covered in today's class in the space provided.
- Note: If you cannot access the MobiLearn application now, try to complete this activity on your own time before the next lecture.

Figure 5.2: Individual activity on general material covered in class

Usage data for Activity 1 indicates that 22 students were able to login to the application and entered their question(s). There was one student who completed this activity through a computer, instead of a cellular phone, after the class session. It is interesting to note that the text typed by this particular student was the longest. It contains 314 characters (with spaces). This might be attributed to the fact that typing on the computer keyboard is probably more convenient and faster than with a key pad with small keys on a cellular phone (Webcredible, 2011).

The MobiLearn application may also be used to administer multiple-choice questions. For the second class activity, students had to collaborate in their pre-assigned groups to answer the eight multiple-choice questions on MobiLearn (as described in Figure 5.3). Only one student from each group was required to login to the MobiLearn application and enter the group's answers. Usage data for Activity 2 indicates that all 14 students/groups (100%) who logged in to the application were able to complete the activity.

Activity 2

- Only one student from each group will use his/her cellular phone to login to the MobiLearn application (http://csi.uovs.ac.za/mobi). Use the password provided by the lecturer.
- In your group, study the diagram on the worksheet hand-out that illustrates various divisions on a web page. Each of the MobiLearn questions will refer to a specific section of this diagram.
- For each question asked on the MobiLearn application:
    - Discuss the question and the possible answers in your group.
    - Only one student should enter the group's final answer to each question on MobiLearn.

Figure 5.3: Group activity on multiple choice questions

For the third and final activity (as described in Figure 5.4), students again had to individually answer an open-ended question on the MobiLearn application. Each student had to identify the JavaScript aspects in which s/he then experienced the most difficulty with. The usage data for this activity indicates that all 14 students (100%) who managed to access the MobiLearn application were able to complete the given task. This is in agreement with Seffah et al. (2006) who believe that users' success to achieve goals when they work with a software application implies that such application is effective. Nonetheless, the tasks that students completed with the MobiLearn application were not as defined as the tasks that Adebesin et al. (2009) assigned to their participants (see Section 3.6.1).

Activity 3

- Use your cellular phone to login to the MobiLearn application (http://csi.uovs.ac.za/mobi). Use the password provided by the lecturer.
- Identify the JavaScript aspects that are you are currently struggling with and list them in the space provided.
- Note: If you cannot access this website through your mobile phone, write your answer to the question on a piece of paper and submit it to the lecturer.

Figure 5.4: Individual activity on JavaScript concepts

It is evident that all the students who were able to log into the MobiLearn application were able to successfully complete the given tasks. According to Seffah et al. (2006), the success of users to achieve goals when they use a software application implies that such application is effective.

5.3.1.2 Error rate

In the data that was collected through the questionnaire, most of the students (more than 70%) indicated that they did not encounter errors for more than 50% of the total number of times they used the MobiLearn application (see Statement 13 in Table 5.2: mean = 3.07, s = 1.14). This implies that the frequency with which students encountered errors in using the MobiLearn application was relatively low. As Nielsen (1993) regards low error rate as one of the attributes of a usable application (see Section 3.3), it can be deduced that the MobiLearn application was found to be technically usable in terms of the rate at which students experienced errors with it. Talib and Abdullah (2010) regard error rate as one measure of effectiveness. It can be inferred that in terms of the error rate usability metric, the MobiLearn application was effective.

5.3.2 Efficiency

Efficiency was measured in terms of the seven technical usability metrics as discussed in the following sub-sections.

5.3.2.1 Internal consistency

More than 85% of the participants agreed/partly agreed that the MobiLearn application was internally consistent (see Statement 1 in Table 5.2: mean = 1.89; s = 0.85). As indicated earlier (see Section 3.9.2), there are various aspects of internal consistency that can be measured. These include the shape, size and colour of the letters, the main user interface and the buttons' design. A distinct aspect measured in this study was consistent placement of interface components on the MobiLearn application as emphasised by Stone et al. (2005).

When the students were asked what they enjoyed the least about the MobiLearn application (in Section 5.3 of the questionnaire), some gave responses that were directly related to consistency. For example, one student mentioned that s/he was not happy with the "*physical appearance*" of the MobiLearn application's user interface. This was confirmed by another student who mentioned that s/he was "*mostly*" concerned about "*the layout of the application itself*". A number of students also made suggestions for the improvement of the MobiLearn application interface as indicated underneath:

- *"A little decoration to the background [should be added]"*;
- *"Better and faster interface"*;
- *"…decorate it [the user interface] to appear more attractive to the user"*; and
- *"The interface of the MobiLearn [application] can be improved with more information and instructions".*

Although it can be concluded from the obtained results that the MobiLearn application was efficient as far as the internal consistency metric is concerned, it is clear that there is definitely room for improvement in this regard. If students do not find the interface aesthetically pleasing (Galitz, 2002, p. 41), they might be discouraged to use such application as part of their learning.

5.3.2.2 Error handling and prevention

The students had mixed feelings about the way in which the MobiLearn application handled and prevented errors. More than 55% of them believed that the application did not provide meaningful error messages where necessary (see Statement 12 in Table 5.2: mean = 2.56, s = 1.01). Following from these results, the focus group discussions were used to shed more light on this issue. Most of the students who participated in the focus group discussions indicated that they always ensured that they only did what was expected of them in the MobiLearn application. They did not try to enter invalid input that could cause errors. This is consolidated by one participant who remarked: "*I didn't ever enter invalid inputs, so it never gave me the error messages*". Another participant said: "*you know in my age, we don't try things to see whether we can do them or not, we make sure that we can*".

From all the students involved in the focus group discussions, only one student mentioned that she encountered an error message. The remark given by this student was: *"I did once, … she [the lecturer] had a question, she opened it for us to answer and I clicked on the 'Next' button to go to the next question which was not available, and the application displayed 'sorry, question not available', so it was not opened yet*". It is, therefore, clear that students did not encounter a lot of error messages when they used the MobiLearn application. In a few cases where students managed to trigger the application to give an error message, the error messages were at least meaningful.

5.3.2.3 Learnability

The majority of the participants (more than 80%) believed that the MobiLearn application was learnable (see Statement 3 in Table 5.2: mean = 1.67; s = 0.96). This is encouraging as a learnable application is more likely to encourage students to be actively involved and to participate in the learning process (Brandes & Ginnis, 1986; Zhiming, 2004).

5.3.2.4 User's memory load

Most of the students (more than 85%) indicated that the MobiLearn application did not require them to remember a lot of information in order to complete their tasks (see Statement 4 in Table 5.2: mean = 189; s = 0.75). Borrowing from Nielsen (1993), it is more likely that through the use of the MobiLearn application the students did not have to *remember* concepts and data, but rather *recognised* them. It can be concluded that the MobiLearn application was usable as far as the user's memory load metric is concerned. This implies that it was easy to process information with this application. If the application does not require students to use a lot of memory to complete their learning tasks or activities, students may be encouraged to use it regularly.

5.3.2.5 Screen display

Although 63% of the students (see Statement 11 in Table 5.2: mean = 2.30; s = 1.01) had no problem to view all the MobiLearn text on their mobile phones, there was still a significant number of students (37%) who indicated that they experienced problems in this regard. The negative responses with regard to the screen display metric were further investigated during the focus group discussions. The students indicated that the only problem might have been the kind of cellular phones that were used by some students. One student explained: "*[when using a slide-open phone] … your view switches between portrait and landscape … it automatically increases the width of the [page] and when you go to portrait, it cuts at the sides".* The point raised was that during the switching of views, some cellular phones do not always change the width of the page back to the original width. It is possible that this issue was not directly caused by the MobiLearn application, but rather by the phone itself.

From the questionnaire data, one student raised a concern that the small screens of the cellular phones posed a problem during the group activities. S/he remarked: "*having to concentrate on a smaller screen and it became frustrating since only one person used a phone in a group*". It can be deduced from this remark that the small screens might have had a negative effect on the effectiveness of group activities that required the use of the MobiLearn application. Students might feel excluded if they cannot all view the information on the cellular phone screen. Apart from this concern, students did not mention any other problems with the small screen when they individually used their cellular phones. Based on this, and the results obtained from the questionnaire survey, it can be concluded that the small screen was not a big problem for students during the individual activities.

5.3.2.6 Data entry and viewing

Although some of the MobiLearn application activities only required the students to select answers to multiple-choice questions, there were also activities where students had to answer open-ended questions. This required longer answers. The questionnaire responses indicated that about 74% of the students experienced no real problems to enter answers on the MobiLearn application through their cellular phones (see Statement 10 in Table 5.2: mean = 1.74, s = 1.10). Evaluation of the actual answers entered by the students on the MobiLearn application provides further evidence in this regard. The length of the answers entered for open-ended questions ranged from four characters with the longest answer recorded at 202 characters (with spaces). The following are two examples of such answers:

> **Example 1:** "*If you set the max-height of the container to a value, but the content inside has a bigger dimension. What happens to the content that's outside the max-height?"*
>
> **Example 2:** "*Validating the form on my final project's contact page. Setting da focus to the 1st textbox on my cntacts page. I added it bt, duznt work. Da last modified date doesn't appear even in compatibility view?"*

It should also be noted that the length of the students' answers were related to their degree of comprehension of the work discussed during the lecture. One student who clearly understood all the work, discussed during the lecture, only entered "*None*".

The limited time that the lecturer gave students to respond to the questions might have been the reason why the student in Example 2 used short message (SMS) language to save time. Another reason might be that s/he is used to texting in that way. The length of the student answers and the relatively high percentage of students who were in agreement/partial agreement with the data entry and viewing statement on the questionnaire provide ample evidence that data entry and viewing was not a problem in the MobiLearn application.

5.3.2.7 Navigation

A high percentage of the students (more than 75%) believed that it was easy to navigate through the MobiLearn application (see Statement 9 in Table 5.2: mean = 1.89; s = 0.93). In answering the questionnaire, some students also made recommendations with regard to navigation on the MobiLearn application. One student recommended that the MobiLearn website should be designed in such a way that it "*fit[s] on the [cellular phone] screen*" to avoid scrolling. It is clear that, although the majority of the students were satisfied with the amount of navigation they had to do in the MobiLearn application, it is possible that an improvement can be made in this regard. In the focus group discussions, it was mentioned that students had to scroll to see all the text on their cellular phones. The participants accepted that they would not be able to smoothly navigate on their cellular phones the same way as they would on a desktop computer, because they knew the cellular phone screens are small. One participant remarked: "*it didn't bother me to scroll in this instance [using a cellular phone] because I know this huge amount is now on my phone, … look at the two screens [computer screen and cell phone screen], then you will know that you have to scroll somewhere because the full sentence [that fits on your computer screen cannot fit on your cellular phone screen, it would have to go to the next line]*".

The participants also indicated that they would prefer vertical scrolling to horizontal scrolling, because horizontal scrolling is inconvenient. Dubai eGovernment Department (2010, p. 17) posits that horizontal scrolling must always be avoided, because users tend to lose context of the remaining page. This is consolidated by one participant who commented: "*you don't mind going down [scrolling vertically in reading a page] … that's the normal way of reading a book*". Another participant commented: *"I think it makes doing your work kind of slower because when you scroll to that side and you have to scroll back [horizontal scrolling] now you kind of be[come] too slow*".

It may be concluded that the MobiLearn application was technically usable as far as navigation was concerned. This implies that the students did not have to scroll extensively (Collier & Dahanayake, 2008) to view the pages of the MobiLearn application which renders its navigational efficiency.

5.3.3 User satisfaction

The user satisfaction quality criteria category was measured in terms of three technical usability metrics whose results are discussed in the subsequent sub-sections.

5.3.3.1 Internal user control and freedom

The internal user control and freedom technical usability metric was measured by the examination of two aspects. Firstly, students were asked whether they were able to perform tasks without any fear that the MobiLearn application would crash. Secondly, students were asked if the MobiLearn application allowed them to complete activities at a later stage if they failed to complete them during the class sessions.

Most of the students (more than 70%) believed that they did not have any fear to use the application (see Statement 5 in Table 5.2: mean = 1.93, s = 1.17). This finding is in agreement with Squires and Preece (1996) who stated that a technically satisfying application should give users freedom to use it without any fear that the application might break any time. It can be inferred that the MobiLearn application did not make the students anxious to use it.

Most of the students (more than 70%) agreed/partly agreed that with the MobiLearn application, they were able to complete the class activities at a time convenient for them (see Statement 6 in Table 5.2: mean = 1.96, s = 0.98). It should be noted that the students were only able to complete Activity 1 and 3 at a later stage, because the lecturer decided not to close these activities after the class. Activity 2 was not accessible after the end of the class. Students only had internal user control and freedom on the MobiLearn application when it was allowed by the lecturer. It can be deduced that the MobiLearn application was technically usable as far as internal user control and freedom usability metric was concerned.

5.3.3.2 Memorability

The memorability metric was measured when students were asked whether the interface of the MobiLearn application made it easy for them to remember how to carry out the mobile class activities (see Statement 2 in Table 5.2). In their response, the majority of the students were in agreement/partial agreement (more than 75%; mean = 1.85; s = 0.86). It can be deduced that the MobiLearn application was memorable. In this regard, Preece et al. (2007) recommend that all software applications should be memorable.

5.3.3.3 Accessibility

The first step to measure the accessibility of the MobiLearn application was to compare the application's usage data with the lecturer's class attendance records. This comparison revealed that only about 40% of the students who attended the classes in which Activities 1 and 3 were conducted, were able to access the MobiLearn application through their cellular phones. For Activity 1, a number of 21 of the 55 students present (38%) were able to access the MobiLearn application on their cellular phones (one student accessed the application through a computer) while for Activity 3, the number of 14 of the 33 students present (42%) were able to log in. The decision of the lecturer to make Activity 2 a group activity, where only one student from each group had to access the MobiLearn application ensured that all 62 students, who were present, had access to the application. This meant that 100% of the students who participated in Activity 2 had access to the MobiLearn application, although it implies indirect access for some.

In the questionnaire, the accessibility metric was measured when students were asked to name the model of the cellular phone they used to connect to the MobiLearn application. Cellular phones usable in this study were regarded as those that are WAP-enabled and make mobile Internet connection possible. The students' responses to this question were also used to verify the number of ‘Users’ (66%) and the number of ‘Observers’ (34%) who completed the questionnaire (also see Section 5.2.1).

As most of the 'Observers' have at least tried to access the MobiLearn application, it was understandable that they made related comments on the open-ended questions (in Section 5 of the questionnaire). Some of the comments are: “*at times it was difficult to login to the application*” and “*struggling to connect every time we had to* *log in"*. Some students also raised concerns such as "*some phones can't connect*" and that the application should be made to be "*accessible to all phone models*".

In relation to accessibility, the following concerns were also raised by the students:

- "*Sometimes the network could not allow us to enter the MobiLearn, but not always";*
- *"Make it to be supported by almost all the phones …";*
- *"Not being able to access the site during some of the activities";*
- *"Encourage the students to buy cell phones that can easily access the MobiLearn"*; and
- "*Sometimes it was fully working on other student's phone[s] and not working at all when other students tried to access it*".

It can be deduced that the main factors that prevented students to access the MobiLearn application were that their cellular phones were either not WAP-enabled or they did not possess their own cellular phones. Another interesting comment made by a student was that the MobiLearn application should be *"easily accessible to everyone in the class and even at home".* As noted by Hill and Howlett (2005, p. 60), students are more likely to participate actively in the learning activities if they come to class prepared. So if students are able to access the MobiLearn application from home, it could potentially be used to aid students in their preparation for class.

From the questionnaire data, it is apparent that the costs that students had to incur to access the application also prevented access in some cases. One student even requested that *"free airtime should be provided".* Nevertheless, in the focus group discussions, it was clarified that the lecturer stated it clearly with the introduction of the MobiLearn application that students did not necessarily have to have a lot of airtime to be able to use the application. One participant supported it by remarking: "*she [the lecturer] did mention it in class [that] you don't have to have a lot of money [on] your phone … if you have a few rands, then you can [connect to] the Internet, but in cases where you don't have airtime then you won't be able to access it*". In the questionnaire, one student suggested that cheaper methods of mobile Internet access should be investigated by remarking as follows: "*the requirement to spend airtime, regardless of the amount, when other possible methods of wireless communication could be offered by the varsity where available, such as Wi-Fi on [UFS] campus*".

When all the data is considered, it is clear that there is ample space for improvement of accessibility in the MobiLearn application. Nokelainen (2004) also mentions that the learning material is only valuable if students can access and use it. With the investigation of alternative options for more students to be able to access the MobiLearn application, more students will be able to benefit from the learning material contained in the application.

5.4 Pedagogical usability evaluation

Pedagogical usability was evaluated, not only through the responses to statements in Section 3 of the questionnaire, but also from responses obtained from the focus group discussions with the students and the interview with the lecturer. As was the case with the technical usability evaluation, pedagogical usability of the MobiLearn application was evaluated by means of the pedagogical usability metrics that had been identified from contemporary literature (as summarised in Table 3.2).

Since it was not possible to identify broad categories of pedagogical usability metrics from the literature (as explained in Section 3.8), the discussion in this section follows the order in which the statements were arranged in the MobiLearn questionnaire. Exceptions occur in cases where more than one statement was used to measure a certain metric. Table 5.3 provides a summary of the responses to the questions on the learning support provided by the MobiLearn application.

5.4.1 Instruction

In response to whether the language used in the MobiLearn application was clear (see Statement 3 in Table 5.3), almost all the students (more than 90%) agreed/partially agreed with the statement. Although some (about 7%) partly disagreed with the statement, there was no one (0%) who completely disagreed with the statement (mean = 1.33; s = 0.62). It can be concluded that the MobiLearn application provided clear instruction to the target users. Heinich et al. (1996) assert that if one intends to use the technology of this nature, it should contain clear and concise language.

Table 5.3: Summary of responses to statements on the learning support provided by the MobiLearn application

Statements	Responses					
	Agree (%)	Partly Agree (%)	Partly Disagree (%)	Disagree (%)	Mean (n=27)	s
1. Questions for class activities were well organised on the MobiLearn application.	51.9	29.6	18.5	0.0	1.67	0.78
2. The mobile class activities were broken down into meaningful parts.	51.9	29.6	14.8	3.7	1.70	0.87
3. The language used in the MobiLearn application was clear.	74.1	18.5	7.4	0.0	1.33	0.62
4. The MobiLearn activities helped to improve my understanding of the course material.	18.5	51.9	14.8	14.8	2.26	0.94
5. The way in which the lecturer utilised the MobiLearn application helped me to gain knowledge on the subject matter.	25.9	40.7	29.6	3.7	2.11	0.85
6. I was eager to take part in the mobile class activities.	37.0	22.2	22.2	18.5	2.22	1.15
7. I liked the mobile class activities more than normal class activities.	22.2	25.9	18.5	33.3	2.63	1.18
8. The mobile class activities encouraged discussion and collaboration among students.	37.0	29.6	25.9	7.4	2.04	0.98
9. The MobiLearn application provided clear directions and descriptions of what I had to do at every stage in answering the questions.	44.4	37.0	11.1	7.4	1.81	0.92
10. Other Computer Science lecturers should also make use of the MobiLearn application in their classes.	44.4	25.9	18.5	11.1	1.96	1.06

Provision of clear instruction to students is more likely to improve their academic performance, because they do not spend too much time struggling with how to perform tasks or activities with the application. Instead, they get access to the learning material well in time and complete the assignments or tasks they are supposed to do on the application. If the instruction is not clear, students may not even get to the learning material or may ultimately get there already frustrated. SlideShare (2011) asserts that learning stops when learner frustration outweighs learner motivation.

5.4.2 Learning content relevance and structure

Most of the students (more than 65%) believed that the learning content included in the MobiLearn application was relevant to their learning (see Statement 5 in Table 5.3: mean = 2.11; s = 0.85). This implies that the learning content matched its purpose (Lim & Lee, 2007), the curriculum (Heinich et al., 1996) and was useful for educational purposes (Trickel, 2005). It can be concluded that as far as the learning content relevance was concerned, the MobiLearn application was pedagogically usable.

On the learning content structure, the majority of the students (more than 80%) were in agreement/partial agreement that the questions for class activities were well organised on the MobiLearn application (see Statement 1 in Table 5.3: mean = 1.67; s = 0.78). Although some students (about 19%) partly disagreed with the statement, there was no one (0%) who completely disagreed. This implies that the learning content included in the MobiLearn application was arranged clearly, consistently and coherently (Lim & Lee, 2007) and that the entire design of this application (Fetaji, 2008) made learning easy, and encouraged students to use it. Nevertheless, the questionnaire data indicated that there was one student who mentioned that s/he was not happy with "*the way those questions were placed in the MobiLearn [application]*". Although a relatively high percentage of students were satisfied with the learning content structure, it is evident that there is still room for improvement in this regard.

5.4.3 Tasks

The majority of the students (more than 70%) agreed/partly agreed that the tasks they performed on the MobiLearn application helped them to improve their understanding of the course material (see Statement 4 in Table 5.3: mean = 2.26; s

= 0.94). These tasks might also have promoted self-monitored learning (Lim & Lee, 2007) which could possibly have aided in improving the students' understanding of the course material.

The fact that the activities or tasks that students performed on the MobiLearn application helped in the understanding of the course material was also mentioned by the lecturer during the interview. She mentioned that although Activity 2 (see Figure 5.3) required the students to answer multiple-choice questions, "*the students were definitely involved in doing it*" as they had to "*analyse the diagram that they had in order to answer it, it was not just straight [forward, or simple] testing of knowledge, there was some … analysis and synthesis [involved] in order to answer those particular questions*". Analysis and synthesis are regarded by Bonwell and Eison (1991) as higher order thinking tasks. These tasks are deemed important for students in the understanding of the learning material.

5.4.4 Learner variables

More than 70% of the participants recommended that the MobiLearn application should be incorporated in other Computer Science courses (see Statement 10 in Table 5.3: mean = 1.96; s = 1.06). Even on the general comments about the experiences of students with the MobiLearn application, one student mentioned that the *"MobiLearn application should be implemented in all the other IT [Information Technology] subjects*".

During the interview with the lecturer, the researcher asked a similar question. She responded as follows: "*I think there is definitely potential for it but … there are a lot of hurdles that we will have to overcome, the major one being the number of students who can actually access it through their [cellular] phones*". She raised this concern, because with the use of this application in her classes, "*the biggest shock was that there were [very] few students from the class that could actually access [the] MobiLearn [application] from their cell phones*". This came as a shock to her because she was aware of the findings of an earlier survey, [conducted a year prior to this particular study by Blanche (2009) at the UFS] which indicated that 97.1 per cent of the cellular phones owned by UFS first-year students were WAP-enabled.

As a result, the lecturer decided to instead require the students to work in groups when they had to do the class activities through the MobiLearn application. In this regard, she remarked as follows: "*I didn't want to alienate the students who couldn't access it, and that's why with the second and third activities, I tried something different [making students work in groups or provide a paper-based alternative], but as I said it's a pedagogical challenge to incorporate something like this. It requires an effort from the lecturer because you now have to go and restructure the way that you are going to present that class to make time for such activities"*. The lecturer also mentioned that for Activity 2, she took two additional cellular phones that were WAP-enabled to class to ensure that each group had access to a phone that could access the MobiLearn application. She remarked as follows: "*there is only one cell phone needed per group … but I was afraid that there might have been some problems, so I took two of my own cell phones … to class*".

It follows from this discussion that although students in other Computer Science courses might also benefit from applications of this nature, accessibility is the top priority issue to be addressed. Failure to improve the accessibility of the MobiLearn application might instigate frustration among lecturers and students. The teaching and learning process may thus be adversely affected.

5.4.5 Collaborative learning

In the questionnaire, about 67% of the students agreed/partially agreed that the mobile class activities encouraged discussion and collaboration amongst them (see Statement 8 in Table 5.3: mean = 2.04; s = 0.98). The students also made numerous comments on the use of the MobiLearn application to encourage collaborative learning. One student was discouraged and frustrated by "*having to concentrate on a small screen*" especially when they worked in a group and the cellular phone was operated by one person. Another student mentioned that the "*screen was too small for the whole group*". One student suggested that the use of a cellular phone to access the MobiLearn application should be "*an individual activity*". Yet another student mentioned that "*it was difficult to participate if there is only one cell phone*". This implies that the benefits of collaboration as established from other studies (Johnson & Johnson, 1993; Johnson et al., 1998; Kagan, 1994; Shafritz et al., 1988), namely to assist other group members to learn and create a conducive learning atmosphere were not necessarily realised by all the students. These students clearly felt that the MobiLearn application did not create an atmosphere that was more dynamic and collaborative as Boone (2008) affirms such applications should do.

Although some students (about 33%) might not have felt that the collaborative activity (Activity 2) encouraged discussion and collaboration, the lecturer indicated during the interview that she was of the opinion that this activity definitely encouraged students to be more active in class. In this regard, she remarked as follows: "*the students were busy, they were not just sitting there … they were actually collaborating so they were already active participants*". She also mentioned that the seating arrangements for the groups (where the six group members had to sit in rows of three), "*three in front and three at the back"*, helped to make the collaboration easier. The small groups' activity prevented students from hiding behind others. In this regard, the lecturer remarked: "*for that particular activity there was not a chance for someone not to participate … the groups were small enough so that everyone could more or less be involved … I would say that they were engaged. It's not that they were sitting there and looking out through the window*". From this discussion, it can be concluded that the MobiLearn application was pedagogically usable and encouraged collaborative learning.

5.4.6 Ease of use

The majority of the students (more than 80%) agreed/partially agreed that the MobiLearn application provided clear directions and descriptions of what they had to do in every stage when questions are answered (see Statement 9 in Table 5.3: mean = 1.81; s = 0.92). According to Khan (1997), students are more likely to participate actively if ease of use is well incorporated into an educational application. An easy-to-use application is more likely to encourage students to use it in their learning. The questionnaire results imply that the MobiLearn application was pedagogically usable with regard to the ease of use metric.

5.4.7 Learner control

Most of the students (more than 80%) agreed/partially agreed that the mobile class activities were broken down into meaningful parts (see Statement 2 in Table 5.3: mean = 1.67; s = 0.87). Wilson and Myers (2000) assert that if the learning material is broken down into meaningful chunks, it becomes easy for students to grasp the concepts in the material. Accordingly, students may be encouraged to become active participants in their learning and learn more by themselves.

The lecturer also mentioned during the interview that the MobiLearn application was specifically designed for the course facilitator to organise class activities into meaningful parts. In this regard, she provided the following explanation: "*Like today's lecture, that's the class and in that class I can have different activities, and each activity can have its own separate set of questions*". This implies that students are less likely to get confused when they look for certain sections or items of the learning material, because they are forced to follow the defined hierarchy.

Another useful feature of the MobiLearn application is that the course facilitator could control the students' access to specific activities. The lecturer provided the following explanation: "*Let's say you have two activities for today's class, one at the beginning and one at the end of the session. Although the students will be able to see links to both activities when they log in on the MobiLearn application, they will only be able to select these links after I have opened them*". In the MobiLearn application, "*the password [was] not linked to a specific student, [but, was] linked to a specific class*". Students were only able to login to a specific class section of the MobiLearn application after the lecturer provided them with the correct password. The blockage and password features helped to reduce the risk of students from getting lost in the application and preventing students not to fulfil their expectations (Duchastel & Spahn, 1996). It can be concluded from this discussion that the students had positive views on the learner control metric of the MobiLearn application as far as making the mobile class activities distinct from one another on the application was concerned.

5.4.8 Motivation

The motivation usability metric was measured through examination of the following two aspects:

- The eagerness of students to participate in mobile class activities; and
- The interest of students in mobile class activities versus normal class activities.

With regard to their eagerness to participate in mobile class activities, the students had mixed feelings. The percentage of students who partially agreed with the statement (22%) is equal to the percentage of students (about 22%) who partially disagreed with the statement. The mixed feelings are also reflected in the value of the standard deviation (s = 1.15) which has very large degrees of freedom from the mean (x= 2.22) (see Statement 6 in Table 5.3). Comparison of mobile class activities to normal class activities led to contrasting views amongst the students. While approximately 22% of the students completely agreed and almost 26% partially agreed with the statement, more than 33% of them completely disagreed with it (see Statement 7 in Table 5.3: mean = 2.63; s = 1.18).

As none of the students made any negative remarks regarding their motivation to use the MobiLearn application in the open-ended questions or during the focus group discussions, the lecturer was asked why she thought the students might have been demotivated to use the MobiLearn application. In response, she mentioned that students originally struggled to connect to the application and that might have frustrated them. This most probably resulted in their demotivation to use the application. She also mentioned that "*maybe they [some students] didn't want to use it [the MobiLearn application] because they struggled to understand the work that was discussed during the lecture*".

It seems that some students were motivated by the fact that the class activities on the MobiLearn application were entirely mobile. One student remarked in his/her questionnaire response that "*it was a new way to do activities, and it made me want to learn more about programming and web designing so that one day I [would] be able to design a similar application*". Another student mentioned that s/he enjoyed the "*accessibility and the convenience of doing activities anywhere and at any time*". The latter remark raises the important issue to do class activities anywhere. This is in agreement with Mellow (2005) (see Section 2.7.3) who claims that the *study anywhere* feature is key in educational applications. This feature was only to a limited extent possible in the MobiLearn application (as used in this study) as it is mainly used for in-class activities.

The students who participated in the focus group discussions indicated that they were always motivated to go to class irrespective of whether they were going to use the MobiLearn application or not. One student made the following remark: "*I was always motivated to go to class, but when I had to do it [MobiLearn] in class, I was [more] eager*". This student also mentioned that he definitely would not have missed the class if he knew in advance that they were going to use the MobiLearn application on that particular day. Although the students agreed that the mobile activities took longer than normal class activities, it did not seem to bother them. One student remarked: "*Yah that takes a bit of time, … slows the answering process, … and even slow connections…it's a bit time consuming but I would rather answer MobiLearn questions than physical class questions you have to do by hand*". It is evident that although students are aware of the longer time it takes to do class activities with their cellular phones, they are more motivated to participate in the mobile class activities (as opposed to normal class activities).

It can be deduced from the above discussion that, although some students might have been originally fascinated by the MobiLearn application, the technical problems might have demotivated them from using it. But, students who did not struggle that much or those who did not struggle at all, might have been more motivated to use this application in class.

5.5 Value added through the use of the MobiLearn application

The researcher also found it necessary to evaluate the value added to the students' learning experience through the use of the MobiLearn application. This added value helped to measure the effectiveness of the MobiLearn application to encourage active classroom participation. The evaluation was done specifically based on the measures of active classroom participation as deduced from literature (see Section 2.8). These measures are elements that need to happen in a class as proof that active classroom participation has occurred. The results of the questionnaire survey on these measures are summarised in Table 5.4.

Table 5.4: Summary of responses to statements on the value added by the use of the MobiLearn application

Statements	Responses					
	Agree (%)	**Partly Agree (%)**	**Partly Disagree (%)**	**Disagree (%)**	**Mean (n=27)**	**s**
1. The MobiLearn application helped me to interact with the lecturer.	25.9	44.4	22.2	7.4	2.11	0.89
2. The MobiLearn application encouraged me to interact with the lecturer.	40.7	25.9	22.2	11.1	2.04	1.06
3. The MobiLearn application encouraged me to concentrate more in class.	29.6	33.3	22.2	14.8	2.22	1.05
4. The MobiLearn application helped me to ask questions without any fear.	40.7	22.2	18.5	18.5	2.15	1.17
5. The MobiLearn application helped me to perform better in the subject.	18.5	40.7	18.5	22.2	2.44	1.05
6. The MobiLearn application helped me to develop a more positive attitude towards the subject.	22.2	37.0	22.2	18.5	2.37	1.04
7. The MobiLearn application helped me to improve the way I think when answering questions.	33.3	33.3	14.8	18.5	2.19	1.11

5.5.1 Assistance to interact with the lecturer

Most of the participants (more than 70%) were in agreement/partial agreement with the statement that the MobiLearn application helped them to interact with the lecturer (see Statement 1 in Table 5.4: mean = 2.11, s = 0.89). During the interview with the lecturer, it became clear that she thought lecturer-student interaction definitely happened in her classes. She remarked: "*I think I got the best reaction from the group activity*". The fact that lecturer-student interaction occurred is an important finding, because natural interactions between students and lecturers break the psychological barrier to perceive lecturers as experts (Darling, 1994).

When asked what the students enjoyed the most about the MobiLearn application (in Section 5 of the questionnaire), one student remarked that the application provided an "*easy and [a] fast way to contact my lecturer*". This consolidates the results where over 70% of the students indicated that the MobiLearn application provided them with an easy way to interact with the lecturer during the class sessions (see Statement 7 in Table 5.2: mean = 2.00, s = 0.92). Approximately 67% of the participants believed that the MobiLearn application provided them with a fast way to interact with the lecturer during the class sessions (see Statement 8 in Table 5.2: mean = 2.07, s = 0.87).

On close examination of Activity 1, it becomes evident that the lecturer made attempts to enhance the interactions between her and the students. The environment that she created, exhibited the characteristics of an environment that should prevail in a student-centred approach and one that is conducive to active classroom participation (see Section 2.9). It is evident from this discussion that the MobiLearn application helped students to interact with the lecturer. Through this interaction, students are more likely to receive feedback from the lecturer. This may ultimately help them to improve their performance.

5.5.2 Encouragement to interact with the lecturer

About 67% of the students reacted positively to the statement that the MobiLearn application encouraged them to interact with the lecturer (see Statement 2 in Table 5.4: mean = 2.04, s = 1.06). All the focus group participants also agreed on this statement. A remark given in this regard was: "*because once you communicate with the lecturer, the lecturer will communicate back*". This type of communication is not face to face, and according to one participant, it encourages "*shy students to communicate [further] with the lecturer because they don't physically interact with her*". One participant observed the convenience introduced by the use of cellular phones for educational purposes. The advantage is that students do not have to physically go to the lecturer; instead they can interact remotely. A remark in this regard was: “*we don’t really necessarily come to her [the lecturer] every time there are some information we can get through our cell phone[s], and that ... would be more easy to use as part of our development*”.

It can be concluded that the MobiLearn application encouraged students to interact with the lecturer. This finding is important because, if students are encouraged to interact with the lecturer, that may help them to ask questions throughout the lecture. This may help them to grasp the concepts under discussion in class and keep them updated with the material being presented. The lack of lecture-student interaction in the learning process contributes to reduced student throughput (Greyling et al., 2008).

5.5.3 Encouragement to concentrate more in class

The survey questionnaire results were wide ranging on the statement that was intended to measure whether the MobiLearn application encouraged students to concentrate more in class. Approximately 30% of the students completely agreed with the statement, about 33% partly agreed, while about 22% partly disagreed and about 15% of them completely disagreed with the statement (see Statement 3 in Table 5.4: mean = 2.22, s = 1.05).

There were some students who demonstrated characteristics of students who did not want to participate in class. One of those students did not like to do anything in class, except to listen and he remarked: “*the effort of taking out your cell phone when you actually just want to listen*”. This was a response to the questionnaire question about what students enjoyed the least about the MobiLearn application. It is evident that this student just wanted to sit and listen in class. This student was, therefore, not willing to be an active participant in correspondence with Egan and Gibb (2002) who state that students that are actively engaged in class do more than simply listening to a lecture.

It can be concluded that the MobiLearn application encouraged students to concentrate more in class. Research (Biggs, 2003; Gibbs & Jenkins, 1992, p. 17;

Hauske et al., 2007, p. 1571) revealed that if students concentrate more, or participate actively in class, they are more likely to perform well academically.

5.5.4 Assistance to ask questions without fear

The students had mixed feelings on the statement that measured whether the MobiLearn application helped them to ask questions without any fear (see Statement 4 in Table 5.4: mean = 2.15, s = 1.17). It is about the same percentage of participants (approximately 63%) who agreed and disagreed (about 37%) as in the statement on enhanced concentration in class (see Statement 3 in Table 5.4: mean = 2.22, s = 1.05). The percentage of participants who completely agreed and those who completely disagreed with the statement were equal (approximately 19%).

Questionnaire data indicated that the students were interested in the fact that they could answer questions through the use of the MobiLearn application without necessarily speaking to the lecturer. A comment to consolidate this was: *"[the] MobiLearn [application] is a good learning technology. I learned to interact and ask questions and answer question[s] to the lecturer not verbally*". Another observation was: "*I can just simply send my answer to the lecturer without talking to her verbally*". And "*it was easy to understand the questions and to answer them*". Other students were fascinated to use their "*own cell phones [in] answering questions*".

From the questionnaire data, it can be seen that the initial reaction of students, when it was announced that they would be using their cellular phones to participate in class, was: "*I was happy because I was shy to ask and answer question[s] physically in class*" and "*it [the MobiLearn application] makes everything easier for everyone, especially students who have the fear problem of asking during the lecture*". Ample evidence is provided in this discussion that some students are shy to ask questions verbally in class. The issue was also raised in similar fashion during the focus group discussions. This indicates that lecturers should seek ways, such as to use technology (e.g. the MobiLearn application), that encourages students (irrespective of whether they are shy or not) to actively participate in class.

It can be deduced from the above discussion that the MobiLearn application helped the students to ask questions without fear. This is consolidated by one student who remarked that what s/he enjoyed the most about the MobiLearn application was: "*asking questions to my lecturer without speaking*". Another comment was: "*expressing yourself without doubt and be[ing] free*". A very interesting remark by one participant was: "*you are able to ask question[s] over the phone if you are afraid or scared to ask in class*". This shows that the MobiLearn application encouraged the students to participate actively in class in an anonymous way. This is the concept that was introduced in the literature study chapter (see Section 2.7.1) by DeBourgh (2008) and Martyn (2007) about the student response systems.

5.5.5 Assistance to perform better in the subject

With regard to the statement that the MobiLearn application helped the students to perform better in the subject, there was not enough evidence to draw a clear conclusion. From the results, 59% of the students agreed/partially agreed while 41% did not agree/partially agree with the statement (see Statement 5 in Table 5.4: mean = 2.44, s = 1.05). This issue was further investigated during the focus group discussions. It became apparent that the students regarded the MobiLearn application as a tool to help them to participate in class, but not to perform any better in the subject. An excerpt from the focus group discussions (as listed in Figure 5.5) emphasises this point:

The views of the lecturer on better performance in the subject through the use of the MobiLearn application were also sought. She indicated that though students' performance was not measured in this regard, she thought that the three MobiLearn activities were not enough for that to be noticed. Her remark was: "*I think we didn't use it necessarily enough to now go and make such a distinction and also because … it wasn't specifically measured. So, I don't think in this regard it really had an influence*". The lecturer and the students had similar views on the '*assistance to perform better in the subject*' active classroom participation measure.

New innovations are constantly introduced in teaching and learning with the objective to bring improvements in the teaching and learning process. It is inevitable that, if improvements are introduced in this process, students are more likely to perform better than they used to before the advent of the innovation. It was a genuine expectation by some students that their performance would improve. One student remarked: "*I was expecting [that] it was going to be easy and improve our marks but it didn't*". This implies that students should still work hard, irrespective of the availability of technology to help them in their learning. Such technology is there to facilitate interactivity in class and/or to provide easy access to learning materials or resources. It can be concluded that the MobiLearn application did not specifically help the students to perform better in the subject.

Question from Researcher: *Did the use of the MobiLearn application help you to perform any better in the subject?*

Responses in Session 1:

Student A: *No, Not really.*

(… all students nod in agreement …)

Researcher: *Not really.*

Student A: *Nope.*

Researcher: *… if you were going to get like an "A", you could still get it without the use of the application?*

Student A: *Yah!*

Response in Session 2:

Student B: *I think it didn't go as much as … I had better [marks] because of that [application] …*

Figure 5.5: Excerpt from focus group discussions on student performance

5.5.6 Assistance to develop an increased positive attitude towards the subject

The questionnaire survey results on the statement that measured whether the MobiLearn application helped students to develop an increased positive attitude towards the subject were as follows: About 22% of the students completely agreed, 37% partly agreed, about 22% partly disagreed and approximately 19% were in complete disagreement with the statement (see Statement 6 in Table 5.4: mean = 2.37, s = 1.04).

In the focus group discussions, students indicated that the use of the MobiLearn application helped to increase their interest in the subject. An interesting point raised was that students like their cellular phones very much, and anything that has to do with their cellular phones is likely to interest them. The love of cellular phones was indicated by this assertion: "*we really love our [cell] phones … [laughter]*". One student even gave the scenario to attract people into something through the use of perhaps a tool or anything that they like and use in their everyday life. He remarked: "*students love using their phones … because they love using their phones, I think it's like … taking education to the playgrounds, something like that*". This is ample evidence that through the use of the MobiLearn application, which also involves the use of a favorite component (a cellular phone) of their daily lives, students developed a more positive attitude towards the subject.

There was a different opinion given that students are more likely to like the subject only if the MobiLearn application helped them to do well in the course and that students are likely to hate the subject if the application does not help them to perform well in the subject. A remark is this regard was: "*it's different viewpoints, if it … helps you excel in the course, then you will probably like it ... [but, if it doesn't] … it's just extra work you have to [do, so you probably hate it]*". The discussion in this section provides sufficient evidence to conclude that the MobiLearn application mostly helped students to develop a more positive attitude towards the course.

5.5.7 Assistance to improve thinking ability

Approximately 67% of the students agreed/partly agreed that the MobiLearn application helped them to improve the way they thought when they answered questions (see Statement 7 in Table 5.4: mean = 2.19, s = 1.11). It was further investigated why some participants (about 33%) might have had different views on this matter. The students in the focus group discussions indicated that the use of the MobiLearn application in the subject helped them to improve their thinking ability (see Sections 2.5.1 and 2.5.3). One student remarked: "*I think it will give you a bit more experience in answering questions because you are doing more questions or working out more questions, so it will probably better your answering skills*". The claim on intellectual capacity shows from this remark: "*yah, what I didn't understand in today's lecture, … she [the lecturer] asked us to send a question [through the MobiLearn application], so it's not like sitting there and you needed to listen because now you have to make sure that you understand everything so that you can formulate a question to ask … so it really allowed you to be more alert*".

The class activities, especially Activity 2 (see Figure 5.3) also indicated that students had to critically analyse the questions to produce possible answers. In that activity, the lecturer specifically asked the students to discuss the questions. This promoted the ability of students to debate amongst themselves and ultimately arrive at an agreed answer. The questions were not just straightforward testing of knowledge. It is evident that students were required to use critical thinking skills (see Section 2.9) to complete this activity.

5.5.8 Knowledge sharing

Knowledge sharing, an active classroom participation measure, was not included in the questionnaire. It was raised in the comments provided by students in response to the open-ended questions in Section 5 of the questionnaire. As discussed in Section 2.5.3, knowledge sharing is an important aspect in an environment where students are active participants in their learning. This is why one student remarked: "*the fact that it [the MobiLearn application] helped us to interact with other students and therefore allowing us to share knowledge we know with each other*". This is an important remark as far as learning communities (see Section 2.5.4) are concerned, because in these communities students share a lot of knowledge with their group members. This was also mentioned by the lecturer in the interview when she said: "*the reaction from the students from the groups, the excitement when they saw that they got the questions right, and … where I think the only one group got the answer right obviously that group knew that it was them who did that and I think that helped to create a sense of community within that particular group as well*". Through this comment, the lecturer clearly indicated her belief that one of the benefits of group activities is that it introduces a delightful mood in class.

Another comment on knowledge sharing was: "*I gained knowledge and had a good understanding [through the MobiLearn class activities]*". This implies that effective knowledge sharing may help to address some of the challenges, such as to increase student throughput and to help the academically under prepared students, which lecturers face in their teaching (see Section 2.5). It is obvious that there was a lot of knowledge sharing by the students through the use of the MobiLearn application.

5.6 Experiences with the MobiLearn application

In the final section of the questionnaire (Section 5), students were asked to share some of their personal experiences with regard to the use of the MobiLearn application through the use of open-ended questions. The discussion in this section does not treat each question individually, but rather considers a combination of issues raised by students with regard to the use of their cellular phones in combination with the MobiLearn application to participate in class activities. Some feedback gathered from the focus group discussions and the interview with the lecturer is also incorporated in the following sub-sections.

5.6.1 Costs to use new innovations

Some students were concerned about the costs that they would need to incur to use their cellular phones to participate in the MobiLearn application class activities. Although the use of cellular phones for class activities is not as inexpensive as the manual strategies discussed in Section 2.6 (e.g. think-pair-share, one minute paper, affective response, ConcepTest, the fish bowl, finger signals and send-a-problem), it can definitely be regarded as much less expensive than other technology-driven strategies such as student response systems (see Section 2.7.1).

At other institutions that use student response systems, students are often required to purchase a clicker as part of the study resources required for the course (Herreid, 2006). This can be quite expensive for students. It is clear from the student responses in this study that even the relatively low costs to access the MobiLearn application is a genuine concern. One student remarked: "*expenses (we are students after all). Browsing is cheap, but didn't know if we're going to download or not" while another student just asked "what it will cost?*" The cost aspect should be regarded as a very important consideration, especially in a developing country.

5.6.2 Interest in how the MobiLearn application functions

During the analysis of the questionnaire responses, it became apparent that even prior to the use of the MobiLearn application for the first time, students were already interested in the functioning of the application. The students made the following comments:

- *"It sounded fun and interesting as I was curious on how my cell [phone would come] into connection with my module";*
- *"Intrigued, to see in what way we could use our cell phones in class";*
- *"I was eager to see how it will all work and help";*
- *"I was surprised and did not know how it was going to work"* and
- *"I was curious and yet excited to see how it will work out".*

As the use of cellular technologies for classroom activities was a completely new idea to these students, their initial interest might have spurred them to be eager to use the MobiLearn application. This might not necessarily be the case if students are already familiar with such classroom technologies and especially if they have had bad mobile activity experience in the past.

5.6.3 Reaction based on previous experiences

There is a tendency for people to react to new innovations based on their previous experiences. In the questionnaire, one student asserted: "*I got a bit shocked, thinking along the process it might crash*". This might have been due to prior experience this student had with other applications that might have troubled her/her with crashing a lot. For students as such, their prior experiences might have a negative influence on their attitude towards the use of classroom technologies, such as the MobiLearn.

5.6.4 Use of cellular phones in class

As indicated in Section 5.2, the students were from different backgrounds and obviously their cultural practices are different. Some of them might have previously been prohibited to use cellular phones in class and, for some students, that might not have been a concern. As proof to this, one student noted: "*I was surprised as I had never heard of the use of cell phones for academic purposes in the lectures*". Another student commented: "*using my cell phone for academic purposes as in most cases, cell phones are not allowed*". The reactions of these students are understandable, as most lecturers normally instruct students to either put their phones on silent or turn them off completely for the duration of a class to avoid unnecessary disruptions. In some classes, students are even subjected to some form of punishment if their cellular phones were to ring during class. This issue was further investigated during the focus group discussions.

All the students indicated that they were aware of the disruptions that the use of cellular phones presents in class. Figure 5.6 is an excerpt from a discussion in one of the focus groups on this issue.

Researcher: …so you are against the use of cellular phones in class?
Student A: No, I am not against the use…
Researcher: But…
Student A: I am just saying it causes disruptions…

Figure 5.6: Excerpt on disruptions caused by the use of cellular phones in class

One participant remarked: "*I tend to get so furious if they[students] do the Mix-It thing, and I don't know [what] they are doing in class with the phone ... the whole time doing the thing [the Mix-It thing] with the cell phone and they think you don't see it, but you do, you really do see*". The participants still encourage the further use of cellular phones in class, but with more discipline. A remark ~~i~~s: "*in [the] technology world … we can't say … it [cell phone] irritates me, [and] no cell phones or whatever if that is a useful thing in class. I say definitely yes, but then in a disciplined manner … (all the other participants agree) … but don't leave it because it irritates you sometimes, just help the students to be disciplined about it*".

The researcher also sought the views of the lecturer on the use of cellular phones in class. In response, she said: "*that was one of my concerns at the beginning, having cell phones that ring*". She indicated that cellular phones have never been a nuisance in her classes. She thought that the disruptions may occur in very large classes. Her comment was: "*if maybe you get to a class of 500 students where they are now doing things, that might be an issue*". She validly remarked that: "*if you use it [cell phone(s)] for assessment or something, they [students] have a limited time for them to now go and do other things on the phone than to concentrate on the activity*". Taking the responses of all the participants into consideration, it is clear that no one has a problem when cellular phones are used in class as part of a learning activity, but the use needs to be closely regulated and monitored by the lecturer to avoid unnecessary disruptions.

5.6.5 Reaction of academically under prepared students

In Section 2.4, dealing with academic under preparedness was identified as one of the challenges in implementing a student centred approach. The reactions of some of the students projected that some of them were academically under prepared. One student raised a concern that s/he "*might not complete some of the class activities*". Another student commented: "*reluctance to participate. Disappointment*". These comments may imply that these students were already negative about anything that could be introduced in class in an attempt to support them in their learning. These students might also react negatively to other support programmes (see Section 2.5.4) that institutions might offer in this regard.

5.6.6 Use of technology in the place of a pen and paper

As discussed in Section 2.6, active classroom participation implementation strategies, such as the one minute paper and think pair share, mainly use a pen and paper. If such strategies are automated, the pen and paper use can be eliminated. In the questionnaire responses, one student made a very interesting when s/he remarked: "*the aspect of traditional pen [and] paper base[d] learning evolving to take advantage of digitisation and technology*". It was clear that this student was fascinated by the pen and paper use eliminated in favour of the use of cellular phones in combination with the MobiLearn application to participate in class activities.

Detrimental views on this issue were that the use of the MobiLearn application was time consuming. One remark was: "*waste of valuable lecture time"*, while another student commented: "*I don't think it's practical. Paper would consume a lot less time and effort*". Yet another student observed: "*It was fun and interesting but yet on the other hand it was time consuming and that's why I recommend it for homework*". The time factor might have been verbalised because typing on a cellular phone keypad is not as fast as typing on the computer keyboard. But, perhaps it might even be slower when a pen and paper are used. There is also additional time that is required to first browse to, and log in, on the MobiLearn application before the students can start with an activity. It is evident from this discussion that when a new classroom technology is introduced, care should be taken to ensure that it is more convenient than the common use of pen and paper in the learning process. If the students regard their interaction with the technology or an application as inconvenient, they may be discouraged to participate actively in class through the use of that innovation.

5.6.7 Prompt feedback

As discussed in Section 2.5.2, to mark and give feedback has been found to be a serious challenge to lecturers. During the interview, the lecturer indicated that the MobiLearn application was "*a speedy way to gain feedback from the class*" and she could "*see the results on the screen immediately*". The importance of feedback to students to encourage them to participate actively in class cannot be overemphasised. Feedback indicates how well students understand the learning content (McDowell, 2007), and students are more likely to be interested in their learning and participate actively in class if they are given prompt and encouraging feedback. The immediate provision of responses through the use of the MobiLearn application was also raised in the focus group discussions. The remark was: "*yah instantly … it's like these clickers that they have in certain TV shows … [where they ask] for who do you vote? … you vote and [they show the results] immediately"*. This serves as a further indication that the MobiLearn application made it easy to get prompt feedback from the students and allowed the lecturer to give prompt feedback to the students based on their MobiLearn responses.

5.7 Conclusion

This chapter has presented an analysis of the data that were collected during the various data collection activities and also presented an interpretation of the findings. The discussion mainly focused on the findings from the questionnaire survey, focus group discussions and interview with the concerned lecturer. The questionnaire mainly focused to gather students' perceptions on the technical and pedagogical usability of the MobiLearn application as well as the role that the use of this application played in encouraging active classroom participation. All the uncertainties that arose from the analysis of the students' responses on the questionnaire were investigated through the use of focus group discussions and an interview with the lecturer. Class attendance records were specifically used to measure the accessibility metric while the MobiLearn usage data was used to measure the percentage of tasks completed and accessibility metrics. The responses provided by all the participants were interesting and intriguing, and in many cases corresponded with the findings from contemporary literature.

After thorough analysis of all the collected data it becomes apparent that the majority of the students have positive feelings regarding the use of the MobiLearn application in their teaching and learning environment and the role that this application plays to encourage active classroom participation. The majority of these students evaluated the MobiLearn application to be both technically and pedagogically usable and believed that the application added enormous value to their learning experiences. The lecturer also emphasised the important role that the MobiLearn application played in encouraging students to be more actively involved during lectures. Although she agreed with the challenges experienced by the students to use the MobiLearn application and also identified some of her own challenges, it was apparent that she saw a lot of potential in the use of the application. All the findings of this chapter, together with the findings from literature (as discussed in Chapter 2 and 3), were used to formulate technical and pedagogical guidelines for best practices to use mobile learning applications to encourage active classroom participation. These guidelines are presented in the final chapter.

Chapter Six:
Conclusions and recommendations

6.1 Introduction

The aim of this study was to determine how usable mobile learning applications can be in encouraging active participation in large undergraduate Computer Science classes. The investigation was directed by three main objectives. The first objective was to conduct a comprehensive literature review on various aspects related to the aim of this study (as discussed in Chapters 2 and 3). The second objective was to evaluate both technical and pedagogical usability of the selected mobile learning application in order to determine its overall usability and effectiveness to encourage active classroom participation. This objective was pursued through an empirical investigation (as discussed in Chapters 4 and 5).

The third objective was to compile a set of technical and pedagogical guidelines for best practices in using mobile learning applications to encourage active participation in large undergraduate classes in similar contexts. This objective is addressed in this final chapter where the researcher provides an overview of the findings deduced from this study and the consequent conclusions that were drawn to compile this set of guidelines. The chapter concludes with some suggestions for future research and thereafter indicates the significance of the study.

6.2 Main findings of the study

This section provides an overview of the main findings from the literature review and the empirical investigation.

6.2.1 Findings from the literature review (with supporting evidence from the empirical investigation)

The researcher conducted a comprehensive literature review in which the following aspects were studied:

- The global shift from the traditional teacher-centred teaching and learning approach towards a more student-centred approach.

- The teaching and learning challenges associated to implement a student-centred approach in large undergraduate classes in general, as well as in the South African context.
- The strategies which can be employed to implement a student-centred teaching and learning approach.
- The strategies that may be used to address the lack of participation in large undergraduate classes.
- Existing mobile learning applications and the role they can play to address the lack of active classroom participation in large undergraduate classes.
- Usability quality criteria categories and metrics used to measure both technical and pedagogical usability of educational applications.

This part of the study identified the lack of resources, facilitation of student assessment and feedback, pressure to increase student throughput and the academically under-preparedness of students as the four main teaching and learning challenges experienced by lecturers and students in large undergraduate courses (see Section 2.4). With regard to these challenges, the researcher concludes that it is not easy to address them by the simple use of a traditional teacher-centred approach. This is mainly because of the ineffectiveness of this approach to support the construction of conceptual understanding by students (see Section 2.2). After various teaching and learning issues were considered (as described in Section 2.3), a student-centred approach was identified to be more promising for quality teaching and successful learning in the 21^{st} century. In a teaching and learning environment where a student-centred approach is practiced, active classroom participation is identified as one viable solution that has the potential to lower the intensity of the four stated challenges. It demonstrates how active classroom participation can mitigate the effects of these challenges (see Section 2.5).

To deal with the limited resources challenge, it is suggested that students can be encouraged to work in teams and that lecturers can prepare short lecturettes for the students. These strategies can help students to share considerable knowledge and create an opportunity for them to continue with class by themselves should the need arise (see Section 2.5.1). A shortage of resources is definitely an issue. The lecturer mentions that she brought her personal cellular phones to class so that she could borrow it to students who did not own WAP-enabled phones. Apart from this, she expected students to form groups in order for them to share the knowledge as well as the limited resources. Knowledge sharing is an important aspect as far as active classroom participation is concerned (see Section 2.9).

For the facilitation of student assessment and the feedback challenge, it is suggested that lecturers should try to give as many assignments to students as possible, but that they should try to simplify marking and award a "1" to students who submitted and a "0" to those who did not submit. An open culture, lecturer immediacy behaviours and lecturettes are also recommended, because they foster interaction and students become free to discuss a lot of issues with the lecturer. This could help the lecturer to identify strategies that suit the students best in their learning (see Section 2.5.2). To use the MobiLearn application, the lecturer employed a different approach. She engaged the students in class activities and through the use of the MobiLearn application, she could receive immediate feedback from the students on their level of understanding of the course content. In turn, she was able to provide immediate feedback. The implication is that there is a lot of interaction among the lecturer and the students. This is an important aspect in a class environment where a student-centred approach (see Section 2.3) is employed and where active classroom participation should occur (see Section 2.9).

In order to increase the student throughput, it is suggested that students should be encouraged to actively ask questions, engage in group discussions, share experiences, demonstrate class activities and work on assignments. It is also suggested that students should engage in constructivist learning, because they construct their own knowledge in this type of learning. This can have a positive effect on their performance in the course (see Section 2.5.3). In this study, the lecturer also made it possible for students to ask questions through the MobiLearn application (see Section 5.3.1.1 - Figures 5.2 and 5.4). The students preferred this anonymous way of voicing their opinions and/or questions (see Section 5.5.4). Providing for opportunities for student voices to be heard, is necessary in a student-centred approach. Herein students are not just passive absorbers of information (see Section 2.2).

To deal with the last mentioned challenge, which is academic under preparedness of students, it is suggested that learning communities and support programmes should be established. Being part of such communities and programmes, students are likely to expose their skill deficiencies to their peers, and create an opportunity for such skills to be improved (see Section 2.5.4). With regard to the strategies used in this study, the lecturer facilitated students' learning in small communities. This was achieved by students who collaborated in groups. It helped them to learn from one another. These are characteristics necessary in a student-centred approach.

Apart from some of the strategies used to individually address the four challenges, various classroom activities, such as think-pair-share, one minute papers, affective response, ConcepTest, the fish bowl, finger signals and send-a-problem (see Section 2.6) were identified as strategies that may be employed by lecturers to encourage active classroom participation. Nevertheless, it was established that large class environments further complicate the implementation of these strategies and that students might show some resistance towards these strategies (see conclusion of Section 2.6).

It was established that there are some technological tools that can be used to manage the implementation of active classroom participation strategies more effectively in large classes. These tools are organised into three categories, namely response systems, web-based student response systems and mobile phones (see Section 2.7). After the advantages and disadvantages of each of these tools were evaluated, the researcher concluded that mobile-based technology tools might be the most viable option to encourage active classroom participation in the context of large undergraduate Computer Science classes at the UFS.

The next step was to investigate how educational applications (including mobile applications) can be evaluated to determine their suitability to achieve the goals for which they were developed. It is evident that educational applications should not only be evaluated for their technical usability, but also for their pedagogical usability. This helps to ascertain whether the application really supports students in their learning process. The researcher, thereafter, identified a set of usability metrics that may be used to measure both the technical usability and pedagogical usability of educational applications.

The technical usability metrics were grouped into three quality criteria categories, namely effectiveness, efficiency and satisfaction (see Table 3.1). Although the researcher was unable to identify pedagogical usability quality criteria categories from the literature, nine individual pedagogical usability metrics were established (see Table 3.2). The researcher also evaluated previous usability studies conducted on educational applications to identify how these applications have been evaluated for usability.

6.2.2 Findings from the empirical study

In the empirical study, the researcher aimed to:

- Evaluate both the technical and pedagogical usability of the selected mobile learning application by means of an interview, questionnaire survey and focus group discussions to determine the overall usability and effectiveness of this application to encourage active classroom participation.

The mobile learning application (MobiLearn) used for this investigation was specifically developed for this study. Its purpose was to allow students to use their cellular phones to participate in class activities. The lecturer used the application by the addition of class activities on it and with the request to students to log in and do those activities with the use of their cellular phones (see Section 5.3.1.1). The application accepted the responses of the students on questions in the class activities and drew graphics for the aggregated responses. Those graphics helped the lecturer to immediately identify areas that students had concerns on and/or did not understand. Upon identification of those areas, the lecturer addressed them.

The researcher used several methods to collect data (both qualitative and quantitative). The quantitative data was collected by means of close-ended questions in the questionnaire survey, the MobiLearn usage data and class attendance records. The qualitative data was collected through open-ended questions in the questionnaire, focus group discussions with voluntary participants from the selected population and the personal interview that was conducted with the lecturer.

6.2.2.1 Technical usability evaluation

Technical usability of the MobiLearn application was evaluated by means of the 12 technical usability metrics identified from the literature (see Table 3.1). The results obtained from the evaluation (as discussed in Section 5.3) are summarised in Table 6.1.

Table 6.1: Summary of the technical usability evaluation

Usability quality criteria category	**Technical usability metrics measured**	**Technically usable?**	
		Yes	**No**
Effectiveness	Percentage of tasks completed	✓	
	Error rate	✓	
	Accessibility		✓
Efficiency	Internal consistency	✓	
	Error handling and prevention	✓	
	Learnability	✓	
	User's memory load	✓	
	Screen display	✓	
	Data entry and viewing	✓	
	Navigation	✓	
Satisfaction	Internal user control and freedom	✓	
	Memorability	✓	

Overall, the MobiLearn application was perceived to be technically effective, efficient and satisfactory. The only exception arises from the accessibility metric in the effectiveness category. The negative evaluation of the accessibility of the MobiLearn application can mostly be attributed to small percentage (about 40%) of the students who were able to access the application from their cellular phones (see Section 5.3.3.3). The decision by the lecturer to use the MobiLearn application for a group activity (where only one student from each group had to access the MobiLearn application – as described in Section 5.3.3.3) ensured that all the students at least had access to the application for that particular activity. This initiative from the lecturer was not enough to improve the overall accessibility of the application.

6.2.2.2 Pedagogical usability evaluation

The pedagogical usability of the MobiLearn application was evaluated by means of the nine pedagogical usability metrics identified from the literature (see Table 3.2). The results obtained from the evaluation (as discussed in Sections 5.4) are summarised in Table 6.2.

Table 6.2: Summary of the pedagogical usability evaluation

Pedagogical usability metrics measured	**Pedagogically usable?**	
	Yes	**No**
Instruction	✓	
Learning content relevance	✓	
Learning content structure	✓	
Tasks	✓	
Learner variables	✓	
Collaborative learning	✓	
Ease of use	✓	
Learner control	✓	
Motivation		✓

Overall, the MobiLearn application was perceived to be pedagogically usable. The only exception relates to the motivation metric. The students' lack of motivation to use the application is directly related to their inability to access the MobiLearn application from their cellular phones. This is a clear indication of a situation where a perceived problem with the technical usability of the system (low level of accessibility) directly influenced the pedagogical usability of the system (low level of student motivation).

6.2.2.3 Evaluation of the active classroom participation measures

The effectiveness of the MobiLearn application to encourage active classroom participation was evaluated by means of the seven active classroom participation measures established from the literature (see Section 2.9). The principle behind these measures is that if students are able to:

- Interact with the lecturer;
- Concentrate more in class;
- Ask questions without fear;
- Perform better in the subject;
- Develop more positive attitude towards the subject;
- Improve critical thinking skills; and
- Share knowledge,

they might be more inclined to participate actively in class. The results obtained from the evaluation are as shown in Table 6.3.

Table 6.3: Summary of the evaluation of active classroom participation measures

Active classroom participation measures	**Did the MobiLearn application help in this regard?**	
	Yes	**No**
Assistance to interact with the lecturer.	✓	
Encouragement to interact with the lecturer.	✓	
Encouragement to concentrate more in class.	✓	
Assistance to ask questions without fear.	✓	
Assistance to perform better in the subject.		✓
Assistance to develop a more positive attitude towards the subject.	✓	
Assistance to improve critical thinking.	✓	
Assistance to share knowledge.	✓	

The MobiLearn application was perceived to be effective to encourage active classroom participation. The only exception was the *assistance to perform better in the subject* measure. This might be attributed to the fact that the MobiLearn application was only used three times during the semester which formed part of this study. It can be concluded that the students did not really realise the impact of this application to improve their performance. Although knowledge sharing (see Section 2.9) was not specifically measured, it emerged from the data. It was demonstrated that knowledge sharing happened in class through the use of the MobiLearn application (see Section 5.5.8).

6.2.3 Best practice technical and pedagogical guidelines

The final objective of this study was to compile a set of technical and pedagogical guidelines to describe the best way in which mobile learning applications can be utilised in a learning environment to encourage active classroom participation in similar contexts. Based on the information gathered during the literature review and the findings of the empirical investigation, the researcher formulated a set of best practice, technical and pedagogical guidelines, as respectively indicated in Tables 6.4 and 6.5. In these tables, the sections where these guidelines were derived from are also specified. While some of the guidelines were derived either directly from literature or only from the findings research, there are others which were derived from both the literature and research findings.

If lecturers ensure that they adhere to the guidelines (as indicated in Tables 6.4 and 6.5) and the functionalities of the selected mobile application support these guidelines, it is more likely that students will be encouraged to actively participate in their learning process through the use of the selected application. These guidelines should be regarded as preliminary, because they were developed based on experiences with the use of a mobile learning application in an undergraduate course at the UFS with a relatively large number of students. The researcher hopes that, through future application and more research, this set of guidelines can be further refined for wider use in the South African higher education context.

Table 6.4: A framework for best practice technical guidelines

Technical aspects	Technical guidelines to encourage active classroom participation through the utilisation of mobile learning applications	References
Accessibility	Ensure the application is accessible form different mobile platforms.	Sections 3.6.3.3 & 5.3.3.3
	Make sure that it is easy to connect to the application (e.g. there should at least be cellular phone network coverage where the application is used).	Sections 2.4.1 & 5.3.3.3
	Keep the costs incurred by students to use the application as low as possible.	Sections 2.8 & 5.6.1
	The use of the application should not discriminate against any student (e.g. those from disadvantaged backgrounds).	Sections 3.6.3.3 & 5.3.3.3
	Ensure that the resources required to access and use the application are readily available to everyone.	Section 5.4.4
Navigation and ease-of-use	Select an application that: • is easily viewable on small cellular phone screens, and • does not require horizontal scrolling.	Sections 3.6.2.5 & 5.3.2.5 Sections 3.6.2.7 & 5.3.2.7
	Select an application that allows for easy entry of data from the limited cellular phone keypad.	Sections 3.6.2.6 & 5.3.2.6
System control & flexibility	Select an application that allows the lecturer to control the availability of class activities on the application.	Section 5.3.2.2
	Ensure that the learning material contained in the application is broken down into meaningful units.	Sections 3.8.7 & 5.4.7

6.3 Areas for future research

The researcher identifies the following possible extensions to this study that may be carried out in future.

6.3.1 Different context

Firstly, a similar study can be conducted in a different setting with perhaps participants from a different field of study (other than Computer Science). This will be important, because mobile learning applications are not only meant for Computer Science students, but for all students in different areas of study. Secondly, a similar study can be repeated with people who have anxiety to interact with computers and/or the latest technologies. A comparative study may be executed and finally conclusions could be made.

Table 6.5: A framework for best practice pedagogical guidelines

Pedagogical aspects	Pedagogical guidelines to encourage active classroom participation through the utilisation of mobile learning applications	References
Student motivation	Select an application that contains tools to encourage student voices to be heard, anonymously (e.g. anonymous posting of responses).	Sections 2.7.1 & 5.5.4
	Ensure that the class activities afforded by the application are more appealing than the normal class activities.	Sections 3.8.3, 3.8.8 & 5.4.8
	Create opportunities for students to practice using the application prior to its first actual use (especially if the application will be used for assessment purposes).	Section 3.9.3
Collaborative learning	Select/Create mobile class activities that compel or encourage students to work in teams.	Sections 2.2, 2.5.1, 2.6.7 & 5.4.5
	Ensure that the groups are small enough to create an opportunity for all students to participate (e.g. students should not be able to hide behind each other).	Section 5.4.5
	Plan the seating arrangement for group activities in such a manner that it encourages maximal participation by all group members.	Section 5.4.5
Teaching strategies	The lecturer should plan very carefully how s/he will split the allotted time for the lecture between teaching and doing class activities on the application (bearing in mind that mobile class activities are more time consuming than activities done with pen and paper).	Section 5.4.4
	Limit the amount of time students spend on completing in-class activities in order to keep their attention.	Section 5.6.4
	Use the application on regular basis for students to get used to it. Over time, this will help to reduce the time required to start mobile class activities.	Section 5.4.4
Feedback	Select an application that provides for both the students and the lecturer to give and receive instant feedback.	Sections 2.3, 2.4.2, 2.5.2, 2.7.3 & 5.6.7

6.3.2 Design of mobile learning applications

The guidelines developed in Tables 6.4 and 6.5 are not mainly based on the design issues of mobile learning applications. Another study that specifically investigates how a mobile learning application should be designed to definitely encourage active classroom participation in a large class, can be conducted.

6.4 Significance of the study

This study contributes to the body of knowledge in the field of *the usability evaluation of educational applications* in South Africa. It also adds a set of technical and pedagogical guidelines for best practices in the use of mobile learning applications to encourage active classroom participation in large undergraduate classes in similar contexts. These guidelines are key in the field of *the use of educational technologies at South African higher education institutions.* The study contributes the guidelines in cases whereby the mobile learning applications are used at tertiary level to encourage active classroom participation in large classes. This implies that the findings of this study are not only useful to the Computer Science and Informatics department at UFS, but also to the entire university. It became evident during the data collection (face-to-face interview with the lecturer) that other lecturers also use mobile learning applications.

There is not much research into pedagogical usability. As a result, the developed guidelines will be helpful in future research in this area. Other stakeholders, who are likely to benefit from this study, are lecturers who appreciate the successful learning of their students and researchers in this field. As the application used in this study is aimed to encourage active classroom participation, research (Biggs, 2003; Hauske et al., 2007; Gibbs & Jenkins, 1992) shows that students who participate actively in class are likely to perform well. Good performance leads to higher student throughput. This is a critical issue for South African higher education institutions, especially for undergraduate students.

6.5 MobiLearn recommendations

Although it was not one of the objectives of this study to critique the MobiLearn application, the researcher feels it necessary to mention a few important shortcomings of this application. If these issues can be addressed in future versions of the application, it might improve the support provided by the application to encourage active classroom participation and ensure the wide-spread use of the application.

One of the main problems with the MobiLearn application is that it is uni-directional. There is no way in which students can check the comments made by a lecturer on their input. The lecturer is just able to receive the students' input, and it is his/her discretion to address or ignore the concerns raised by students. The researcher recommends that mobile learning applications should have at least some multidirectional features (or be bi-directional) to encourage mobile communication and interaction between the students and the lecturer.

In order to further enhance mobile communication and interaction, the introduction of an SMS functionality can also be considered. Such functionality will allow students to send SMS messages on course related issues directly to the application without the necessity to first login on the application. The lecturer should then be able to reply to these messages directly from the application.

The MobiLearn application was developed with the specific aim to encourage active classroom participation. Other aspects of mobile learning were consequently ignored. One of the important aspects that may be considered for future versions is the addition of a *study anywhere* functionality, where students will be able to access small sections of learning content through their cellular phones. Through the addition of this feature, the MobiLearn application might be able to play a bigger part to support the overall learning experience of students.

6.6 Conclusion

This chapter has presented the conclusions of this study which relate to its key aim, namely to determine how usable mobile learning applications can be to encourage active participation in large undergraduate Computer Science classes. The chapter further indicated how the four main teaching and learning challenges mentioned in Chapter 2 could be mitigated through the use of several active classroom participation strategies. As the ultimate objective of this study, the chapter also presented the technical and pedagogical guidelines for the best way in which mobile learning applications can be used to encourage active participation in a large class.

The primary theme in this study was active classroom participation. The study illustrated how this can be achieved through the use of several strategies which culminate in the achievement thereof through the use of mobile learning applications. The active classroom participation incorporated four of the principles of good practice mentioned by Chickering and Gamson (1991). Those principles addressed in this study are contact between students and the lecturer, co-operation among students, active learning and prompt feedback. The set of technical and pedagogical guidelines that are devised for the effective use of mobile learning applications to encourage active classroom participation will hopefully encourage more lecturers (from various academic disciplines) to incorporate mobile activities in their teaching and learning strategies.

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Appendix A:

MobiLearn questionnaire

Dear Student

Thank you for giving your attention to this questionnaire. The approximate time needed to complete this questionnaire is 10 - 15 minutes. The purpose of these questions is mainly to explore students' experiences with the MobiLearn application that was tested in the RIS164 classes.

By completing this questionnaire, you give the researcher consent to use your information for research purposes only. Responses will be confidential and your privacy will be protected to the maximum extent allowable by law.

Participation is voluntary. Completing or failing to complete this questionnaire has absolutely no bearing on your grade for RIS164.

Instructions:
Please circle your selected answers.

Section 1 - Demographic Information

Tell us a little bit about yourself:

Gender: Male Female

Age: 18 19 20 21 22 23+

Home Language ________________________________

Which RIS164 lectures did you mostly attend? Afrikaans English

What is the model of the cellular phone you used to access the MobiLearn application?

If you were never able to access the MobiLearn application through a cellular phone, please proceed directly to Section 5 of this questionnaire. (Only students who have used the MobiLearn application at least once should complete Sections 2, 3 and 4.)

Section 2 - Using the MobiLearn application

On a scale of 1 - 4, indicate the extent to which you agree or disagree with the following statements regarding the MobiLearn application:

	Agree	**Partly agree**	**Partly disagree**	**Disagree**
1. The user interface components were placed in a consistent way across the MobiLearn application.	1	2	3	4
2. The interface of the MobiLearn application made it easy for me to remember how to carry out the mobile class activities.	1	2	3	4
3. It was possible to work out how to use the MobiLearn application by just exploring its interface.	1	2	3	4
4. While using the MobiLearn application, I sometimes had to remember information from the previous step(s).	1	2	3	4
5. I was free to carry out all tasks without any fear that the MobiLearn application would crash.	1	2	3	4
6. The MobiLearn application allowed me to complete activities at a later stage if I did not have enough time to complete them in class.	1	2	3	4
7. The MobiLearn application provided me with an easy way to interact with the lecturer during the class sessions.	1	2	3	4
8. The MobiLearn application provided me with a fast way to interact with the lecturer during the class sessions.	1	2	3	4
9. It was easy to navigate through the MobiLearn application.	1	2	3	4
10. It was easy to enter the answers to the MobiLearn question answers on my mobile phone.	1	2	3	4
11. It was not easy to view all the MobiLearn text on my cellular phone at once.	1	2	3	4
12. The MobiLearn application provided meaningful error messages where necessary.	1	2	3	4
13. I encountered errors for more than 50 per cent of the total number of times I used the MobiLearn application.	1	2	3	4

Section 3 – Learning support provided by the MobiLearn application

On a scale of 1 - 4, indicate the extent to which you agree or disagree with the following statements regarding the MobiLearn application:

	Agree	Partly agree	Partly disagree	Disagree
1. Questions for class activities were well organised on the MobiLearn application.	1	2	3	4
2. The mobile class activities were broken down into meaningful parts.	1	2	3	4
3. The language used in the MobiLearn application was clear.	1	2	3	4
4. The MobiLearn activities helped to improve my understanding of the course material.	1	2	3	4
5. The way in which the lecturer utilised the MobiLearn application helped me to gain knowledge on the subject matter.	1	2	3	4
6. I was eager to take part in the mobile class activities.	1	2	3	4
7. I liked the mobile class activities more than normal class activities.	1	2	3	4
8. The mobile class activities encouraged discussion and collaboration among students.	1	2	3	4
9. The MobiLearn application provided clear directions and descriptions of what I had to do at every stage in answering the questions.	1	2	3	4
10. Other Computer Science lecturers should also make use of the MobiLearn application in their classes.	1	2	3	4

Section 4 – Added value through the use of the MobiLearn application

On a scale of 1 - 4, indicate the extent to which you agree or disagree with the following statements regarding the MobiLearn application:

	Agree	Partly agree	Partly disagree	Disagree
1. The MobiLearn application helped me to interact with the lecturer.	1	2	3	4
2. The MobiLearn application encouraged me interact with the lecturer.	1	2	3	4
3. The MobiLearn application encouraged me to concentrate more in class.	1	2	3	4
4. The MobiLearn application helped me to ask questions without any fear.	1	2	3	4
5. The MobiLearn application helped me to perform better in the subject.	1	2	3	4
6. The MobiLearn application helped me to develop a more positive attitude towards the subject.	1	2	3	4
7. The MobiLearn application helped me to improve the way I think when answering questions.	1	2	3	4

Section 5: Personal experiences with MobiLearn

1. What was your first reaction when the RIS164 lecturer announced that you would be using your mobile phone to participate in a class activity?

____

____

2. What did you enjoy most about the MobiLearn application?

____

____

3. What did you enjoy the least about the MobiLearn application?

____

____

4. What do you think can be done to improve the way in which the MobiLearn application was used by the RIS164 lecturer?

____

____

5. Please provide any other comment(s) about your experience with the use of the MobiLearn application in RIS164 classes.

____

____

Thank you for kindly participating and completing this questionnaire!

Appendix B:

Informed consent form for focus group discussions

University of the Free State
Department of Computer Science & Informatics

MobiLearn Focus Group Discussions - Informed Consent Form

The purpose of the study is to investigate how mobile learning applications can be used to encourage active classroom participation in undergraduate Computer Science classes.

During the focus group discussion the researcher will make an audio recording of the proceedings and some written notes where necessary. It should be noted that all information collected during this discussion will be treated as confidential and no participant will be identified at any time in the reporting of the results.

I understand that my participation in this study is voluntarily and I am free to ask questions or withdraw from participation at any time without any penalty of some sort.

______________________________ ______________________

Signature of participant **Date**

Appendix C:

Questions for the focus group discussions

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1. **What is the first thing that comes to mind when you think about the MobiLearn application?**

   (Probes)

   - Accessibility?
   - Knowledge sharing?
   - Did it help you to participate?
   - Did you perform any better?
   - Attitude towards the course?
   - Thinking ability improved?

2. **Was there ever a time when you did not want to use the MobiLearn application anymore?**

   (Probes)

   - When did that happen?
   - What discouraged you?
   - Does that have to do with the application not giving you meaningful error messages [error handling and prevention]?
   - Was it not motivating you enough? (Eagerness to participate in mobile class activities – what about liking normal classes as opposed to the mobile classes).
   - Cost of browsing?
   - Problem viewing all the text on mobile phones (screen display).

3. **Do you think that the MobiLearn application helped you to be more active in class?**

   (Probes)

   - Do more than listening to the lecturer?
   - Interact with other students during the activities that had to be done in groups?

4. **What do you think about the general idea of students using their cellular phones in class for educational purposes?**

   (Probes)

   - Ringing and disturbing the class?

5. **Do you have any suggestions for the future use of the mobile applications (such as the MobiLearn) in class?**

Appendix D:

Questions for the interview with the lecturer

1. **How did you use the MobiLearn application in your classes?**

   (Probes)

   - Usage data indicated that it was a large number of students who used the MobiLearn application when it was first used (22), but for the subsequent class activities the number dropped (14). What do you think was the cause of that?

2. **The results obtained from the questionnaire indicated that students seemed not to be very motivated with the use of the MobiLearn application in class. What do you think was the problem or cause?**

   (Probes)

   - Was it time wasting consuming to do mobile class activities as opposed to doing activities by hand [pen and paper]?

3. **What do you think were the benefits gained from using the MobiLearn application in your classes?**

   (Probes)

   - More lecturer-student/student-lecturer interaction?
   - More concentration in class?
   - More asking questions without fear?
   - Better performance in the subject – Did students perform any better? Some students thought the MobiLearn application was going to improve their marks, but it did not. Why do you think this was the case?
   - Development of love for the subject (more)?
   - Improving thinking ability?
   - Knowledge sharing?
   - Collaborative learning?

4. **Students recommended that the MobiLearn application should be used by other Students in other IT Courses. Do you share the same view? If yes,**

how do you think the future use of the MobiLearn application to encourage active classroom participation can be improved?

(Probes)

- What is so unique in the MobiLearn application that other students in other IT courses are likely to gain if they use it?

5. **Do you have any suggestions for the future use of the mobile applications (such as the MobiLearn) in class?**

   (Probes)

   - Your view on the use of cellular phones in class?
