College of Engineering and Science

The role of ICT in student engagement in learning mathematics in a preparatory university program

by

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ABSTRACT

The steady decline of students' competency in mathematics has become known as the "Mathematics Problem". Researchers identified that the level of student engagement is one of the most important factors affecting the academic performance of mathematics students. Strong link between students' attitudes towards the use of technology for learning mathematics and their achievements also has been identified by recent studies.

The mathematical problems have a multidimensional source and are initiated from the students' personal characteristics and attitudes. Thus attitude is important educational concept about learning mathematics with technology. The association between student engagement and the use of ICT suggests that a positive attitude toward the use of ICT in learning mathematics is an important outcome in itself, especially when ICT is used. Student engagement can be influenced by a plethora of factors. These factors include student personal characteristics, learning experiences, perceptions, three aspects of engagement (cognitive, affective and behavioural) and attitudes towards the use of technology in learning of mathematics.

This study is aimed at further investigating the factors that might be affected by the use of ICT with two major purposes: (1) to investigate the complex interrelationships between students' demographic factors, mathematics confidence, access to technology outside university, confidence with technology, perception towards the use of technology for learning and attitude towards learning mathematics with technology, cognitive, affective and behavioural engagement; and student achievement and (2) to determine if the use of ICT impacts on the level of student engagement and achievements in mathematics.

The sample which was investigated consisted of 92 students, who were enrolled in a mathematics foundation studies program at Victoria University in 2012. The students were randomly allocated into two groups – one group was taught mathematics with the use of ICT and the other group was taught mathematics

without the use of ICT. In this study, ICT refers to the online learning environment to enable students to learn mathematics outside of the classroom, at a time and place which is convenient for them. This learning environment was designed using the Learning Management System (Moodle) by the researcher. Moodle was deployed on remote server, maintained and supported by the researcher during the period of study.

In an absence of widely accepted standard methodologies and indicators to assess impact of ICTs in education, which in itself is “an incredibly complex and inherently multidisciplinary endeavour” (Mor & Mogilevsky, 2013) the researcher developed a conceptual framework to manage the complexity of articulating the relationship between the above mentioned factors and educational elements. This study constructed a true educational experiment with four sequential phases and three stages, adopting a range of educational experimental research methods: design of the questionnaire, formalising the data and application of Multiple Regression Analysis, Correlation Analysis, Multivariate Analysis of Variance (MANOVA) and Multivariate Analysis of Covariance (MANCOVA) to the data.

An investigation into the profile of “at risk” mathematics students over time enabled the author to identify various individual factors, such as the students’ demographics, level of access to technology outside the university, perceptions towards the use of technology for learning, level of confidence with technology and level of confidence with mathematics, which were used to model the students’ attitudes towards the use of technology in the learning of mathematics.

The analyses revealed that these factors did not affect directly students’ attitude towards the use of technology in the learning of mathematics, but the combination of these factors could partially explain students’ attitude towards the use of technology for learning mathematics. Even more, the students’ perception towards the use of technology was found to be related to students’ attitudes towards the use of technology in the learning of mathematics.

It was found that there is a relationship between students' level of access to technology outside university and students' achievements; the students' level of mathematics confidence and their cognitive engagement; the students' level of mathematics confidence and their behavioural engagement; the students' level of mathematics confidence and their achievements. Gender was also found to play a significant role in the students' affective and behavioural engagement, but gender did not affect the students' mathematical performance.

Contrary to expectations, the data analysis demonstrated no significant difference in the levels of student engagement between the two aforementioned groups of students.

The study identified some crucial factors that prevented the teacher and the students from using ICT in teaching and learning of mathematics effectively, the most important being institutional factors. They are in line with the literature which demonstrates that the use of ICT requires quality and strategic ICT training for teachers and students.

The analysis of data revealed that integrating ICT into Foundation Study mathematics programmes is yet to be accomplished.

Declaration

I, Helen Chenoby, declare that the Master thesis entitled “The role of ICT in student engagement in learning mathematics in a preparatory university program” is no more than 60,000 words in length, exclusive of tables, figures, appendices, references and footnotes. This thesis contains no materials that have been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signature: Date:

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LIST OF ABBREVIATIONS

ICT	Information and Communication Technologies
ALTC	Australian Learning and Teaching Council
MANCOVA	Multiple Analysis of co-Variance
MANOVA	Multiple Analysis of Variance
NESB	Not English speaking background
ESB	English speaking background
STEM	Science, Technology, Engineering and Mathematics subjects
VU	Victoria University

Operational definition of terms

Blended Learning - refers to learning models that combines the face-to-face classroom practice with e-learning solutions. For example, a teacher may facilitate student learning in class contact and uses the Moodle to facilitate out of class learning.

Constructivism - is a paradigm of learning that assumes learning as a process individuals ‘’construct’’ meaning or new knowledge based on their prior knowledge and experience (Johassen, 1991). Educators also call it the emerging pedagogy in contrast to the existing behaviourism view of learning.

Learner-centred learning environment - is a learning environment that pays attention to knowledge, skills, attitudes, and beliefs that learners bring with them to the learning process where its impetus is derived from a paradigm of learning called constructivism. In the context of this study, it means students personal engagement in learning mathematics using the computer and internet.

LIST OF EQUATIONS

Chapter 1

Introduction

1.1 Background of the study

Difficulties performing basic arithmetic and algebraic manipulations, poor numeracy skills and the overall decline of the level of students' mathematical competency – all form a part of the growing "Mathematics Problem", which has become a major issue within the education industry, both nationally and internationally (Celik &Yesilyur, 2013; EACEA, 2013; Gill, 2010; Hourigan & Donoghue, 2006; AAS, 2006). Thus, the need to find a solution to this problem has become a priority of many institutions worldwide (ACER, 2010; Symonds et al 2008).

Student engagement forms part of the solution to this Mathematics Problem. There is a general consensus, amongst educators, that an engaged student is a good learner (Sharma, 2013). Consequently, the level of student engagement in the learning of mathematics has been identified as a crucial factor in determining the academic outcome of the student. Accordingly, student engagement is considered as being one of the most important factors of curriculum implementation (Huebner, 1996).

The concept of student engagement is one which is not only complex, but also multifaceted. According to Lippman and Rivers (2008), engagement can be broken down into three main types: cognitive, behavioural and emotional. Cognitive engagement consists of students' investment in learning and their willingness to go beyond the minimum requirements to master difficult skills. Behavioural engagement consists of the students' level of participation in study related activities and their involvement in academic and learning tasks. Emotional engagement consists of the relationships the students have with their teachers and their peers.

Student engagement has been found to be dependent on a variety of factors and the complexity of the factors that can influence a student's mathematics performance has been demonstrated by recent studies. Singh, Granville & Dika (2002) reported that high achievement in mathematics is a function of many interrelated factors related to students, families, and schools. However, in order to manage the complexity of these factors more precisely, the factors which have been identified as most relevant to this study can be grouped as follows: (1) student related factors, (2) family related factors and (3) school related factors, in accordance with Singh, Granville and Dika (2002).

Psychological studies have concluded that student engagement alone cannot be considered as a factor of student achievement, especially if ICT is used within the classroom (Roth et al., 2011; Bohner and Dickel, 2011, Ironsmith et al., 2003). But studies have also shown that a strong relationship exists between the students' attitude towards the use of technology in the teaching and learning of mathematics and the academic achievement of the student (Appleton et al., 2006; Olson and Zanna, 1993). These same studies also attempted to identify the factors which affect the students' attitude towards the use of technology in the study of mathematics.

There is a growing body of research, which attempts to investigate the various characteristics of students and how these characteristics influence the level of student engagement and ultimately their academic achievement in the study of mathematics.

This thesis reports on a study which constructed a meta-analytic matrix of the inter-related factors and modelled the many aspects of individual characteristics of students and how they influenced the attitude of the students, towards the use of technology in the learning of mathematics. Some of these characteristics included the students' demographics, their level of access to technology outside the university, the students' confidence with technology and also their confidence in mathematics. This modelling led to the construction of the self-report instrument, which is designed to measure the complex relationships that exist between the three dimensions of student engagement and the students' attitude towards the learning of mathematics with and without the aid of technology.

Another possible solution to the "Mathematics Problem" which has been suggested by policy makers is the implementation of ICT in the learning and teaching environment. Research suggests that the implementation of ICT can aid the low achieving students. Graff and Lebens (2007) found that the implementation of a web-based programme can lead to significant learning gains in mathematics for struggling students.

By analysing the current ICT innovations within the education industry, it has been shown that the use of ICT in teaching and learning has an effect on all the various elements of the educational environment – from the policy makers to the teaching methods employed by the teachers. The use of ICT to form e-learning environments is becoming common practice worldwide. This is due to evidence showing that effective, innovative and challenging uses of ICT, in the teaching and learning of mathematics, stimulates and sustains the engagement levels of students (Sharma, 2013), which positively affects all three aspects of student engagement.

Dewey (1932) stated, "We practically never teach anything by direct instruction but rather by the creation of settings" (p.1032). The Learning Management System, Moodle, facilitates the design and creation of online courses. It provides an interactive and collaborative learning environment and offers the means to create a powerful setting for the learning of mathematics.

This study has attempted to investigate the complex relationships which exist between the students' cognitive, affective and behavioural engagement and the students' attitude towards the use of technology as an aid in the teaching of mathematics, whilst taking into account the various individual characteristics of the students who are enrolled in the foundation study program at Victoria University.

The main objective of this project is to investigate how the use of a Learning Management System (Moodle) in the teaching and learning of mathematics, impacts on the level of student engagement and how this technology can assist mathematics teachers in accommodating individual needs of the students. Concurrently, the researcher also attempt to investigate the influence that technology has on enhancing the learning experience of the student as well as the influence it has on the students' attitude towards technology supported learning.

1.1.1 Victoria University's Students

The student demographic at Victoria University is more educationally, culturally, linguistically and economically diverse than the norm for other universities in Australia. These include early school leavers enrolled in the Victoria Certificate of Applied Learning, apprentices, TAFE diploma students as well as higher education undergraduate and postgraduate students undertaking course work and research based qualifications. The University's students come from all over Melbourne as well as from other countries. Many of the students are from Western suburbs of Melbourne and are the first in their family to participate in tertiary studies.

1.1.2 Foundation Studies program at Victoria University

Supporting the learning of mathematics and statistics is an additional, non-compulsory program which is aimed at helping students to develop their mathematical and statistical skills required by STEM courses, offered by College of Science of Victoria University. The main purpose of this mathematic foundation studies program is to bring the students level of mathematical understanding up to the minimum level which the University requires. This program is a pathway program into the first year of studies.

1.1.3 Foundation study students

The majority of the students, who are enrolled in this foundation studies program, are females from low socioeconomic backgrounds who are from a non-English speaking background and have had a very limited exposure to formal education or they had very limited opportunities to further their level of education. Many of the students have been at home for prolonged periods of time in order to be able to take care and provide for their families.

1.1.4 The use of ICT in a Preparatory program

Besides the use of LMS, the use of ICT is very limited, in the foundation studies program which is run by Victoria University. The University's strategic plan recommends a blended learning approach using technology across all courses, but this approach is yet to be implemented across the entire University.

1.1.5 Blended learning in the current VU approach

Innovative blended teaching approaches are becoming more and more evident at Victoria University and the interest is constantly growing regarding various issues, such as the introduction of a new e-learning environment as well as ways to utilize social media effectively in teaching (VU, 2012). However, using e-learning tools is not very well supported by the current systems; therefore procedures are implemented on an ad-hoc basis. Without a thoroughly coordinated implementation, the learning experience that the students will encounter – will likely be a combination of innovative learning experiences mixed with a 'stand and deliver' approach.

1.1.5.1 Victoria University Conceptualisation of Blended Learning

Implementing blended learning approaches, within the context of the Curriculum Framework, will require a significant amount of effort and resources. It will be very crucial and extremely challenging to put in place strategies to monitor and evaluate the effectiveness of these approaches, in terms of improving the students' learning outcomes. The same strategies that will monitor and analyse student data will also be required to evaluate the effectiveness of all the aspects of the Curriculum Framework.

Victoria University has directed its focus towards three specific groups of students, whose aspiration and achievement rates are currently less robust than they might be. These are:

- students from low socioeconomic backgrounds;
- students of Aboriginal and/or Torres Strait Island descent; and
- students with disabilities.

1.2 Aims, Conceptual Framework and Objectives of the Research

The main objective of this randomized comparative experiment, which was conducted throughout the duration of a preparatory mathematics course, was to explore the effect ICT has in the level of student engagement in the learning of mathematics. It investigated the experiences and perceptions of students, enrolled in a foundation studies program at Victoria

University, towards the technology supported learning of mathematics in order to determine if the use of ICT impacts the level of student engagement and ultimately their academic achievement.

This study also aimed to understand how interrelated variables such as the students' demographic factors, the students' confidence with technology, the students' confidence with mathematics, the students' access to technology outside university and their perception towards the use of ICT in the learning affect the students' engagement levels.

Previous work indicates the importance of generic tools (LMS, etc.) as, if not more than specific mathematics tools (calculators, software, CAS etc.). Because this prior research focused on hardware such as calculators and other instruments to speed up mathematical calculations, a need existed to investigate student experiences, perceptions and attitudes towards technology-supported learning and/or how they relate to the levels of student engagement and academic achievement in the learning of mathematics. This study concentrates on the generic tools and in particular on the use of an LMS, which has been shown by recent studies (Mor and Mogilevsky, 2013b; Sharma and Bhaumik, 2013; IMS, 2013; Sharples, et al., 2012; Abel, 2012; MacGillivray, 2012; Taylor and Parsons, 2011; Newhouse, 2002a) to enhance student engagement in the learning of mathematics addressing this gap in literature.

The use of ICT in universities has increased significantly for pedagogical purposes. Despite this growth, however, the quality, extent and impact on learning of ICT use in blended learning environment remain under-researched area (Mor and Mogilevsky, 2013b; HERSDA, 2009).

ICT was used to provide the online learning environment (SigmaNet), which was based on the LMS Moodle, where students were enabled to develop their mathematics knowledge with the help of various Web 2.0 tools, which were integrated within this environment. SigmaNet has been designed, developed, hosted on external server, customised and maintained for this study by the researcher, specifically for Victoria University foundation studies mathematics teachers, in accordance with the applicable mathematical curriculum.

The four aims of the study were:

1. To explore the effect that various student characteristics and demographic factors have on the attitude of the students towards the use of technology for learning mathematics [A1].
2. To investigate student experiences, perceptions and attitudes towards technology-supported learning and/or how they relate to the levels of student engagement and academic achievement in the learning of mathematics [A2].
3. To determine if and/or how the use of ICT impacts on the level of student engagement and achievements in learning mathematics [A3].
4. To develop a set of recommendations that will assist mathematics teachers in making informed decisions about the deployment of technology in teaching of mathematics [A4].

1.2.1 The conceptual Framework

The purpose of this study is to analyse the difference in the level of student engagement, between two groups of students: those who undertook ICT-enhanced mathematics instruction and those who undertook traditional mathematics instruction, in order to be able to evaluate and understand the effect of ICT.

There are many sub-questions which arose throughout various stages of the study, but they all relate back to the major question – what is the difference between the levels of student engagement in learning mathematics, between the two aforementioned groups of students?

Following an extensive literature review of many modern studies, relating to this topic, it has been noted that it’s not possible to provide a meaningful framework, which can measure the direct impact that ICT has on student learning (Newhouse, 2002, b). Also, most researchers view the media comparison studies as being of little value and misleading, due to the fact that it is not possible to accurately separate and measure the impact of ICT, from all the other environmental elements.

Newhouse (2002, a) concluded that any studies which attempted to identify the impact of ICT on student learning, have found it impossible to entirely remove the effects of the other elements of the learning environment. The Framework (Figure 1) shows the relationships between the learning environment entities and the various external entities.

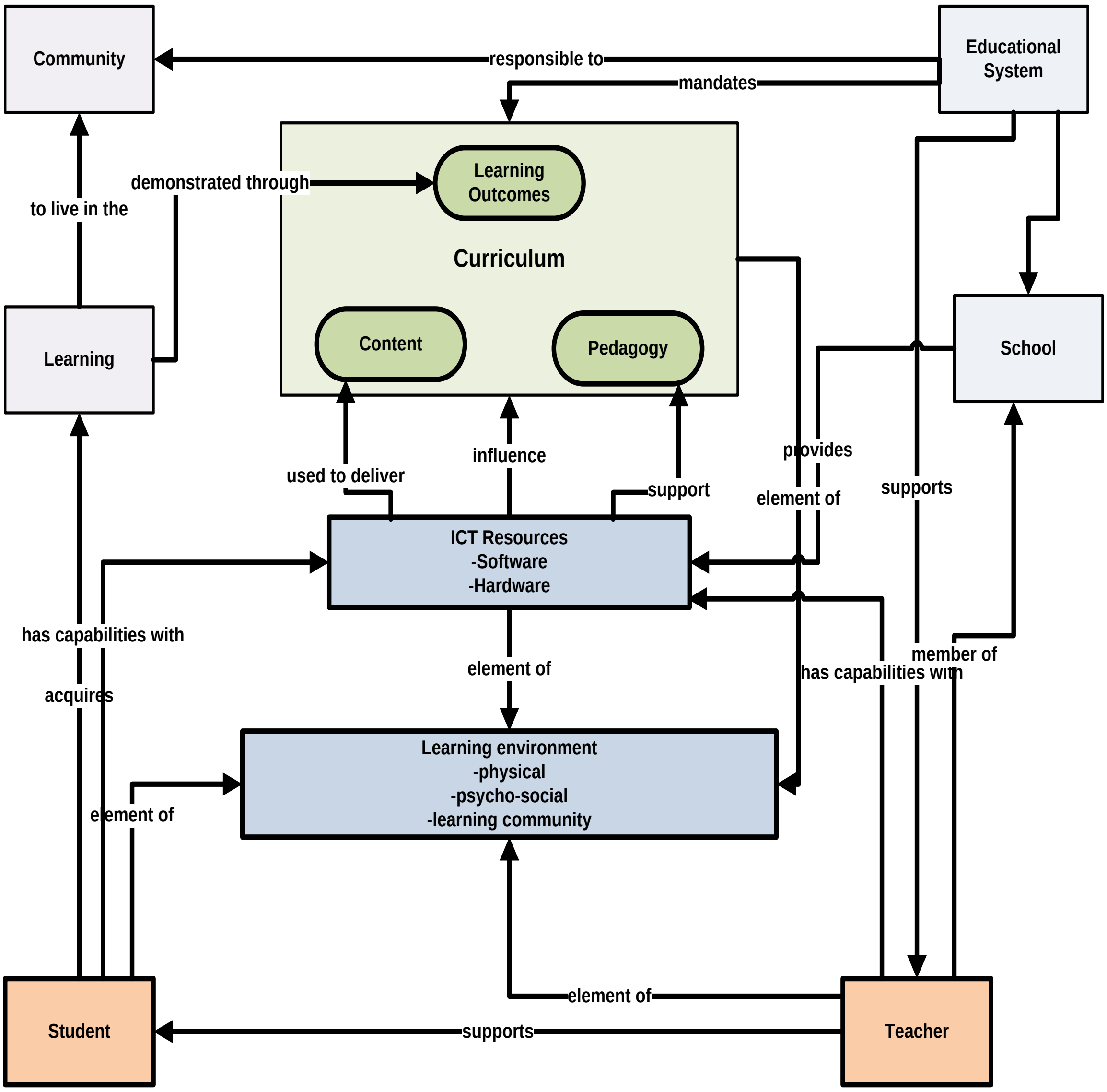

Figure 1 Theoretical Framework to articulate the Impact of ICT on Learning

Adapted from Newhouse, C.P., (2002). The IMPACT of ICT on LEARNING and TEACHING.

From Figure 1, it is clear that ICT is one of many components of the learning environment but there is no direct link between learning and the use of ICT. On the other side ICT should be an enabling component of the educational environment, rather than a determining component, as concluded by Newhouse (2002, a). Nevertheless, ICT has an influence over all the aspects of the educational process. Many studies have shown that ICT can indirectly have a significant positive impact on the students, the learning environments, the teachers, the schools and the system organisation. All of those components contribute towards the students' learning achievements. Other factors associated with the learning environment, will contribute to student achievement that make it hard to ascribe any gains specifically to the use of ICT.

Newhouse (2002, b) developed A Framework to Articulate the Impact of ICT on Learning, where he suggested five dimensions which should be considered when evaluating the use of ICT in the improvement of student learning. These dimensions could be represented by a particular outcome (Table 2). The Framework was based on an extensive literature review which he performed for the Western Australian Department of Education in 2002.

Figure 1 represents a theoretical framework and shows the relationships between the learning environment entities and the various external entities of education environment. These entities are shown in the diagram and demonstrate a central role of ICT in complex teaching and learning environment, where ICT in schools are both a focus of study in themselves (technology education) and a support for learning and teaching (educational technology). ICT has an influence over all the aspects of the educational processes, including the organization of the curriculum, the organization and staffing of schools; the culture, policies and procedures of schools; the training and support of teachers; the provision of hardware and software infrastructure.

This Framework will be used throughout this study to articulate the role of ICT in the level of student engagement in learning of mathematics. The five dimensions of the Framework need to be considered, when attempting to evaluate the role of ICT in the improvement of student learning. Each dimension may be represented by an outcome, as described in the Framework. This study will focus on the role that ICT has in two Dimensions of the Framework: (1) Students, (2) Learning Environment Attributes. The Engagement and Achievement of Learning Outcomes components of the Student Dimension (engagement and achievements) will be subsumed within the Learning Environment Attributes Dimension (Pedagogical Practice). No evidence exists to support the fact that simply using ICT will make any difference at all. The theoretical framework indicating relationships between learning environment entities and external entities is illustrated in Figure 1, showing "*No direct link between learning and the use of ICT"*. Studies which were conducted to investigate this, reported that when ICT is used appropriately, it did have a positive impact (Newhouse 2002, b). Working from these findings, this study will describe, rather than measure, the ways in which ICT, as an enabling component, may be able to contribute to the development of the learning environment, which caters for students with differing learning needs.

Table 5. Dimensions considered in this study when evaluating the use of ICT

Dimensions	**Outcomes**
Students	Through the use of ICT students become more engaged with their own learning, and achieve learning outcomes across the curriculum at a higher level.
Learning environment Attributes	ICT is used to support pedagogical practices that provide learning environments that are more Learner-centered.
Teacher professional ICT Attributes	The teacher exploits the characteristics of ICT to support the learning of students by integrating their use into constructivist learning environment.
School ICT Capacity	The school provides ICT capacity to ensure that all teachers and students have immediate access to all software that is required to support the curriculum and adequate support to implement its use.
School Environment	That school environment is supportive of teachers and students use of ICT

As a result of adopting this Framework, the following areas of focus have been identified: the teaching and learning paradigms, technologies and the ICT skills which would be required for the implementation of the educational paradigms and also, the factors into which student engagement in the learning process are broken down. The dimensions and outcomes considered in this study are presented in Table 5.

The hypothetical outcomes from Table 5 have formed the research questions and the instruments which were used for the collection of data and methodological considerations of data analysis are presented in Figure 4.

Salomon (1991) described classrooms as complex and nested combinations of interdependent variables such as perceptions, attitudes, experiences and behaviours, and thus their study “cannot be approached in the same way that the study of single events and single variables can" (p. 11).

Every chosen component of the education system has been presented as a box of tools, a box of theories, many different teacher training programs, different teacher’s levels of competencies, different school infrastructures, different pedagogical theories, different approaches and practices, many different support programs and wide varieties of student backgrounds, skills and attitudes. This entire multidimensional and interrelated component could be affected by ICT.

Based on extensive literature review and recent findings about the role of ICT in student engagement this study has developed the framework suitable for this study design to articulate the role of ICT in student engagement. A summary of the conceptual framework developed for this study is illustrated in Figure 2.

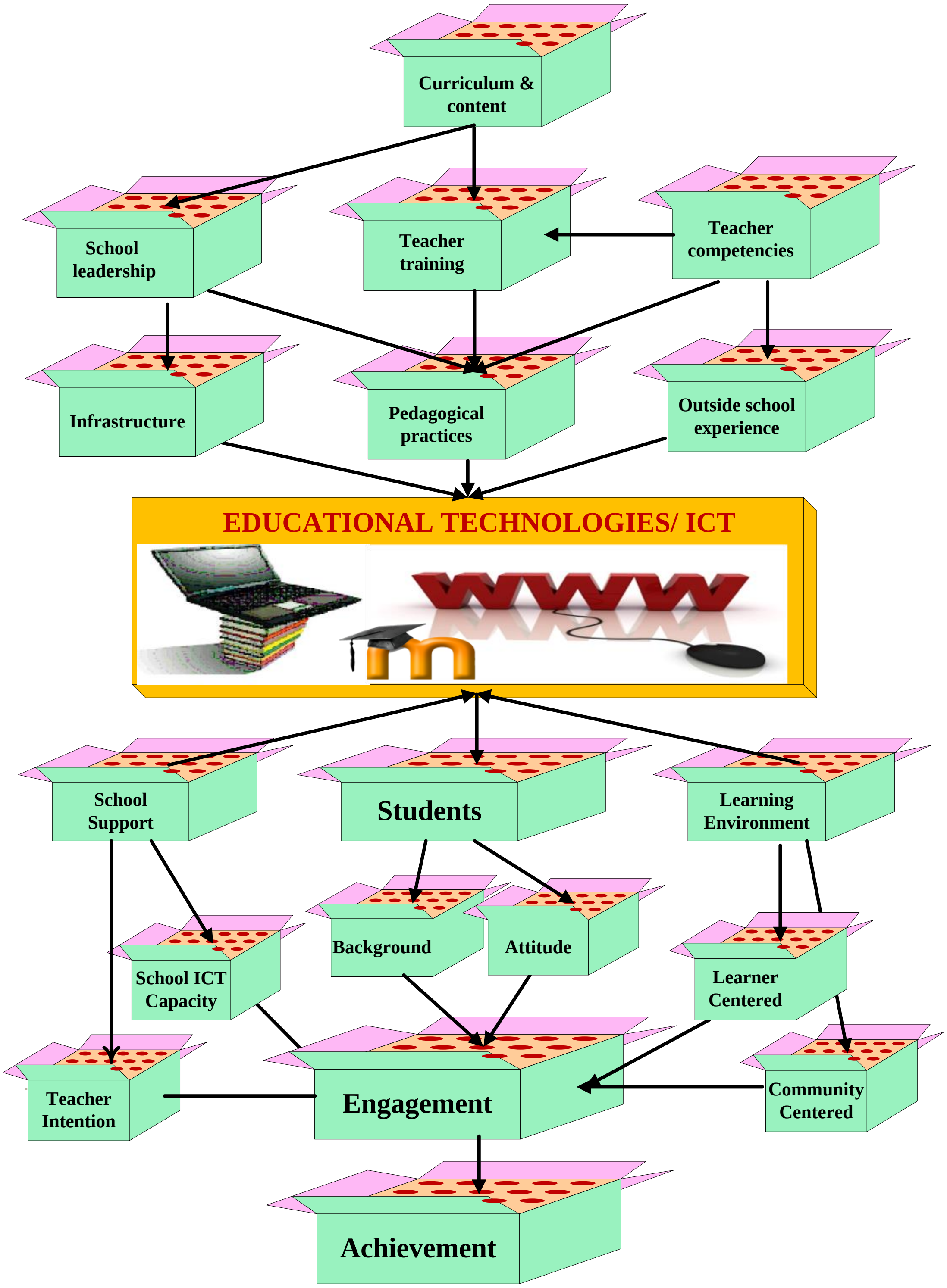

Figure 2 Conceptual Framework for this study

1.3 Research Questions

The aims of the study were guided by the four research questions:

Research question One

How are students' demographic factors, such as gender, age and cultural background, socio-economic status, related to their attitudes towards the use of technology in learning?

Research question Two

To what degree are access to technology and perception towards the use of technology for learning related to students' attitude towards the use of technology for learning mathematics?

Research question Three

To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?

Research question Four

Is there a difference in engagement (affective, behavioural and cognitive) between students who are taught mathematics with the aid of technology or those who are taught in a traditional way?

1.4 Overview of this study

This research project was broken down into four phases. Each phase was to address the corresponding research question. The research questions have emerged from the objectives of the thesis. The hypotheses of the study as well as a breakdown of each individual phase are detailed below and summarised in Table 1.

1.4.1 Phase I

Multiple Regression Analysis was used to examine the relationship between the students' attitudes towards learning of mathematics with the aid of technology and eight potential predictors, using only one dependent variable.

1.4.2 Phase II

Throughout the second stage of the study, Multivariate Analysis of Covariance (MANCOVA) was used, in order to determine the effect that variables such as demographic factors, mathematical confidence, confidence with technology, perceptions towards the use of technology for learning and the level of access the students have to technology, had on the three components of engagement – cognitive, affective and behavioural.

1.4.3 Phase III

During the third stage, Multivariate Analysis of Variance was conducted to examine if a statistically significant difference can be found between the levels of student engagement and the final marks between students who are taught mathematics with the aid of the LMS Moodle and the students who are taught mathematics the traditional way.

1.4.4 Phase IV

In the fourth stage of the study, the recommendations that were developed were based on the findings, which were obtained during the prior three stages, as well as careful study of The Victoria University Blueprint for Curriculum Reform (2012), including Pre-Tertiary curriculum Framework. The Four-Phase Study Design is illustrated in Figure 5.

Table 1 Research Questions and Hypothesis per Phase

Phase	Research Questions
Phase I	***<u>Research Question 1</u>*** *How are students' demographic factors, such as gender, age, socio-economic status and cultural background related to their attitudes towards the use of technology in learning?* *<u>Hypothesis 1</u>* *Students' attitude towards the use of ICT in learning mathematics depends on their gender, age, socio-economic status and their English speaking background.* ***<u>Research Question 2</u>*** *To what degree are access to technology and perceptions towards the use of technology related to students' attitude towards the use of technology for learning mathematics?* *<u>Hypothesis 2</u>* *Students' attitudes towards the use of ICT in learning mathematics depend on their access to technology and perceptions towards the use of technology.* ***<u>Research Question 3</u>*** *To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive and achievement in mathematics?* *<u>Hypothesis 3</u>* *Students' attitudes towards the use of ICT in learning mathematics depend on their mathematics confidence and confidence with technology.*
Phase II	***<u>Research Question 3</u>*** *To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?* *<u>Hypothesis 4</u>* *Students' engagements in learning mathematics [SE] depend on their mathematics confidence and confidence with technology.* *<u>Hypothesis 5</u>* *Students' cognitive engagements in learning mathematics depend on their mathematics confidence and confidence with technology* *<u>Hypothesis</u> 6* *Students' affective engagements in learning mathematics depend on their mathematics confidence and confidence with technology.*

Phase II	<u>*Hypothesis 7*</u> *Students' behavioural engagements in learning mathematics depend on their mathematics confidence and confidence with technology.* <u>*Hypothesis 8*</u> *Students' achievements in mathematics depend on their mathematics confidence and confidence with technology*
Phase III	<u>***Research Question 4***</u> *Is there a difference in engagement (affective, behavioural and cognitive) and student achievement between students who are taught mathematics with the aid of technology and those who are taught in a traditional way?* <u>*Hypothesis 9*</u> *Students cognitive engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students cognitive engagement in learning mathematics who are taught in a traditional way.* <u>*Hypothesis 10*</u> *Students affective engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students affective engagement in learning mathematics who are taught in a traditional way.* <u>*Hypothesis 11*</u> *Students' behavioural engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students behavioural engagement in learning mathematics who are taught in a traditional way.* <u>*Hypothesis 12*</u> *Students' achievements in learning mathematics, who are taught mathematics with the aid of technology are different to student achievement in learning mathematics who are taught in a traditional way.*
Phase IV	*What do the research findings in this thesis have to offer the university sector?*

1.5 Ethics

The research project has met the requirements of the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007)'. The HES HREC Committee of the Health Engineering and Science Human Research Ethics Committee has accepted this project. Approval has been granted 5 April 2012 to 5 April 2014 by Health Engineering and Science Human Research Ethics Committee of Victoria University (Appendix 15).

1.6 Scope and significance of research

Scope of research

This study will endeavour to provide possible methods to help alleviate the Mathematics Problem with the aid of ICT. As the literature will outline, previous research into the impact of ICT on the students learning concluded that due to uncontrollable and interrelated environment variables, the findings were limited to the very general statement that ICT seems to influence all aspects of the educational process.

The main goal of this project has been to explore and investigate student related factors that may play an important role in the effectiveness of technology in the learning of mathematics. The first conceptual task was to define and identify the various factors which may influence the level of student engagement. The other task was to explore the extent that these factors were related to the students' cognitive engagement, affective engagement and behavioural engagement.

This study also intended to identify the extent that the students' mathematical confidence and their confidence with technology are related to student engagement and achievement in mathematics.

Significance of research

The Victoria University Strategic Plan 2012–2016: *Excellent, Engaged and Accessible* has established an important and challenging educational mission for its diverse student population over the next five years.

A number of reference groups will work on cross-university projects to achieve the Strategic Plan goals of curriculum reform. A reference group focusing on "Implementing transitions pedagogy for transitions hot spots" includes Foundation Studies students who are the first in their family to participate in tertiary education and consequently require support to succeed. Achievement of the University's goals for this diverse student population is a complex task (VU, 2012). The study utilised research from secondary and tertiary sources with a focus on undergraduate mathematics students, taking into consideration that many of these students did not complete VCE studies or had they engaged in fundamental mathematics in undergraduate programs.

Thus, this project specifically addresses the gap in the literature and highlights its relevance to the significant impact of secondary student readiness to engage in tertiary studies.

It is particularly pertinent to understand the changing profiles of Foundation Studies students while new initiatives are being implemented to alleviate the "Mathematics Problem".

To policymakers

This study identified and investigated student personal characteristics, learning experiences, perceptions towards the use of technology for learning, confidence with technology, access to technology outside university, attitudes towards the use of technology for learning mathematics, actual computer use in the course and instructional techniques, which were applied for teaching of mathematics to students enrolled in a preparatory Victoria University program to determine how the use of such technology impacts on their level of engagement.

To students

A blended learning approach promoted in current VU curriculum reforms targets three groups of students, including students from low socioeconomic backgrounds. This study can serve as a source of additional information for the current requirement to implement the curriculum reforms of innovative blended teaching approaches, developing a new e-learning environment, including the new Learning Management System (LMS) and how to use ICT effectively in teaching and learning. It can also contribute to increasing understanding of factors affecting the students' attitudes towards the use of ICT in the learning of STEM subjects.

To teachers

This study will also be beneficial to the Foundation Study mathematics teachers intending to incorporate technology in their curriculum. The limitations of this study and the challenges which arose throughout its duration could be useful as a source of additional information relating to the practical implementation of such curriculum reforms at educational institutions, including Victoria University. These limitations could also provide direction and insight for future research on these topics.

The findings can contribute to VU strategies to monitor and analyse student data for evaluating the effectiveness of the Curriculum Framework related to transitions “hot spots” such as Foundation Studies programs.

To worldwide Moodle community

An abstract paper was accepted for the 1st Moodle Research International Conference (14-15 September 2012, Crete-Greece). The proposed paper drew on selected findings from this Masters thesis, examining the role of Moodle in student engagement and achievement in learning mathematics. The paper was to be presented in the form of a poster and was invited for publication in the Conference Proceedings.

Unfortunately, due to administrative inconsistencies at Victoria University, it was decided not participate in the conference. Nevertheless, the results of this investigation add substantially to our understanding of the factors which might explain the role of ICT in student engagement in learning mathematics in a preparatory University program.

General

The study confirmed that implementing blended learning approaches within the context of the Curriculum Framework will inevitably require significant effort and resources. This research can be replicated, given its design provides high reliability. Future research can be linked to this study and probably eliminate its limitations. This can be a promising direction for future investigation and analysis.

1.7 Definitions of Terms

ICT	Information and Communication technology ;
	Refers to the technology required for the finding and processing of information in a digital format (CAS are not included).
JCM0110	Unit of mathematics studied by Intake 1 and Intake 2 students, focusing on percentages, ratios and exponentials and logarithms;
JCM0113	Unit of statistics, studied by Intake 3 students, focusing on univariate and bivariate statistics;
Learning environment	
	The learning environment refers to the social, psychological and pedagogical contexts in which learning occur, which affects student attitudes, engagement and achievement.
LOTE	Language other than English;
MOOCs	Massive Open Online Courses;
OERs	Open Education Resources;
SES	Socio-economic status;
SigmaNet	Online learning environment designed by the researcher for foundation study teacher and students for teaching and learning mathematics;

1.8 Limitations of the Study

Within every research project, there is a pre-defined scope which limits the material being researched. Within this particular research project most of the limitations were outside of the control of the researcher.

Some of the participating students were not properly enrolled in the University, did not have access to their student e-mails which in turn meant they were not able to sign up to the learning environment and fully participate in this study from the very beginning of the semester. This in itself is a cause for concern, as these students were not able to fully utilise the learning resources which were available to them.

Other limitations presented themselves during the intervention phase of the research. Whilst the use of the online learning environment was not compulsory, the students were strongly encouraged to use it as much as was possible to do so. The result of this was that some groups of students always had a limited period of time to participate in the intervention. This meant they were not able to access the online tutorials and online assessment tasks which were incorporated into the learning environment. Also the teacher did not encourage the students to use this software.

Various organizational issues, including allocation of computer rooms, set up of appropriate software, student enrolment issues, students' capabilities and skills in using their VU e-mail addresses. These were necessary prerequisites in the creation of Moodle accounts and other technical difficulties had not been anticipated by the researcher, added to the difficulty of this study and appeared to add significant limitations to this study and affected dramatically the timeline of this study. All of these issues have contributed to the complexity of data collection, verification, validation and statistical methodology.

The constant shuffling of students enrolling and withdrawing from the course throughout the study was a challenge in itself as it was not possible to train all the students, as well as the teacher, in the appropriate use of this learning environment. This also went against the initial prerequisite of this study, which was that the students and the teacher were meant to be trained in the use of this environment. Due to the dynamic foundation of the study environment, there wasn't enough time allocated to the provision of training for the teacher and the students.

Teaching mathematics with the aid of technology requires a considerable change in the teaching behaviour of the teacher, especially if they themselves were taught in the traditional way. The ICT environment was developed by the researcher for the teacher, but this environment was used in a teacher-centred approach, which prevented the students from using the environment in accordance with their needs, because they didn't know how to use it correctly.

In regards to the quantitative data that was obtained throughout this study, a few items must be noted as they may have influenced the overall data analysis:

- The teacher was not appropriately trained in the use of the learning environment and also used ICT in a teacher-centred approach, rather than a student-centred approach; (Appendix 20, Appendix 21)
- The students were not adequately trained in using technology in their learning;
- The second intake of students was taught by a teacher with no formal educational qualifications, which affected the sample size, data analysis as well as the timing of the study.

Another limitation of this study is that it only focused on two dimension of the framework. These dimensions are student outcomes and the learning environment. Three other factors are recognised as being the most influential on the student learning with technology, this is the teacher factor, school ICT capacity and school environment, which appeared highly interrelated.

This being a Masters Study, time constraints were also a major limitation for this study. The duration of the intervention phase was short. It was hoped that despite this short time period the amount of the effort and research that went into the design and the implementation of the intervention would result in an improvement in the students' learning – both in their attitudes and in their interest in the learning of mathematics.

However, the limitations that have been identified can also be seen in a positive way as these same limitations can be used to provide direction and guidance for any further research which may be conducted in this area of study.

1.9 Summary

High attrition rates among first-year university students have led educational researchers to seek solutions to improve student engagement and achievements. For students studying science, technology, engineering and mathematics subjects (STEM) and cognate disciplines, engagement in learning mathematics has been identified as the most important factor in the decrease of dropout rates. A new generation of students – the “Millennial” born after 1982 (Oblinger, 2003), exhibits different characteristics to previous generations and requires greater flexibility and more options than ever before (Hanna, 2003). The changes anticipated several years ago, pointed out by Jones-Dwyer (2004), regarding new learning needs of students require consideration of technological innovations in teaching.

Victoria University, as many institutions, has introduced pre-tertiary education programs to prepare students for tertiary study. Students in the preparatory programs still appear to struggle with mathematics (Woodley et al., 2005), and researchers and teachers alike look for ways to make the learning of mathematics more engaging for students. Students in the Foundation Studies program in the College of Engineering and Science at Victoria University are generally under-prepared for tertiary studies and find the study of mathematics particularly challenging. This indicated that deployment technology-based solutions appears to be one way worth of exploring and should be appropriately ‘pitched’ to suit a particular student cohort (Sztendur & Milne, 2009).

The study involved students in the Foundation Studies program at Victoria University, enrolled in mathematics units (JCM0110 - unit of mathematics study, focusing on percentages, ratios and exponentials and logarithms, JCM0113 – unit of study, focusing on univariate and bivariate statistics) and aimed to examine the role of ICT in student engagement and achievement in mathematics. Consideration would be given to students’ characteristics, experiences with technology, as well as attitudes related to mathematics, technology, and technology-supported learning.

An exploratory research method was adopted to examine possible relationships between factors, such as demographics, access to technology, attitudes, confidence and engagement. However, in order to investigate the effects of two teaching methods (traditional and technology-supported) on student engagement in mathematics a true educational experimental approach was used.

Technology-supported teaching methods have involved different types of ICT, including generic tools. Previous work (Mor and Mogilevsky, 2013; Shuva, 2010) indicates the importance of generic tools (LMS etc.) as much as, if not more than, specific mathematics tools (calculators, software, CAS calculators etc.). This study concentrates on the generic tools, and in particular on the use of an LMS, which has been shown by recent studies (IMS, 2013; DERN, 2013; Fredricks, et al., 2011) to enhance student engagement in the learning of mathematics.

The research study adapted the theoretical conceptual framework developed by Newhouse (2002), considering five dimensions when attempting to investigate and evaluate the role of ICT in student engagement in learning of mathematics: Students, Learning Environment, Teacher professional ICT attributes, School ICT capacity and School Environment.

1.10 Organisation of the study

This study is organized into five chapters. In Chapter 1, the background of the study, statement of the problem, research questions, significance of the study, limitations of the study, and delimitations of the study are presented. Chapter 2, a brief overview of history of ICT in learning and teaching mathematics, the theoretical framework, and the relevant literature review are presented. Chapter 3 contains the research design and methodology. In Chapter 4, the approach to data analysis, the results and discussions of major findings of the study are found. Chapter 5 covers a summary of the study, conclusions and their implications for practice, recommendations and suggestions for further research and the researcher’s post study comments.

Chapter 2

Literature review

This literature review is composed of six sections: mathematics in tertiary education, factors affecting student scores in learning mathematics, perspectives on student engagement in learning mathematics, technology supported mathematics education, pedagogical approaches in ICT supported learning and teaching and impact of ICT on learning mathematics.

This study, will combine the key issues emerging from the above six areas of research to explore the role of ICT in a particular cohort of students engaged in learning mathematics.

2.1 Introduction

Information and communication technology (ICT) has been identified as an integral part of the new curriculum for mathematics. Teachers are now encouraged to incorporate ICT in teaching programs to support and enhance student learning and their engagement with mathematics (VCAA, 2011).

Students in the Foundation Studies program in the College of Engineering and Science at Victoria University are generally under-prepared for tertiary studies and find the study of mathematics subject particularly challenging. This is a concern, as mathematics is a fundamental component of all tertiary engineering and science courses and student success in mathematics largely determines their transition to tertiary study.

The role of ICT in student engagement in learning mathematics has been a source of keen interest among government policy makers, teachers, and researchers worldwide (Dix, 2007). Hudson and Porter (2010) revealed several ways of conceptualizing the way in which technology can impact on learning. These include: technology as a cognitive tool (Hudson and Porter, 2010), the computer as a tool for teaching students (Jonassen, 2010) and the computer as a computational device (Stacey, et al., 2009). Pierce and Ball (2009) suggested that the incorporation of ICT into learning and teaching of mathematics motivates and engages students. However, the impacts of ICT on learning mathematics have not been identified clearly and the researchers' views of its benefits differ. An analysis of research findings from nearly two hundred studies of technology-supported mathematics classrooms identified practices that had positive impact on student learning (Neal, 2005); Marshall (2002) too, offered supporting evidence that educational technologies benefit learning. In addition, Romeo (2009, p. 43) pointed out that:

> *ICT produced increased motivation, improved behaviour and an improved paced of work in the students, especially apparent in those groups that were characterised by a lack of interest in learning mathematics.*

However, some researchers contend that schools use too much technology. Oppenheimer (2003) stated that placing computers in the classroom had been almost "entirely wasteful" and teachers, administrators and parents had fallen for "e-lusions". Other critics have pointed out that schools should not use technology for a variety of reasons ranging from creating social isolation to preventing students from learning critical basic skills, and suggested that human imagination cannot be mechanised (Jonassen, 2010). Attard (2011) argued against Collins & Halverson's (2009) view that computer technologies are changing the ways in which we think and make sense of our world.

Student engagement is considered to be one of the most important factors of curriculum implementation (DEEWR, 2011) and a crucial element of classroom learning (Hall, Strangman & Meyer, 2011). It is a multifaceted concept in education and has many definitions. Newmann, Wehlage and Lamborn (1992) defined engagement, based on the psychological theory of Connell (1990) and sociological theory of Merton (1968), as students' psychological effort toward understanding, learning and mastering skills required by the mathematics curriculum (Kong, Wong & Lam, 2003). It includes several dimensions: cognitive, behavioural and emotional (Lippman & Rivers, 2008). Recent research has expanded these dimensions to: Cognitive / Intellectual / Academic, Social / Behaviour /

Participatory and Emotional Engagement (Connell & Wellborn, 1991; Kong et al., 2003; McLaughlin et al., 2005).

On top of the identifying it as a complex matter, research has also revealed some issues that could negatively impact on student engagement as a result of how the technologies integrate with existing pedagogies. This includes the tendency among teachers to use ICT in a teacher-centred approach (Pierce & Ball, 2009; Samuelsson, 2010). Attard (2011) confirmed instances of technology driving pedagogy, rather than pedagogy driving technology, and Dix (2007) established that the integration of ICT has focused on what is done with technology rather than on its effect on student learning.

The above concerns could be alleviated by incorporating ICT into the L&T of mathematics in a constructivist way, which offers flexibility to teachers to individualise learning for each student, while using technology tools to augment cognitive processes (Nanjappa & Grant, 2010). Thus, within the shift in focus from the objectivist to the constructivist context domain, technology can play an integral part in the learning environment (Duffy & Cunningham, 1996). Research on on-line learning platforms, implemented using open-source learning management systems (LMS) such as Moodle, confirmed support of constructivist pedagogy, whereby students develop their capacities such as self-regulation, self-discipline, collaborative learning and creative thinking (OECD, 2012a; OECD, 2012c; Cuttance, 2002; OECD, 2006a; Dougiamas & Taylor, 2003).

Debate on how ICT should be used to improve student engagement with mathematics is continuing, as pointed out by Orlando (2011). Another recent research study (Çakır et al., 2010) showed that students performed better in the cognitive dimension of engagement when a blended learning approach (a combination of face-to-face and online teaching) was followed. Recent studies (Anastopoulou et al., 2012; Agyei and Voogt, 2012; Agyei and Voogt, 2011b) suggested that there is a lack of research about the level of student engagement in blended learning environments and comparison between blended and face-to-face learning environments. Marshall (2002) stated that with ever-expanding content and technology choices, from video to multimedia, to the Internet, there is a need to know how to implement ICT in the teaching of mathematics to increase student enthusiasm towards learning mathematics. ICT skilled teacher-designers are looking for ways to integrate widely available open source Web 2.0 tools, such as digital mathematical objects (DMO) and Java Applets (learning object can be taken independently) with on-line learning management systems (Mott, 2010). Even though a significant amount of such DMOs leads to better test scores than does conventional instruction (Moursund, 2007), the use of ICT in L&T of mathematics is still presenting challenges for teachers and students (Vale et al., 2010).

High attrition among secondary schools and first-year university students, have led educational researchers to seek solutions to improve student engagement (Goos & Bennison, 2008; Greenwood, Horton & Utley, 2002; Legters, Balfanz & McPartland, 2002; McInnis et al., 2002; Perie, Moran & Lutkus, 2005). Similarly, student academic preparedness for higher education studies, as well as their engagement with study, continues to be a concern for tertiary institutions. Many institutions, including Victoria University, have introduced pre-tertiary education programs to prepare students for tertiary study and facilitate their academic engagement (Nelson, Duncan & Clarke, 2009). However, many students in the preparatory programs still appear to struggle with mathematics study (Woodley et al., 2005), and researchers and teachers alike look for ways to make the learning of mathematics more attractive and engaging for students; deployment of technology-based solutions appears to be one way worth of exploring (Adams et al., 2010).

Despite the rapid growth of ICT, teachers in preparatory university programs appear to make limited use of technologies in the mathematics classroom (Trace & Ball, 2009). In 2003, McInnis found that a large proportion of students are not familiar with technology-supported learning and anecdotal evidence strongly suggests that this is still the case. This indicates that the decision to incorporate technology-based solutions in the L&T of mathematics should be appropriately ’pitched’ to suit a particular student cohort (Sztendur & Milne, 2009).

2.2 Mathematics in tertiary education

The importance of mathematics and statistics has been acknowledged worldwide as an indispensable problem-solving and decision-making tool in many areas of life (Smith, 2004). Thus, they are considered a necessary inclusion in any curriculum for schools and universities in the 21st century (AAMT, 2009, a). In Australia, mathematics and statistics have been identified as “critical skills for Australia’s future” (AAS, 2006, p. 52).

In tertiary education mathematics is vital in many areas of study including engineering, science, economics, medicine, or finance, as it allows the formation, interpretation, and modeling, using mathematical and statistical tools (Hamming, 1980; Olusi & Easter, 2010; Wigner, 1960). According to Rubinstein (2012, p. 3),

> *Data analysis, risk analysis, signal processing and optimisation are essential mathematical tools in a competitive technological nation. Medical imaging, epidemiology, bioinformatics and genomics, information technology and engineering, physical sciences, financial analysis, environmental management and actuarial studies are all areas requiring high levels of mathematics.*

Mathematics, as well as its many applications in other fields, has undergone a radical change in the past 30 years especially due to the development and integration of powerful technologies which aid the teaching and learning of mathematics (AAMT, 2009b).

These changes have introduced a broad array of sophisticated teaching and learning tools, which require students to not only be competent in their understanding of mathematics but also be technologically competent in order to maximise the benefits of these tools (King, 2007). In addition, educational systems are required to give high priority to using technology as a tool to support the learning processes and to provide learners with the latest professional technological skills (Rhema and Miliszewska, 2011).

2.2.1 Student preparedness for learning mathematics at tertiary level

The increasingly weaker mathematics background of university entrants and its consequences have been reported around the world and identified as a “worldwide phenomenon” at the Global Science Forum held in 2005 (Varsavsky, 2010, p. 1). This Forum discussed student performance in mathematics globally to identify remediation programmes that support student transition from secondary school to university.

In Australia, The National Strategic Review of Mathematical Sciences Research (2006) suggested that “The future of mathematical sciences in Australia is in jeopardy” (p. 6), and that the country “will be unable to produce the next generation of students with an understanding of fundamental mathematical concepts, problem-solving abilities and training in modern developments to meet projected needs and remain globally competitive” (AAS, 2006, p.9). McPhan et al. (2008) has also investigated the concerns about Australia’s capacity to produce a mathematically capable workforce. Due to these concerns, programs have been implemented that assess mathematical capability of primary and early secondary school students and regularly identify areas that require additional action.

Many students are said to demonstrate knowledge that is “fragmented, variable, and insecure” (Faulkner, 2012). Slattery (2010) reported that "very bright" secondary school graduates are entering universities with inadequate mathematics skills. As a consequence, universities are required to take remedial steps and provide an increasing number of students with secondary school mathematics at university through expensive “enabling" programs (Slattery, 2010, p.2).

Students continue to view mathematics as a difficult subject and are often unclear about the relevance of mathematics to their future careers. Although the importance of acquiring mathematical skills has been rising, the appreciation of mathematics by the students as well as the mathematics standards have continued to decline (Gill, 2010; Hourigan & Donoghue, 2006; Hoyles, Neman & Noss, 2001; Steele, 2003). This decline in standards, referred to as the ‘Mathematics Problem”, includes student difficulties with basic arithmetic, algebraic manipulations, poor numeracy skills, an inability to cope with mathematics in unfamiliar format.

The National Strategic Review of Mathematical Sciences Research in Australia Mathematics and Statistics (2006, p52) has provided insights into the decline of mathematics standards in Australia and identified the following contributors:

- declining enrolments in mathematics and science subjects in year 12 of secondary school;

- declining numbers of appropriately qualified mathematics and science teachers in schools; and,
- declining demand for university courses in science and engineering.

2.2.2 Approaches to supporting the development of mathematics skills in Tertiary students

The past two decades have added new difficulties and pressures for the students of mathematics and statistics and learning support in these subjects has become a critical component of enabling student learning. Tertiary teachers have responded to the difficulties by using a variety of techniques and teaching methodologies to provide students with better learning to alleviate the so called "Mathematics Problem".

Hong and et al, (2009) identified a vital need for a learning support system for students who are under-prepared in mathematics and statistics across a wide range of disciplines in universities. He noted that such support can fulfill the needs across the range of student capabilities, including students choosing mathematics degree programs.

In some universities, the support is associated with a central service, in others it is provided by a mathematics/statistics department, and in others by a combination. In many universities it was started in order to meet the growing support needs of students in specific courses such as engineering, nursing, business and economics (MacGillivray, 2012).

The Australian Learning and Teaching Council (ALTC, 2012) has provided recommendations for the university sector on the provision of such support. The aim was to develop national capacity in cross-disciplinary mathematics and statistics learning support to enhance student learning and confidence (ALTC, 2012). One of the key points in terms of recommendations was "The provision of physical and electronic structure and facilities should facilitate and maximise accessibility and supportive environments for students as appropriate for the nature of the institution" (MacGillivray, 2012, p.2). It was also suggested that all aspects of the provision of learning support systems needs to be "collaborative and complementary" (MacGillivray, 2012, p.3).

The recent establishment of mathematics and statistics learning support (MSLS) facilities in Australian universities has a focus on learning support which " tends to be on building mathematical fitness, confidence and transferability, all with reference to the specific courses being taken by the students" (MacGillivray, 2012, p.2). This kind of support distinguishes between learning support and bridging programs in mathematics, which here are defined as preparatory programs to enable a prospective student to obtain prerequisite or assumed knowledge in mathematics before commencing their degree course (MacGillivray, 2009). There are now many different forms of bridging programs available at universities, as well as the availability of external study for senior school subjects, and preparatory programs for international students (ELICOS and Foundation courses). In some universities, the group providing learning support also provides bridging courses in some form.

Each university sets up its programs at its own discretion resulting in a wide diversity of programs and approaches (Clark, Bull & Clarke, 2004). The VU has introduced mathematics support structures such as bridging courses, support tutorials, computer assisted learning, peer assisted support, mathematics drop-in centres and diagnostic testing in an effort to support mathematically under-prepared students (McLennan & Keating, 2005).

The application of ICTs in the form of e-learning is influencing teaching and learning of mathematics and online learning environments are becoming part of best practice worldwide. They are already used in a range of individual school settings across Australia. At VU the Student Centered Approaches (SCA) to teaching and learning in mathematics is one of the reforms currently being advocated and implemented with the use of ICTs. A recent study at VU explored the models, meanings and practices of student centred approaches (Vale & Davies, 2012). The study concluded that a constructivist model of student centred teaching and learning should be promoted at VU and cited Black (2007) who promoted three models of SCA: (1) Inquiry and problem based learning where students have control over their learning and there are high levels of co-operation among learners; (2) Authentic curriculum, where learning is connected to students' interests and needs using rich and authentic tasks; (3) Constructivism where teachers tailor their instruction to students' learning needs.

Despite all the studies undertaken throughout the years, there still is no consensus as to which approach is better; however, one point does stand out – an over-reliance on any one particular approach is not recommended (OECD, 2012b; OECD, 2008b; Rowe, 2007). Galligan and Taylor (2008) asked the question of 'what constitutes success for students enrolled in mathematics bridging courses?' and they rated the most important things which students expected to achieve out of the course. The most prevalent responses were:

- An increase in mathematical understanding
- A change in attitude towards mathematics
- An increase in confidence in doing mathematics
- An increase in student engagement

Galligan and Taylor's (2008) findings have indicated that student engagement in mathematics bridging courses may be an issue for relatively large groups of students due to the fact that in large and diverse groups of students, it is often difficult to identify and help the students who are struggling. Gordon and Nicholas (2006) have revealed that developing appropriate teaching approaches for the wide range of student abilities was seen as a priority, and that the demands for skillful teaching were exacerbated by the short time frame of a bridging course.

2.2.3 Factors affecting student achievements in learning mathematics

The performance of students in mathematics, as well as in other subjects, depends on many interrelated factors pertaining to the students themselves and their family, curriculum and context, school environment and teacher attitude, the use of ICT, and support provided by school. Researchers and policy makers continue to identify factors affecting student performance in mathematics to find a way to solve the persisting 'Mathematics Problem', described in section 2.2.1.

The complexity and interrelationship of these factors has been demonstrated by many research studies as multidimensional (Alexander, 2000; Saritas & Akdemir, 2009; Faulkner, 2012; Mata, Monteiro & Peixoto, 2012). Only few studies assessed student scores while taking into consideration multiple factors. Crede and Kuncel (2008) reported that it is very difficult to construct a meta-analytic matrix of inter-correlations and test all aspects of individual differences to model of academic performance. McPhan (2007), analysing different methodological approaches to investigate what factors are more influential, has concluded that there is no evidence of a systematic approach to these issues. However, in order to manage such complexity more precisely, the factors identified as most relevant to this study can be grouped as follows: (1) student related factors, (2) family related factors and (3) school related factors, in accordance with Singh, Granville and Dika (2002).

Student related factors include: students attitudes towards mathematics, motivation for entering a particular study program, initial level of knowledge of mathematics, the students' own level of confidence and persistence, beliefs and attitude towards learning mathematics with ICT (Bruinsma, 2004; Saritas & Akdemir, 2009; Berge & Huang, 2010; Mata, Monteiro & Peixoto, 2012).

Family related factors include family background and environment i.e. language spoken at home, financial situation, parents' educational background, family structure and involvement in child's education (Rosebery et. al., 1992; Barkatsas & Ball, 1993; Bransford et al., 2004; Keong, Horani & Daniel, 2005; Kasimatis & Gialamas, 2009; Berge & Huang, 2010; Varsavsky, 2010; Faulkner, 2012; Gettinger & Seibert, 2002).

School related factors include curriculum reforms, the use of ICT in class, the teaching methods, a level of support offered by the teacher and the educational institution, an experimentation with new digital instructional design models and new mobile technologies, teacher competency in mathematics education and their level of ICT skills, pedagogical knowledge and knowledge of their students personalities (Alexander, 2000; Singh, Granville & Dika, 2010; Tinto, 2002; Steele, 2003).

2.2.3.1 Student related factors

Student attitude and motivation have been found to have strong relationships with academic performance (Nicolaidou & Philippou, 2003; Barkatsas, 2005; Mohamed & Waheed, 2011; Mato & Torre, 2011; Faulkner, 2012; Mata, Monteiro & Peixoto, 2012; Celik & Yesilyur, 2012). Faulkner (2012) suggested that study skills, attitudes and motivation play a critical and central role in determining students' academic performance. Moreover, Faulkner's (2012) study findings suggest that the effect of certain personality traits on academic performance may be partially mediated through study attitudes. Bruinsma (2004) found that student attitude, engagement and motivation are heavily influenced by the student's initial level of knowledge of mathematics as well as their motivation for entering the particular study program; mathematical performance is deeply related to student motivation and support provided by the teacher (Kogce et al., 2009; Osbornea et al., 2010; Mato & Torre, 2011; Mohamed & Waheed, 2011). BECTA report (2002) concluded that students had positive attitudes due to the ICT curriculum and home use of computers.

Other student related variables include: anxiety, self-concept, self-efficacy, level of engagement and ICT experience at school (Mohamed & Waheed, 2011). Mata's (2012) study pointed to a lack of student motivation and engagement in academic work and identified it as an issue of concern amongst teachers. Many researchers regard these variables as key factors that should be taken into account when considering the variability in the performance of students in the study of maths (Kogce et al., 2009). Student confidence in their ability to succeed in mathematics has been recognised as a primary motivational effect (Appleton et al., 2006).

While a considerable amount of research has been conducted on attitudes towards mathematics, most of the analyses have focused on how specific factors, such as support and motivation, relate to attitude (Mata, Monteiro & Peixoto, 2012). On the other hand, studies concerning the relationship between motivation, support and attitude towards mathematics are scarce.

Various demographic factors have been found to be related to mathematics achievement to a greater or lesser degree. Gender, socio-economic status and parents 'educational levels are factors that have been identified as predictors of math achievement (Nelson, Duncan &Clarke, 2009; Saritas & Akdemir, 2009). Pierce and Stacey (2007) reported that attitude to learning mathematics with technology has a wider range of scores than other variables studied and gender differences need to be taken into consideration when planning instruction.

One other major factor is the impact of English as a medium of instruction; specifically, language used in mathematics contexts has been found to be significantly different from ordinary English (Mapolelo, 2009). However, Dumont, Istance & Benavides (2010), noted that research focusing on the relationship between English proficiency and mathematics achievement is limited.

Research suggests that when gender is combined with one of more student related factors, such as ethnicity, race and demographic status, there tends to be a cumulative effect (Blackmore et al., 2003). However, Mata (2012) and (Vale et al., 2010) have claimed that gender-related attitudes towards mathematics seem to be of limited importance. Her finding discusses the results of other research claims that boys and girls present very similar attitudes towards mathematics. On the contrary, Tinto (2002) identified, that high-achieving boys appear to be more confident in mathematics, demonstrate stronger cognitive, behavioural and affective engagement; they appear more confident in using computers and have a more positive attitude to learning mathematics with computers, than girls do.

2.2.3.2 Family related factors

Family related variables take into account the fact that students from disadvantaged backgrounds and first generations of students face greater challenges than other students (Mapolelo, 2009).

A number of studies indicated that student achievement is correlated highly with the educational attainment of parents (Coleman, 1966; NCSC, 2002a; NCSC, 2002b); Russell & Frydenberg, 2005; Mapolelo, 2009; Israel & Beaulieu, 2010). For example, children who have well-educated parents tend to perform well academically. Otherwise, students whose parents did not have high school education obtained lower grades in mathematics than those whose parents had higher levels of education (Campbell, Hombo, & Mazzeo, 2000). Research has shown that parents' educational levels not only impact student math achievement scores, but also impact attitudes toward learning mathematics.

In general, families' ability to invest in the education of their children depends on their economic resources (Divjak et al., 2010). High Socio-Economic Status has been found to be positively associated with student academic outcomes. High parental expectations and good educational background, high family income and professional parent occupation have been associated with student academic success (Jordan, Lara & McPartland, 1996; Mohamed & Waheed, 2011). Israel & Beaulieu, (2010) have found that in rural areas, family income had more impact on student scores in mathematics than family background.

2.2.3.3 School related factors

School related variables include pedagogical choices made by the teacher and the classroom environment which has been established to aid the students learning of mathematics. A teacher who is supportive to students and promotes cooperative learning environments will motivate students in their studies as well as contribute to the development of a more positive attitude towards maths (Mata, 2012). The choice and quality of teaching materials, teacher knowledge, classroom management, guidance and support also play a role. Teacher competency has been identified as yet another factor impacting student achievement in mathematics (Ball, 1993; Rosebery et. al., 1992; Varsavsky, 2010). There have been, however, conflicting findings about the relationship between student achievement and teachers' education (Murnane & Phillips, 1981; Stockard & Mayberry, 1992). Israel & Beaulieu (2010) also identified a significant relationship between staff turnover, discipline problems in schools and weak school leadership.

High staff turnover has shown the strongest association with lowered academic achievement by Stockard & Mayberry (1992). Alexander (2000) and Saritas and Akdemir (2009) have identified curriculum, instructional strategies, methods, teacher competency in mathematics, school context and facilities as significant factors in math instruction and student achievement.

The need to understand the learner has been emphasised in many studies. Accordingly, a qualified mathematics teacher should be able to understand student learning styles and needs to apply the most appropriate teaching method to achieve the objectives for any given mathematics lesson (Olusi & Easter, 2010).

Many studies have reported student and teacher perceptions that learning is improved through using ICT, but have not provided any evidence of the actual measurement of learning gains, as summarised BECTA (2003). Joy and Garcia (2000) argue that it is not the effect of ICT alone on learning gains which should be studied, but the combination of ICT with particular pedagogical practices; Kennewell (2001) supported this conclusion.

Many claims have been made in the literature about the motivational effects of ICT on student performance and engagement (Singh, Granville & Dika, 2002; Ironsmith, et all, 2003; Bruinsma, 2004; Russell, et all, 2005; Mata, et all, 2012). Among student related factors, ICT experience at school has been identified as a motivational factor which leads students to have a positive attitude to their work, and previous positive experiences with digital technology in the classroom, and confidence with technology in general, leads them to have more commitment to their learning and their achievements in mathematics (Cox & Preston, 1999; Mohamed & Waheed, 2011). On the other hand, despite confidence in using computers and positive attitude to learning mathematics with computers, students have demonstrated negative attitudes toward mathematics, low levels of mathematics achievement and confidence, low levels of affective engagement and behavioural engagement (Barkatsas, Kasimatis and Gialamas, 2009).

Digital instructional technology has been identified as a key factor influencing how students learn and how instructors teach at universities (Sung & Huang, 2009; Rasmussen & Marrongelle, 2006). Adoption of digital instructional design techniques has the potential to lead to higher achievement rates in mathematics (Rasmussen & Marrongelle, 2006). Experimentation with new digital instructional design models in a variety of different circumstances is vital to optimize the instruction of mathematics based on known critical factors that affect mathematics achievement (Saritas & Akdemir, 2009). Innovative instructional approaches and techniques, such as digital instruction are recognised as most important factors, which should be developed to ensure that students become successful learners. Libienski & Gutierrez (2008) concluded that the instructional designer must know crucial factors that affect student learning and build a bridge between goals and student performance.

Instructional design of mathematics courses is recognised by many studies as one of the most important factors affecting student scores in learning mathematics and comparable with the factors identified for mathematics achievement (Saritas, 2004). Saritas and Akdemir (2012, p. 1) pointed out that instructional design is the most influential factor, when taking into consideration pedagogical approach or methodology used in course preparation. This has been recognised as the most influential factor affecting student performance, when it takes into consideration awareness of students' experience and background. Thus, it was revealed, that instructional strategies and methods, teacher competency in math education and motivation or engagement were the three most influential factors that should be considered in the design decisions to improve students' achievements in mathematics.

Thus, factors such as pedagogies, the nature of the ICT environment, and available ICT resources are yet another combination of factors which influence learning outcomes (Chance, et al., 2007; Dougiamas, 2007; Dougiamas, 2003). Many studies do not take into account the necessity to design instruments which can measure the learning gains promoted by a particular task or activity (Dori & Barak, 2001; Convery, 2009; Celik & Yesilyur, 2012). These studies have also clearly shown that the effects of an aspect of ICT (e.g. conceptual, pedagogical, methodological, enabling collaboration, interactivities and so on) on attainment will be dependent upon the context in which teaching and learning take place, and the ability of the learners to use the technology. Therefore it is necessary to identify the actual aspects of ICT which the learners will experience. For example, Nanjappa and Grant (2010), Orlando (2011), Jonassen (2010) and Barnea and Dori (1999) Pierce and Ball (2009) reported considerable gains in the understanding of geometry by pupils who were given access to three-dimensional modelling software. They have shown the value of simulations for enabling visualisation and hence helping pupils to solve problems. Pierce and Ball (2009) and Monaghan and Clement (1999) also found that interaction with a computer simulation online can facilitate a pupil's appropriate mental simulations offline in related target problems. Celik & Yesilyur (2013), claiming that no study has been conducted on the correlation between computer supported education, perceived computer self-efficacy, teacher computer anxiety and attitude to technology, have discovered that attitude to technology, perceived computer self-efficacy and computer anxiety together significantly affect student performance. Celik & Yesilyur (2013) concluded that teacher attitude to technology, perceived computer self-efficacy and computer anxiety are important predictors of students attitude toward computer supported education and a crucial gain in terms of positive teacher attitude toward ICT supported education in general.

Pierce and Stacey (2007), in developing a scale for monitoring students' attitudes to learning mathematics with technology, have provided a tool for teachers and researchers to monitor these affective variables relevant to learning mathematics with technology, including two aspects of engagement in learning mathematics and additionally explained their relationship to each other. They also found positive correlation between attitude to the use of technology to learn mathematics, confidence in using technology and student engagement. The Mathematics and Technology Attitude Scale (MTAS), developed by Pierce and Stacey (2007), has provided the instrument that can be used by either teachers or researchers interested in trialling teaching technological innovations.

Most recent studies relate student variables and on-line program design options which influence mathematics achievement (Saritas & Akdemir, 2012; MacGillivray, 2012; Saavedra & Opfer, 2012). Knowing the factors affecting math achievement is particularly important for making the best design decisions (Saritas & Akdemir, 2009). These researchers have shown that high achievements in mathematics are positively related to the main components of program design decisions related to incorporation of ICT in mathematics curriculum such as instructional strategies and teaching methods, teacher competency in math education, and motivation and engagement.

This section has outlined a growing body of research related to student variables, contextual variables, and online design options based on awareness of students experience, background and instructional technology. Instructional strategies, teacher competency in using ICT in mathematics education and motivation and engagement have been identified as the most important factors affecting student scores in learning mathematics.

2.3 Student engagement in learning mathematics

High student engagement in learning of any subject is an aim of any school education (Guthrie & McCann, 1997). It is a crucial element of classroom learning (Hall, Strangaman & Meyer, 2011) and an important factor surrounding the implementation of curricula (DEEWR, 2011; Huebner, 1996).

The construct of 'student engagement' has been attracting a growing level of interest, because it is seen as a solution to the "Mathematics Problem" (discussed in previous chapters). This construct is a highly complex and multi-faceted element of education (Fredricks et al., 2004). Due to this complexity, little has been done to formally define engagement (Fielding-Wells & Makar, 2009). Psychological research and educational research differ in their views on what constitutes engagement in a school setting and how to accurately measure it. A recent study has defined engagement as a scientific snapshot, composed of three parts: how people interact in engaging environments, how people behave, and how people feel (Gallup, 2013).

2.3.1 Dimensions of student engagement

It is vital for researchers to have a consistent approach to defining and measuring the construct of student engagement to avoid obscurity of a study (Appleton et al., 2006). A growing body of literature about student engagement in education suggests that it encompasses three areas: cognitive, behavioural, and emotional (Connell, 1990; Connell & Wellborn, 1991; Kong, Wong & Lam, 2003; Fredricks, Blumenfeld, & Paris, 2004; McLaughlin et al., 2005; Hall, Strangman & Meyer, 2011).

Cognitive engagement

Cognitive engagement includes an investment in learning and a willingness to go beyond the basic requirements to master difficult skills. There is a distinction in cognitive engagement between students adopting surface strategies, deep strategies and reliance (Kong, Wong & Lam, 2003; Fredricks et al., 2004).

Behavioural engagement

Behavioural engagement is the level of participation in the school activities and the involvement in academic learning tasks, positive conduct and the absence of disruptive behaviors (Fredricks et al., 2004).

Affective engagement

Affective engagement relates to the relationships of students and teachers and refers to students' emotional responses, including interest and anxiety according educational and psychological researchers (Russell, Ainley & Frydenberg, 2005; Skinner & Belmont, 1993). In the school context – emotional engagement can include emotions which are experienced by students such as anxiety and frustrations, attitude, interest, boredom, expectations and involvement, and a sense of belonging (Kong et al., 2003; Connel & Wellbon, cited in Kong et al., 2003, Horn-Hasley, cited in Fielding-Wells & Makar, 2009).

Numerous studies focusing on engagement, have attempted to identify the many inter-relationships between the elements of engagement. Fredricks et al., (2004) and Kong et al., (2003) noted that it may not be feasible to consider and analyse each of the individual dimensions of engagement, due to the complexity and the inter-relatedness of these components. For example, a student who works diligently to complete a highly interesting and complex mathematic problem may be behaviourally engaged and also affectively and cognitively engaged. However, a student "slouched in their seat and doodling on a notebook may be attentively listening and quite cognitively and affectively engaged by a presentation but giving the appearance of behavioural disengagement" (Fielding-Wells & Makar, 2009, p. 234).

Another definition of student engagement distinguishes between procedural engagement and substantial engagement (McLaughlin, et al., 2005). A procedurally engaged student is one who follows the traditional rules of behaviour i.e. is quiet, pays attention to the teacher, and has the book on the correct page, whilst a substantially engaged student is one who not only attends to the built-in procedures of instruction but also interacts with the teacher and other students in the class, in a deep and thoughtful manner. Perhaps one way to define student engagement is to see how it is measured (Taylor & Parsons, 2011).

2.3.2 Measures of student engagement

Measuring student engagement has become an integral part of any university curriculum and a selection of methods is available to measure this variable. The most common method uses information reported by students themselves. A variety of self-report questionnaires have been used in research on student engagement, reflecting the multi-faceted nature of the construct and the fact that no one instrument is likely to be able to assess student engagement comprehensively. Using separate indices allows educators to adapt the focus of their study towards their own instructional goals.

Attitude change remains a core topic of contemporary social psychology (Bohner & Dickel, 2011; Roth and et al., 2011; Olson and Zanna, 1993). Research on student attitudes has shown that implicit measures of attitude predict spontaneous behaviour, whereas explicit measures of attitude predict deliberative or more controlled behaviour. Thus, implicit and explicit measures of attitude may improve the prediction of behaviour. Studies on the consequences of attitudes focus on the impact of attitudes on affective (emotional) and cognitive (belief) engagement, have suggested the scales which could detect an experimental manipulation of the affective and cognitive bases of attitudes (Roth and et al., 2011; Jimerson and et al., 2003). It was noted that attitudes towards, and interests in, learning mathematics are often assessed within the same scale and are highly interrelated (Appleton et al., 2006; Olson & Zanna, 1993). To this end, attitudes affect information processing and behaviour.

In general, teachers interested in assessing student engagement in the classroom have to consider the separate aspects of engagement: cognitive, affective, behavioural, and their factors. According to Marks (2000), student engagement with the intellectual work of learning is an important goal for education which leads to the students' achievement and also contributes to the students' social and cognitive development.

2.3.3 Importance of student engagement in student retention

The teaching profession aims to optimise student learning, and therefore student engagement is absolutely essential. While academic factors are not recognised as a major influence on student retention, student engagement with the learning environment and the learning community around them is now internationally recognised as a prominent indicator of the success of the first year experience (Sheard et al., 2010, Varsavsky, 2010).

The most recent studies (Varsavsky, 2010) have concluded that engaged students are more likely to succeed at university and also that the first year of studies is particularly important in establishing a positive attitude between the student and the learning environment (Krause & McEwen, 2009). Adams et al. (2010) have identified student demographic factors impacting on retention. These factors include gender, age, socio-economic, family, and non-English speaking background. The Hobson Retention Project (2010) has also confirmed that student engagement, satisfaction and support provided by teacher are strongly correlated with student retention.

2.3.4 Factors influencing levels of student engagement

Researchers have proposed a variety of different ways to determine the level of student engagement. Chickering & Gamson's (1987) engagement indicators, including seven principles for good practice, have been widely applied in determining student engagement. Other researchers presented various forms of engagement ranging from engagement through to disengagement (Murray et al. 2004). Appleton et al. (2006) developed and validated their own taxonomy, which breaks engagement into four subtypes: academic, behavioural, cognitive and psychological.

Many studies have pointed out that the first step should involve the development of a consensus about the definition of the construct; and identifying reliable measures of the dimensions of the construct (Christenson et al., 2008; Appleton, Christenson, Kim, & Reschly, 2006; Fredericks et al., 2004). Policy makers can develop effective interventions, if they recognize which factors are the most important in identifying the levels of student engagement and develop policies that address these factors. For example, if school practices are associated with early school leaving, then education programs which target these practices may reduce the number of students dropping out.

Typically, researchers have incorporated three factors which emphasize the affective, behavioural, and cognitive dimensions of engagement (Finn, 1989; Fredericks et al., 2004; Jimerson, Campos and Greif, 2003). Based on these components, engagement is conceptualised as a state of being which is highly influenced by contextual factors, such as – home, school and the peers (Wentzel, 1998). Engagement itself is not conceptualized as an attribute of the student (Wentzel, 1998). Instead, many student related factors, such as their attitudes, motivation and self-efficacy beliefs indirectly contribute to the determination of the levels of student engagement. These levels have the capacity to fluctuate, as a result of individual student motivation for learning and the learning environment which has been organized by the teacher (Fredericks, Blumenfeld and Paris, 2004). Each individual element of cognitive, affective, behavioural engagement determines the level of student engagement separately, but also together with other elements, as they are interrelated.

The influencing of the above factors can be seen as the responsibility of a teacher. Literature points to the teacher, as being the critical intermediary in the determination of the level of engagement in the classroom which is aided by ICT. The teacher's familiarity, competence and confidence, in the use of ICT, is of paramount importance (Sharma & Bhaumik, 2013). For example, Shuva (2010) and Sharma & Bhaumik (2013) have studied teacher intention to use ICT in their classroom and have found that when the use of an online learning management systems was mandated, teachers have provided little in the way of pedagogical or technical support to their students. These researchers have asserted that it is not technology that engages the learner, but the learning activities and the pedagogy that was used by teacher in online learning environment.

Student satisfaction also influences the level of student engagement: the Student Experience survey (CSHE, 2005) measured the students' satisfaction with the course of study. The

results indicated that 75% of students found their course to be intellectually stimulating, 71% enjoyed their course and 70% were satisfied with the overall university experience.
The socio-economic status of students has also been recognised as a determining factor of the level of student engagement. However, the socio-economic status also has been shown to have its own effect, over and above the effects which are commonly associated with the students' own family background (Mohamed and Waheed, 2011).

Technology has proven to be helpful in engaging students in learning mathematics and in helping students to control their learning (AAS, 2006; Abel, 2005a; Abel, 2005b). A combination of a taxonomy developed by Kong (2003) and mathematics technology attitudes scale (MTAS) developed by Pierce, Stacey, and Barkatsas (2007), seems to have a good measure of levels of student engagement in relation to student attitude towards use of technology for learning mathematics; MTAS can be used to track changes in the attitudes and student levels of engagement in response to the altered learning environment and to identify how technology can be implemented to increase the levels of student engagement. Peer influences, prior learning, and social mix also play a role, particularly in the adolescent and post-compulsory years (Alton-Lee, 2002; Bowen et al., 2008).

The challenge for researchers is in the development of a model that incorporates the most significant factors which can influence student engagement. No empirical study focused on solving the "Mathematics Problem" to date incorporates all factors (Audas & Willms, 2001; Willms, 2000). Knowing the factors affecting the levels of student engagement is particularly important for making the best decision when using technology in the teaching and learning of mathematics.

2.3.5 Role of technology in improving student engagement

An improvement of student engagement through an innovative use of ICT can help solve the "Mathematics Problem" and improve retention (Appleton et al., 2006). With the use of ICT, student engagement improves substantially over time, whilst limited access to ICT as well as low confidence in the use of ICT can correspond to low level of student engagement and performance. Studies have found that ICT can help visualise student thinking; promote critical listening, evaluating, and explaining; and, provide instant performance feedback (Paechter, Maier and Macher, 2010; Bransford, Brown & Cocking, 2004).

Many studies have also investigated the complex interrelationship between students' confidence in mathematics, their confidence with technology, their attitude to learning mathematics with the aid of technology, affective engagement levels, achievement, gender, and the socio-economic status of students. McPhan et al. (2007) pointed out that further research into the learning of mathematics, from early childhood through to the tertiary level, must be carried out to better understand all the possible influences of student engagement.

2.3.6 Significance of Internet in student engagement in blended learning environment

Previous research into student engagement devoted little attention to online learning. Research focused on online learning has mainly focused on the pedagogical, technical and managerial issues surrounding it. Students often appear to be treated as 'users' rather than as learners (Akbiyik, 2011).

The rapid diffusion of the Internet has created a lot of potential to transform education as a whole. Students are increasingly expecting their university to fit in with their lives, rather than vice versa (Petocz and Reid, 2005). Students appear to be less engaged with university overall and with study in particular. Undergraduate students now have more choices about when, where, what they will study and how much commitment they need to make to university life (McInnis, 2003).

Blended learning is defined as "a combination of various instructional modalities intertwined with synchronous and asynchronous web-based technologies to facilitate interactive and reflective individual and collective learning" (Lupshenyuk and Adams, 2009, p. 428). Blended Learning Environments (BLE) combines the strengths of face-to-face teaching and online learning environments (Cadwalladr, 2012).

While they provide an opportunity to design engaging learning environments for students, research on student engagement in blended learning environments is scarce. Likewise, despite a high level of penetration of online learning systems in the higher education curriculum and the growing recognition of the importance of student engagement, the understanding of the influence which Learning Management Systems (LMS) have on student engagement remains in its infancy (Cadwalladr, 2012; Coats, 2005).

Research has shown that students demonstrate better cognitive engagement when a blended teaching and learning approach is implemented by a teacher with the use of ICT, taking into consideration the weaknesses and strengths of each individual student studies (Gallup, 2013; Marshall, 2002; Vale & Julie, 2010). In addition, Coats (2005) suggested that incorporating online LMSs to better engage students in learning mathematics can help improve retention.

2.3.7 Influence of the design of online learning environment on student engagement

There are two clear advantages of learning platforms: first, learners can take a more active part in their education; and second, learning platforms offer 'anytime, anywhere learning' (NCTM, 2012a, BECTA, 2007a). Online environments provide great opportunity for teacher-student interactions; allows for instant, timely feedback; facilitates more current content delivery and flexibility of access; and, empowers learners to make more decisions, and thus, to be more engaged in their own learning (NCTM, 2012b; Conrad & Donaldson, 2004; Fung, et al., 2007). Recent studies have recognised online learning opportunities as a major factor impacting on student learning outcomes. Hattie's (2003) study indicates that after family and socio-economic status background, teacher-student interactions in online learning environment are the greatest predictor of learning outcomes. However, whilst there is evidence that affective, cognitive, and behavioural characteristics of individuals are recognised as a pre-condition that can enhance learning in an online learning environment, there are concerns that the technology is not used with an appropriate pedagogy (NCTM, 2012a; Sheard, 2010).

2.3.8 The role the online teacher

Teachers contribute to learning through a variety of roles, as the facilitator, researcher, designer, developer, etc. In fact the term ‘teacher’ rarely appears in an online environment, where they are the facilitators of learning or the course designers. Authors widely agree that improved educational experiences require teachers to have knowledge of both technology and of subject content (NCTM, 2012a; Shuva, 2010).

When the learning environment is designed by the teacher for his/her learners, it becomes a significant factor in student engagement, and when technology is used strategically, it can provide access to the course material for all students (Conrad and Donaldson, 2004).

There are significant differences between a teacher’s personal teaching website and other educational websites. A teacher’s site is an additional constructed resource, designed to take account of participants’ characteristics, be responsive to student attributes across cohorts, deploy a variety of tools for continuous and gradual improvement of the site, and provides a learning platform for various teaching modes (Netspot, 2012). Thus, the designed learning environment holds enormous potential for effective learner-centred pedagogies and practices. It significantly extends the range of possible class activities and educational experiences, such as creating opportunities for students to initiate collaborative peer activities, hence taking responsibility and engaging more deeply with their own learning process.

Unfortunately, there remains a gap in institutional and professional understanding about how learning management systems affect the way students learn (Coates, 2005). The successful implementation of educational technology is intricately linked to the teacher’s skills and interest in this technology (Pelgrum, 2001; Valentine, 2002; Allen & Seaman, 2007). Collis (1995) stated that “it is not the technology but the instructional implementation of the technology that determines the effects on learning” (p. 146).

2.4 ICT supported mathematics education

In mathematics education, computer-based technologies are now commonplace in classrooms. Electronic technologies are expected to be used to enhance student mathematics learning. The “Standards for Excellence in Teaching Mathematics in Australian Schools” (Australian Association of Mathematics Teachers, 2002, 2006) assume that excellent teachers of mathematics are responsive in their use of technologies and are aware of a range of strategies and pedagogical techniques for using information and communication technologies in mathematics teaching. However, many questions about the impact of computer-based technologies on classroom mathematics learning remain unanswered, and debates about when and how they ought to be used continue (Lynch, 2006; Mac Gillivray, 2012; Celik & Yesilyur, 2013).

The influx of computing technology into schools reflects policies that position such technologies as powerful tools for learning and for life, and to which all students should have access. In Australia, governments have promoted the integration of computer use across the school curriculum since the 1980s.

2.4.1 Evolution of ICT supported Learning and Teaching of mathematics

Many studies have been carried out, reviewing the evolution of ICT as well as the effect that it has had on teaching and learning, in order to identify the influence that the current development stage of ICT has on the learning of mathematics, whilst taking into account the students ICT skills and their current learning needs (White, 2011; Akbiyik, 2011). Posse (2012) discussed the evolution of the use of ICT in education. He identified five major periods for the use of computers in the education system, which are summarized in Figure 3 below.

The phases were:

(1) Late 1970’s through to the early 1980’s – was the programming, drill and practice phase;

(2) Late 1980’s through to the early 1990’s – was the computer based training (CBT) with multimedia phase;

(3) Early 1990’s – was the Internet-based training phase;

(4) Late 1990’s through to the early 2000’s – was the e-Learning phase; and

(5) Late 2000’s – is the social software, Web 2.0 and free and open content phase.

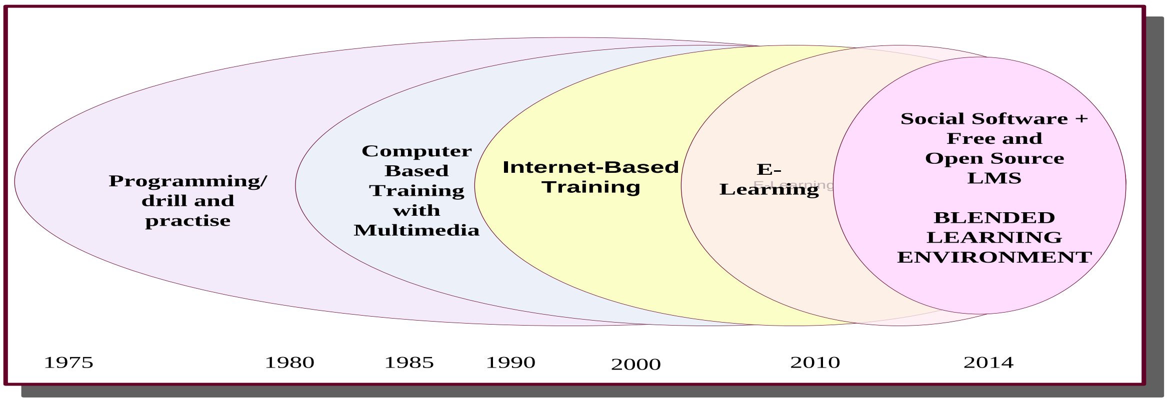

Figure 3 Evolution of ICT. Adapted from Posse (2012).

It is worth noting, that an old stage overlaps with its successor. The older stages don’t disappear completely - instead they are present in the formation of new paradigms (Posse, 2012).

Initially computers were used to teach computer programming, but the development of the microprocessor in the early 1970’s, saw the introduction of affordable microcomputers into schools at a rapid rate (Newhouse, 2002a). During the early days of the use of ICT in the school classroom, traditional computer assisted instruction which was based on rigid drill and practice, was the main method of utilizing ICT. With the efficiency of the drill and practice software being questioned, more flexible and open learning programs were developed (Katz, 2002 cited in Akbiyik, 2011).

During the period of the late 1970's through to the early 1980s, computers had become more affordable to schools. Whilst tutorial software continued to be developed (Chambers & Sprecher, 1984), a range of other educational software was developed that was not based on the premise of teacher replacement – such as simulation and modelling software. However, the major driving force supporting the need for the introduction of greater amounts of computer hardware into schools concerned the perceived need to increase the level of computer literacy among students (Carleer, 1984; Downes, Perry, & Sherwood, 1995 cited in Newhouse, 2002a).

The period of the 1990's was the decade of computer communications and information access, in particular the popularity and accessibility of internet-based services, such as the e-mail and the World Wide Web. Concurrently, the CD-ROM was replacing the floppy disk as the standard medium for the distribution of packaged software. This replacement, allowed large information-based software packages such as encyclopaedias to be distributed in a cheap and easy manner. As a result of this, educators became more focused on the use of the technology to improve the student learning as the rationale for the investment (Newhouse, 2002b).

In the present day, computers in schools are now not only the focus of study (technology education) but are also a support for learning and teaching (educational technology).

The impact of ICT within the educational industry has been assessed in all of the five phases with mixed results. Improved attitudes towards use of technology for learning and development of a teacher's technological skills, has been recognized as an important factor in the use of ICT. Literature from the past 20 years also affirms that the affective factors and beliefs impact on the student learning. Ruffell, Mason and Allen (1998) have noted, that attitudes may not be defined conceptually in order to be reliable, but instead they may be "influenced by social and emotional context and the personal construction of these" (p.15).

Attitudes are commonly distinguished from beliefs in that they are moderate in duration, intensity and stability and have an emotional content, while beliefs become stable and are not easily changed (McLeod, 1992; Mayes, 1998; Pajares, 1992 cited in Akbiyik, 2011). Akbiyik

(2011) found that positive attitudes and beliefs generally have a positive impact on the students learning. Ruffell et al. (1998) indicated that attitudes can rapidly change from a negative one to a positive one and in particular that ‘good teaching’ can have a similar effect.

Research has shown the effectiveness of using representational technologies in mathematics, to support student learning (Mayer, 2005). However, multiple obstacles have delayed the rollout of these technologies to the broader society – such as the perception that technology is too difficult to implement in diverse classrooms (Becker, 2001), and the inconsistent findings on the actual benefits of using educational technology in mathematics (Dynarski et al., 2007). The fifth phase is the era of social software and free and open content. Throughout the last decade, ICT have been dynamically introduced into society. At this stage, formal education (i.e. primary, secondary and higher education) as well as all the various modes of informal education (i.e. professional training etc.) have been affected by ICT. All the contemporary digital tools, such as computers and the internet, smart phones and tablets have become widely used within the educational profession. An analysis of various “net generation” related literature reveals three prominent types of claims about:

(1) the widespread use of ICT;
(2) the impact that digital immersion has on learning; and
(3) the distinctive personal and behavioural characteristics of this generation.

The popular “net generation” discourse suggests that this generation, born roughly between 1982 and 2000, has been profoundly influenced by the advent of digital technologies as well as their immersion in a digital and networked world. There is little doubt that the younger people have a tendency to use digital technologies much more than their older counterparts, although digital technology use by older people is growing (Jones and Fox, 2009).

Many studies have found that the use of some particular ICTs (i.e. mobile phones, email and instant messaging) is ubiquitous, but there is no evidence to support claims that digital literacy, connectedness, a need for immediacy and a preference for experiential learning were the characteristics of any particular generation of learners (Bennett et al., 2008; Guo et al., 2008; Jones & Cross, 2009; Kennedy et al., 2007, 2009; Kvavik, 2005; Margaryan & Littlejohn, 2008; Pedró, 2009; Reeves & Oh, 2007; Selwyn, 2009).

Throughout the fifth phase, there have been many different uses and applications of ICT made available to the general public – such as open source software. These applications range from using ICT as a free tool to support the traditional teaching methods, to courses which have had ICT fully integrated into their curriculum, which entails a completely different approach to teaching. This raises the question of whether ICT should only be a supplementary tool or if it should be an enabler of innovation (Nehouse, 2002).

There is a plethora of different technologies, which are currently being used in mathematics classrooms, with varying degrees of success. Technologies such as graphing and CAS calculators allow students to explore much more difficult problems, than educators would have dared to assign years ago. Such calculators allow the investigation of functions through the use of tables, graphs and equations in ways that were not possible prior to their proliferation. Those calculators allow the students to focus on the setting up and the interpretation of results (Dick, 1992; Hopkins, 1992).

Studies focusing on the introduction of ICT into the mathematics curriculum generally can be divided in three main viewpoints:

(1) some are of the view that ICT is a basis for a revolutionary reform in this field or that it is a panacea;
(2) others consider that ICT in education is a very useful tool, yet it will not dramatically affect or reform this field; and
(3) others are of the belief that ICT will help solve the “Mathematics Problem”, but to do so there must be a considerable investment into ICT, which will take time, resources and pedagogical change and will have no immediate return on this investment.

The current stage of ICT supported mathematics education can be characterised as a new way of learning mathematics. Numerous open source and free mathematical software packages such as Sage, GeoGebra and Maxima are available to both the teachers and the students.

These packages also offer free educational resources for teachers and also more ways for students to learn mathematics, by providing free and customizable digital content.

Mathematics and technology instruction, such as computer-mediated learning, are becoming more prevalent within the mathematics classroom and their positive affect, on student learning is becoming evident. Replacing the “drill and kill” worksheets, with software which is one-on-one, self-paced by the student and provides immediate feedback can help remediate and enhance student understanding. Despite this, some studies have reported that “no measurable differences in the learning outcomes for students, who used various kinds of technology in their classrooms” (Gouvêa, 2007, p. 11). One particular study examined the use of various technological products, such as graphing calculators, computer algebra systems and dynamic geometry software indicated that all these tools have had positive effects on student outcomes (Almeqdadi, 2000; Funkhouser, 2002; Harskamp, Suhre and Van Streun, 2000).

2.4.2 Pedagogical approaches in ICT supported Learning and Teaching

The current stage of ICT supported mathematics education can be characterised as a new way to learn mathematics. Numerous open source and free mathematical software tools are available for teacher and students, such as computerized mathematical modelling. Such software offers free education resources for teaching and more ways for students to learn mathematics by providing customizable, free, standards-aligned digital content.

2.4.3 New Architecture for Learning

Integrated learning environments where students are provided with activities which are relevant and integrated into the course design provides some motivation for engagement, although students’ participation may need to be actively encouraged (Wallace and Young, 2010; Coghlan, 2007; Minocha, 2009).

The Global Learning Impact Report (2013) has provided the results of analysis of studies with the approach of focusing “on project types rather than attempting to identify specific technologies and their adoption timeframes”, including a visual summary of difficulties to implement the project which aim to identify the role of ICT in learning and teaching, implemented in blended learning environments with the use of open LMS. Open digital content platforms containing a variety of learning materials to enable students to have access to high-quality educational materials at a low cost and ability to explore the world beyond the classroom requires the dynamic optimisation of blended learning, which has a significant complexity (Global Learning Impact Report, 2013; Mor and Mogilevsky, 2013b). Current education systems provide such a level complexity for teachers and students.

IMS Global Learning Consortium (2013a) in discussion about “A New Architecture for Learning” has identified that the use of software such as LMS can help to ease the pains of integration of these tools in order to enhance teaching and learning in a blended learning environment. A measure of this enhancement of learning and teaching with LMSs has presented a challenge for researchers and policy makers.

2.4.4 Impact of ICT on learning

The current literature seems to indicate that there is a consensus that ICT has a positive influence on learning, and many teachers are convinced that ICT offers better learning opportunities than ‘traditional’ approaches. A considerable amount of literature has been published on the role of ICT in student engagement in learning mathematics. Overall there is strong evidence that educational technology complements what a good teacher does naturally (Wachira et al., 2013; Marshall, 2002). However, inconsistent findings on the benefits of educational technology in mathematics have been pointed by Dynarski et al., (2007).

Research has shown the effectiveness of using representational technologies in mathematics to support student teaching and learning (Mayer, 2005). However, there have been barriers to broad use, such as the perception that technology is too difficult to implement in diverse classrooms (Becker, 2001).

A literature review of ICT in learning mathematics showed that the most robust evidence of ICT use enhancing pupils' learning was from studies which focused on specific uses of ICT (Cox & Webb, 2004). They concluded, that where the research aim was to investigate the impact of ICT on learning without clearly identifying the type of ICT, then unclear results were reported, making it difficult to identify impact of a type of ICT on students' learning.

Many studies conducted over several years provided contradictory and different answers to the question of whether or not ICT has made significant impacts on a wide variety of student learning outcomes (Cox & Marshall, 2007). Their findings have important implications for designing and developing the research studies trying to identify the role of ICT in learning. Cox and Marshall (2007) have suggested five ways of conceptualizing the ways in which technology can be considered when addressing the complexity of impact of ICT on learning:

- technology as a cognitive tool (Jonassen, Peck and Wilson, 1999)
- the computer as a mental and computational device (Tessmer and Jonassen, 1998)
- the computer as a tool for teaching students (Robleyer, 2008)
- the way that the computer acts in the acquisition of cognitive skills (Pappert, 1980)
- the use of computers as a tool for enhancing student learning (Schoenfield, 1987).

In summary, a multilevel approach towards ICT in education has been identified, elaborating the need for multi-level and multi-method approaches, which enables better insight into the impact of ICT for learning and teaching.

As mentioned earlier, research on the impact of ICT on learning consistently reported that students demonstrated considerable improvements in learning in affective learning domains. However, the implementation of inquiry learning in classrooms presents a number of significant challenges. It is axiomatic that none of these benefits is guaranteed to flow automatically from the use of technology. Many of them may be achieved through good teaching and the modelling of an effective learning environment (Cuttance, 2001). The learning environment is not a factor that can be directly related to achievement, but like the affective domain, remains an important factor in student achievement. It was found when ICT is used in the classroom it creates more opportunities for individualised and differentiated curriculum (Calnin, 1998), it increases self-management and self-regulation as learners (Cuttance, 2001), and relationships between teachers and students are more interactive (Shears, 1995). The critical factor in supporting effective learning with ICT is to focus on the way it is integrated into classrooms.

2.5 Moodle as a catalyst for pedagogical renewal

Moodle is the most widely used open source learning management system in the world (Zakaria and Yusoff, 2013). Moodle is being used by many thousands of educators around the world, including universities, schools and independent teachers in 214 countries and has been translated into 82 different languages (Tserendorj et al., 2013).

MOODLE stands for Modular Object-Oriented Dynamic Learning Environment. It is a Course Management System that is designed using sound pedagogical principles to help educators create effective online learning environment, completely free to download, install , and use indefinitely. Not having to pay license fees or to limit growth, an institution can add as many Moodle servers as needed. As teaching and learning evolves, Moodle has continued to evolve. Users can freely distribute and modify the software under the terms of the GNU General Public License. Because Moodle is open source software, Moodle can be customized to fit academic needs for students, instructors and the Moodle administrators. As it is an increasingly dynamic environment, Moodle keeps evolving to meet the needs of the educational community.

2.5.1 Moodle Philosophy

Moodle is a global development project designed to support a social constructionist framework of education (Tserendorj et al., 2013).

2.5.2 Moodle Pedagogical approach

Moodle was designed for learning and teaching by people in the education sector who have direct experience and an understanding of how to apply technology to learning and teaching.

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The stated philosophy of Moodle includes a constructivist and social constructionist approach to education. Using these pedagogical principles, Moodle provides a flexible environment for learning communities, focusing on fostering active and social learning, enhancing monitoring and evaluation, promoting planning and productivity, enhancing district-wide efficiency, and facilitating professional development (Zakaria and Yusoff, 2013; Dougiamas and Taylor, 2003).

2.5.3 Benefits of using Moodle

The benefits of open source software such as Moodle are many, ranging from its flexibility, support for new modes of learning and teaching, user-friendly interface, and its longevity and viability into the future. Sustained by a strong community of educational practitioners, developers and commercial partners, Moodle will continue to grow and evolve, allowing lecturers to reinvigorate pedagogy within their courses (Dougiamas & Taylor, 2003).

Recent studies (Zakaria and Yusoff,2013; Tserendorj et al., 2013) revealed that students have positive attitude towards the use of Moodle. They concluded that Moodle if its use appropriately and systematically benefits lecturer and students accordingly (Zakaria and Yusoff, 2013). Among other benefits:

- Increase retention rates;
- Increase student engagement;
- Improve student outcomes;
- Save time and money.

(Zakaria and Yusoff, 2013; Tserendorj et al., 2013).

Many Australia universities implement Moodle as the institutional LMS in part due to its ” anecdotal ease of use, flexible toolset and pedagogically sound philosophy which combine to enable positive change in teaching practice and thus the student learning experience”

(Dougiamas and Taylor, 2003). Questions arise however over whether this actually does happen, whether it can happen, and how improvements in teaching practice can be engendered through Moodle.

Moodle is flexible system to cater for a wide variety of needs while remaining simple enough for ordinary teachers to start making good use of the power of the internet. Moodle 2.5 (2013) is the most recent major upgrade to the Moodle platform, and included some fundamental improvements on previous versions of the LMS:

- Supports students working at their own pace by releasing activities and resources as they progress.
- Better and more dynamic user interface.
- Integration with e-portfolio solutions, such as Mahara.
- Easier to develop and modify new themes.
- Effective tracking of a student's progress over time

Moodle provides a range of intuitive tools that make content easy to create and simple to present including standard web pages, SCORM packages and native playback of video and a simple, consistent interface allowing users of all skill levels to get started quickly, whether creating courses, or participating as a learner. One day's instruction is generally sufficient for even the most tentative beginner to be able to create a sound online learning course.

2.5.4 Moodle Usability

Moodle usability goes far beyond ease of course creation, with Moodle providing a range of other usability features such as homepage customisation, accessibility compliance and configurable blocks (Zakaria and Yusoff, 2013).

2.5.5 Moodle tools

These include:

- Putting up the handouts (Resources, SCORM)

- Providing a passive Forum (unfacilitated)
- Using Quizzes and Assignments (less management)
- Using the Wiki, Glossary and Database tools (interactive content)
- Facilitate discussions in Forums, asking questions, guiding
- Combining activities into sequences, where results feed later activities
- Introduce external activities and games (internet resources)
- Using the Survey module to study and reflect on course activity
- Using peer-review modules like Workshop, giving students more control over grading and even structuring the course in some ways
- Conducting active research on oneself, sharing ideas in a community of peers

(Tserendorj et al., 2013).

2.6 A Framework to Articulate the Impact of ICT on student engagement

A classroom is a "complex, often nested conglomerates of interdependent variables, events, perceptions, attitudes, expectations and behaviours and thus their study cannot be approached in the same way that the study of single events and single variables" (Salomon, 1991; p.11). Constructing a conceptual framework is a good starting point for investigating a complicated phenomenon, and then providing integrated outcomes, even though the process has some limitations (Kikis, Scheuerman and Villalba, 2009).

Newhouse (2002b) has concluded that "it is not possible to provide a meaningful framework to describe or measure the direct impact of ICT on student learning" (page 26). Nevertheless, he has identified the significant impact of ICT on the students, teachers, learning environments, policies, procedure and pedagogies.

2.6.1 Dimensions to consider when evaluating the use of ICT for learning

Newhouse (2002b) suggested a number of dimensions, which should be considered when evaluating the use of ICT in the improvement of student learning:

I. Students (their ICT capability, engagement and the achievement of learning outcomes);
II. Learning Environment Attributes (Learner- centred, Knowledge-centred, Assessment-centred and Community-centred);
III. Teacher Professional ICT Attributes (vision and contribution, integration and use, capabilities and feelings);
IV. School ICT Capacity (hardware, software, connectivity, technical support and digital resource materials); and
V. School Environment (leadership and planning, curriculum organisation and support, community connections and accountability).

Each of the above dimensions can be represented by a particular outcome as described in the following enhancement of Table 5 and presented in Table 2 .

Newhouse (2002b) pointed out that the engagement and achievement of learning outcomes components of the Students dimension (I) should be subsumed within the learning Environment Attributes dimension (II). As it was pointed by Newhouse (2002b), it is not possible to develop a framework for judging the impact on learning environments, but is possible to describe the ways in which ICT could be contributing to the development of constructivist learning environment.

2.6.2 The relationships between learning environment and ICT

ICT is one of many factors impacting on the success of the learning environment and should be an enabling component not a determining component of the environment. Also, it's not possible to provide a meaningful framework which can measure the direct impact that ICT has on student learning, but it is possible to explore the elements of outcomes to consider when evaluating the use of ICT to improve student learning. Figure 1 illustrates relationships between learning environment entities and external entities and shows that there are no direct links between learning and the use of ICT (Newhouse, 2002b).

2.7 VU Curriculum Reform

The Victoria University Strategic Plan for 2012–2016: Excellent, Engaged and Accessible has established a challenging educational mission for its diverse student population over the next five years. It was proposed to establish a number of reference groups to commence work on some of the cross-university projects to achieve the goals set by the VU Strategic Plan through the curriculum reform program. One of these reference groups is focusing on "Implementing transitions pedagogy for transitions hot spots", which includes foundation studies students, who are "more educationally, culturally, linguistically and economically diverse than is the case for other universities in Australia" (VU, 2012. page 5). Majority of these students are students who are the first in their family to participate in tertiary education, with low socio-economic background and require support to succeed. VU (2012) has admitted that "achievement of the University's goals for this diverse student population is a complex task" and requires "significant effort and resources" and "explicit pedagogy" (p.24).

2. 7.1 The VU Pre-Tertiary curriculum Framework

The Victoria University Pre-Tertiary Curriculum Framework (2012) highlighted the importance of a whole of course approach to the development of student knowledge and skills and proposed transitions pedagogy:

"Implementation of an innovative, institution-wide approach to blended learning will be central to learning and teaching development strategies at Victoria University into the future" (VU, 2012. page 10).

2.7.2 Blending with Purpose' within the VU Context

"Innovative blended teaching approaches are already evident at Victoria University amongst early adopters, and interest in current issues such as the introduction of a new e-learning environment (including the new Learning Management System (LMS)) and ways to use social media effectively in teaching is high" (VU, 2012. page 10).

2.8 Conclusion

This chapter has introduced the complex phenomena in education, related to a mathematics problem acknowledged internationally and nationally as a main focus of policy makers and educational institutions; and, investigated different approaches to solving this problem which is still prevalent today in tertiary environs including at Victoria University.

The impact of technology on student engagement has not been determined clearly even many years after the introduction of ICT into learning and teaching. Today there are optimistic and pessimistic views regarding the use of ICT in education. Although promising results on benefits of ICT use in education have been reported in the literature, ICT is not used in teaching in such way as it could be in accordance with the potential described in the research literature. The integration of ICT is still weak as technology evolves rapidly, and there are some difficulties in front of implementing affective learning management systems in real educational settings as well as student access to technology and perceptions of technology, teacher pedagogical and ICT skills and ICT support.

It is clear that the integration of ICT is a complex and multidimensional process which includes many educational dynamics such as teachers, students, school administration, ICT learning environment and school ICT capacity. Many researchers now feel strongly that LMS usage is expected to have a positive impact on student engagement and achievement, if student characteristics are taken into consideration when designing the program with the use of technology.

There is a growing body of research related to student characteristics and how they relate to student engagement and achievements in mathematics. Student engagement has been recognised as a major factor effecting student achievement. The complexity of inter-relationships between the dimensions of student engagement and student characteristics has compelled introducing and investigating other factors of student achievement such as their attitudes towards and perceptions of learning environment and also their confidence in mathematics and confidence in using technology for learning mathematics.

This chapter has attempted to provide insights into ICT-supported education and new pedagogical approaches to improve student engagement in learning of mathematics. Sections 2.2, 2.3 and 2.4 utilised research from secondary and tertiary sources with a focus on undergraduate mathematics students. It must be noted and taken into consideration than many of these students did not complete VCE studies or had they engaged in fundamental mathematics in undergraduate programs. Thus, this project specifically addresses the gap in the literature and highlights its relevance to the significant impact of secondary student readiness to engage in tertiary studies.

Analyses of the current stage of ICT-innovations in education which affect all elements of education, including policy makers, curriculum, teaching methods, students and learning environments has shown that the use of ICT in teaching and learning can help teachers to teach and learners to learn mathematics more effectively if ICT has been used and implemented in student-centred approach rather than teacher-centred approach. This new pedagogical approach has been identified as a focus of current stage of curriculum reform at Victoria University:

> *"Pre-Tertiary teaching will be underpinned by a range of pedagogical approaches which foster ... student centred and engaged learning and the integration of foundation skills development". It is stated that: "Innovative blended teaching approaches are already evident at Victoria University amongst early adopters, and interest in current issues such as the introduction of a new e-learning environment (including the new Learning Management System (LMS)) and ways to use social media effectively in teaching is high".* (VU, 2012, page 23).

> *"Implementation of an innovative, institution-wide approach to blended learning will be central to learning and teaching development strategies at Victoria University into the future ..." and "... possibilities that these developments might present for innovative learning opportunities could, and should, be explored further within the implementation of a VU Blended Learning Strategy".*

(The VU Agenda and blueprint for Curriculum reform, 2012).

The use of ICT in Victoria University has increased significantly for pedagogical purposes. Despite this growth, however, the quality, extent and impact on learning of ICT use in blended learning environment remains an under-researched area. There are many effective statistical methods through which the understanding of students' mathematics performance can be carried out, the majority of which have seldom been taken advantage of in Victoria University.

After establishing the significant characteristics to understand students' performance in learning mathematics, research-informed intervention practices that can be implemented to exploit these findings to the benefit of students involved. Following the literature review, the methodologies which are used in each phase of the research are outlined in the next chapter.

Chapter 3

Research Design and Methodology

This chapter provides a description of the methodologies employed by the researcher throughout the project. The research questions addressed in this study were as follows:

1. How are students' demographic factors, such as gender, age and cultural background, socio-economic status, related to their attitudes towards the use of technology in learning?
2. To what degree are access to technology and perception towards the use of technology for learning related to students' attitude towards the use of technology for learning of mathematics?
3. To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?
4. Is there a difference in engagement (affective, behavioural and cognitive) between students who are taught mathematics with the aid of technology or those who are taught in a traditional way?

These questions dictated the type of research methodologies which were most appropriate for this type of study. The controversy about student engagement in online learning environment and achievement has been reported by psychological studies. They have concluded that student engagement cannot be considered as a factor of student achievement, especially if ICT is used in the classroom (Roth and et al., 2011). A strong relationship between students' attitudes towards using technology for studying mathematics and their achievement has been reported in the literature (Furlong and Christenson, 2008; Black, 2007).

Shivetts (2011) concluded that student attitude towards using technology for learning is a major factor for e-learning and blended learning success. These studies attempted to identify factors affecting student attitude to use technology for studying mathematics.

Figure 2 presents the research conceptual framework to articulate the role of ICT in learning mathematics in blended learning environment using Moodle as supplementary resources to enhance student engagement in learning mathematics. The conceptual research framework was based on theory of education, a literature review and findings from previous studies that concluded that Moodle is e-learning software for designing of learning management systems that could help teachers to create interaction and collaboration with the course content. It is believed that, when Moodle is used, it helps blended learning where both Moodle and blended learning lead to student engagement and achievement.

3.1 Study Design

The research study was an experimental educational study, which aimed at attempting to manipulate independent variables and examining the effect this manipulation had on the dependant variables. Since it was possible to manipulate the independent variable, experimental research has enabled the researcher to identify the cause-effect between variables.

The study was descriptive, correlational and explanatory. It investigated and examined the experiences, perceptions and attitudes of students towards technology supported learning of mathematics, in an attempt to determine the impact that ICT has on the level of student engagement in the learning of mathematics in a preparatory University program and to develop a set of recommendations that will assist mathematics teachers in making informed decisions regarding the deployment of ICT in the teaching of mathematics. A structured interpretation of study Aims and Meta data evaluation is presented in Figure 5.

This research study employed a Quantitative framework that reflected the type of questions that the study was intended to answer, and hence, the framework has incorporated elements of descriptive, exploratory (correlational) and experimental research.

Descriptive methods were used to summarise information about student characteristics, experiences with technology, as well as student attitudes related to mathematics, technology, and technology-supported learning. Exploratory approaches were used to investigate relationships between various factors, such as student demographics, access to technology, attitudes, confidence and engagement. Finally, an experimental approach was used to investigate the effect of two teaching methods (traditional and technology-supported) on student engagement in mathematics. Explanation of statistical methods used to analyse the data is presented in Section 3.11.3 (p. 97).

The study has the following characteristics: (1), the independent variables were manipulated; (2) the participants were randomly assigned to groups; and (3) a control group was incorporated within the design in accordance to Mertens (1998).

The experiment was designed to investigate possible relationships between independent and dependent variables, attempting to control the relevant variables that influence the outcome.

The statistical procedures of analyses of covariance adjusted the impact on the dependent variables to account to the covariance and controlling for potential influence of the set of independent variables in each model.

Summary

Based on the conceptual framework (Figure 2) and explained at the beginning of this chapter the overall structure of the study design and methodology used is presented also in pictorial illustration of Four Phases of Study Design in Figure 5. The relationship between Aims of Study, Research Questions, Hypothesis and Outcomes is presented in Figure 4. A structural interpretation of this study aims and metadata evaluation is presented in Figure 6.

3.2 Ethical considerations

The study was designed as a pre-test - post-test control group design (randomised controlled trial). The researcher anticipated that students could or could not actually want to be in the assigned group. To deal with this situation, this study has analysed the data, using an intention to treat approach, in which data were analysed assuming each student participated in the group to which he or she was assigned.

The researcher carefully considered the issue of 'disadvantage' when designing the study. A pre-test - post-test design was most suitable for the needs and resources of this study. In addition, there was no disadvantage for the control group as the students were taught with the existing method of subject delivery.

The researcher was monitoring the process closely. Using Ethical practices the participants were debriefed by informing them of the purpose and reasons for the experiment (Neuman, 2000). This minimised the threats related to participants and their experiences. To ensure the fairness among students and that no student was disadvantaged in the experimental group of study, the following measures were applied:

1) The process of assigning students to classes was carried out using a table of random numbers. The students corresponding to the lowest 25 random numbers were assigned to group 1, while the remaining students were assigned to group 2.

2) ICT and TR (traditional) groups of students in Intake-1 and Intake-2 were following the same level of curriculum, taught with the same content provided with the same material and assessment tasks.

3) There is related research showing that using ICT is overall beneficial for learning and teaching (Attard, 2011; Pierce & Ball,2009; Samuelsson, 2010; Dix, 2007).

4) The control group was taught in the existing settings.

5) One student (from randomised controlled trial) has chosen not to participate in the study.

Another student did not want to be in the assigned group and has changed TR-group to ICT-group. Intention to treat approach has been applied to deal with those situations.

To minimise the effect of extraneous factors, the same teacher taught both groups of students throughout the duration of the mathematics unit. Two first intakes of participating students learnt the same curriculum. The third intake of students learnt different topics of study.

Online learning provided students immediate feedback regarding activities engaged in. Teachers monitoring students' online learning in real time were able to use an analysis of their needs for grouping students in need based homogeneous learning groups enabling individualisation of instruction. Because the objective assessment and subsequent grouping of students with needed readiness levels prior to engaging new learning activities may have influenced student achievement outcomes in mathematics. Some activities may not have revealed a student's learning need and this could possibly influenced student achievement of outcomes in mathematics. This could have resulted in different outcomes.

Points 1-5 issues were considered by following Ethics Committee and VU Research Project Design Guidelines.

All the students were provided written information explaining the study purpose in a covering letter, instructions regarding the questionnaire and participants rights. Informed consent was given by all participants who willingly participated in the study (Appendix 4). The students filled the questionnaire (Appendix 3). Anonymity of the participants and confidentiality of the data was maintained (Appendix 14). To obtain the student permission to access student record from VU database the students filled the Consent Form (Appendix 5).

3.3 Research questions

Using descriptive statistics, correlational analysis and multiple regression analysis and analysis of (co)variance this study intended to answer the following questions:

1. Are students' demographic factors, such as gender, age, cultural background, socio-economic status, related to their attitudes towards the use of technology in learning?
2. To what degree is access to technology and perceptions related to students' attitude towards the use of technology for learning mathematics?
3. To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?
4. Is there a difference in engagement (affective, behavioural and cognitive) between students who are taught mathematics with the aid of technology and those who are taught in a traditional way?

To answer the first research question (RQ 1) the relationship between students' demographic factors (gender, LOTE, SES, age) and their attitude towards use of technology for learning mathematics was investigated.

To answer the second research question (RQ 2) the relationship between students access to technology outside university, perceptions towards the use of technology and their attitudes towards the use of technology for learning mathematics was investigated.

To answer the third research question (RQ 3) the relationship between students mathematics confidence, confidence with technology and how do they relate to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics was investigated.

To answer the fourth research question (RQ 4) the difference in student engagement (affective, behavioural and cognitive) between students who are taught mathematics with the aid of technology and those who are taught in a traditional way was investigated.

A structural interpretation of methodological considerations of data analysis is demonstrated in Figure 4.

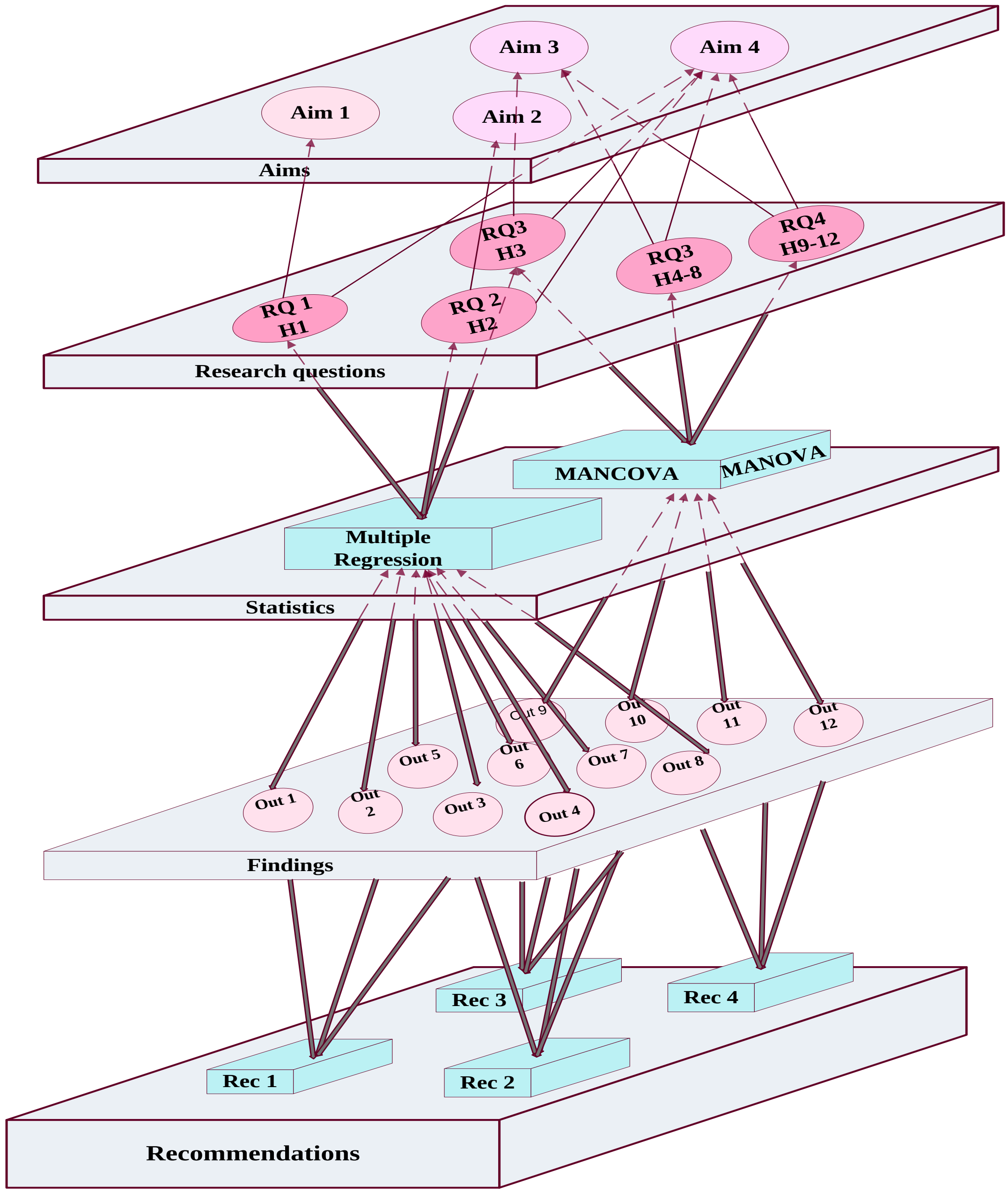


Figure 4 Methodological considerations of Data Analysis

Aim: Aims of the study; RQ: Research Questions; H: Hypothesis; Out: Findings; Rec: Recommendations.

Figure 4 illustrates an explanation of the complexity and levels of data analysis, providing 3-D visual representation of methodological consideration of statistical approach applied and based on the relationship between Aims of the Study, the Research Questions and the Statistical Methodology.

The first layer (Aims) includes Aim 1, Aim 2, Aim 3, and Aim 4. They are described in paragraph 3.11. The second layer (Research Questions) represents RQ 1, RQ 2, RQ 3, RQ 4, which are described in paragraph 3.3 and corresponding Hypothesis: H1-H12, formulated in paragraph 3.4. The third layer of the figure (Statistics) represents Statistical methods used (Multiple Regression and MANCOVA) to check twelve hypotheses and to answer the four research questions. Overall, the Aims, the Research Questions and the Statistical Methods applied and their outcomes are explained in paragraph 3.4. In summary:

Aim 1 and Aim 2 were guided by the research questions RQ-1, RQ-2 and RQ-3 and have been addressed using Multiple Regression Analysis. Aim 2 and Aim 3 were guided by research questions RQ-3 and RQ-4 and have been addressed using Multiple Analysis of co-Variance (MANCOVA). Aim 4 was addressed in accordance with the outcomes of research questions RQ-1, RQ-2, RQ-3, RQ-4, literature review and analysis of VU blueprint curriculum reform.

The fours layer of this figure (Findings) represents the findings of this study (Out 1- Out 12).

Finally, the fifth layer of this figure (Recommendations) represents recommendations developed (Chapter 5). A structural and more detailed roadmap of this study is also presented in Figure 6.

3.4 Methodological considerations for study design

This research aims to study student perceptions of and experiences with learning mathematics to help determine factors influencing their engagement in learning mathematics. The research project is also expected to explore how students' demographic factors, such as gender, age and cultural background, related to their attitudes towards the use of technology in learning mathematics, and to what extent are mathematics confidence and confidence with technology related to students' attitudes towards learning mathematics with technology, engagement and achievement in mathematics.

The complexity of articulating the relationship between the aforementioned educational elements prompted organization of the study in four sequential phases using quantitative analyses to determine the role of ICT in student engagement in learning mathematics.

Phase I consisted of four parts including student demographic characteristics and three hypotheses of first three research questions: (1) How are student demographic factors, such as gender, age and cultural background and socio-economic status related to their attitudes towards the use of technology in learning? (2) To what degree are access to technology and perception towards the use of technology for learning related to students' attitude towards the use of technology for learning mathematics? (3) To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics? These three research questions and tree hypothesis have been addressed using Descriptive Statistics and Multiple Regression Analysis.

In Phase II the effect of ICT on student engagement in learning mathematics was investigated, including also research question three mentioned above and four other hypotheses, using Multiple Analyses of Co-Variance MANCOVA.

In Phase III was an attempt to determine the role of ICT in student affective, behavioral, cognitive engagement and achievement, including research question four and four hypothesis, using Multiple Analyses Variance MANOVA.

In Phase IV a set of recommendations for mathematics teachers of foundation study and for curriculum reform at Victoria university have been developed based on the outcomes of all four research questions, literature review and researcher experience.

Methodological considerations for study design are illustrated in Figure 4. Four research questions and twelve hypotheses are detailed below.

Phase 1 Exploration of Student Experiences and Attitudes

Why Multiple Regression?

To answer the first three research questions Multiple Regression analysis has been used as a family of techniques that can explore the relationship between one continuous dependent variable and a number of independent variables (predictors, usually continuous).

The choice of Multiple Regression was based on an extensive literature review regarding the relationship between student attitude towards the use of technology for learning mathematics and factors affecting student attitudes and student demographic characteristics (gender, age, socio-economic status, English speaking background) and access to computers outside university and their perceptions towards using computers for learning including their confidence with technologies and confidence in mathematics. The relationship between all these variables was investigated.

The literature review provided theoretical and conceptual reasons for the analysis of this combination of variables. The results of Multiple Regression analysis provided the information about the model as a whole (all sub scales) and the relative contribution of each of the variables that make up the model (individual scales).

There is a large body of research regarding computer supported education, perceptions of computer self-efficacy, computer anxiety and the technological attitudes towards the use of technologies for learning mathematics. However, studies conducted on the correlation between and effect of computer supported education, student perceptions and their access to technology and which additionally explains their relationships are scarce. This study was conducted in order to test the effect levels among the latent variables of attitude towards use of technology, student access to technology and their perceptions towards the use of technology for learning mathematics. Three hypotheses were developed in light of theoretical information by review the literature.

Recognising the effectiveness of computer supported education is possible when student and teacher have a positive attitude, this study has utilised MTAS and two scales for measuring student access to technology and their perceptions towards the use of technology for learning mathematics.

Research questions RQ 1, RQ 2, RQ 3 and Hypotheses

RQ 1 H-1 Students' attitude towards the use of ICT in learning mathematics depends on their gender, age, socio-economic status and their English speaking background.

RQ 2 H-2 Students attitudes towards the use of ICT in learning mathematics depend on their access to technology and perceptions towards the use of technology.

RQ 3 H-3 Student attitudes towards the use of ICT in learning mathematics depend on their mathematics confidence and confidence with technology.

Phase 2 Investigation of Effect of ICT on learning experiences

Research questions RQ 3 and Hypotheses

RQ 3 H-4 Students engagement in learning mathematics depends on their mathematics confidence and confidence with technology.

RQ 3 H-5 Students cognitive engagement in learning mathematics depends on their mathematics confidence and confidence with technology.

RQ 3 H-6 Students affective engagement in learning mathematics depends on their mathematics confidence and confidence with technology

RQ 3 H-7 Students behavioural engagement in learning mathematics depends on their mathematics confidence and confidence with technology.

RQ 3 H-8 Students achievements in mathematics depends on their mathematics confidence and confidence with technology

Phase 3 Determination of the Role of ICT in student engagement

Research questions RQ 4 and Hypotheses

RQ 4 H-9 Students cognitive engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students cognitive engagement in learning mathematics who are taught in a traditional way.

RQ 4 H-10 Students affective engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students affective engagement in learning mathematics who are taught in a traditional way

RQ 4 H-11 Students behavioural engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students behavioural engagement in learning mathematics who are taught in a traditional way.

RQ 4 H-12 Student achievement in learning mathematics, who are taught mathematics with the aid of technology are different to student achievement in learning mathematics who are taught in a traditional way.

Phase 4 Developing Recommendations

Following the collection and analyses of data, set of recommendations for improving student engagement in learning mathematics have been developed. Pictorial Illustration of the Four-Phase Study Design is illustrated in Figure 5.

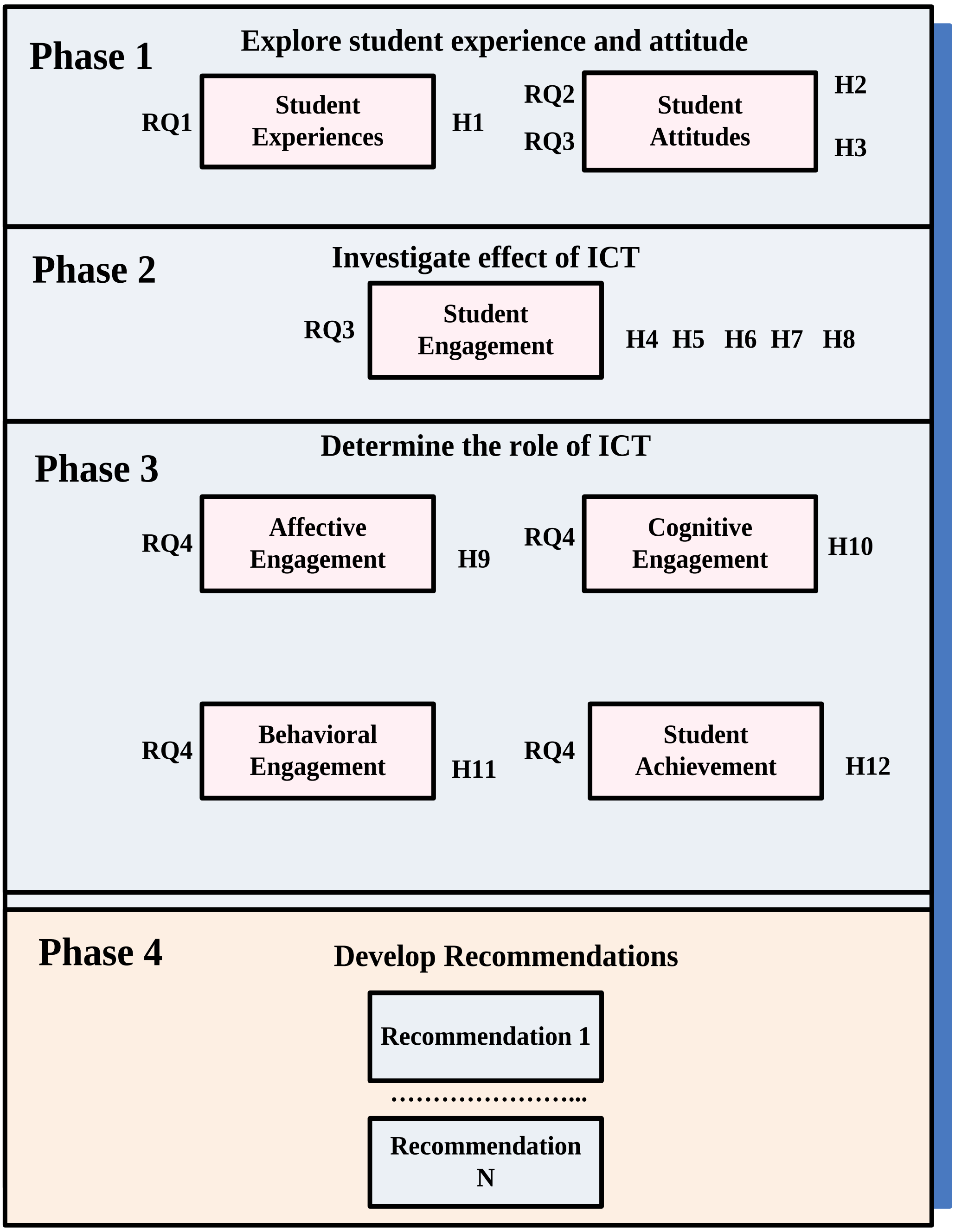


Figure 5 Pictorial Illustration of the Four-Phase Study Design

Figure 5 identifies the practical stages involved in the organisation of the study and theoretically grouped them into four Phases. These Phases are described above in detail in this section.

3.5 Participants

Participants in this study were 87 students enrolled in the Foundation Studies course at Victoria University. Three intakes of students, enrolled in mathematics units JCM0110 and JCM0113 in Semester 1 and Semester 2, participated in the study for different durations of time. Students were admitted into the Foundation Studies course without an entrance exam. Information about Mathematics study programs is presented in Table 3 below.

Table 3 Information about Mathematics study programs

Intake	Mathematics Unit	Teacher	Duration of participation	Period of participation
1	JCM0110	Teacher 1	12 weeks in Semester 1	18 April 2012 - 11 July 2012
2	JCM0110	Teacher 2	4 weeks in Semester 1	02 July 2012 - 27 July 2012
3	JCM0113	Teacher 1	4 weeks in Semester 3	13 Aug 2012 - 10 Sept 2012

For each intake, students were randomly allocated into two groups, where two teaching methods were used to teach mathematics concepts. Units of study for every intake of students are presented in corresponding appendices Appendix 6, Appendix 7 and Appendix 8. These concepts were considered in the subject as pre-requisites for entering Victoria University's science and engineering degree courses. The two teaching methods were:

(1) ICT method (blended) - combination of on-line LMS created in Moodle and face-to-face instruction

(2) TR (traditional) method - face-to-face instruction.

Students in the ICT group were enrolled into the web-based course, designed and published by the researcher using LMS Moodle

These students were provided “any time“ and “anywhere” access to the course resources. Students in the TR group were taught with traditional lecture based approach.

The topics included: Arithmetic, Fractions, Percentages and Ratios, Algebra, Exponentials and Logarithms and Linear Equations, Statistics and Probability Distribution (Appendix 6 & Appendix 7).

3.5.1 Flow of participants throughout the study

The environment has been redesigned many times to accommodate the dynamics of new students. The teacher was overwhelmed with constant moving in and out of the room, of the course and of the unit of study students.
Flow of participants throughout the study is shown in Table 4.

3.6 Survey Instrument

The data collection process was carried out using a combination of three different instruments that was adapted form previously validated survey tools: (1) based on the mathematics and technology attitudes scale (MTAS) developed by Pierce, Stacey and Barkatsas (2007); (2) based on Student Engagement in learning Mathematics scale, developed by Kong, Wong and Lam (2003) and (3) Perceptions of the use of technology for learning, developed by (Gasaymeh, 2009; Mishra & Panda, 2007).

The resulting instrument consisted of 91 questions related to the following areas: student access to technology, confidence with technology, attitude towards technology, mathematics confidence, attitudes towards learning mathematics with technology, and student engagement in learning mathematics (cognitive, affective and behaviour).

The survey was used for obtaining information from all groups of students at the beginning of the semester (pre-intervention) and at the end of the semester (post-intervention); the same survey instrument was used for all groups of students, and for both pre- and post-intervention data collection. Information about the research study (Appendix 4) was distributed to participating students by their teacher before the first data collection; it was also attached to the survey instrument. Student permission to obtain their data was obtained using Consent Form to Access Student Record (Appendix 5).

The survey was administered by the researcher and teacher during a tutorial; it took about 15-20 minutes to complete. Before the survey was handed out to students, they were informed again that participation is voluntary.

While the students were required to provide their student IDs (to support the pre- and post-intervention research design), the students were assured that they will not be identified in any way following the collection of data. Students have returned completed surveys to a special collection box in the tutorial room. Every student who has completed the survey was given a token of appreciation: a VU USB drive.

3.7 Data collection and preparation for analysis

Data has been collected using a survey to obtain information from all groups of students at the beginning of the semester (pre-intervention) and at the end of the semester (post-intervention); the same survey instrument was used for all groups of students, and for both pre- and post-intervention data collection (Appendix 3). Data collection process and preparation for analysis are presented in Figure 10.

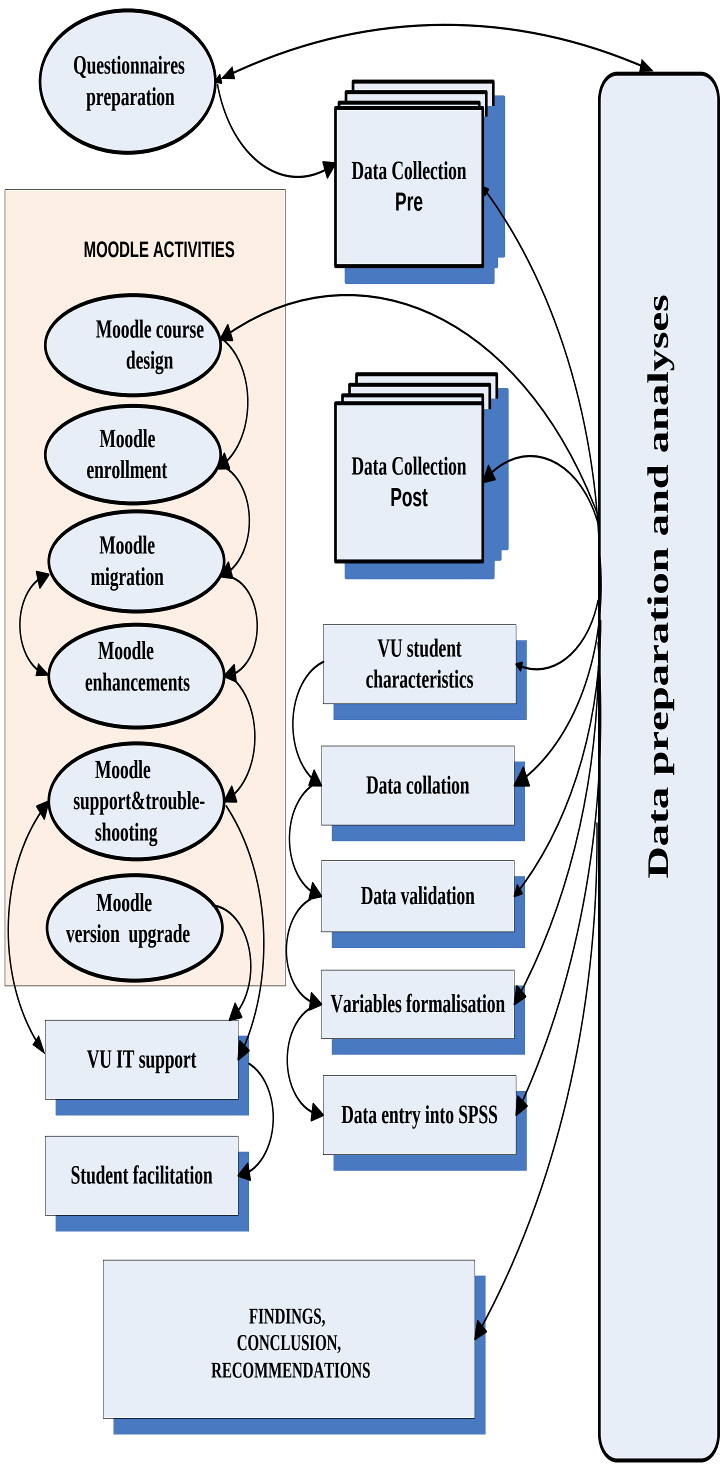


Figure 10 Data collection process and preparation for analysis

Figure 10 represents the major processes involved in the conduction of the study. It includes: questionnaires preparation; first data collection; course design and implementation for the participants, using LMS Moodle; communication with VU IT support and teachers involved; second data collection; data preparation for statistical analysis (validation, formalisation, coding, transcribing, cleaning, variables transformation, statistical adjustments and analysis strategy selection); training and consulting the participants. This figure also shows some unpredicted activities, included Moodle support, Moodle migration and enhancements, Moodle troubleshooting, student enrolment. Arrows and links show flow and relationships between those processes.

3.8 Measures

In order to compare technology-enhanced instruction with traditional instruction in student engagement and student attitude towards technology, a variety of measures were used.

3.8.1 Access to technology

Items 1-11 of the survey instrument asked students to indicate their level of access to different types of technologies. The access was measured on a 3-point Likert scale (1=no access, 2=limited access, and 3=full access).

3.8.2 Perceptions of the use of technology for learning

Items 12-19 of the survey measured students' perceptions of learning with Information and Communication Technology ; for each item a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree) was used (Gasaymeh, 2009; Mishra & Panda, 2007).

Mathematics and Technology Attitude

A scale for monitoring students attitudes to learning mathematics with technology, developed by Pierce, Stacey & Barkatsas (2007), consists of five subscales: (1) mathematics confidence, (2) confidence with technology, (3) attitude to learning mathematics with technology, (4) affective engagement and (5) behavioural engagement.

Three subscales have been used to measure affective variables: Confidence with technology, Mathematics confidence and Attitudes towards use of technology for learning mathematics.

3.8.3 Confidence with technology

Items 20-24 measured students' confidence with technology; for each item a 5-point Likert scale was used. The items came from a validated instrument (Pierce, Stacey, & Barkatsas 2007).

3.8.4 Mathematics confidence

Items 25-29 measured students' mathematics confidence[1]; for each item a 5-point Likert scale was used (Pierce, Stacey, & Barkatsas 2007).

3.8.5 Attitudes towards use of technology for learning mathematics[1]

Items 30-34 measured students' attitudes towards use of technology for learning mathematics; for each item a 5-point Likert scale was used (Pierce, Stacey, & Barkatsas 2007). Permission was obtained from scale owners for using scales in line with the research objective (Appendix 13).

3.8.6 Student engagement

Student engagement was measured by items 35-90 of the survey; these items were adopted from a validated instrument developed by Kong (2003). The measured dimensions of engagement together with their subscales include:

[1] A license to use the instrument for monitoring students' confidence with, and attitudes to, learning mathematics with technology has been obtained free of charge from RightsLink through the publisher Elsevier (Appendix 9).

3.8.7 Dimensions of student engagement

3.8.7.1 Cognitive (surface strategy, deep strategy and reliance)

Three dimensions of cognitive engagement, namely self-regulated learning, deep learning and reliance on teacher, were measured by items 35-55 on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).

3.8.7.2 Affective (interest, achievement, anxiety, and frustration)

Four dimensions of affective engagement, namely interest, achievement, anxiety, and frustration were measured by items 56-76 were measured on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).

3.8.7.3 Behavioural (attentiveness, diligence, and time spent)

Three dimensions of behavioural engagement, namely attentiveness, diligence and time spent on homework and after-class learning, were measured by items 77-91 on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).

Items 35-88 were measured on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree); and, items 89 and 90, concerned with time spent on mathematics, were measured on an interval scale. The corresponding items for every subscale of the measured three dimensions of engagement are presented in Figure 11 and Figure 12 below.

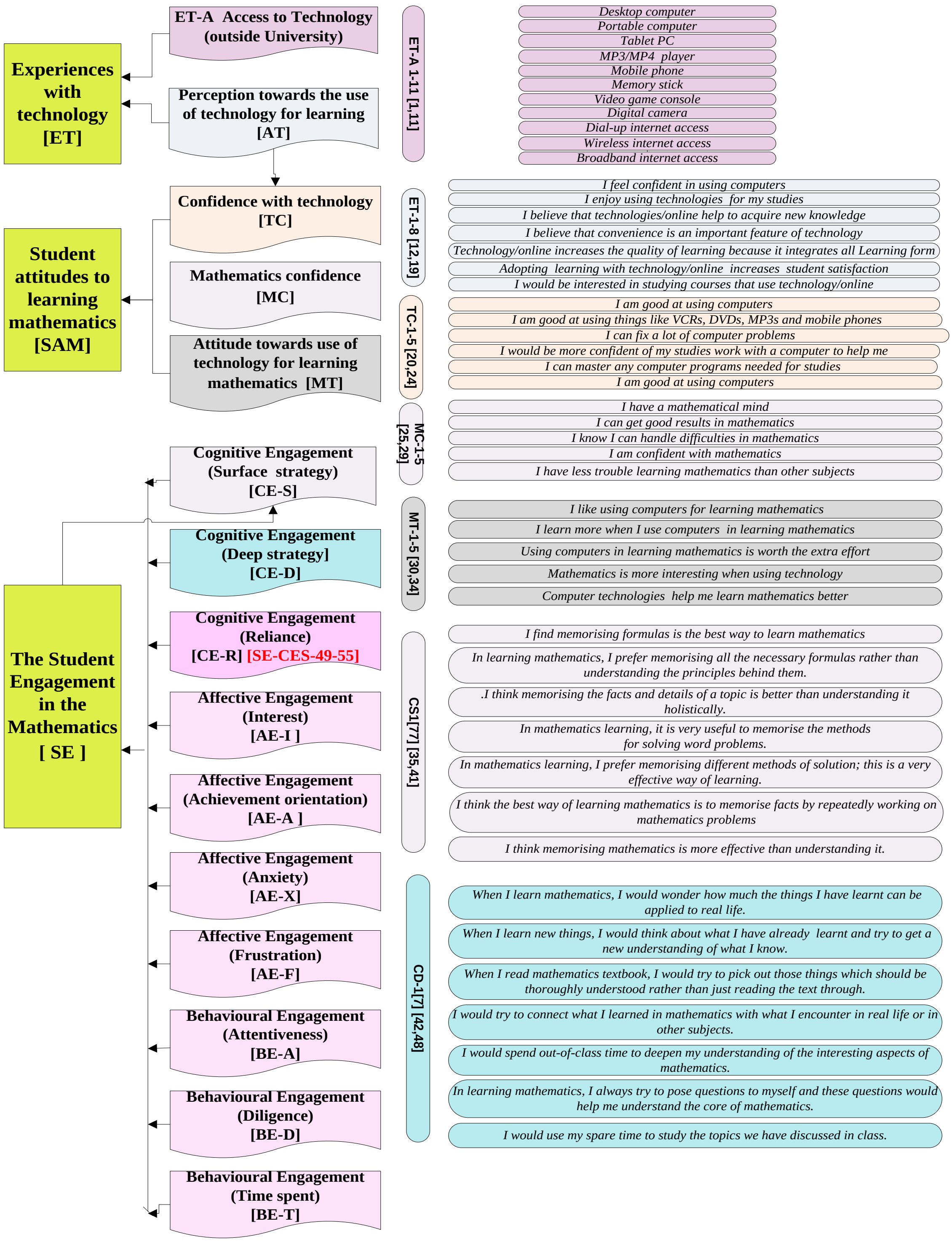


Figure 11 Data Formalisation (Part 1). For more details refer to Appendix 24.

Continue Figure 11 Data Formalisation (Part 2).

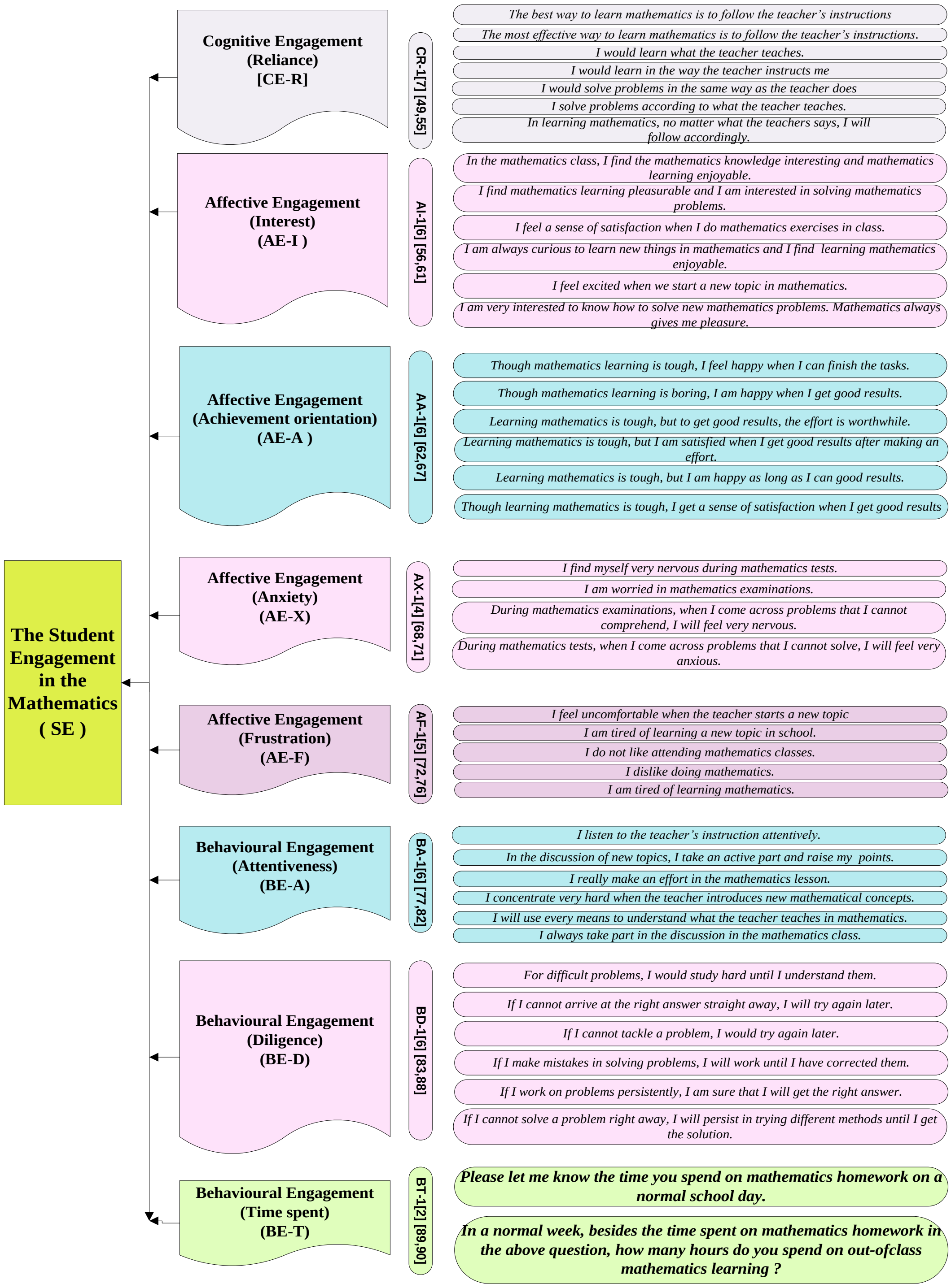


Figure 12 Data Formalisation (Part 2).

For more details refer to Appendix 25 and Appendix 26.

3.8.8 Validity and Reliability of the Survey Instrument

The survey instrument has been adopted from four different tools:

(1) “Students Access to technology” (general questions about currently used technology)

(2) “Students perceptions towards the use of technology for learning Mathematics” (Gasaymeh, 2009).

(3) “Students attitudes to learning mathematics” (Pierce, Stacey, & Barkatsas, 2006).

(4) “Student Engagement in Mathematics” (Kong, 2003).

3.8.8.1 Scale 1: Access to technology

The survey instrument (1) “Students Access to technology” are general questions about currently used technology outside the university. It consisted of eleven names of different technology. Participants were requested to use a rating scale (from “1” ‘No Access to “3” ‘Full Access) to indicate the degree to which they have access to these technologies.

3.8.8.2 Scale 2: Perceptions towards the use of technology for learning

The scale of ‘Perceptions towards the use of technology for learning mathematics’ was adapted from a study conducted to measure student perceptions towards the use of technology for learning (Gasaymeh, 2009). It consisted of eight positive statements to determine students’ perceptions towards the use of technology for learning. Participants were requested to use 5-point Likert scale (from “1” ‘strongly disagree’ to “5” ‘strongly agree’) to indicate the degree to which they feel towards technology-based learning mathematics.

3.8.8.3 Scale 3: Attitudes to learning mathematics with technology

The survey instrument (3) “Students attitudes to learning mathematics” has been adjusted from a validated tool, developed by Pierce et al. (2006). Three subscales have been used and one has been adjusted in accordance with the developers' agreement (Pierce, Stacey, & Barkatsas, 2006). This survey tool has been used to measure the three constructs:

- Student confidence with technology ([TC]);
- Student mathematics confidence ([MC]);
- Student attitudes towards learning mathematics with technology ([MT]).

This scale was designed for monitoring students' attitudes to learning mathematics with technology. The subscales measure mathematics confidence, confidence with technology, attitude to learning mathematics with technology and two aspects of engagement in learning mathematics.

To measure the third construct two items have been changed. The original items MT-3, MT-4, MT-5 consisted of questions about using graphics calculators for our survey with the words "computer technology" instead of "Graphic calculators" used.

The scale consisted of fifteen positive statements to determine students' confidence with technology, mathematics confidence and Attitude towards use of technology for learning mathematics. Participants were requested to use 5-point Likert scale (from "1" 'strongly disagree' to "5" 'strongly agree') to indicate the degree to which they are confident with technology, confident with mathematics, and to measure their attitude towards use of technology for learning mathematics.

3.8.8.4 Scale 4: Student engagement in learning mathematics

The survey instrument (4) "Student Engagement in Mathematics" has been used without changes from a validated tool to measure student engagement in learning mathematics with technology, developed and validated by Kong (2003). It consists of fifty seven positive statements to determine the level of students' engagement in learning mathematics. Participants were requested to use 5-point Likert scale to indicate the degree to which they are engaged in learning mathematics. Twenty one questions were used to identify cognitive engagement. Twenty one questions were used to determine affective engagement and fifteen questions were used to determine behaviour engagement. Participants were requested to use 5-point Likert scale to indicate their level of cognitive, affective and behaviour engagement.

3.8.8.5 The resulting instrument

The resulting instrument consists of 91 questions related to the areas of variables, described in section 3.6.

3.8.8.6 Other measure

Number of Moodle logins

The use of ICT as a factor affecting the performance of students was measured by number of Moodle logins by every student. It was obtained from automatic record, generated by Moodle, for every student enrolled in the course.

3.8.8.7 Mathematics achievement

Students' prior-knowledge of mathematics was obtained from the course coordinator. All students performed very poorly on initial diagnostic test. Initial level of mathematics of all students was very low. According to the teacher, "most of the students could not add, subtract, multiply or divide without the aid of a calculator or computer".

Information about examination results at the end of the semester was obtained from student academic records. The permission to access their academic record was obtained from students before the study (Appendix 5).

3.9 Variables

To answer the four research questions described in section 3.3 different statistical methods were used, including descriptive statistics, correlation analysis, multiple regression analysis and analysis of (co)variances.

One *independent variable* in this study was the teaching method, with two levels: (1) technology-supported instruction (experimental group), and (2) traditional instruction (control group). The three *dependent variables* in the study, cognitive engagement, affective engagement and behavioural engagement, were measured at the beginning of the semester (baseline) and at the end of the semester (outcome).

Researcher controlled for the following ***covariates***: baseline measurement of student engagement; students' knowledge of mathematics, estimated via a course test after study; baseline mathematics confidence; baseline confidence with technology; baseline attitudes towards use of technology for learning mathematics; age, gender, socio-economic status and cultural background. Independent variables (predictors) in this study were demographic variables and descriptive measures.

Moodle usage

Moodle usage data collected from the logs of the user's actions, the student's worksheets and their assignments submitted were coded in a table of categorical and numeric variables. For the "Moodle usage" variable, the information related to the users entrance to the Moodle (date and time of entry), was recorded. From the log files, a series of numeric variables depicting the systems usage in general and the frequency of accessing each service in specific were recorded. The variable "Moodle usage" was transformed using two dummy variables (low use and moderate use) (Howwit & Cramer, 2010). The reason for creating Boolean variables was to simplify the analysis.

Thus, the independent variable was Moodle usage (low use and moderate use). The dependent variable analysed was the student's final marks. The relation between Moodle usage in students' performance was estimated by the method of ordinary least squares using multiple regression analysis.

Research and statistical variables are described in Appendix 30, Appendix 24, Appendix 25, Appendix 26 and Figure 11, Figure 12. These sections map the research parameters to statistical variables and how the scales were created.

3.10 Procedure

In order to conduct this study and collect data from the highly dynamic environment the researcher was involved in the following steps of study preparation: (1) Data collection about student characteristics, (2) Moodle course design, (3) Student enrolment, (4) Moodle support and trouble shooting, (5) Moodle migration, (6) Moodle enhancement, (7) Computer room set-up, booking and organisation, (8) Communications with VU IT services to install an additional software, (9) Communication with course coordinator, (10) Facilitation students VU enrolment, (11) Survey administration.

3.10.1 Implementation challenges

A challenging aspect of this study was that it took place within a school with significant attendance issues as well problems in engaging these students in mathematics and in out of school work. A positive aspect was that we were working with a population of students that does not normally participate in trials of new technology and new pedagogy.

It has offered a significant problems for the research (e.g. decreased sample size, amount of time not considered for this study, data collected required more complicated statistical analysis, the researcher financially supported by herself) and for the pedagogy (e.g. students did not attend training, required by this study, created obstacles for teachers to attend training which was also prerequisite for using new learning and teaching environment before commencing the study, students were also missing important lessons, forgetting equipment at home and were not able to access their VU e-mail box for different reasons). Furthermore, it was not possible to work with an equivalent class of students who were following the same curriculum. This limited any comparative claims we can make from this study. It offered, however, a rich environment to identify further directions for study this challenging topic.

3.10.2 Moodle course design

The Moodle website of this mathematics course (“SigmaNet”) was designed, developed, implemented and maintained by the researcher, a mathematics teacher with extensive software designing experience and instructional design using open source LMS Moodle (Figure7). Moodle was deployed on remote server, which was also maintained and supported by the researcher during the period of study.

This website has been designed in accordance with the requirements of Instructional Design based on the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) and was based on:

- An extensive researcher experience in the use of LMS Moodle in creating learning management systems (learning environment) in accordance with the recent pedagogical and technological developments, related to constructivist and constructionism learning and teaching philosophy;

- Wide literature review of recent studies, national and international conferences, workshops and training courses (including Moodle Creator and Moodle Administration) focusing on the pedagogical use of ICT in learning and teaching of mathematics.

"SigmaNet" has provided the environment for interactive learning activities, self-assessment modules, opportunity to leave instant feedback, tutoring which is focused on student progress, early diagnosis of student requirements for basic skills, provision of appropriate support and monitoring and follow up of poor attendance. The target setting has been allied with formative assessment and instant feedback.

The components of the Moodle website included course description, course outline, mathematics contents and topics, worksheets, assignment, and chat room. Mathematics activities were designed and embedded in this website. Students were required to use this online resource to submit drafts of their work, communicate with the teacher and with their classmates and to access course materials. "SigmaNet" has been used by the VU mathematics teacher in a preparatory VU program as online learning environment together with the help of the traditional face-to-face teaching approach.

The environment involved 5 teaching elements:

- VU mathematics teacher, who taught the students the mathematics Units in accordance with the curriculum requirements;
- Teacher-designer who assisted during the classes and observed the students learning and how did they use the environment;
- On-line LMS designed in Moodle;
- Learning objects (Web 2.0 tools);
- IT service technician.

In accordance with the curriculum of Foundation Study course JCM00110 (Appendix 6) innovative teaching and learning resources have been incorporated into SigmaNet website. Students were provided with opportunities to construct their mathematics knowledge through Moodle in virtual classes (or an on-line learning environment) by communicating and receiving help from teacher and peers. The students could explore their mathematics activities with a wide variety of java applets, mathematical objects, interacting by dragging and animating as much as they wanted. Through Moodle, the shy students who never asked questions in class could ask and received feedback from lecturer and their friends. The students could reflect their thinking by online chats, entering answers, informal talk and discussions with their friends, developing a positive attitude toward learning mathematics with technology. Students were required to access the Internet in order to develop skills in critically researching and evaluating material on the World Wide Web. Group interaction was also provided to analyse and evaluate students' printed material. A critical and independent approach to learning was supposed to be encouraged by the teacher.

For example, the designer (the researcher) incorporated a 'smart test' which is a specific mathematics assessment that reveals thinking (Stacey, Price, Gvozdenko and Steinle, 2013). This test could be accessed through an intelligent on-line environment, which provides teachers with an informative diagnosis of their students' conceptual understanding of most of the topics in foundation mathematics and strongly aligned with the Unit plan of the JCM0110 (Appendix 6). A permission to use this innovative assessment has been obtained from University of Melbourne free of charge (Appendix 28).

The complexities of maintaining of a learning environment to provide students with differentiated instructions to cover different students' needs, abilities and learning styles are illustrated in appendix (Appendix 27).

3.10.3 Student enrolment

To be able to use "SigmaNet" the students have to be enrolled in their course following the instructions, described in Appendix 16. They were supposed to have an official VU e-mail address and communicated with their teacher using their Moodle account and VU e-mail box.

3.10.4 Data collection

Primary data from the university student records and from survey instruments have been collected. Personal data (obtained from student records) included information regarding student demographic characteristics, such as age, gender, socio-economic status (SES)[2], cultural background (LOTE identifier). In addition, information regarding student mathematics achievement at the beginning and the end of semester has been obtained from students' records.

Information about the research study (Appendix 4) was distributed to participating students and discussed in class by their teacher before the first data collection. A consent form to access student record (Appendix 5) was handed out, detailing the purposes and processes of the surveys and that participation were entirely voluntary, but in fact all students elected to be involved. There was a time for discussion in class. In the consent form, students were told that their student records will be accessed by the researcher for the explicit purpose of gathering socio-demographic data. The consent form has outlined how their data remains confidential, by reference to relevant clauses in the Privacy Legislation. While the students were required to provide their student IDs on the completed questionnaires (to support the

[2] *The socio-economic status (SES) distribution of the sample was determined using the Australian Bureau of Statistics Socio-Economic Indexes for Areas (2006) data cubes. The SES standing of students' home suburbs relative to those of Victoria as a whole was rated using the index of relative socio-economic advantage and disadvantage. Suburbs which fell into deciles 1-5 of the index were designated low SES areas, while suburbs in deciles 6-10 were considered high SES areas.

pre- and post- intervention research design), the students were assured that they will not be identified in any way following the collection of data. Consent forms gathered before the study. The teacher collected data from students through survey instruments. The survey instrument (Appendix 3) was handed out before and after study. Personal data (self-reported by students) were used to assess attitudinal, behavioural, cognitive, and affective aspects of student engagement in learning mathematics.

3.10.5 Data preparation for analysis

Data has been collected from all groups of students at the beginning of the semester (pre-intervention) and at the end of the semester (post-intervention); the same survey instrument was used for all groups of students, and for both pre- and post-intervention data collection. After a formal data collection process, data has been validated, formalised and analysed using a different statistical methods, described in Section 3.11.3 with the use of IBM SPSS v 20. This is illustrated in Figure 10. Data formalisation has been briefly described in Section 3.9 and shown in details in Appendix 24, Appendix 25, Appendix 26, Appendix 30 and Figure 11, Figure 12.

3.11 Research Propositions

The aim of this study was to investigate the complex interrelationship between students' demographic factors, mathematics confidence, access to technology outside university, confidence with technology, perception towards the use of technology for learning and attitude towards learning mathematics with technology, cognitive, affective and behavioural engagement; and student achievement.

3.11.1 Study Aims, Research Questions and Statistics Methods used

The First and Second Aims of study were guided by research questions RQ-1 & RQ-2, RQ-3. Multiple regression analysis has been used to address these research questions. The Second and Third Aims of study were guided by research questions RQ-3 & RQ-4. MANCOVA has been used to address these research questions. The fours aim of study Aim 4 was guided by research questions RQ-4. MANOVA has been used to address this research question. To answer the four research questions the data has been analysed in three stages, demonstrated by structural interpretation of study Aims and meta data evaluation (Figure 6).

STAGE 1 Multiple Regression Analysis

To answer RQ-1 (H-1), RQ-2 (H-2) & RQ-3 (H-3) Multiple Regression has been used to find the relationship between student attitude and eight predictors.

[MT] = F ([Gender], [Age], [SES], [LOTE], [ET], [AT] ([MC], [TC])

STAGE 2 MANCOVA

To answer RQ-3 (H-4), RQ-3 (H-5), RQ-3 (H-6), RQ-3 (H-7), RQ-3 (H-8), MANCOVA has been used to find to what extent are mathematics confidence and confidence with technology related to students' attitudes towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics.

STAGE 3 MANOVA

To answer RQ-4 (H-9), RQ-4 (H-10), RQ-4 (H-11), RQ-4 (H-12), MANOVA has been used to identify if there a difference in student engagement (affective, behavioural and cognitive); specifically between students (Intake 1 and Intake 3) who were taught mathematics with the aid of technology and those who were taught in a traditional way.

Three stages of data analysis have been illustrated by three Figures: Figure 13, Figure 14, Figure 15.

3.11.2 Research Questions and Hypothesis

STAGE 1

RQ-1. *How are students' demographic factors, such as gender, age, SES and cultural background LOTE related to their attitudes towards the use of technology in learning mathematics?*

RQ-1, H-1 *MT = F ([Gender], [Age], [SES], [LOTE])*

Students' attitudes towards the use of ICT in learning mathematics are depending on their gender, age, socio-economic status and their English background.

RQ-2. *To what degree are access to technology [ET] and perceptions towards the use of technology [AT] related to students' attitudes towards the use of technology for learning mathematics [MT]?*

RQ-2, H-2 MT = F ([ET], [AT])

Student's attitudes towards the use of ICT in learning mathematics depend on their access to technology and perceptions towards the use of technology [AT].

RQ-3: To what extent are mathematics confidence and confidence with technology related to students' attitudes towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?

RQ-3, H-3 MT = F ([MC], [TC])

Student attitudes towards the use of ICT in learning mathematics depend on their mathematics confidence and confidence with technology.

STAGE 2

RQ-3: To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?

RQ-3, H-4 SE = F([MC], [TC])

Students engagement in learning mathematics depends on their mathematics confidence and confidence with technology.

RQ-3, H-5 CE = F([MC], [TC])

Students' cognitive engagement in learning mathematics depends on their mathematics confidence and confidence with technology.

RQ-3, H-6 AE = F([MC], [TC])

Students' affective engagement in learning mathematics depends on their mathematics confidence and confidence with technology.

RQ-3, H-7 BE = F ([MC], [TC])

Students' behavioural engagement in learning mathematics depends on their mathematics confidence and confidence with technology.

RQ-3, H-8 Final Mark = F([MC], [TC])

Student's achievements in mathematics depend on their mathematics confidence and confidence with technology.

STAGE 3

RQ-4. Is there a difference in engagement (affective , behavioural and cognitive) and final mark between students who are taught mathematics with the aid of technology and those who are taught in a traditional way?

Hypothesis

Students who are taught mathematics with the aid of technology, have different final mark and cognitive affective and behavioural engagement in learning mathematics, than the final mark and cognitive, affective and behavioural engagement of students who are taught in a traditional way.

The use of technology for learning mathematics affects three dimensions of student engagement and final mark.

RQ-4, H-9 CE = F (Group)

The use of ICT in learning mathematics affects student cognitive engagement in learning mathematics or students cognitive engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students cognitive engagement in learning mathematics who are taught in a traditional way.

RQ-4, H-10 AE = F (Group)

Students affective engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students affective engagement in learning mathematics who are taught in a traditional way.

RQ-4, H-11 BE = F (Group)

Students behavioural engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students behavioural engagement in learning mathematics who are taught in a traditional way.

RQ-4, H-12 Final Marks = F (Group)

Students final marks who are taught mathematics with the aid of technology are different to those of students who are taught in a traditional way.

Pictorial Illustration of the Four-Phase Study Design is presented in Figure 5.

3.11.3 Methodological considerations of Data Analysis

The overall data analysis plan has been presented by Figure 16 as a multilevel path diagram clearly showing the statistical methods applied to address the four aims of the study and answer four research questions with twelve hypotheses. Three stages of data analysis are illustrated by Figure 13 (STAGE 1), Figure 14 (STAGE 2) and Figure 15 (STAGE 3).

3.12 Position of researcher

The researcher has extensive industry experience as a software developer and as an analyst programmer as well as extensive experience in teaching mathematics at both secondary and tertiary levels, which also included the design and implementation of the on-line Learning Management System based on Moodle. A list of courses the researcher has designed for different subjects and educational levels are listed in appendix (Appendix 23).

The researcher designed, developed and maintained the online learning environment (SigmaNet) using LMS Moodle, provided all administration tasks and system enhancement in order to accommodate the particular needs of Foundation Studies students, taking into consideration students ICT skills and reviewing the outcomes from a "moving target". The Map of Moodle administration demonstrate the challenging task of maintaining and supporting such a huge environment, which requires technical skills, pedagogical knowledge and mathematics expertise and an enormous amount of time (Appendix 27). The researcher observed the difficulties related to student enrolment and teacher challenges to accommodate such a dynamic student cohort with wide varieties of mathematics knowledge, ICT skills and technology access outside of the university.

3.13 Conclusion

This chapter outlined the conceptual framework which aimed to guide the author's research. The methodology employed in each phase of the research with the research aims and objectives which were guided by research questions were also detailed. The chapter outlined the considerations which were undertaken by the researcher relating to validity and reliability and ethics. An extensive account of the methods used to explore and investigate the intervention and the conceptual models which informed the evaluation were set out. The methodology employed throughout this study has been outlined providing a clear chronology of the work which follows. Chapter 4 details the data analysis and major findings relating to student attitudes and engagement in learning mathematics with technology.

Chapter 4

Data Analysis, Results and Discussions

STUDENT EXPERIENCES, ATTITUDES TOWARDS TECHNOLOGY SUPPORTED LEARNING AND THEIR ENGAGEMENT

The results of the data analysis related to this study are presented in this chapter: (1) the students' demographic factors, cultural background and socio-economic status and how they are related to their attitudes towards the use of technology in learning mathematics, (2) access to technology and perceptions towards using technology and how they are related to students' attitude towards the use of technology for learning mathematics , (3) mathematics confidence and confidence with technology and how are they related to students' attitude towards learning mathematics with technology, student engagement (affective, behavioural and cognitive) and achievement in mathematics, (4) differences in engagement (affective, behavioural and cognitive) and student achievement between students who were taught mathematics with the aid of technology and those who were taught in a traditional way. Approach used to analyse the data, the results of the data analyses and discussions are also presented.

4.1 Data Analysis

Using Newhouse's concept model as theoretical framework a number of factors, which might have formed students' attitudes towards learning mathematics in a preparatory university program were identified for investigation. The data for this study was collected from VU students using self-reported survey. This survey instrument consisted of four scales (91 items) that align with independent and dependent variables. The collected data was validated and analysed using different statistical methods. IBM SPSS software is widely used in the social sciences to generate cross-tabulation in order to demonstrate the combined distributions of variables in a contingency table in matrix format. The SPSS v.20 package was used. Data collection process and preparation for analysis are presented in Figure 10. Data formalisation is presented in Figure 11 and Figure 12. Detailed presentation of data formalisation can be found in Appendix 24, Appendix 25 and Appendix 26.

Descriptive statistics have been used to summarise and describe the data concerning demographic characteristics. To examine relationships between dependent variables and independent variables linear modelling and multiple regression analyses were used to answer Research Question 1, Research Question 2 and Research Question 3. To answer the Research Question 3 multivariate analysis of covariance (MANCOVA) also has been used. To answer the Research Question 4 multivariate analysis of variance (MANOVA) has been used.

4.1.1 Overall Structure of Data Analysis

The conceptual framework developed in this study is illustrated in Figure 2. The statistical approach and methods used to analyse the data is explained in Section 3.11.3 and illustrated in Figure 4. The overall structure of data analysis including the study Aims, Research Questions, Hypothesis and Outcomes is presented in Figure 16.

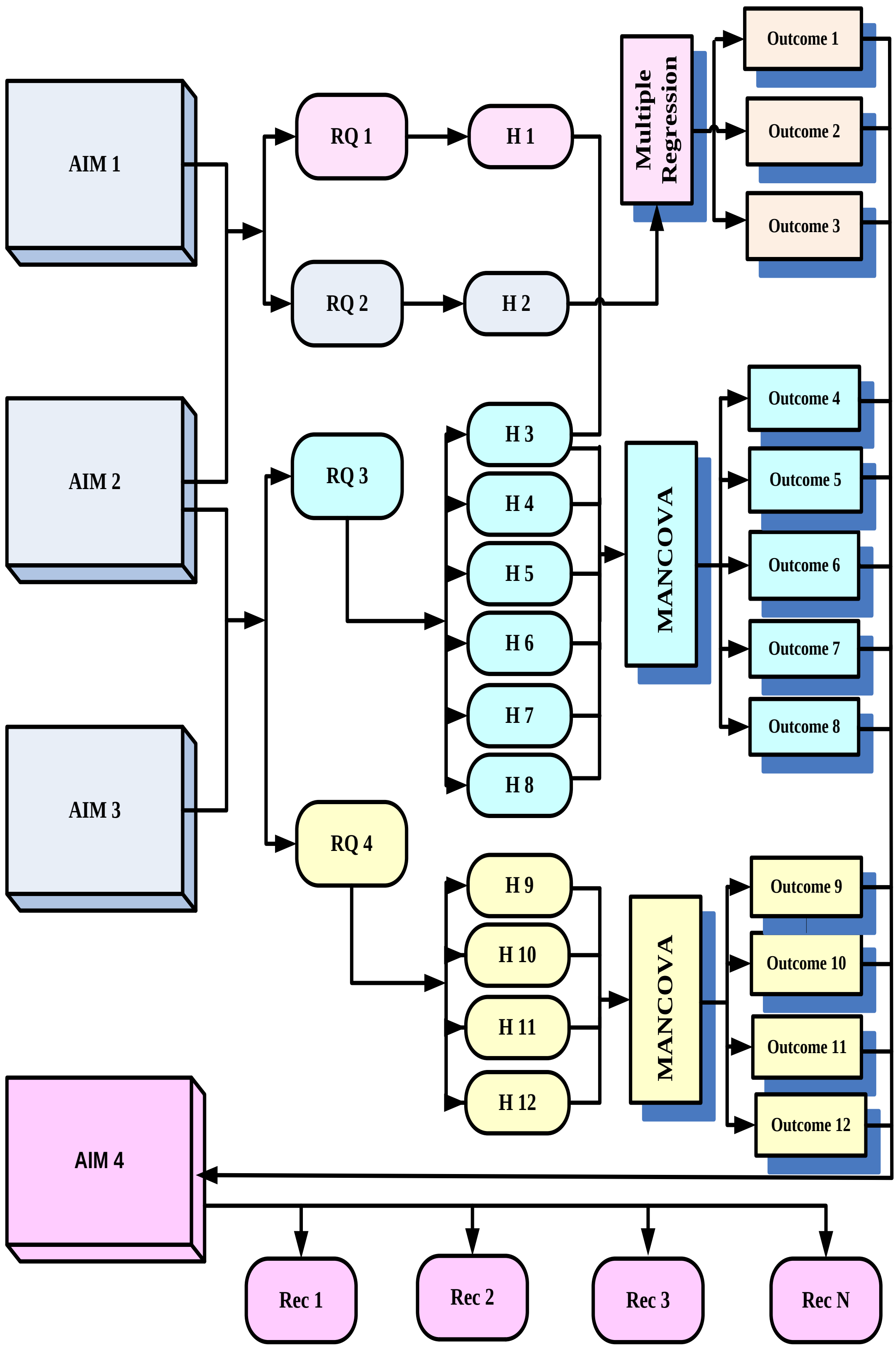


Figure 16 Overall Structure of Data Analysis

4.1.2 Research Questions and hypothesis revisited

4.1.2.1 Research Question 1 & Hypothesis (RQ-1, H-1)

How are students' demographic factors, such as gender, age and cultural background, LOTE, SES, related to their attitudes towards the use of technology in learning of mathematics? Hypothesis was that students' attitude towards the use of ICT in learning mathematics depends on their gender, age, socio-economic status and their English-speaking background ([MT] = F([Gender], [Age], [SES], [LOTE])).

4.1.2.2 Research Question 2 & Hypothesis (RQ-2, H-2).

To what degree is access to technology and perceptions towards the use of technology related to students' attitude towards the use of technology for learning mathematics? Hypothesis was: Students attitudes towards the use of ICT in learning mathematics depends on their access to technology and perceptions towards the use of technology ([MT] = F ([ET], [AT])).

4.1.2.3. Research Question 3 & Hypothesis (RQ-3, H-3)

To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics? Hypothesis was: Student attitudes towards the use of ICT in learning mathematics depend on their mathematics confidence and confidence with technology (MT = F ([MC], [TC]).

4.1.2.4 Research Question 3&Hypotheses (RQ-3, H-4,H-5,H-6,H-7,H-8)

To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?

Hypothesis was: Students engagement in learning mathematics depends on their mathematics confidence and confidence with technology (SE = F ([MC], [TC]), [H-4]). Students cognitive engagement in learning mathematics depends on their mathematics confidence and confidence with technology (CE = F ([MC], [TC]), [H-5]). Students affective engagement in learning mathematics depends on their mathematics confidence and confidence with technology (AE = F ([MC], [TC]), [H-6]). Students behavioural engagement in learning mathematics depends on their mathematics confidence and confidence with technology (BE = F ([MC], [TC]), [H-7]). Student achievement in mathematics depends on their mathematics confidence and confidence with technology (FinalMark= F ([MC], [TC]), [H-8]).

4.1.2.5 Research Question 4&Hypotheses (RQ-4, H-9, H-10, H-11, H-12)

Is there a difference in student engagement (affective, behavioural and cognitive) and their final mark between students who are taught mathematics with the aid of technology and those who are taught in a traditional way?

Students who are taught mathematics with the aid of technology have a different cognitive engagement in learning mathematics to students who are taught in a traditional way (CE = F (Group), [H-9]). Students who are taught mathematics with the aid of technology have a different affective engagement in learning mathematics to students who are taught in a traditional way (AE = F (Group), [H-10]). Students who are taught mathematics with the aid of technology have a different behavioural engagement in learning mathematics to students who are taught in a traditional way (BE = F (Group), [H-11]). Students who are taught mathematics with the aid of technology have a different final marks to students who are taught in a traditional way (Final Marks = F (Group), [H-12]).

4.1.3 Descriptive statistics

This section provides information based on the results gathered from demographic characteristics obtained from Victoria University students' records and in the survey administered to these students. In total, 200 questionnaires were distributed to respondents from Foundation study students between April 2012 and September 2012: 100 questionaries were distributed before study and 100 questionaries were distributed after the study. Out of this total, 194 respondents (97 per cent) returned a completed questionnaire.

To ensure that data collected during the course of this study is valid, different types of data validation techniques were used. The data were entered into a Microsoft Excel worksheet and coding errors were tested for by a range of checks on all variables. Before this procedure, data screening and cleaning were performed to ensure that data were entered correctly. After entering into SPSS, the data were also inspected for the same problem by running frequency analyses for each of the variables according to the range of responses (Cohen, 2007). This analysis produced results in the form of a percentile distribution for each variable, which is practical for error recognition in data coding. Incomplete questionnaires were not taken into account.

Student demographics

The descriptive summary of the 87 participants' demographic characteristics and Moodle (SigmaNet) usage are presented in this section. The examined demographic characteristics were: gender, cultural background, social-economic status (see section 3.10.1), and age.

Overall there were more female students than male (68% female and 32% male). The majority of the student participants in the first two intakes were female: Intake 1 - 72% female and 28% male and 94% female and 6% male in Intake 2. In Intake 3 there were even numbers (50% female and 50% of male).

More than a half of all students were from non-English speaking background (59% Non-English and 41% English background). This proportion slightly varied between intakes. Students from Non-English background in Intake 1 contributed 56%, Intake 2 – 81 %, Intake 3 – 52%. Descriptive summary of the participants' demographic characteristics is presented in Table 6 below.

The majority of students in three intakes were from Medium socio-economic status (SES) families. Only 12% of students came from families with High SES, 35% of all participants were from Low SES family, 53% from Medium SES families. In Intake 2 there were no students from families with High SES and in Intake 3, 23% of students came from High SES students. The average age of all students was 19 years.

Table 6 Descriptive summary of the participants' demographic characteristics

Demographic Variable		All Students		Intake 1		Intake 2		Intake 3	
		N	%	N	%	N	%	N	%
Gender	Female	59	68	28	72	15	94	16	50
	Male	28	32	11	28	1	6	16	50
Language	Non-English	51	59	22	56	13	81	16	52
	English	35	41	17	44	3	19	15	48
SES	Low	30	35	15	38	4	25	11	35
	Medium	46	53	21	54	12	75	13	42
	High	10	12	3	8	0	0	7	23
Average Age		19.3		18.36		19.31		20.48	

4.1.3.1 Access to technology

This section of investigation is focusing on the demographic variables: gender, cultural background, social-economic status, and age in shaping the pattern of access to technology. Access to technology outside university is presented by gender, LOTE and SES can be found in Table 8.

Full access to Portable computers

Full access to portable computers differed across gender (81% Female, 52% male), with average of full access 71%, limited access – 24% and with no access – 5%. For High SES group the score was accordingly 80%, 20%, 0%. Students from Non-English speaking background [NESB] demonstrated similar access to portable computers as students with English as a first language, but have less access to electronic devices.

Access to electronic devices

It is important to note that students with Low SES have less access to electronic devices than students with High SES. As mentioned above, students from Non English Speaking Background have less access to electronic devices than students with English speaking background (ESB). Female students have higher level of access to electronic devices than males (Table 8).

Access to internet

More female had full access to the internet (29% female, 11% male); limited access – 15% and with no access – 56% for female and for male limited access – 19% and with no access – 70%.

It is worthwhile to mention that there is less difference in access to wireless connection. Full access to wireless internet has more female (64% female, 53% male); limited access – 25% and with no access – 11% for female and for male limited access – 22% and with no access – 25%, the lowest value for full access is for Low SES (50%) and highest value for full access was reached among students with High SES (78%). Average score across all students was 63% for full access and 26% for limited access.

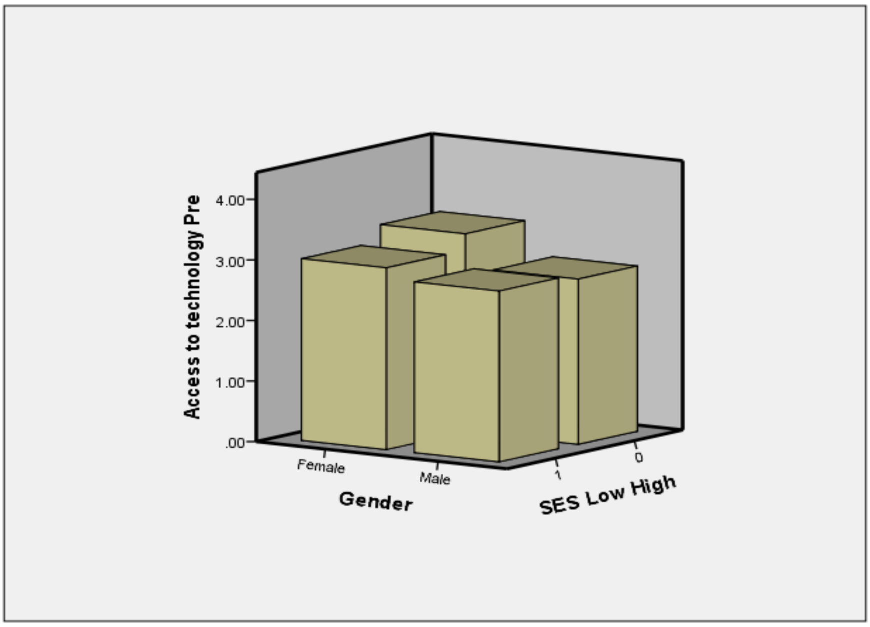
It is important to note that students with Low SES have less access to Internet than students with High SES. Students from Non English Speaking Background have less access to Internet than students from ESB. Female students have higher level of access to Internet, than males (Table 8).

Summary

The averages were calculated with the use of software (SPSS) using data mapped to numerical values. A 5-point Likert scale was transformed accordingly following rules: 1=strongly disagree, 2=disagree, 3=neutral, 4 =agree, 5=strongly agree. The results were tabulated based on the data collected.

The average level of access to technology was 2.48 among female and 2.40 for male students. Average scores on Likert scale of access to technology was 2.43 for NESB students and 2.50 for English speaking with average total - 2.45.

It is apparent from this section that there was very little difference in the average level of access to technology between students with Low SES and High SES (2.39 for Low SES, and the same for High SES - 2.49), as illustrated in the bar graph below.



4.1.3.2 Perceptions towards the use of technology for learning

This section of investigation and analysis is focusing on the role demographic variables: gender, cultural background, social-economic status, and age in shaping the pattern of students' perception of the use of technology for learning.

Data showing perceptions towards the use of technology for learning mathematics is presented for ICT-group and TR-group in Table 9. Perceptions towards the use of technology for learning are presented for TR- group in Table 10 and for ICT-group in Table 11.

4.1.3.3 Attitude towards use of technology for learning mathematics

This section of investigation was focusing on the attitude towards learning mathematics with technology and provided a comparison between student attitudes before study and after study for each group of students (TR and ICT groups). Summary results are presented in Table 12, Table 13, Table 14.

Three subscales: confidence with technology, mathematics confidence and attitude to learning mathematics with technology for all respondents, TR-group and ICT- group are presented in Table 15. Student attitude towards the use of technology by gender, language background and socio-economic status is presented in Table 16.

4.1.3.4 Moodle usage

Distribution of students by teaching method and average participant' Moodle usage is presented for every intake of students and for all participants in Table 7 below. Average Moodle Usage for all participants was 27.5 hours (per month).

Moodle was used more intensively by students from Intake 1. Distribution of students by teaching method is presented in Table 7. Students who learnt mathematics with the use of ICT were 56 % and without ICT - 44%.

Table 7 Moodle usage

Variable		**All Students**		**Intake 1**		**Intake 2**		**Intake 3**	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Teaching Method	Traditional	38	44	14	36	4	25	20	62
	ICT	49	56	25	64	12	75	12	38
Average Moodle Use in ICT Group (hrs./month)		27.57		34.59		25.75		16.5	

4.1.3.5 Student engagement

This focuses on the role of demographic variables: gender, cultural background, socio-economic status, and age in shaping the pattern of students' engagement in learning mathematics in three dimensions: Cognitive, Affective and Behavioural.

Every dimension of student engagement was considered by different sub-scales to address the fourth aim of this study which was to compare the effect of ICT-based mathematics instruction and traditional mathematics instruction on student engagement in three dimensions: cognitive, affective and behavioural.

Cognitive Engagement

Cognitive Engagement consists of 3 subscales:

Surface strategy
Deep strategy
Reliance

Affective Engagement

Affective Engagement consists of 4 subscales

Interest
Anxiety
Achievement
Frustration

Behavioural engagement

Behavioural engagement consists of 2 subscales

Attentiveness
Diligence

Time spent on out-of class mathematics learning on a normal week

Descriptive data for sub-scales of students' cognitive, affective and behavioural engagement is presented in Table 18 and Table 19. Summary of students' engagement data by intake is presented in Table 17.

4.1.4 Summary of Descriptive statistics

The analyses of data obtained from descriptive statistics shows that majority of students were female, age 19, NESB but with an appropriate language level, from low SES background, has high level of access to technology and devices and good perception toward the use of technology for learning (average score was close to 4 on 5 Likert scale).

Students from non-English speaking background and with High socio-economic status have demonstrated a better attitude towards using ICT in learning mathematics if they have higher perceptions towards the use of technology for learning.

Other observations are that the data shows more decreases within the ICT group in student confidence with technology, attitude to learning mathematics with technology and mathematics confidence than it was observed in the TR-group. Confidence with technology and mathematics confidence were found to differ between genders.

Summaries of students' engagement, perceptions and attitudes for ICT and TR groups are presented in Table 20.

4.1.5 Regression and Correlational Analyses

4.1.5.1 Stage 1 Multiple Regression Analysis

Research Questions One, Two, Three

A multiple regression analyses were conducted to examine the relationship between student attitudes towards learning mathematics with technology and eight potential predictors:

[Gender], [Age], [SES], [LOTE], [ET], [AT], [MC], [TC]

The description of variables can be found in Appendix 30.

Before conducting multiple regression analysis, there are some assumptions that need to be checked. They include lack of multicollinearity, normality of errors, linearity, homoscedasticity, influential points and outliers (Stevens, 1990).

The assumptions of linearity independence of errors, homoscedasticity, unusual points and normality of errors were tested and met (Appendix 31).

The multiple regression model with eight predictors produced $R^2 = .204$, $F(8, 74) = 2.375$, $p < 0.05$ (Durbin-Watson coefficient = 2.035) shows very good fit for the model, presented in Table 21 and Table 22. This model explains more than 20% of the variance in the students' attitude towards the use of technology for the learning of mathematics. Summary statistics can be found in Table 23.

Table 23. Summary of Multiple Regression Analysis.

Summary of Multiple Regression Analysis					
Variable	**Mean**	**B**	**Std. Error**	**b**	**Sig.**
Coefficient		1.85	0.948		
Gender	0.3	-0.18	0.195	-0.108	0.357
Age	19.33	-0.011	0.027	-0.046	0.685
SES	0.77	0.218	0.174	0.136	0.214
LOTE	0.42	-0.274	0.175	-0.176	0.122
ET	2.46	-0.297	0.274	-0.132	0.282
AT	3.94	0.332	0.148	0.276	0.028
MC	3.15	-0.006	0.088	-0.008	0.943
TC	3.69	0.226	0.148	0.199	0.131

Note. *P <0.05; B=unstandardized regression coefficient;

SEB = Standard error of the coefficient; b = standardized coefficient

A multiple regression model with eight predictors is presented by Equation 1.

Equation 1 Linear regression analysis prediction equation

MT = 1.85 +0.332 x [AT] + 0.226 x [TC] + 0.218 x [SES] - 0.297 x [ET] - 0.274 x [LOTE] - 0.18 x [Gender] - 0.011 x [Age] - 0.006 x [MC]

The description of variables included in the Equation 1 can be found in Appendix 30.

The regression coefficients (Beta) (Table 23), give an indication of the contribution of each independent variable in predicting the dependent variable (Aron, Aron, & Coups, 2005).
The Sig (p) for each independent variable represent a measure of the significance of this variable in predicting the independent variables.

The general form of the Equation 1 to predict students' attitude towards use of technology for learning mathematics from their general perceptions towards the use of technology for learning, confidence with technology and in mathematics, level of access to technology outside University and their demographics, is:

Predicted Attitude = 1.85 + (0.332 x general perceptions towards the use of technology for learning) + (0.226 x confidence with technology) + (0.218 x socio-economic status) – (0.297 x access to technology) – (0.297 x English as a second language) – (0.18 x gender) – (0.011 x age) – (0.008 x mathematics confidence)

For the first independent variable ([AT]), the test was statistically significant (t = 2.245, Beta = .332; p =.028). This suggested that students' perceptions towards the use of technology for learning has a significant positive relationship with the dependent variable (students' attitudes towards the use of technology for learning mathematics)

For the second independent variable ([TC]), the test was not statistically significant (t = 1.528, Beta = .226; p =.131). This suggested that students' confidence with technology has no relationship with the dependent variable (students' attitudes towards the use of technology for learning mathematics).

For the third independent variable ([SES]), the test was not statistically significant ($t = 1.254$, Beta = .218; $p = .214$). This suggested that students' socio-economic status has no relationship with the dependent variable (students' attitudes towards the use of technology for learning mathematics).

For the fourth independent variable ([ET]), the test was not statistically significant ($t = -1.083$, Beta = .297; $p = .282$). This suggested that students' access to technology outside university has no relationship with the dependent variable (students' attitudes towards the use of technology for learning mathematics).

For the fifth independent variable ([LOTE]), the test was not statistically significant ($t = -1.565$, Beta = - .274; $p = .122$). This suggested that students' English speaking background has no relationship with the dependent variable (students' attitudes towards the use of technology for learning mathematics).

For the sixth independent variable ([Gender]), the test was not statistically significant ($t = -.927$, Beta = - .18; $p = .357$). This suggested that students' gender has no relationship with the dependent variable (students' attitude towards the use of technology for learning mathematics).

For the seventh independent variable ([Age]), the test was not statistically significant ($t = -.407$, Beta = -.011; $p = .357$. This suggested that students' age has no relationship with the dependent variable (students' attitude towards the use of technology for learning mathematics).

For the eighth independent variable ([MC]), the test was not statistically significant ($t = -.071$, Beta = -.006; $p = .943$. This suggested that students' mathematics confidence has no relationship with the dependent variable (students' attitude towards the use of technology for learning mathematics).

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Table 24. Multiple Regression Analysis Coefficients

Coefficients[a]													
Model 1		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1.850	.948		1.953	.055	-.038	3.739					
	Gender	-.180	.195	-.108	-.927	.357	-.568	.207	-.151	-.107	-.096	.793	1.261
	Age	-.011	.027	-.046	-.407	.685	-.066	.043	.063	-.047	-.042	.843	1.186
	SES	.218	.174	.136	1.254	.214	-.128	.564	.132	.144	.130	.921	1.086
	LOTE	-.274	.175	-.176	-1.565	.122	-.622	.075	-.159	-.179	-.162	.848	1.180
	Access to technology Pre	-.297	.274	-.132	-1.083	.282	-.844	.250	.037	-.125	-.112	.722	1.385
	Perception using ICT for learning Pre	.332	.148	.276	2.245	.028	.037	.627	.360	.253	.233	.713	1.403
	Confidence with technology Pre	.226	.148	.199	1.528	.131	-.069	.520	.254	.175	.158	.635	1.574
	Mathematics confidence Pre	-.006	.088	-.008	-.071	.943	-.182	.170	.005	-.008	-.007	.852	1.174

a. Dependent Variable: Attitude learning maths with technology Pre

Summary

Correlation coefficients of multiple regression equation (Equation 1) for every variable: [Gender], [Age], [SES], [LOTE], [ET], [AT], [MC], [TC] provides a level of contribution for every factor included in this model.

The analysis identified the relative contribution of each predictor to the explanation of variance of students' attitude toward the use of technology for learning mathematics. Students' perception towards the use of technology for learning has been found to be the most influential contributor to students' attitudes toward the use of technology for learning mathematics.

A multiple regression model, with eight predictors has shown a very good fit for the general linear model (GLM).

$$[MT] = 1.85 + 0.332 \times [AT] + 0.226 \times [TC] + 0.218 \times [SES] - 0.297 \times [ET] - 0.274 \times [LOTE] - 0.18 \times [Gender] – 0.011 \times [Age] - 0.006 \times [MC]$$

It is important to note that this is a mean predicted value. That is, it is the mean expected value of all students with these values for the independent variables. The coefficients identified from Table 24 indicate how much the dependent variable varies with an independent variable, when all other independent variables are held constant.

It was found that more than 20% of the variance in the students' attitude towards the use of technology for the learning of mathematics [MT] can be explained by the students' demographic factors ([LOTE], [Gender], [Age], [SES]), their perceptions towards the use of technology for learning [AT], their access to technology outside of University [ET] and their mathematics confidence [MC] and confidence with technology [TC].

The variable – students' perceptions towards the use of technology for the learning [AT], was found to have a statistically significant affect, whilst the remaining variables did not.

Thus Hypotheses H-1, H-3 were rejected. Most variables measured in this study did not have an impact on students' attitudes towards use of technology for learning mathematics except of students' perceptions towards the use of technology for learning. Hypotheses H-2 was supported. It was found that students' perceptions towards the use of technology for the learning significantly contribute ($T (74) = 2.245$, $p < 0.05$ (Table 24)) to students' attitudes towards the use of technology for learning mathematics. All other variables have been found not statistically significant. Their regression coefficients cannot be used for prediction of students' attitudes towards the use of technology for learning mathematics.

4.1.5.2 Stage 2 MANCOVA

Research Question Three

To address research question RQ-3 and check five hypotheses (1) H-4, (2) H-5, (3) H-6, (4) H-7 and (5) H-8 a multiple analysis of covariance was used.

Results of MANCOVA Test

A multivariate analysis of variance was run to determine the effect of demographic factors and MC, TC, AT and ET on components of engagement and final mark.

Preliminary assumption checking revealed that data was normally distributed, as assessed by Shapiro-Wilks test ($p > .05$); there were no multivariate outliers. There was no multicollinearity and the assumption of homogeneity of variances was met, as shown in Levene’s test (Table 25).

Table 25. Levene’s Test of Equality of Error Variances

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Cognitive engagement Pre	.653	15	61	.819
Affective engagement Pre	.725	15	61	.750
Behavioural engagement Pre	2.218	15	61	.015
Final mark percent	1.208	15	61	.291

Tests the null hypothesis that the error variance of the dependent variable is equal across groups

a. Design: Group2 + Avg_ET_Pre + Avg_AT_Pre + Avg_TC_Pre + Avg_MC_Pre + Avg_MT_Pre + Gender + SES_Low_High + LOTE

The MANCOVA had 2x3x2x2 design. Groups for analyses being used in MANCOVA tests were identified by following factors:

Gender (F, M), SES (1, 2, 3), LOTE (1, 2) and

Group (TR, ICT) and

Covariates (MC, ET, AT, TC)

The covariates were included in the analysis to control for the differences on the independent variable. Four dependent variables (affective engagement, cognitive engagement, behavioural engagement, final mark) have been selected which all measure different aspects of very cohesive theme- engagement, and final marks as indicator of student success. Some studies pointed out that representing Engagement by its three components is sufficient modelling of very complex educational process (Furlong and Christenson, 2008).

Wilks' Λ was selected as a test statistic to use in evaluating the presence of differences across the levels of the independent variables with regard to the set of dependent variables. The table below (Table 26) shows that observed covariance matrices of the dependent variables are equal across groups, and the overall test is not significant indicating that differences do not exist in the covariance matrices.

Table 26 MANCOVA Test results (RQ-3)

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Group2	Pillai's Trace	.041	.682[b]	4.000	64.000	.607	.041	2.728	.210
	Wilks' Lambda	.959	.682[b]	4.000	64.000	.607	.041	2.728	.210
	Hotelling's Trace	.043	.682[b]	4.000	64.000	.607	.041	2.728	.210
	Roy's Largest Root	.043	.682[b]	4.000	64.000	.607	.041	2.728	.210
Avg_ET_Pre	Pillai's Trace	.073	1.266[b]	4.000	64.000	.293	.073	5.065	.374
	Wilks' Lambda	.927	1.266[b]	4.000	64.000	.293	.073	5.065	.374
	Hotelling's Trace	.079	1.266[b]	4.000	64.000	.293	.073	5.065	.374
	Roy's Largest Root	.079	1.266[b]	4.000	64.000	.293	.073	5.065	.374
Avg_AT_Pre	Pillai's Trace	.106	1.902[b]	4.000	64.000	.121	.106	7.608	.545
	Wilks' Lambda	.894	1.902[b]	4.000	64.000	.121	.106	7.608	.545
	Hotelling's Trace	.119	1.902[b]	4.000	64.000	.121	.106	7.608	.545
	Roy's Largest Root	.119	1.902[b]	4.000	64.000	.121	.106	7.608	.545
Avg_TC_Pre	Pillai's Trace	.029	.470[b]	4.000	64.000	.757	.029	1.881	.154
	Wilks' Lambda	.971	.470[b]	4.000	64.000	.757	.029	1.881	.154
	Hotelling's Trace	.029	.470[b]	4.000	64.000	.757	.029	1.881	.154
	Roy's Largest Root	.029	.470[b]	4.000	64.000	.757	.029	1.881	.154
Avg_MC_Pre	Pillai's Trace	.314	7.324[b]	4.000	64.000	.000	.314	29.298	.994
	Wilks' Lambda	.686	7.324[b]	4.000	64.000	.000	.314	29.298	.994
	Hotelling's Trace	.458	7.324[b]	4.000	64.000	.000	.314	29.298	.994
	Roy's Largest Root	.458	7.324[b]	4.000	64.000	.000	.314	29.298	.994
Avg_MT_Pre	Pillai's Trace	.105	1.871[b]	4.000	64.000	.126	.105	7.482	.537
	Wilks' Lambda	.895	1.871[b]	4.000	64.000	.126	.105	7.482	.537
	Hotelling's Trace	.117	1.871[b]	4.000	64.000	.126	.105	7.482	.537
	Roy's Largest Root	.117	1.871[b]	4.000	64.000	.126	.105	7.482	.537
Gender	Pillai's Trace	.249	5.310[b]	4.000	64.000	.001	.249	21.242	.962
	Wilks' Lambda	.751	5.310[b]	4.000	64.000	.001	.249	21.242	.962
	Hotelling's Trace	.332	5.310[b]	4.000	64.000	.001	.249	21.242	.962
	Roy's Largest Root	.332	5.310[b]	4.000	64.000	.001	.249	21.242	.962
SES_Low_High	Pillai's Trace	.027	.437[b]	4.000	64.000	.781	.027	1.750	.146
	Wilks' Lambda	.973	.437[b]	4.000	64.000	.781	.027	1.750	.146
	Hotelling's Trace	.027	.437[b]	4.000	64.000	.781	.027	1.750	.146
	Roy's Largest Root	.027	.437[b]	4.000	64.000	.781	.027	1.750	.146
LOTE	Pillai's Trace	.009	.151[b]	4.000	64.000	.962	.009	.605	.080
	Wilks' Lambda	.991	.151[b]	4.000	64.000	.962	.009	.605	.080
	Hotelling's Trace	.009	.151[b]	4.000	64.000	.962	.009	.605	.080
	Roy's Largest Root	.009	.151[b]	4.000	64.000	.962	.009	.605	.080

a. Design: Group2 + Avg_ET_Pre + Avg_AT_Pre + Avg_TC_Pre + Avg_MC_Pre + Avg_MT_Pre + Gender + SES_Low_High + LOTE

b. Exact statistic

c. Computed using alpha = .05

Box's Test of Equality of Covariance Matrices

Box's M	F	df1	df2	Sig.
79.868	.910	60	1537.841	.670

According to theories behind MANCOVA we can conclude that our subset (Gender, SES, LOTE, Group) from complete model (8 independent variables) had a significant effect on dependent variables (AE, CE, BE, FinalMark). Complete model is the majority of the main effects for the test.

Follow-up analyses were performed to find whether there are differences among groups for certain dependent variables and for particular linear combinations of dependent variables.

It has been found that:

There was a statistically significant difference between the mathematics confidence on the combined dependent variables $F(4, 64) = 7.324$, $p < .0005$; Wilks' $\Lambda = .686$; partial $\eta 2 = .314$ and Gender $F(4, 64) = 5.310$, $p < .001$; Wilks' $\Lambda = .751$.

There was a statistically significant difference in the effect of mathematics confidence on Cognitive Engagement $F(1,76) = 11.719$, $p < .001$, Behaviour Engagement $F(1,76) = 19.997$, $p < .0005$ and final marks $F(1,76) = 6.235$, $p < .05$. Gender also was linked to statistically significant difference in Affective Engagement $F(1, 76) = 6.918$, $p < .05$ and in Behavioural Engagement. $F(1, 76) = 6.474$, $p < .05$.

A statistically significant difference was found in the effect of access to technology outside the university on the final mark $F(1, 76) = 3.975$, $p < .05$.

The primary purpose of the test of the covariate is that it evaluates the relationship between the covariate and the dependent variable, controlling for the other factors. Additionally, what this shows us is that there is a relationship (effect) between the covariate and the dependent variable.

At that level of study we can conclude that there are existing statistically significant relationships between:

Students access to technology and students achievements;

Mathematics confidence and Cognitive Engagement;

Mathematics confidence and Behavioural Engagement

Mathematics confidence and achievements;

Gender and Affective Engagement; and

Gender and Behavioural Engagement.

Thus Hypotheses H-4, H-6 were rejected. No relationships were found between students' affective engagement in learning mathematics and their mathematics confidence and confidence with technology. Hypotheses H-5, H-7 and H-8 were supported. The test results indicated that significant relationships exist between cognitive engagement and mathematics confidence; behaviour engagement and mathematics confidence; and mathematics confidence and achievements; and it was also found that students' access to technology outside the university significantly correlated with the students' achievements.

Detailed results of the tests are in Table 26 and Table 27.

4.1.5.3 Stage 3 MANOVA

Research Question Four

To address the research question RQ-4 and check four hypotheses (1) H-9, (2) H-10, (3) H-11, (4) H-12 multiple analyses of variance MANOVA was used for analysing data obtained from Intake-1 and Intake-3 separately. Intake-2 students were taught by an unqualified teacher and all students were using SigmaNet. There was no control group.

Results of MANOVA Test (Intake - 1)

MANOVA were conducted to examine is there a difference in student engagement (affective, behavioural and cognitive) and Final Mark between students who are taught mathematics with the aid of technology and those who are taught in a traditional way.

Wilks lambda test of the multivariate significance shows that model is non-significant (Table 28, Table 29). MANOVA test has not revealed a significant multivariate main effect for Group factor, Wilks' Λ = .521, $F(2, 10) = 0.385$, $p = 0.865$, partial $\eta^2 = .278$. Power to detect the effect was .096. Thus Hypotheses H-9, H-10, H-11 and H-12 were rejected and no significant effect was found of using ICT on student engagement components and final marks.

Results of MANOVA Test (Intake - 3)

MANOVA were conducted to examine is there a difference in student engagement (affective, behavioural and cognitive) and Final Mark between students who are taught mathematics with the aid of technology and those who are taught in a traditional way. Wilks' Λ test of the multivariate significance shows that model is non-significant (Table 31).

MANOVA test has not revealed a significant multivariate main effect for Group factor, Wilks' Λ = .874, $F(1, 29) = 0.613$, $p = 0.659$, partial eta squared = .126. Power to detect the effect was .164. Thus Hypothesis H-9, H-10, H-11 and H-12 were rejected and no significant effect was found of using ICT on student engagement components and final mark. Similarly to tests for Intake 1, no statistically significant effect was found for Intake 3 (Table 30 and Table 31).

4.2 Results and discussions

The first three research questions investigated students' experiences and perceptions of ICT supported learning in Phase 1, and found that student demographic factors such as gender, age, cultural background, socio-economic status are not related to their attitudes towards the use of technology in learning mathematics.

However, with a combination of perceptions towards the use of technology for learning and their level of access to technology (such as portable computers, Tablet PCs such as iPad/Android, mobile phones/iPhones and access to wireless internet), it was found that all eight variables are linked with statistically significant to attitude towards the use of technology in learning mathematics, if student confidence with technology and mathematics confidence are taken into account.

It was found that more than 20% of the variation in student attitude towards use of technology for learning mathematics can be explained by student's demographic characteristics, their perceptions towards the use of technology for learning, their confidence with technology and mathematics confidence, and their access to technology outside of University. However, most variables measured in this study were found to be not statistically significantly linked. The only factor which did have an impact on students' attitude towards technology for learning mathematics was student perception towards the use of technology for learning in general.

One knows that the education world is complex. One's models should also be complex. Whenever one looks at the effect of one independent variable on the dependent variable, one runs the risk of over-simplification. With the use multiple linear regression equation (Equation 1) the researcher has identified a way to specify a model that includes several independent variables. However, the researcher has the responsibility of specifying an appropriate model where independent variables should be included based on a theoretical argument, rather than literature review or empirical evidence alone. At this stage of study it is not possible to fully justify the theory behind the model and it was decided to avoid interpreting the independent effect of only one predictor (students' perception towards the use of technology for learning) that is significant. This can be a promising direction for future investigation and analysis.

Research question three investigated the students' engagement in learning mathematics. In Phase II the study explored to what extent student mathematics confidence and their confidence with technology are related to student cognitive engagement, affective engagement and behavioural engagement. It also asked to what extent student mathematics confidence and their confidence with technology are related to student achievement in mathematics.

Statistically significant relationships were found between:

1. Students access to technology and students achievements;
2. Mathematics confidence and Cognitive Engagement;
3. Mathematics confidence and Behavioural Engagement;
4. Mathematics confidence and achievements.

It was also found that gender is related to students' affective engagement and behavioural engagement:

5. Gender and Affective Engagement;
6. Gender and Behavioural Engagement.

The fourth research question (Phase III) was concerned with the differences in cognitive, affective, and behavioural engagements and achievements between the students taught mathematics with the aid of ICT and those taught in a traditional "chalk and talk" way.

The study found no difference between these variables in the two groups of students. It means that the use of an online learning management system developed for mathematics teachers by a mathematics teacher (the researcher) for this particular cohort of students and educational settings did not affect student engagement (cognitive, affective, and behavioural) in learning mathematics or student learning achievements.

Discussion

This study produced results which corroborate the findings of a great deal of the previous and current work in this field. In general, these findings are in agreement with most recent studies (Mor and Mogilevsky, 2013a; IMS, 2013b; IMS, 2013c; Mor and Mogilevsky, 2013b; Mor and Craft, 2012; IMS 2011; Mor, 2011) which concluded that the role of ICT depends on many interrelated and multidimensional factors of the education system. There is a consensus that ICT has a positive influence on learning, but measurement of this enhancement of learning and teaching with ICT has presented a challenge for researchers and policy makers (DERN, 2013; IMS ,2013; Abel, 2012; Akbiyik, 2011).

A major aspect of the complexity involved with ICT integration into education systems is the many factors involved with it, including factors associated with the human side of the integration (e.g. teachers, on-going support, designers, trainers, and students and administration) and the technological side of it (e.g. access to computers, technical support, ICT tools, and the e-materials). As a solution, a multilevel approach towards ICT in education has been identified (Mor and Mogilevsky, 2013a; Mor and Mogilevsky, 2012) emphasising the need for multi-level and multi-method approaches, which enables better insight into the impact of ICT for learning and teaching (IMS, 2014; Zakaria and Yusoff, 2013; Tserendorj et al., 2013).

This study has identified some crucial factors related to particular cohort of students enrolled in a Foundation study program at Victoria University, and has investigated the complex interrelationships between students' confidence with technology, mathematics confidence, attitude to learning mathematics with technology, cognitive engagement, affective engagement and behavioural engagement, achievement, gender, socio-economic background, age, access to technology outside university, students' perceptions towards using technology for learning and students' cultural background.

The questionnaire developed was used to track changes in the attitudes and engagement of the students in their learning of mathematics in response to the change of integrated ICT (in particular, a learning environment) to find the factors which could help identify the role of ICT in student engagement and achievements.

Attitude and Perceptions

The findings of this study suggest that students' perception towards the use of technology significantly influence the students' attitudes towards the use of technology in the learning of mathematics. It can be suggested that for this particular cohort of students (mostly in their late teens), with low SES, with English as a second language, the study has found that their perceptions towards the use of technology for learning play a very important role in developing their attitudes towards the use of technology for learning mathematics.

Gender and Attitudes

One study has pointed that it is important to note that not all the students with negative attitudes to learning mathematics with technology are females (Barkatsas et al., 2009). In contrast with Barkatsas et al. (2009) this research has found no significant gender difference in attitude towards using technology in learning mathematics.

Findings of this study have confirmed the results of a recent study (Diemer, et al., 2012) that "No effects due to age, gender, or language were found" (p. 21), but it was found that gender was related to behavioural engagement and affective engagement. The study also corroborates that age, gender, and the use of English as a first language had little influence on students' attitudes and engagement (Diemer, et al., 2012).

Gender and Behaviour engagement

This study found that gender affected students' behaviour engagement. This finding does not contradict to the findings of Barkatsas et al. (2001), who identified that male students expressed higher level of behavioural engagement than female students.

Gender and Affective Engagement

This study has identified that gender has affected students' affective engagement. This finding does not contradict the findings of Barkatsas et al. (2009), who identified that male students expressed higher level of affective engagement than female students.

Gender and Achievements

The results of this study did not show relationships between students' achievements and gender. This finding does not contradict the findings of Barkatsas et al. (2001).

Gender and Cognitive Engagement

This study found that gender did not affect students' cognitive engagement. This finding corroborates the findings of Wang (2011), who identified that male students and female students expressed the same level of cognitive engagement.

Age and Cognitive Engagement

This research does not support a stereotype that older students are more resistant to instructional technology or that they are relatively novice in computer use compared to what Prensky (2001) called digital natives.

Mathematics confidence and Achievements

The results indicate that there are existing relationships between students' achievements and mathematics confidence. This finding is in agreement with the findings of Barkatsas et al.

(2009). They found that achievement in mathematics was associated with levels of mathematics confidence.

Access to technology and Achievements

There is a relationship between students' access to technology outside university and students' achievements. When students have better access to technology they may be more capable to achieve better results when they learn mathematics with the use of technology.

Mathematics confidence and Cognitive engagement

It was found that there are significant relationships between mathematics confidence and cognitive engagement. This finding corroborates the findings of Wang et al., (2011) who reported that cognitive engagement was found to be strongly associated with mathematics confidence.

Mathematics confidence and Behaviour engagement

It was also found that there are significant relationships between mathematics confidence and behavioural engagement. This finding is in agreement with the findings of Barkatsas et al. (2009), who reported that mathematics confidence was found to be strongly associated with behavioural engagement.

Thus, factors of student engagement in learning mathematics with ICT and discussion about which are most important for learning mathematics, as well as factors effecting student attitudes towards learning mathematics with ICT become of interest to policy makers and as such are included in strategies of curriculum reforms at many universities around the word. The Victoria University agenda of curriculum reforms promotes blended learning for all students, including foundation studies.

This study has identified and explored eight factors affecting students' attitudes towards using technology. The particular cohort of students was enrolled in foundation units to improve their knowledge of mathematics to a degree required by the STEM subjects of VU College of Engineering and Science. This project has shown that designing a learning environment requires the program developer to consider students' characteristics in order to best assist the students and their teachers.

The results of this study suggest that students who identified themselves as enjoying using technologies and feel confident in using technology for their studies reported significantly higher levels of attitudes towards the use of technology for learning mathematics. Those who reported being interested in studying courses that use technology online were more likely to use ICT for learning of mathematics and as a result they might be more willing to take part in additional training.

Thus, the expected positive attitudes towards the use of technology for learning mathematics strongly depend on students' self-perceptions towards the use of technology for learning in general. This is a critical issue for the implementation of technology into classes of mathematics under the assumption that proper technologically oriented materials are developed and teachers are ready to use them in classrooms.

Another important finding was that:

ICT did not affect student cognitive, affective, behaviour engagement and achievements.

Contrary to expectations, and recent studies (Sharma and Bhaumik, 2013; MacGillivray, 2012; Parker et al., 2008, Abel, 2005b; Newhouse, 2002a) which claimed that a link between use of instructional technology and increased student engagement is strongly supported in the literature, the results of this study did not show any significant increase in student engagement and achievement. However, findings of this study have confirmed the results of a recent study, conducted a research experiment focusing on improving student engagement through a blended teaching method using LMS Moodle. These researchers (Lai and Sanuci, 2013) concluded that the absence of an effect of collaboration could be attributed to a lack of engagement. One of the limitations with this explanation is that it does not take into account the complexity and interrelationships of all other factors of learning environment. This research does not support this statement. Thus, it is argued that lack of engagement can be explained by only one attribute of the learning environment.

This study has not considered particular ICT tools which have been designed specifically for the learning mathematics, but has rather focused on the use of a learning environment. As it is not possible to separate this outcome from other outcomes of other dimensions of the learning environment, the discussion about the role of ICT in student engagement and achievement has to take into account other dimensions of educational environment. These are interrelated and also affect the use of ICT in teaching and learning (Newhouse, 2002, a). Newhouse concluded, that “the engagement and achievement of learning outcomes components of the students dimension should be subsumed within the learning environment attributes dimension” (p.234).

Many studies have reported that in an online environment the instructor plays a different role from a traditional instructor when they teach courses with LMS enhancements. Balanskat et al. (2006) pointed out the crucial role of teachers’ pedagogical approach to students’ learning outcomes. Their study identified that the impact of ICT is highly related to how teachers exploit it efficiently for pedagogical purposes. A significant relationship was found between teacher attitude and student attitude towards mathematics. A teacher’s attitude towards mathematics, therefore, matters as it has a powerful influence on student attitudes (Mensah et al. 2013).

The characteristics of the classroom teacher were found to be significantly related to their students' achievement. For example, Summers and Wolf (1977) found that 25% of the variance in student scores can be explained by many factors, which included teacher characteristics. Thus, teachers require training and support enable them to change from teaching face-to face to an online setting.

We anticipated that the learning environment SigmaNet would be used by the teacher using a student-centered approach. However, the teacher used this environment in a teacher-centered approach and did not encourage the students to use this environment outside the university. Thus SigmaNet has not been used by all students. This experiment shows that ICT was not used appropriately, and as a result students did not demonstrate better learning outcomes, better marks and higher engagement.

Another aspect that must be considered is that this study collected data from "moving objects" where the teacher was overwhelmed with constant moving in and out of the room, of the course and of the unit of study students, with the restricted timeframe, many other aspects related to student enrolment, organization, student email access, and also teaching students to remember their passwords.

In general it would be necessary to identify these characteristics and circumstances before making a decision to incorporate ICT as the students in this cohort all have very different needs and most of them relied on the teacher for ICT support.

Another interesting question arises about who has to design the learning environment (such as the one which is based on Moodle): the teacher or third party companies such as Mahara or other Moodle partners. The researcher has concluded that teachers of foundation study programs might need considerable training and support before mandated reforms require them to design a constructivist learning environment.

As noted in the literature review (Chapter 2), prior research studies have not expanded or investigated further the broad conclusion that ICT affects all aspects of the students' learning. This is most likely, due to the presence of many uncontrollable and inter-connected environmental variables. Many studies have found that assessing engagement is potentially useful when evaluating the quality of the students' learning experiences and making decisions about the course design, resource provision and delivery styles (Coates, 2007), all of which are required during curriculum reforms.

This thesis has built upon previous research and attempted to isolate the influence of specific variables of the learning environment, in order to more accurately determine the effect that ICT has on the level of student engagement in the learning of mathematics in a preparatory university program. Research literature notes that the students' attitude towards learning mathematics with the aid of technology is usually assumed to be of a high degree of importance – and this statement has been further verified by the results of this study. Using statistical analysis, a positive correlation was found between the use of computers and the students' attitude towards the learning of mathematics with ICT.

The definition and identification of the various factors or variables which may influence the level of student engagement was the first conceptual task. Factors that might be important in predicting computer technology effectiveness include student characteristics, learning experiences, learning perceptions, pedagogical approach and instructional techniques, and actual computer use in the course (Laurillard, 2008). It became evident, that not only is it necessary to identify the factors which may affect the students' attitudes, but also to understand and formalise each of these factors. A high level of importance was also placed on the development of a model which had the capability of identifying and isolating the effects of the individual factors. The approach adopted was based on the findings of the research which has focused on the identification of the impact that ICT had on the level of student engagement. This study set out also to investigate how technological innovation affects students who are from low socio-economic backgrounds and for whom English is a second language.

It is not surprising that opinions about the benefits of ICT in the teaching and learning of mathematics are mixed (Mor and Mogilevsky, 2013). Technology has played and continues to play an important role in the development of online education, which is an "incredibly complex and inherently multidisciplinary endeavor" (Global Learning Impact Report, 2013).

Opportunities presented by new educational technologies are inevitably coupled with challenges (Laurillard, 2012; Laurillard, 2008). Abel (2006) also points out the main reasons why some higher education institutions have not seriously considered open source approaches, include a lack of resources for implementation, an unclear future for open source in higher education, satisfaction with current non-open source software and lack of clarity of associated costs (Abel, 2006). Therefore, the real challenge for educators is how to use the potential of ICT to design a learning environment, which can complement the role of the teacher. Moreover, how instructors use the technology will have an impact on how students use it. For example, Parr (1999) found that the way students use technology depends largely on how they perceive the instructor intends the technology be used.

Newhouse (2002) pointed out that "bringing ICT into the classroom can have a considerable impact on the practice of teachers", in particular when ICT is conceptualised as a tool that supports a real change in the pedagogical approach. Many studies confirmed that teachers who use ICT in classrooms have to demonstrate hard work and high levels of energy and often in the face of considerable difficulties (Leach, 2003). Mor (2013) concluded "Future empirical investigation is envisaged using a design based research framework and participatory design approach to engage teachers with the integrated model in a professional development process" (p. 38).

In addition, there is no single learning theory, educational technology or research method that is best suited for all learning situations (Jonassen, 2004). Educational technologies are changing so rapidly that many teachers have difficulty developing pedagogies that would most effectively utilize the latest technologies (Laurillard, 2006).

The complexity goes beyond technology itself, as it includes all parties involved: teachers, learning designers, infrastructure resource solutions, administration, and of cause students. In order for learning to be effective the learner must actively use the tools available in order to build a deeper understanding of the material to be learned (Mor, 2011). Simply presenting information to students does not guarantee that learning will take place.

In order to fully assess the effects of ICT in education we need to know more about how ICT operates at the different levels and domains of an educational system, and what we are really measuring on which level of every domain. The challenge also is to investigate different levels of different domains at the same time.

To identify the broad scope of impact of ICT on student engagement and to develop a set of different indicators and bring everything together into one strategy is a challenge of educational research and can be done best in large projects, such as the IMS Global Learning Consortium. Their Learning Impact Report (2013) has provided the results of analysis of studies with the approach of focusing "on project types rather than attempting to identify specific technologies and their adoption timeframes" (p.45).

Open digital content platforms such as Moodle contain a variety of learning materials to enable students to have access to high-quality educational information at a low cost and provide the ability to explore the world beyond the classroom, but this platform requires the dynamic optimisation of blended learning, which has a significant complexity (Global Learning Impact Report, 2013). Such a level of significant complexity was operationalised in this project and offered by the researcher for use in broader educational settings. Unfortunately, the use of this environment was very limited and at this scale did not indicate a positive effect on student engagement. Further investigation is needed to explore the reasons for the limited usage of this environment, which is beyond the scope of this study.

However, the increasingly diverse student population provides many explanations about the nature of their engagement. To explain that ICT did not affect student engagement, we may consider other domains of the education environment. The author conducted an experiment in the educational settings of the Foundation Studies Victoria University to explore the potential of ICT. We investigated only one of the five interrelated domains of an education system, namely the student domain, and focussed on isolating specific student related variables.

The results of the current study could be consistent with the main conclusions found in the research literature about the role of ICT in student engagement in learning mathematics (IMS Global Learning Consortium, 2013; DERN, 2013) and might confirm that ICT has the potential to improve student engagement if it is used properly (DERN, 2013; Mor & Mogilevsky, 2013; DE&T, 2012; RAND, 2012; Dix, 2007; Wang, 2001).

Discussion about the role of ICT in other domains is out of scope of this study. Further analysis of SigmaNet design and implementation may be done for a bigger study and with appropriate funding. This aspect of study requires technical, pedagogical and instructional design skills, including knowledge and experience of using LMS Moodle.

The findings of this study corroborate the findings of recent studies (Tserendorj et al., 2013; Taylor and Parsons, 2011; Agyei and Voogt, 2012; Agyei and Voogt, 2011a) which were conducted to investigate the role of ICT in student engagement in learning of mathematics. These studies reported that when ICT is used appropriately, it did have a positive impact.

Thus, this research has mainly focused on isolated student related factors to explain the role of ICT integration in student engagement in learning mathematics in a preparatory university program. The implications of lack of engagement discussed above will be used to develop recommendations related to VU curriculum reforms and Foundation Study mathematics teachers for professional development about implementing ICT in blended learning environments. Future research directions and recommendations with practical suggestions for implementation including this researcher's post study comments are the subject of Chapter 5.

Chapter 5

Conclusions, Recommendations and Suggestions for Further work and Post Study Comments

This four-phase study has addressed four main aims, which were outlined in Chapter 1 (section 1.2), in an attempt to determine the effect that Information and Communication Technology has on the level of student engagement in the learning of mathematics in a preparatory university program.

Major findings, implications for practice and recommendations related to current VU curriculum reforms and for foundation study teachers are presented in this chapter. Practical suggestions have also been provided, as part of this study, for any further research that may arise from this study.

5.1 Summary

The main purpose of this study was to investigate the effect of ICT on the level of student engagement in the learning of mathematics. To do this, the impact of ICT on the three dimensions of student engagement – cognitive, affective and behavioural – needed to be examined. To accurately measure the impact of ICT on the level of student engagement, the influence of the other variables was excluded. The effects of those variables were quantified and then isolated.

Various individual factors were identified, such as the students' demographics, their level of access to technology outside the university, their perceptions towards the use of technology for learning, their level of confidence with technology and their level of confidence with mathematics. These factors were used to model the students' attitudes towards the use of technology in the learning of mathematics. The conceptual framework was developed, using a comprehensive literature review, regarding the role of ICT in student engagement and achievement. The study design was based on this conceptual framework. The self-report instrument was also constructed, which was designed to measure the complexity of the relationships between the three dimensions of students' engagement and the identified factors. It is important to emphasise that the findings of the study are context specific and may not be easily generalised.

5.1.1 Key Findings

The study has found that:

- The students' perception towards the use of technology is significant predictor of the students' attitudes towards the use of technology in the learning of mathematics.
- The students' demographic factors combined with the students' level of access to technology outside of the university, their perceptions towards the use of technology for learning, confidence with technology, mathematics confidence account for more than 20% of the variation in the students' attitude towards the use of technology.
- The students' demographic factors, such as their gender, age, cultural background and socio-economic status were found to be not significantly related to the students' attitude towards the use of technology in the learning of mathematics.
- The students' level of confidence with technology, mathematics confidence, and their perceptions towards the use of technology for learning, level of access to technology outside of the university did not affect directly students' attitude towards the use of technology in the learning of mathematics.
- Statistically significant relationships exist between students' level of access to technology outside of the university and their achievements.
- Statistically significant relationships exist between students' mathematics confidence and cognitive engagement.
- Statistically significant relationships exist between students' mathematics confidence and behavioural engagement.
- Statistically significant relationships exist between students' affective engagement and gender.

- Statistically significant relationships exist between students' behavioural engagement and gender.
- The use of ICT did not have an impact on the level of student engagement in the learning of mathematics; however there were extenuating circumstances, surrounding the way that ICT was integrated into the classroom, which may have affected this outcome.

5.1.2 Limitations

There are many factors which may affect the overall level of student engagement. It would be unfeasible, if not impossible, to test for and account for all of the possible factors. There were several challenges/difficulties, that this study encountered, which may have influenced the outcomes in one way or another.

- Not all the requirements of the study design were fulfilled. Some of these shortcomings were:
    - Students weren't able to fully utilise the supplied learning system;
    - It took two weeks to create the necessary student accounts due to different administrative reasons;
    - Time was meant to have been allocated for the training of the teacher and the students in the proper use of the system, but this never happened;
    - The course instructor did not guide the students through the learning process in the provided learning environment, whilst using a teacher-centred approach to teaching.
    - The collection of data was extremely difficult, largely due to a lack of cooperation and interest. This task was made more difficult by not having adequate IT support, administrative inconsistencies constantly arising and the inability to raise any issues in a timely manner;
- There were also several critical issues which arose during the collection of data:
    - The need to collect to additional data sets in order to overcome the problem of having such a small sample size. The time required to create two additional courses – was not planned for;

    - The students' first encounter with Moodle was to create a personal account and enrol in a course using a course key and their Student ID. The account creation process required the students validate their account by responding to a confirmation email using their Victoria University e-mail. Some students were not able to access their emails – so the researcher had to intervene and validate the accounts, so that the students could continue with subsequent tasks;
- Technical issues that arose:
    - The computer rooms were not properly timetabled and the students weren't aware when to use the computers classrooms;
    - The researcher was required to set up six computer rooms instead of one;
    - The website designed for the Foundation Study students and the teacher was attacked by malicious software;

Although the conclusion that the use of ICT did not have any statistically significant effect on the student engagement would appear as a negative result, this study did bear positive outcomes, in other ways such as:

- Any research design including innovative technology and pedagogical challenges for learning technologies which are to be used across the learning environment, require appropriate technology preparation, and with proper administration support including motivated teachers and prepared students (Mor and Mogilevsky, 2013).
- Teacher training imposes considerable requirements on the learning situation in educational settings, and thus may not be suitable in certain conditions (Mor and Mogilevsky, 2013).
- Learning design is an incredibly complex and inherently multidisciplinary endeavour (Global Learning Impact Report, 2013) and is not suitable for every educational environment (Mor and Mogilevsky, 2013).
- In any educational ICT study, such as this, a validation and training exercise appears to be useful before the study.

The likely impact of limitations of study results could have been reduced if interest of all stakeholders; specifically school administration and the teachers involved in the project was greater. Thus, student involvement was influenced by lack of interest by teachers in utilising new technology.

If students, teachers and school administration reflected interest in a new teacher approach with technology the study results may have been different resulting in a more positive outcome; thereby confirming the results of other Australian and International Studies for Global Consortium (Abel, 2012; Global Learning Impact Report, 2013).

5.2 Recommendations

The integration of ICT into teaching and learning requires a lot of changes to be made to all the aspects of an educational system. Changing a system at a large school or university is a messy business. Results from the change are at times unpredictable, are difficult to quantify and can also lead to undesirable consequences (Gordezky, Marten and Rowan, 2004). As noted earlier, assessing engagement is important for making decisions about the course design, resource provision and delivery styles (Coates, 2007), all of which are required during curriculum reforms.

The conceptual multilevel framework that was developed in this study appears to provide some indications as to the possible changes to the instructional, learning and ICT conditions which may transform and optimise both the teaching and the learning.

5.2.1 Recommendations related to VU curriculum reforms

Incorporation of ICT into an education system becomes an important long-term strategy of curriculum reforms for many universities, including Victoria University. Accordingly many universities have reported an increase in the integration of online learning management systems for teaching and learning mathematics (VU, 2012).

The use of ICT in Victoria University has increased significantly for pedagogical purposes. Despite this level of growth, the extent and impact the use of ICT has on the students' learning in a blended learning environment remains an under-researched area (VU, 2012). Victoria University has a high percentage of students who come from a low socio-economic background and who have English as a second language. This study suggests further examining the impact that the students' socio-economic status has on the students' attitude towards the learning of mathematics with the aid of technology.

In addition, it may be useful to promote computer training and literacy and to include additional ICT resources such as mobile technologies for the Foundation Study students. Before ICT can be introduced into the teaching and learning of mathematics, the students must firstly be provided with good access to the technologies. Helping students build their confidence in using computers will make learning technology more pleasurable and enjoyable for the students. A fundamental computer literacy course could be a prerequisite to better prepare the students. Many studies have found that the instructors' attitude towards the use of technology in teaching can positively influence the students' attitudes. When the instructors are committed to e-Learning and exhibit positive attitudes – the students will perceive this and it will further engage the students (Sun et al., 2007). In light of this, school administrators must be very careful in selecting instructors for teaching courses with the technology.

The findings of this study may provide an additional resource of information for the implementation of the Victoria University Blended Learning Strategy (VU, 2012).

5.2.2 Recommendations for Foundation Studies teachers

Based on the research findings, the author has the following recommendations:

- Since the recent studies into students engagement in learning mathematics with online learning environment has not demonstrated a positive correlation between student engagement with online learning environment, the author recommends that staff need to rethink their view of engagement in the current educational climate and need to explore different ways of engaging students with the use of ICT, taking into consideration socio-cultural student factors.

- If a more sophisticated view of engagement is adopted with a supportive learning environment, staff will feel less helpless, and will learn the strategies necessary to increase student level of engagement.
- To incorporate ICT in teaching and learning of mathematics there are certain requirements, based on study findings and personal experience of the researcher, which also were mentioned in the study design:
    - The students must be enrolled properly into the VU system and have their credentials already set up.
    - Students must be trained to use the online system before they start the study.
    - Computer rooms should be available for all periods of study. The rooms must have a permanent Internet connection, with appropriate software installed and set up correctly and preliminary student and teacher training before the study begins in order to give the students clear expectations of the course.
    - IT service should be available for solving technical and administrative problems.
    - Teachers should be trained and (at least) confident in using already designed systems. The teacher must also be motivated to learn new technical skills as well as being willing to adopt a new online pedagogical approach, which in itself is “an incredibly complex and inherently multidisciplinary endeavour“ (Mor & Mogilevsky, 2013).
    - The system is supposed to be a dynamic system (a static environment may also be used, but is not so effective as a dynamic environment and would have to be designed and re-designed in accordance with teacher-user requirements, students’ needs, and it would also need to be tested before the study).

5.3 Directions for Future Research

This section will discuss the possible methods and topics, which could further expand upon the current study, which was successfully implemented despite the many challenges and constraints. The data which was collected during the course of this study can be considered as valid and reliable and it can also be used for further analysis or comparisons.

The three dimensions of student engagement (cognitive, affective and behavioural) that were adopted by this study can be developed with further investigation. Cognitive engagement can be broken down into surface strategy; deep strategy; and reliance. Whilst affective engagement can be further broken down into: interest; anxiety; achievement; and frustration. Finally, behavioural engagement can be broken down into attentiveness and diligence. Further studies may be designed based on the findings and discovered challenges of this study to investigate the role of ICT in engagement of mathematically unprepared students.

It was beyond the scope of this study to examine all dimensions of educational processes and to identify the role of ICT in student engagement in learning mathematics. Further studies may be designed taking into consideration teacher professional ICT attributes, learning environment attributes, school ICT capacity and study design methodology.

Despite thousands of studies attempting to identify the impact of ICT use in education, there is an absence of widely accepted standard methodologies and indicators to assess impact of ICTs in education. The positive impact of ICT use in education has not been proven. This study has presented a true educational experiment conducted to investigate the role of ICT in student engagement in the learning of mathematics curriculum. The outcomes of this research may provide an additional resource of information for further analysis of curriculum implementation with ICT.

Further research might address the impact of support from teachers and peers on the facilitation of a positive attitude towards the use of technology for learning mathematics, which could potentially enhance low SES student engagement in foundation study programs at Victoria University. It should depart from investigating the issue of access to IT resources and draw attention to the cultural factors.

The research tool which has been developed in this study consists of 4 scales, where some items were changed:

- The computer perception scale has been adjusted for the needs of study. Some items were revised in favour of more contemporary items.
- MTAS has also been revised in favour of more contemporary items.

The whole questionnaire of 91 items must be tested for internal consistency (for example, using Cronbach's alpha) and test–retest reliability might be run to test if the scale has satisfactory test-retest reliability. This validated tool might be useful to measure student attitudes, perceptions, access to technology outside university when identifying the impact of ICT in student engagement in learning mathematics.

This study investigated one domain of the education system, which can be used for further correlational analysis between the other four dimensions of the framework used in this study to identify the role of ICT in student engagement. Due to practical constraints, this study could not provide a comprehensive review of the online learning management system designed and implemented for this study. Nevertheless, this environment can be analysed further using automatic records collected during this study.

Future research could refine aspects of this topic, if it was to focus on particular factors. Also, more thorough planning of the studies as well as higher levels of communication between the parties involved in the study could provide further insight into this topic.

5.4 Post Study Comments

This study has attempted to provide an in-depth insight into the "Mathematics Problem", as well as investigating a possible solution to this problem, whilst profiling mathematics students to develop a deeper understanding of the relationship between the students' level of engagement in the learning of mathematics with technology, their perceptions surrounding the use of technology in the learning of mathematics and their attitudes towards the use of technology in learning.

To accurately articulate and portray the role that ICT plays in the level of student engagement the conceptual framework was developed, using a comprehensive literature review, regarding the role of ICT in student engagement and achievement, as the basis for it. The study design was based on this conceptual framework. A survey was also developed for this study to collect the relevant data. The self-reported data was used to address the research questions. The sample size of this study consisted of 87 students, randomly allocated into two groups – one group was taught mathematical concepts with ICT and one group was taught mathematical concepts without the use of ICT. The majority of the students who were enrolled in the Foundation Studies program were females, from non-English speaking backgrounds, who also had limited opportunities to further their education.

The idea behind the use of a Learning Management System was to provide students the opportunity to learn mathematics outside of the classroom, at a time and place which is convenient for them, which in theory should have aided the students in achieving better learning outcomes. A range of educational experimental research methods were adopted by this study, including the conducting needs analysis, the identification of the research participants , the design of the questionnaire, the administration of the quantitative survey and various methods of statistical analyses.

Statistical analysis of the data revealed no statistically significant difference between the level of student engagement in students who were taught by the traditional method and the students who were taught by the ICT based modalities.

Others key findings from the statistical analyses:

- The students' perception towards the use of technology is significant predictor of the students' attitudes towards the use of technology in the learning of mathematics.

- The students' demographic factors combined with the students' level of access to technology outside of the university, their perceptions towards the use of technology for learning, confidence with technology, mathematics confidence account for more than 20% of the variation in the students' attitude towards the use of technology.
- The students' demographic factors, such as their gender, age, cultural background and socio-economic status were found to be not significantly related to the students' attitude towards the use of technology in the learning of mathematics.
- The students' level of confidence with technology, mathematics confidence, and their perceptions towards the use of technology for learning, level of access to technology outside of the university did not affect directly students' attitude towards the use of technology in the learning of mathematics.
- Statistically significant relationships exist between students' level of access to technology outside of the university and their achievements.
- Statistically significant relationships exist between students' mathematics confidence and cognitive engagement.
- Statistically significant relationships exist between students' mathematics confidence and behavioural engagement.
- Statistically significant relationships exist between students' affective engagement and gender.
- Statistically significant relationships exist between students' behavioural engagement and gender.
- The use of ICT did not have an impact on the level of student engagement in the learning of mathematics; however there were extenuating circumstances, surrounding the way that ICT was integrated into the classroom, which may have affected this outcome.

The research, despite not investigating causality of the variables, has nevertheless provided some very interesting insights into the attitudes of the students, who were enrolled in the mathematics foundation study program, towards their own use of ICT as well as their engagement in ICT. The empirical component of this study may be further analysed and it may provide a good source of additional information for Foundation Studies teachers to make informed decisions relating to the integrations of ICT in the teaching of mathematics to students who appear to have difficulty engaging in the learning of mathematics.

Using the results, a set of recommendations were developed relating to the current Victoria University curriculum reforms as well as developing recommendations that may assist mathematics teachers in making informed decisions about the integration of technology in the teaching of mathematics. The results of this study emphasized the importance of teachers taking into consideration the students' demographic factors, their previous experience in using computers, their perceptions towards the use of technology in the learning of mathematics and their confidence in mathematics.

The findings of this study demonstrate the many challenges and complexities surrounding the analysis of the factors which have an effect on the level of student engagement in the learning of mathematics with the use of ICT, as well as the analysis of the relationships between the individual factors. The impact of ICT use on student engagement and achievement remains difficult to measure and open to further debate.

The researcher also highlighted directions and justification in further study that may help to open the door to future research.

It is the researcher's hope that the findings may be able to provide useful suggestions, relating to the integration of technology into the learning and teaching of mathematics as well as being a source of additional information for the implementation of the curriculum reforms at Victoria University and other similar institutions.

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Appendix 1 Study referenced Tables

Table 1 Research Questions per Phase

Phase	Research Questions
Phase I	***<u>Research Question 1</u>*** *How are students' demographic factors, such as gender, age, socio-economic status and cultural background related to their attitudes towards the use of technology in learning?* *<u>Hypothesis 1</u>* *Students' attitude towards the use of ICT in learning mathematics are depending on their gender, age, socio-economic status and their English background.* ***<u>Research Question 2</u>*** *To what degree are access to technology and perceptions towards the use of technology related to students' attitude towards the use of technology for learning mathematics ?* *<u>Hypothesis 2</u>* *Students attitudes towards the use of ICT in learning mathematics depends on their access to technology and perceptions towards the use of technology.* ***<u>Research Question 3</u>*** *To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive and achievement in mathematics?* *<u>Hypothesis 3</u>* *Student attitudes towards the use of ICT in learning mathematics depends on their mathematics confidence and confidence with technology.*
	<u>Research Question 3</u> *To what extent are mathematics confidence and confidence with technology related to students' attitude towards learning mathematics with technology, engagement (affective, behavioural and cognitive) and achievement in mathematics?* *<u>Hypothesis 4</u>* *Students engagement in learning mathematics [SE] depends on their mathematics confidence and confidence with technology.* *<u>Hypothesis 5</u>* *Students cognitive engagement in learning mathematics depends on*

Phase II	*their mathematics confidence and confidence with technology.* *Hypothesis 6* *Students affective engagement in learning mathematics depends on their mathematics confidence and confidence with technology.* *Hypothesis 7* *Students behaviour engagement in learning mathematics depends on their mathematics confidence and confidence with technology.* *Hypothesis 8* *Students achievements in mathematics depends on their mathematics confidence and confidence with technology*
Phase III	***Research Question 4*** *Is there a difference in engagement (affective, behavioural and cognitive) and student achievement between students who are taught mathematics with the aid of technology and those who are taught in a traditional way?* *Hypothesis 9* *Students cognitive engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students cognitive engagement in learning mathematics who are taught in a traditional way.* *Hypothesis 10* *Students affective engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students affective engagement in learning mathematics who are taught in a traditional way.* *Hypothesis 11* *Students behavioural engagement in learning mathematics, who are taught mathematics with the aid of technology is different to students behavioural engagement in learning mathematics who are taught in a traditional way.* *Hypothesis 12* *Student achievement in learning mathematics, who are taught mathematics with the aid of technology are different to student achievement in learning mathematics who are taught in a traditional way.*
Phase IV	*What do the research findings in this thesis have to offer the university sector?*

Table 2 Dimensions to consider when evaluating the use of ICT to improve student learning

Dimensions	**Outcomes**
I Students	Through the use of ICT students develop an appropriate level of capability, become more engaged with their own learning, and achieve learning outcomes across the curriculum at a higher level.
II Learning environment Attributes	ICT is used to support pedagogical practices that provide learning environments that are more Learner-centered, Knowledge-centered, Assessment-centered, and Community-centered.
III Teacher professional ICT Attributes	The teacher exploits the characteristics of ICT to support the learning of students by, effectively integrating their use, wherever appropriate, into constructivist learning environments, and contributing to relevant learning communities.
IV School ICT Capacity	The school provides ICT capacity to ensure that all teachers and students have immediate access to all software that is required to support the curriculum and adequate support to implement its use.
V School Environment	That school environment is supportive of teachers and students use of ICT build on a shared, community-based vision that prepares students to learn, work and live successfully in a knowledge-based global society.

Table 3 Information about Mathematics study programs

Intake	Mathematics Unit	Teacher	Duration of participation	Period of participation
1	JCM0110	Teacher 1	12 weeks in Semester 1	18 April 2012 - 11 July 2012
2	JCM0110	Teacher 2	4 weeks in Semester 1	02 July 2012 - 27 July 2012
3	JCM0113	Teacher 1	4 weeks in Semester 3	13 Aug 2012 - 10 Sept 2012

Table 4 Flow of participants throughout the study

	INTAKE 1							INTAKE 2								INTAKE 3							
	JCM0110 (Teacher 1) Semester 1 (18-04-2012 - 11-07-2012)							JCM0110 (Teacher 2) (02-07-2012 - 27-07-2012)								FM JCM0113: (Teacher 1) Semester 2 (13-08-2012 -10-09)							
	Total N: 39, Started- 39 (ICT: 24,TR: 15 Finished - (ICT: 10, TR: 4)							Total N: 26, Started- 16 (ICT: 7, TR: 9) Finished: 16 (ICT: 7, TR: 9)								Total N: 34, Started -34 (ICT: 13, TR: 21) Finished - 34 (ICT: 13, TR: 21)							
	Pre Survey	Post Survey	Consent Form (Record)	Participation	PRE TEST	POST TEST	Moodle usage	Pre Survey	Post Survey	Consent Form (Record)	Participation	PRE TEST	POST TEST	Moodle Account	Moodle usage	Pre Survey	Post Survey	Consent Form (Record)	Participation	PRE TEST	POST TEST	Moodle Account	Moodle usage
TR	15	6	15	15		20			9	6						21		22	22				
ICT	24	9	24	24		24	18		7	9				16	16	13		12	12			12	12
Total	39	15	39	39		44	18	16	11	17	17			16	16	34		34	34			12	12
	Failed: 23, ICT -13, TR-10, Withdrew:1, Away:1							Failed: 8 , Withdrew: 7, Away: 1								Failed: , Withdrew: , Away:							
	Students changed class: 0							Students changed class: 1								Students changed class: 1							

Table 5 Dimensions considered in this study when evaluating the use of ICT

Dimensions	**Outcomes**
Students	Through the use of ICT students become more engaged with their own learning, and achieve learning outcomes across the curriculum at a higher level.
Learning environment Attributes	ICT is used to support pedagogical practices that provide learning environments that are more Learner-centered.
Teacher professional ICT Attributes	The teacher exploits the characteristics of ICT to support the learning of students by integrating their use into constructivist learning environment.
School ICT Capacity	The school provides ICT capacity to ensure that all teachers and students have immediate access to all software that is required to support the curriculum and adequate support to implement its use.
School Environment	That school environment is supportive of teachers and students use of ICT

Table 6 Descriptive summary of the participants' demographic characteristics

Demographic Variable		**All Students**		**Intake 1**		**Intake 2**		**Intake 3**	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Gender	Female	59	68	28	72	15	94	16	50
	Male	28	32	11	28	1	6	16	50
Language	Non-English	51	59	22	56	13	81	16	52
	English	35	41	17	44	3	19	15	48
SES	Low	30	35	15	38	4	25	11	35
	Medium	46	53	21	54	12	75	13	42
	High	10	12	3	8	0	0	7	23
Average Age		19.3		18.36		19.31		20.48	

Table 7 Moodle usage

Variable		**All Students**		**Intake 1**		**Intake 2**		**Intake 3**	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Teaching Method	Traditional	38	44	14	36	4	25	20	62
	ICT	49	56	25	64	12	75	12	38
Average Moodle Use in ICT Group (hrs./month)		27.57		34.59		25.75		16.5	

Table 8 Access to technology (outside university) by gender, language background and socio-economic status

Technology	Total (N=87)			Gender: Female (N=59)			Gender: Male (N=28)			Language: Non-English (N=52)			Language: English (N=35)			Socio-economic Status: Low (N=31)			Socio-economic Status: Medium (N=47)			Socio-economic Status: High (N=11)		
	FA	L A	NA	F	L A	NA	F A	L A	NA	F A	L A	NA	F A	L A	NA	F A	L A	NA	F A	L A	NA	F A	L A	NA
Desktop computer	60	28	12	59	22	19	59	41	0	55	29	16	66	25	9	50	33	17	63	24	13	70	30	0
Portable computer	71	24	5	81	14	5	52	44	4	71	24	5	74	23	3	60	30	10	78	20	2	80	20	0
Tablet PC	29	24	47	31	22	47	26	30	44	27	24	49	31	26	43	30	20	50	28	26	46	30	30	40
MP3/MP4 player	64	14	22	66	10	24	62	19	19	56	16	28	77	9	14	63	10	27	65	13	22	70	20	10
Mobile phone	90	8	2	92	7	1	85	11	4	86	12	2	94	3	3	87	7	6	89	11	0	100	0	0
Memory stick	86	9	5	88	7	5	81	15	4	84	10	6	89	9	2	87	10	3	87	9	4	80	10	10
Video game console	61	18	21	63	13	24	59	26	15	55	20	25	71	14	72	53	27	20	67	11	22	60	20	20
Digital camera	62	24	14	66	24	10	56	26	18	59	29	12	69	17	14	53	30	17	70	20	10	60	30	10
Dial-up internet	23	16	61	29	15	56	11	19	70	21	20	59	26	11	63	13	22	63	30	16	54	20	0	80
Wireless Internet	63	26	11	64	25	11	53	22	25	65	26	9	62	24	14	50	38	12	66	27	7	78	12	10
Average level of access	2.45			2.48			2.40			2.43			2.50			2.39			2.49			2.49		

FA: full access, LA: limited access, NA: no access.

(Note: Access to high-speed Internet represents access to either broadband or wireless Internet)

Table 9 Perceptions towards the use of technology for learning (ICT&TR)

Perceptions ALL-[AT]	Beginning of semester			End of semester		
	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)
I feel confident in using computers/internet	89	11	0	82	16	2
I enjoy using technologies for my studies	63	30	7	73	25	2
I believe that technologies/online help to acquire new knowledge	77	21	2	76	22	2
I believe that technologies/online enhances my learning experience	65	33	2	65	33	2
I believe that convenience is an important feature of technology/online	72	28	0	80	20	0
Technology/online increases the quality of learning because it integrates all forms of media	71	28	1	76	20	4
Adopting learning with technology/online increases student satisfaction	54	38	8	56	35	9
I would be interested in studying courses that use technology/online	47	33	20	38	42	20
Average Perception Score	3.92 (N=86)			3.99 (N=55)		

Table 10 Perceptions towards the use of technology for learning (TR group)

Perceptions TR-[AT]	Beginning of semester			End of semester		
	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)
I feel confident in using computers/internet	87	13	0	81	15	4
I enjoy using technologies for my studies	66	32	3	70	30	0
I believe that technologies/online help to acquire new knowledge	82	18	0	74	26	0
I believe that technologies/online enhances my learning experience	63	37	0	63	37	0
I believe that convenience is an important feature of technology/online	74	26	0	85	15	0
Technology/online increases the quality of learning because it integrates all forms of media	68	29	3	74	22	4
Adopting learning with technology/online increases student satisfaction	55	37	8	56	41	4
I would be interested in studying courses that use technology/online	61	24	16	41	52	7
Average Perception Score		3.96 (N=38)			4.02 (N=27)	

Table 11 Perceptions towards the use of technology for learning (ICT group)

Perceptions ICT- [AT]	Beginning of semester			End of semester		
	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)
I feel confident in using computers/internet	90	10	0	82	18	0
I enjoy using technologies for my studies	61	29	10	75	21	4
I believe that technologies/online help to acquire new knowledge	73	22	4	79	18	4
I believe that technologies/online enhances my learning experience	67	29	4	68	29	0
I believe that convenience is an important feature of technology/online	71	29	0	75	25	0
Technology/online increases the quality of learning because it integrates all forms of media	73	27	0	79	18	4
Adopting learning with technology/online increases student satisfaction	53	39	8	57	29	14
I would be interested in studying courses that use technology/online	37	41	22	36	32	32
Average Perception Score	3.88 (N=48)			3.96 (N=28)		

Table 12 Student attitude towards the use of technology (all respondents)

Student Attitude Towards The Use Of Technology	Beginning of semester			End of semester		
	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)	Agree/Strongly Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)
I am good at using computers	79	21	0	76	22	2
I am good at using things like VCRs, DVDs, MP3s and mobile phones	82	16	2	69	27	4
I can fix a lot of computer problems	32	35	33	44	38	18
I would be more confident of my studies work with a computer to help me	50	43	7	47	35	18
I can master any computer programs needed for studies	44	36	20	46	40	14
I have a mathematical mind	30	38	32	42	38	20
I can get good results in mathematics	49	33	18	60	24	16
I know I can handle difficulties in mathematics	44	40	16	51	36	13
I am confident with mathematics	40	35	25	55	34	11
I have less trouble learning mathematics than other subjects	39	28	43	55	24	21
I like using computers for learning mathematics	28	49	23	27	40	33
I learn more when I use computers in learning mathematics	20	54	26	20	42	38
Using computers in learning mathematics is worth the extra effort	30	40	30	33	42	25
Mathematics is more interesting when using technology	31	47	22	24	46	30
Computer technologies help me learn mathematics better	24	51	25	23	42	35
Average Attitude Score	3.30			3.35		

Table 13 Student attitude towards the use of technology for learning mathematics (TR group)

Student Attitude	Beginning of semester			End of semester		
	Agree/Strongly Agree %	Neutral %	Disagree/Strongly Disagree %	Agree/Strongly Agree %	Neutral %	Disagree/Strongly Disagree %
I am good at using computers	79	21	0	74	22	4
I am good at using things like VCRs, DVDs, MP3s and mobile phones	79	18	3	70	30	0
I can fix a lot of computer problems	32	37	31	44	33	23
I would be more confident of my studies work with a computer to help me	45	50	5	47	41	11
I can master any computer programs needed for studies	42	40	18	45	41	14
I have a mathematical mind	29	40	31	48	44	8
I can get good results in mathematics	58	29	13	74	22	4
I know I can handle difficulties in mathematics	50	34	16	59	33	8
I am confident with mathematics	37	34	19	63	33	4
I have less trouble learning mathematics than other subjects	50	29	21	59	30	11
I like using computers for learning mathematics	21	55	24	33	44	23
I learn more when I use computers in learning mathematics	21	53	26	23	48	29
Using computers in learning mathematics is worth the extra effort	24	46	32	37	52	11
Mathematics is more interesting when using technology	24	53	23	26	56	18
Computer technologies help me learn mathematics better	24	45	31	26	56	18
Average Attitude Score	3.30 N=38			3.49 N=38		

Table 14 Student attitude towards the use of technology for learning mathematics (ICT group)

Student Attitude	Beginning of Semester			End of Semester		
	Agree/Strongly Agree	Neutral	Disagree/Strongly Disagree	Agree/Strongly Agree	Neutral	Disagree/Strongly Disagree
I am good at using computers	80	20	0	79	21	0
I am good at using things like VCRs, DVDs, MP3s and mobile phones	84	14	2	68	25	7
I can fix a lot of computer problems	33	33	34	43	43	14
I would be more confident of my studies work with a computer to help me	55	37	8	46	29	25
I can master any computer programs needed for studies	47	33	20	46	39	15
I have a mathematical mind	30	37	33	36	32	32
I can get good results in mathematics	43	37	19	47	25	28
I know I can handle difficulties in mathematics	39	45	16	43	39	18
I am confident with mathematics	35	35	30	46	36	22
I have less trouble learning mathematics than other subjects	31	26	43	50	18	32
I like using computers for learning mathematics	33	45	22	21	36	43
I learn more when I use computers in learning mathematics	18	55	27	18	36	46
Using computers in learning mathematics is worth the extra effort	34	37	29	28	32	40
Mathematics is more interesting when using technology	39	43	18	21	36	43
Computer technologies help me learn mathematics better	25	55	20	21	29	50
Average Attitude Score	3.29			3.24		

Table 15 Attitude towards the use of technology for learning mathematics in three subscales for all respondents

Student Attitude	Beginning of semester			End of semester		
	All respondents	ICT	TR	All respondents	ICT	TR
Confidence with technology [TC]	3.68	3.68	3.67	3.67	3.62	3.71
Mathematics confidence [MC]	3.20	3.12	3.27	3.47	3.27	3.67
Attitude to learning mathematics with technology [MT]	3.02	3.09	2.95	2.91	2.74	3.08
Average Attitude Score	3.30	3.30	3.30	3.35	3.21	3.49
Average Attitude [SAM]	3.30			3.35		

Table 16 Student attitude towards the use of technology by gender, language background and socio-economic status (PRE)

Student Attitude Towards Technology. Pre	Gender		Language		SES		
	Female (N=59)	Male (N=28)	Non-English (N=52)	English (N=35)	Low (N=31)	Medium (N=47)	High (N=11)
Confidence with technology [TC]	3.62	3.84	3.60	3.82	3.53	3.74	3.90
Mathematics confidence [MC]	2.96	3.64	3.20	3.13	3.21	3.07	3.50
Attitude to learning mathematics with technology [MT]	3.09	2.89	3.14	2.86	2.87	3.07	3.24
Average level of attitude [SAM]	3.22	3.45	3.31	3.27	3.21	3.29	3.56

Table 17 Summary of students' engagement by intake.

Student Engagement [SE]		Intake 1		Intake 2		Intake 3		All respondents	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Cognitive Engagement [CE]	TR	3.22	3.38	3.39	3.63	3.40	3.43	3.31	3.46
	ICT	3.44	3.25	3.47	3.57	3.46	3.35	3.46	3.36
Surface strategy [CES]	TR	3.07	3.36	3.25	3.51	3.11	3.13	3.08	3.18
	ICT	3.29	3.07	3.41	3.29	3.39	3.13	3.35	3.20
Deep strategy [CE]	TR	3.19	2.86	3.35	3.61	3.35	3.39	3.26	3.35
	ICT	3.35	3.14	3.35	3.86	3.60	3.51	3.43	3.40
Reliance [CER]	TR	3.41	3.93	3.55	3.76	3.76	3.77	3.59	3.84
	ICT	3.60	3.51	3.65	3.57	3.39	3.42	3.56	3.46
Affective Engagement [AE]	TR	3.39	3.54	3.38	3.69	3.27	3.22	3.35	3.34
	ICT	3.57	3.42	3.68	3.40	3.21	3.22	3.45	3.36
Interest [AEI]	TR	2.52	2.79	3.07	3.71	3.23	3.28	2.97	3.25
	ICT	2.87	2.98	3.17	2.92	3.71	3.51	3.11	3.32
Achievement [AEA]	TR	4.02	4.33	3.96	3.81	3.93	3.90	4.04	4.03
	ICT	4.17	4.10	4.14	4.17	4.03	3.93	4.08	3.92
Anxiety [AEX]	TR	2.92	4.13	3.83	3.96	3.38	3.09	3.67	3.37
	ICT	4.31	3.78	3.29	4.13	3.13	3.25	3.92	3.57

Continue Table 17

Frustration [AEF]	TR	3.09	2.90	2.67	3.26	2.54	3.62	2.76	2.69
	ICT	3.12	2.94	2.80	3.17	1.97	2.18	2.72	2.73
Behavioural engagement [BE]	TR	3.31	3.67	3.45	3.94	3.48	3.50	3.43	3.64
	ICT	3.41	3.37	3.40	3.65	3.66	3.59	3.47	3.52
Attentiveness [BEA]	TR	3.13	3.46	3.61	4.61	3.33	3.43	3.33	3.57
	ICT	3.08	3.22	3.25	3.64	3.36	3.28	3.30	3.33
Diligence [BED]	TR	3.29	3.88	3.83	4.50	3.63	3.56	3.52	3.71
	ICT	3.20	3.52	3.61	3.67	3.96	3.90	3.63	3.71
Time spent [BT1]	TR	1.25	2.25	2.67	4.00	1.15	1.05	1.55	1.56
	ICT	1.50	2.10	2.67	3.83	1.67	1.83	2.24	2.36
Time spent [BT2]	TR	1.25	2.25	3.00	6.00	3.00	2.80	3.00	3.07
	ICT	3.40	3.60	3.00	6.83	2.42	2.00	4.10	3.35

Table 18 Descriptive analysis (means) of students' engagement (PRE)

Descriptive analysis	Beginning of semester					
	Intake 1		Intake 2		Intake 3	
	ICT	TR	ICT	TR	ICT	TR
Access to technology (outside University) [ET]	2.55	2.55	2.53	2.39	2.19	2.39
Perception towards thy use of technology for learning [AT]	3.88	3.81	3.96	4.46	3.52	3.98
Confidence with technology [TC]	3.88	3.60	3.80	3.80	3.30	3.63
Mathematics confidence [MC]	2.50	3.05	2.80	3.60	3.88	3.76
Attitude learning maths with technology [MT]	3.16	3.40	2.97	3.00	2.92	2.74
Cognitive engagement Surface Strategy [CES]	3.09	3.04	3.26	2.43	3.39	3.11
Cognitive engagement Deep Strategy [CED]	3.01	3.14	3.38	3.14	3.60	3.35
Cognitive engagement Reliance [CER]	3.36	3.21	3.50	3.48	3.39	3.76
Affective engagement Interest [AEI]	2.57	2.50	2.89	3.22	3.71	3.23
Affective engagement Achievement [AEA]	3.67	4.00	4.11	4.39	4.03	3.93
Affective engagement Anxiety [AEX]	4.20	4.00	3.96	4.33	3.13	3.38
Affective engagement Frustration [AEF]	3.12	2.85	2.80	2.47	1.97	2.54
Behavioural engagement Attentiveness [BEA]	3.08	3.13	3.25	3.61	3.36	3.33
Behavioural engagement Diligence [BED]	3.20	3.29	3.61	3.83	3.96	3.63
Time spent on homework on a normal school day [BT1]	1.50	1.25	2.67	2.67	1.67	1.15
Time spent on out-of class mathematics learning on a normal week [BT2]	3.40	1.25	3.00	3.00	2.42	3.00

Table 19 Descriptive analysis (means) of students' engagement (POST)

	End of the semester					
	Intake 1		Intake 2		Intake 3	
	ICT	TR	ICT	TR	ICT	TR
Access to technology (outside University) [ET]	2.69	2.64	2.79	2.64	2.18	2.39
Perception towards thy use of technology for learning [AT]	3.96	4.06	4.46	4.33	3.72	3.96
Confidence with technology [TC]	3.76	3.90	4.40	4.00	3.32	3.63
Mathematics confidence [MC]	2.64	2.95	2.90	3.47	3.98	3.84
Attitude learning maths with technology [MT]	2.22	3.10	3.13	3.67	2.97	3.01
Cognitive engagement Surface Strategy [CES]	3.07	3.36	3.55	3.29	3.13	3.13
Cognitive engagement Deep Strategy [CED]	3.14	2.86	3.62	3.76	3.51	3.39
Cognitive engagement Reliance [CER]	3.51	3.93	3.48	4.19	3.42	3.77
Affective engagement Interest [AEI]	2.98	2.79	3.47	3.67	3.51	3.28
Affective engagement Achievement [AEA]	4.10	4.33	3.58	4.50	3.93	3.90
Affective engagement Anxiety [AEX]	3.78	4.13	3.88	4.25	3.25	3.09
Affective engagement Frustration [AEF]	2.84	2.90	3.17	2.87	2.18	2.62
Behavioural engagement Attentiveness [BEA]	3.22	3.46	3.64	4.61	3.28	3.43
Behavioural engagement Diligence [BED]	3.52	3.88	3.67	4.50	3.90	3.56
Time spent on homework on a normal school day [BT1]	2.10	2.25	3.83	4.00	1.83	1.05
Time spent on out-of class mathematics learning on a normal week [BT2]	3.60	2.25	6.83	6.00	2.00	2.80

Table 20 Students' engagement, perceptions and attitudes (ICT&TR groups)

	ICT-Pre	ICT Post	ICT-Change	TR-Pre	TR-Post	TR-Change
Access to technology (outside University) [ET]	2.44	2.49	0.05	2.46	2.45	-0.01
Perception towards thy use of technology for learning [AT]	3.88	3.96	0.08	3.96	4.02	0.06
Attitude to learning maths [SAM]	3.29	3.24	-0.05	3.30	3.49	0.19
Confidence with technology [TC]	3.68	3.71	0.03	3.67	3.71	0.04
Mathematics confidence [MC]	3.11	3.27	0.16	3.27	3.67	0.40
Attitude learning maths with technology [MT]	3.09	2.74	0.65	2.95	3.10	0.15
Cognitive engagement [CE]	3.46	3.36	-0.10	3.31	3.46	0.15
Cognitive engagement Surface Strategy [CES]	3.35	3.20	-0.15	3.08	3.18	0.10
Cognitive engagement Deep Strategy [CED]	3.43	3.40	-0.03	3.26	3.35	0.10
Cognitive engagement Reliance [CER]	3.56	3.46	-0.10	3.59	3.84	0.25
Affective engagement [AE]	3.45	3.36	-0.09	3.35	3.34	-0.01
Affective engagement Interest [AEI]	3.11	3.32	0.21	2.97	3.25	0.28
Affective engagement Achievement [AEA]	4.08	3.92	-0.16	4.04	4.03	-0.01
Affective engagement Anxiety [AEX]	3.92	3.57	-0.35	3.67	3.37	-0.30
Affective engagement Frustration [AEF]	2.72	2.63	-0.09	2.76	2.69	-0.07
Behavioural engagement Attentiveness [BEA]	3.30	3.33	0.03	3.33	3.57	0.24
Behavioural engagement Diligence [BED]	3.63	3.71	0.08	3.52	3.71	0.19
Behavioural engagement [BE]	3.47	3.52	0.05	3.43	3.64	0.21
Time spent on homework on a normal school day [BT1]	2.24	2.36	0.12	1.55	1.56	0.01
Time spent on out-of class mathematics learning on a normal week [BT2]	4.10	3.35	-0.75	3.00	3.07	0.07

Table 21 Multiple Regression Analysis ANOVA test results

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.968	8	1.246	2.375	.025[b]
	Residual	38.832	74	.525		
	Total	48.800	82			

a. Dependent Variable: Attitude learning maths with technology Pre

b. Predictors: (Constant), Mathematics confidence Pre, LOTE Identifier, Perception using ICT for learning Pre, Age, SES Low High, Access to technology Pre, Gender, Confidence with technology Pre

Table 22 Multiple Regression Analysis Model Summary

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.452[a]	.204	.118	.72440	2.035

a. Predictors: (Constant), Mathematics confidence Pre, LOTE Identifier, Perception using ICT for learning Pre, Age, SES Low High, Access to technology Pre, Gender, Confidence with technology Pre
b. Dependent Variable: Attitude learning maths with technology Pre

Table 23 Multiple Regression Analysis. Summary statistics.

Summary of Multiple Regression Analysis

Variable	**Mean**	**B**	**Std. Error**	**b**	**Sig.**
Coefficient		1.85	0.948		
Gender	0.3	-0.18	0.195	-0.108	0.357
Age	19.33	-0.011	0.027	-0.046	0.685
SES	0.77	0.218	0.174	0.136	0.214
LOTE	0.42	-0.274	0.175	-0.176	0.122
ET	2.46	-0.297	0.274	-0.132	0.282
AT	3.94	0.332	0.148	0.276	0.028
MC	3.15	-0.006	0.088	-0.008	0.943
TC	3.69	0.226	0.148	0.199	0.131

Note. *P <0.05; B=unstandardized regression coefficient;

SEB = Standard error of the coefficient; b = standardized coefficient

Table 24 Multiple Regression Analysis Coefficients

Coefficients[a]													
Model 1		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1.850	.948		1.953	.055	-.038	3.739					
	Gender	-.180	.195	-.108	-.927	.357	-.568	.207	-.151	-.107	-.096	.793	1.261
	Age	-.011	.027	-.046	-.407	.685	-.066	.043	.063	-.047	-.042	.843	1.186
	SES Low High	.218	.174	.136	1.254	.214	-.128	.564	.132	.144	.130	.921	1.086
	LOTE Identifier	-.274	.175	-.176	-1.565	.122	-.622	.075	-.159	-.179	-.162	.848	1.180
	Access to technology Pre	-.297	.274	-.132	-1.083	.282	-.844	.250	.037	-.125	-.112	.722	1.385
	Perception using ICT for learning Pre	.332	.148	.276	2.245	.028	.037	.627	.360	.253	.233	.713	1.403
	Confidence with technology Pre	.226	.148	.199	1.528	.131	-.069	.520	.254	.175	.158	.635	1.574
	Mathematics confidence Pre	-.006	.088	-.008	-.071	.943	-.182	.170	.005	-.008	-.007	.852	1.174

a. Dependent Variable: Attitude learning maths with technology Pre

Table 25 Levene's Test of Equality of Error Variances

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Cognitive engagement Pre	.653	15	61	.819
Affective engagement Pre	.725	15	61	.750
Behavioural engagement Pre	2.218	15	61	.015
Final mark percent	1.208	15	61	.291

Tests the null hypothesis that the error variance of the dependent variable is equal across groups

a. Design: Group2 + Avg_ET_Pre + Avg_AT_Pre + Avg_TC_Pre + Avg_MC_Pre + Avg_MT_Pre + Gender + SES_Low_High + LOTE

Table 26 MANCOVA Test results (RQ-3)

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Group2	Pillai's Trace	.041	.682[b]	4.000	64.000	.607	.041	2.728	.210
	Wilks' Lambda	.959	.682[b]	4.000	64.000	.607	.041	2.728	.210
	Hotelling's Trace	.043	.682[b]	4.000	64.000	.607	.041	2.728	.210
	Roy's Largest Root	.043	.682[b]	4.000	64.000	.607	.041	2.728	.210
Avg_ET_Pre	Pillai's Trace	.073	1.266[b]	4.000	64.000	.293	.073	5.065	.374
	Wilks' Lambda	.927	1.266[b]	4.000	64.000	.293	.073	5.065	.374
	Hotelling's Trace	.079	1.266[b]	4.000	64.000	.293	.073	5.065	.374
	Roy's Largest Root	.079	1.266[b]	4.000	64.000	.293	.073	5.065	.374
Avg_AT_Pre	Pillai's Trace	.106	1.902[b]	4.000	64.000	.121	.106	7.608	.545
	Wilks' Lambda	.894	1.902[b]	4.000	64.000	.121	.106	7.608	.545
	Hotelling's Trace	.119	1.902[b]	4.000	64.000	.121	.106	7.608	.545
	Roy's Largest Root	.119	1.902[b]	4.000	64.000	.121	.106	7.608	.545
Avg_TC_Pre	Pillai's Trace	.029	.470[b]	4.000	64.000	.757	.029	1.881	.154
	Wilks' Lambda	.971	.470[b]	4.000	64.000	.757	.029	1.881	.154
	Hotelling's Trace	.029	.470[b]	4.000	64.000	.757	.029	1.881	.154
	Roy's Largest Root	.029	.470[b]	4.000	64.000	.757	.029	1.881	.154
Avg_MC_Pre	Pillai's Trace	.314	7.324[b]	4.000	64.000	.000	.314	29.298	.994
	Wilks' Lambda	.686	7.324[b]	4.000	64.000	.000	.314	29.298	.994
	Hotelling's Trace	.458	7.324[b]	4.000	64.000	.000	.314	29.298	.994
	Roy's Largest Root	.458	7.324[b]	4.000	64.000	.000	.314	29.298	.994
Avg_MT_Pre	Pillai's Trace	.105	1.871[b]	4.000	64.000	.126	.105	7.482	.537
	Wilks' Lambda	.895	1.871[b]	4.000	64.000	.126	.105	7.482	.537
	Hotelling's Trace	.117	1.871[b]	4.000	64.000	.126	.105	7.482	.537
	Roy's Largest Root	.117	1.871[b]	4.000	64.000	.126	.105	7.482	.537
Gender	Pillai's Trace	.249	5.310[b]	4.000	64.000	.001	.249	21.242	.962
	Wilks' Lambda	.751	5.310[b]	4.000	64.000	.001	.249	21.242	.962
	Hotelling's Trace	.332	5.310[b]	4.000	64.000	.001	.249	21.242	.962
	Roy's Largest Root	.332	5.310[b]	4.000	64.000	.001	.249	21.242	.962
SES_Low_High	Pillai's Trace	.027	.437[b]	4.000	64.000	.781	.027	1.750	.146
	Wilks' Lambda	.973	.437[b]	4.000	64.000	.781	.027	1.750	.146
	Hotelling's Trace	.027	.437[b]	4.000	64.000	.781	.027	1.750	.146
	Roy's Largest Root	.027	.437[b]	4.000	64.000	.781	.027	1.750	.146
LOTE	Pillai's Trace	.009	.151[b]	4.000	64.000	.962	.009	.605	.080
	Wilks' Lambda	.991	.151[b]	4.000	64.000	.962	.009	.605	.080
	Hotelling's Trace	.009	.151[b]	4.000	64.000	.962	.009	.605	.080
	Roy's Largest Root	.009	.151[b]	4.000	64.000	.962	.009	.605	.080

a. Design: Group2 + Avg_ET_Pre + Avg_AT_Pre + Avg_TC_Pre + Avg_MC_Pre + Avg_MT_Pre + Gender + SES_Low_High + LOTE
b. Exact statistic

c. Computed using alpha = .05

Table 27 MANCOVA Test of Between-Subjects Effect (RQ-3)

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[e]
Model	Cognitive engagement Pre	881.115[a]	10	88.112	470.008	.000	.986	4700.080	1.000
	Affective engagement Pre	889.796[b]	10	88.980	633.075	.000	.990	6330.755	1.000
	Behaviour engagement Pre	921.165[c]	10	92.116	334.837	.000	.980	3348.375	1.000
	Final mark percent	86579.569[d]	10	8657.957	13.988	.000	.676	139.882	1.000
Group2	Cognitive engagement Pre	.196	1	.196	1.043	.311	.015	1.043	.172
	Affective engagement Pre	.030	1	.030	.211	.648	.003	.211	.074
	Behaviour engagement Pre	.043	1	.043	.158	.692	.002	.158	.068
	Final mark percent	1278.139	1	1278.139	2.065	.155	.030	2.065	.294
Avg_ET_Pre	Cognitive engagement Pre	.009	1	.009	.045	.832	.001	.045	.055
	Affective engagement Pre	.067	1	.067	.474	.493	.007	.474	.104
	Behaviour engagement Pre	.017	1	.017	.062	.804	.001	.062	.057
	Final mark percent	2460.036	1	2460.036	3.975	.050	.056	3.975	.502
Avg_AT_Pre	Cognitive engagement Pre	.017	1	.017	.088	.767	.001	.088	.060
	Affective engagement Pre	.154	1	.154	1.099	.298	.016	1.099	.178
	Behaviour engagement Pre	.244	1	.244	.888	.350	.013	.888	.153
	Final mark percent	1530.420	1	1530.420	2.473	.121	.036	2.473	.341
Avg_TC_Pre	Cognitive engagement Pre	.156	1	.156	.833	.365	.012	.833	.147
	Affective engagement Pre	.061	1	.061	.433	.513	.006	.433	.099
	Behaviour engagement Pre	.042	1	.042	.152	.698	.002	.152	.067
	Final mark percent	472.128	1	472.128	.763	.386	.011	.763	.138
Avg_MC_Pre	Cognitive engagement Pre	2.197	1	2.197	11.719	.001	.149	11.719	.921
	Affective engagement Pre	.030	1	.030	.213	.646	.003	.213	.074
	Behaviour engagement Pre	5.501	1	5.501	19.997	.000	.230	19.997	.993
	Final mark percent	3858.964	1	3858.964	6.235	.015	.085	6.235	.692
Avg_MT_Pre	Cognitive engagement Pre	.930	1	.930	4.959	.029	.069	4.959	.593
	Affective engagement Pre	.484	1	.484	3.443	.068	.049	3.443	.448
	Behaviour engagement Pre	1.295	1	1.295	4.709	.034	.066	4.709	.571
	Final mark percent	150.987	1	150.987	.244	.623	.004	.244	.078
Gender	Cognitive engagement Pre	.000	1	.000	.002	.961	.000	.002	.050
	Affective engagement Pre	.972	1	.972	6.918	.011	.094	6.918	.736
	Behaviour engagement Pre	1.781	1	1.781	6.474	.013	.088	6.474	.708
	Final mark percent	433.977	1	433.977	.701	.405	.010	.701	.131
SES_Low_High	Cognitive engagement Pre	.180	1	.180	.960	.331	.014	.960	.162
	Affective engagement Pre	.035	1	.035	.251	.618	.004	.251	.078
	Behaviour engagement Pre	.009	1	.009	.033	.857	.000	.033	.054
	Final mark percent	6.994	1	6.994	.011	.916	.000	.011	.051
LOTE	Cognitive engagement Pre	.001	1	.001	.004	.947	.000	.004	.050
	Affective engagement Pre	.029	1	.029	.207	.651	.003	.207	.073
	Behaviour engagement Pre	.069	1	.069	.252	.617	.004	.252	.079
	Final mark percent	77.954	1	77.954	.126	.724	.002	.126	.064
Error	Cognitive engagement Pre	12.560	67	.187					
	Affective engagement Pre	9.417	67	.141					
	Behaviour engagement Pre	18.432	67	.275					
	Final mark percent	41469.431	67	618.947					
Total	Cognitive engagement Pre	893.676	77						
	Affective engagement Pre	899.213	77						
	Behaviour engagement Pre	939.597	77						
	Final mark percent	128049.000	77						

a. R Squared = .986 (Adjusted R Squared = .984)

b. R Squared = .990 (Adjusted R Squared = .988)

c. R Squared = .980 (Adjusted R Squared = .977)

d. R Squared = .676 (Adjusted R Squared = .628)

e. Computed using alpha = .05

Table 28 MANOVA Test results (RQ-4, Intake - 1)

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[d]
Group2	Pillai's Trace	.495	.439	6.000	8.000	.834	.248	2.633	.114
	Wilks' Lambda	.521	.385[b]	6.000	6.000	.865	.278	2.309	.096
	Hotelling's Trace	.886	.295	6.000	4.000	.911	.307	1.772	.076
	Roy's Largest Root	.848	1.131[c]	3.000	4.000	.437	.459	3.393	.151
Avg_ET_Pre	Pillai's Trace	.671	2.035[b]	3.000	3.000	.287	.671	6.106	.194
	Wilks' Lambda	.329	2.035[b]	3.000	3.000	.287	.671	6.106	.194
	Hotelling's Trace	2.035	2.035[b]	3.000	3.000	.287	.671	6.106	.194
	Roy's Largest Root	2.035	2.035[b]	3.000	3.000	.287	.671	6.106	.194
Avg_AT_Pre	Pillai's Trace	.332	.496[b]	3.000	3.000	.710	.332	1.489	.084
	Wilks' Lambda	.668	.496[b]	3.000	3.000	.710	.332	1.489	.084
	Hotelling's Trace	.496	.496[b]	3.000	3.000	.710	.332	1.489	.084
	Roy's Largest Root	.496	.496[b]	3.000	3.000	.710	.332	1.489	.084
Avg_TC_Pre	Pillai's Trace	.497	.989[b]	3.000	3.000	.503	.497	2.968	.119
	Wilks' Lambda	.503	.989[b]	3.000	3.000	.503	.497	2.968	.119
	Hotelling's Trace	.989	.989[b]	3.000	3.000	.503	.497	2.968	.119
	Roy's Largest Root	.989	.989[b]	3.000	3.000	.503	.497	2.968	.119
Avg_MC_Pre	Pillai's Trace	.273	.376[b]	3.000	3.000	.779	.273	1.128	.075
	Wilks' Lambda	.727	.376[b]	3.000	3.000	.779	.273	1.128	.075
	Hotelling's Trace	.376	.376[b]	3.000	3.000	.779	.273	1.128	.075
	Roy's Largest Root	.376	.376[b]	3.000	3.000	.779	.273	1.128	.075
Avg_MT_Pre	Pillai's Trace	.562	1.282[b]	3.000	3.000	.421	.562	3.847	.140
	Wilks' Lambda	.438	1.282[b]	3.000	3.000	.421	.562	3.847	.140
	Hotelling's Trace	1.282	1.282[b]	3.000	3.000	.421	.562	3.847	.140
	Roy's Largest Root	1.282	1.282[b]	3.000	3.000	.421	.562	3.847	.140

a. Design: Group2 + Avg_ET_Pre + Avg_AT_Pre + Avg_TC_Pre + Avg_MC_Pre + Avg_MT_Pre

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Computed using alpha = .05

Table 29 MANOVA Test of Between-Subjects Effect (RQ-4, Intake - 1)

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[e]
Model	Final mark percent	11025.836[a]	10	1102.584	.893	.600	.691	8.929	.139
	CE_change	.836[b]	10	.084	1.195	.468	.749	11.948	.173
	AE_change	.799[c]	10	.080	.446	.863	.527	4.464	.092
	BE_change	3.916[d]	10	.392	4.408	.083	.917	44.077	.527
Group2	Final mark percent	55.723	1	55.723	.045	.842	.011	.045	.053
	CE_change	.035	1	.035	.497	.520	.110	.497	.086
	AE_change	.008	1	.008	.046	.841	.011	.046	.053
	BE_change	.172	1	.172	1.941	.236	.327	1.941	.191
Avg_ET_Pre	Final mark percent	53.271	1	53.271	.043	.846	.011	.043	.053
	CE_change	.053	1	.053	.751	.435	.158	.751	.104
	AE_change	.073	1	.073	.406	.559	.092	.406	.079
	BE_change	.765	1	.765	8.610	.043	.683	8.610	.601
Avg_AT_Pre	Final mark percent	313.394	1	313.394	.254	.641	.060	.254	.068
	CE_change	.142	1	.142	2.034	.227	.337	2.034	.198
	AE_change	.100	1	.100	.556	.497	.122	.556	.090
	BE_change	.241	1	.241	2.712	.175	.404	2.712	.247
Avg_TC_Pre	Final mark percent	46.668	1	46.668	.038	.855	.009	.038	.053
	CE_change	.016	1	.016	.234	.654	.055	.234	.067
	AE_change	.216	1	.216	1.209	.333	.232	1.209	.138
	BE_change	.160	1	.160	1.801	.251	.310	1.801	.181
Avg_MC_Pre	Final mark percent	39.513	1	39.513	.032	.867	.008	.032	.052
	CE_change	.023	1	.023	.327	.598	.076	.327	.073
	AE_change	.054	1	.054	.303	.611	.070	.303	.072
	BE_change	.088	1	.088	.986	.377	.198	.986	.121
Avg_MT_Pre	Final mark percent	813.796	1	813.796	.659	.462	.141	.659	.097
	CE_change	1.242E-005	1	1.242E-005	.000	.990	.000	.000	.050
	AE_change	.089	1	.089	.500	.519	.111	.500	.086
	BE_change	.277	1	.277	3.118	.152	.438	3.118	.275
Gender	Final mark percent	175.152	1	175.152	.142	.726	.034	.142	.060
	CE_change	.023	1	.023	.332	.595	.077	.332	.074
	AE_change	.129	1	.129	.720	.444	.153	.720	.102
	BE_change	.009	1	.009	.099	.769	.024	.099	.057
SES_Low_High	Final mark percent	23.386	1	23.386	.019	.897	.005	.019	.051
	CE_change	.050	1	.050	.712	.446	.151	.712	.101
	AE_change	.026	1	.026	.147	.721	.035	.147	.060
	BE_change	.257	1	.257	2.896	.164	.420	2.896	.260
LOTE	Final mark percent	98.411	1	98.411	.080	.792	.020	.080	.056
	CE_change	.125	1	.125	1.784	.253	.308	1.784	.180
	AE_change	.328	1	.328	1.832	.247	.314	1.832	.183
	BE_change	.011	1	.011	.123	.743	.030	.123	.059
Error	Final mark percent	4939.164	4	1234.791					
	CE_change	.280	4	.070					
	AE_change	.716	4	.179					
	BE_change	.355	4	.089					
Total	Final mark percent	15965.000	14						
	CE_change	1.116	14						
	AE_change	1.515	14						
	BE_change	4.271	14						

a. R Squared = .691 (Adjusted R Squared = -.083)

b. R Squared = .749 (Adjusted R Squared = .122)

c. R Squared = .527 (Adjusted R Squared = -.654)

d. R Squared = .917 (Adjusted R Squared = .709)

e. Computed using alpha = .05

Table 30 MANOVA Test results (RQ-4, Intake - 3)

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Group2	Pillai's Trace	.126	.613[b]	4.000	17.000	.659	.126	2.451	.164
	Wilks' Lambda	.874	.613[b]	4.000	17.000	.659	.126	2.451	.164
	Hotelling's Trace	.144	.613[b]	4.000	17.000	.659	.126	2.451	.164
	Roy's Largest Root	.144	.613[b]	4.000	17.000	.659	.126	2.451	.164
Avg_ET_Pre	Pillai's Trace	.214	1.159[b]	4.000	17.000	.363	.214	4.637	.286
	Wilks' Lambda	.786	1.159[b]	4.000	17.000	.363	.214	4.637	.286
	Hotelling's Trace	.273	1.159[b]	4.000	17.000	.363	.214	4.637	.286
	Roy's Largest Root	.273	1.159[b]	4.000	17.000	.363	.214	4.637	.286
Avg_AT_Pre	Pillai's Trace	.196	1.038[b]	4.000	17.000	.417	.196	4.151	.258
	Wilks' Lambda	.804	1.038[b]	4.000	17.000	.417	.196	4.151	.258
	Hotelling's Trace	.244	1.038[b]	4.000	17.000	.417	.196	4.151	.258
	Roy's Largest Root	.244	1.038[b]	4.000	17.000	.417	.196	4.151	.258
Avg_TC_Pre	Pillai's Trace	.206	1.104[b]	4.000	17.000	.387	.206	4.417	.274
	Wilks' Lambda	.794	1.104[b]	4.000	17.000	.387	.206	4.417	.274
	Hotelling's Trace	.260	1.104[b]	4.000	17.000	.387	.206	4.417	.274
	Roy's Largest Root	.260	1.104[b]	4.000	17.000	.387	.206	4.417	.274
Avg_MC_Pre	Pillai's Trace	.246	1.388[b]	4.000	17.000	.280	.246	5.552	.340
	Wilks' Lambda	.754	1.388[b]	4.000	17.000	.280	.246	5.552	.340
	Hotelling's Trace	.327	1.388[b]	4.000	17.000	.280	.246	5.552	.340
	Roy's Largest Root	.327	1.388[b]	4.000	17.000	.280	.246	5.552	.340
Avg_MT_Pre	Pillai's Trace	.177	.916[b]	4.000	17.000	.477	.177	3.663	.230
	Wilks' Lambda	.823	.916[b]	4.000	17.000	.477	.177	3.663	.230
	Hotelling's Trace	.215	.916[b]	4.000	17.000	.477	.177	3.663	.230
	Roy's Largest Root	.215	.916[b]	4.000	17.000	.477	.177	3.663	.230
Gender	Pillai's Trace	.202	1.075[b]	4.000	17.000	.399	.202	4.300	.267
	Wilks' Lambda	.798	1.075[b]	4.000	17.000	.399	.202	4.300	.267
	Hotelling's Trace	.253	1.075[b]	4.000	17.000	.399	.202	4.300	.267
	Roy's Largest Root	.253	1.075[b]	4.000	17.000	.399	.202	4.300	.267
SES_Low_High	Pillai's Trace	.101	.476[b]	4.000	17.000	.753	.101	1.905	.135
	Wilks' Lambda	.899	.476[b]	4.000	17.000	.753	.101	1.905	.135
	Hotelling's Trace	.112	.476[b]	4.000	17.000	.753	.101	1.905	.135
	Roy's Largest Root	.112	.476[b]	4.000	17.000	.753	.101	1.905	.135
LOTE	Pillai's Trace	.150	.749[b]	4.000	17.000	.572	.150	2.997	.193
	Wilks' Lambda	.850	.749[b]	4.000	17.000	.572	.150	2.997	.193
	Hotelling's Trace	.176	.749[b]	4.000	17.000	.572	.150	2.997	.193
	Roy's Largest Root	.176	.749[b]	4.000	17.000	.572	.150	2.997	.193

a. Design: Group2 + Avg_ET_Pre + Avg_AT_Pre + Avg_TC_Pre + Avg_MC_Pre + Avg_MT_Pre + Gender + SES_Low_High + LOTE

b. Exact statistic

c. Computed using alpha = .05

Table 31 MANOVA Test of Between-Subjects Effect (RQ-4, Intake - 3)

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[e]
Model	Final mark percent	81303.153[a]	10	8130.315	14.290	.000	.877	142.902	1.000
	CE_change	.913[b]	10	.091	1.400	.250	.412	13.996	.511
	AE_change	.869[c]	10	.087	.862	.581	.301	8.616	.313
	BE_change	.696[d]	10	.070	.495	.874	.198	4.949	.183
Group2	Final mark percent	593.417	1	593.417	1.043	.319	.050	1.043	.163
	CE_change	.045	1	.045	.684	.418	.033	.684	.124
	AE_change	.060	1	.060	.592	.451	.029	.592	.113
	BE_change	.081	1	.081	.574	.458	.028	.574	.111
Avg_ET_Pre	Final mark percent	742.029	1	742.029	1.304	.267	.061	1.304	.193
	CE_change	.027	1	.027	.407	.531	.020	.407	.093
	AE_change	.098	1	.098	.968	.337	.046	.968	.155
	BE_change	.129	1	.129	.920	.349	.044	.920	.150
Avg_AT_Pre	Final mark percent	834.119	1	834.119	1.466	.240	.068	1.466	.211
	CE_change	.031	1	.031	.476	.498	.023	.476	.101
	AE_change	.108	1	.108	1.074	.312	.051	1.074	.167
	BE_change	.389	1	.389	2.769	.112	.122	2.769	.354
Avg_TC_Pre	Final mark percent	238.622	1	238.622	.419	.525	.021	.419	.095
	CE_change	.234	1	.234	3.585	.073	.152	3.585	.437
	AE_change	.188	1	.188	1.862	.188	.085	1.862	.255
	BE_change	.089	1	.089	.630	.437	.031	.630	.118
Avg_MC_Pre	Final mark percent	141.173	1	141.173	.248	.624	.012	.248	.076
	CE_change	.274	1	.274	4.202	.054	.174	4.202	.496
	AE_change	.018	1	.018	.176	.679	.009	.176	.069
	BE_change	.275	1	.275	1.956	.177	.089	1.956	.265
Avg_MT_Pre	Final mark percent	13.964	1	13.964	.025	.877	.001	.025	.053
	CE_change	.243	1	.243	3.731	.068	.157	3.731	.452
	AE_change	.000	1	.000	.004	.948	.000	.004	.050
	BE_change	.078	1	.078	.555	.465	.027	.555	.109
Gender	Final mark percent	8.611	1	8.611	.015	.903	.001	.015	.052
	CE_change	.289	1	.289	4.428	.048	.181	4.428	.517
	AE_change	.007	1	.007	.065	.802	.003	.065	.057
	BE_change	.093	1	.093	.662	.425	.032	.662	.121
SES_Low_High	Final mark percent	178.144	1	178.144	.313	.582	.015	.313	.083
	CE_change	.114	1	.114	1.740	.202	.080	1.740	.241
	AE_change	.019	1	.019	.190	.667	.009	.190	.070
	BE_change	.017	1	.017	.118	.735	.006	.118	.062
LOTE	Final mark percent	200.607	1	200.607	.353	.559	.017	.353	.087
	CE_change	.118	1	.118	1.809	.194	.083	1.809	.249
	AE_change	.109	1	.109	1.083	.310	.051	1.083	.168
	BE_change	.101	1	.101	.715	.408	.035	.715	.127
Error	Final mark percent	11378.847	20	568.942					
	CE_change	1.305	20	.065					
	AE_change	2.018	20	.101					
	BE_change	2.811	20	.141					
Total	Final mark percent	92682.000	30						
	CE_change	2.218	30						
	AE_change	2.887	30						
	BE_change	3.507	30						

a. R Squared = .877 (Adjusted R Squared = .816)

b. R Squared = .412 (Adjusted R Squared = .118)

c. R Squared = .301 (Adjusted R Squared = -.048)

d. R Squared = .198 (Adjusted R Squared = -.202)

e. Computed using alpha = .05

Appendix 2 Study referenced Figures

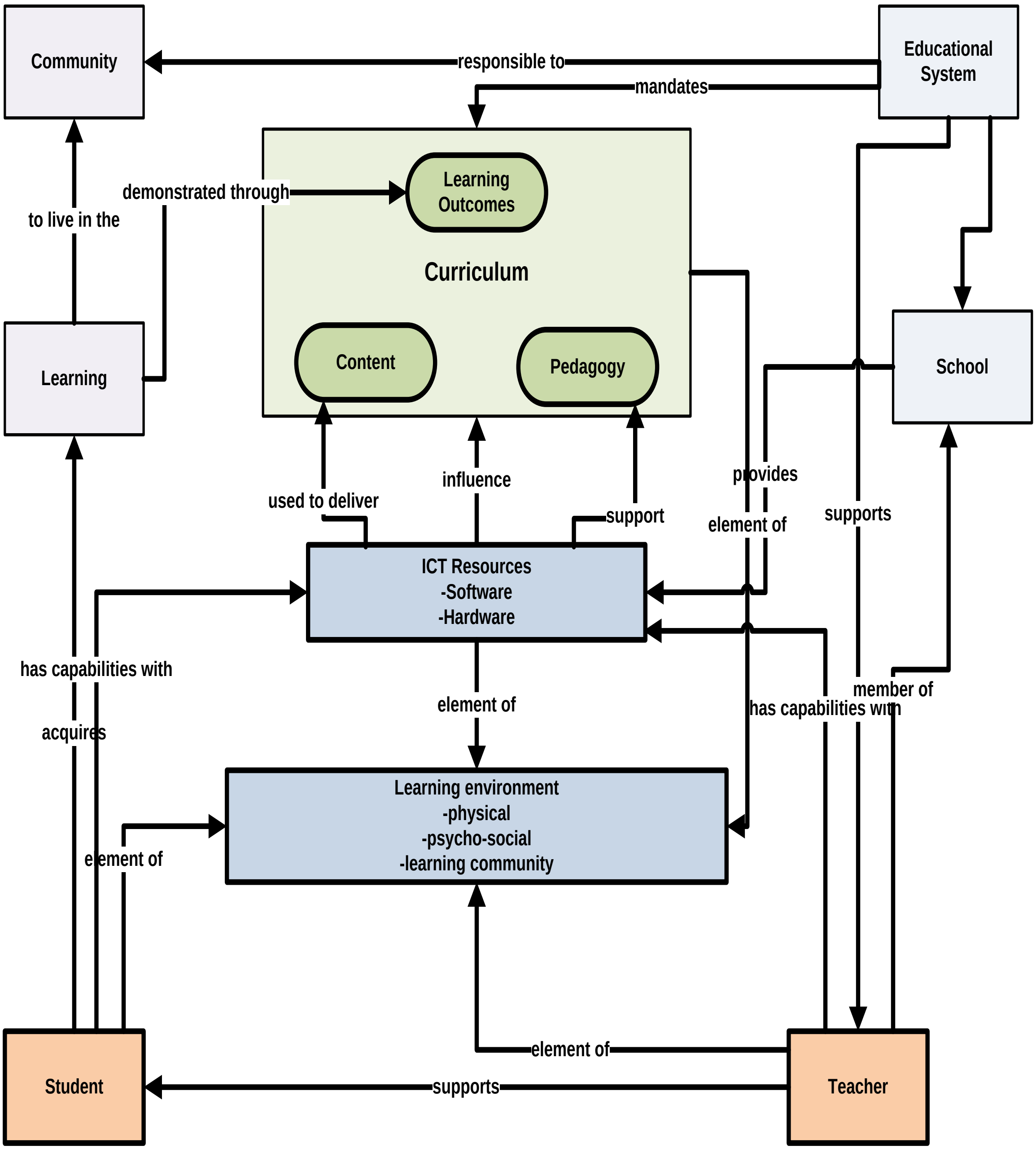

Figure 1 Theoretical Framework to articulate the Impact of ICT on Learning

Adapted from Newhouse, C.P., (2002). The IMPACT of ICT on LEARNING and TEACHING.

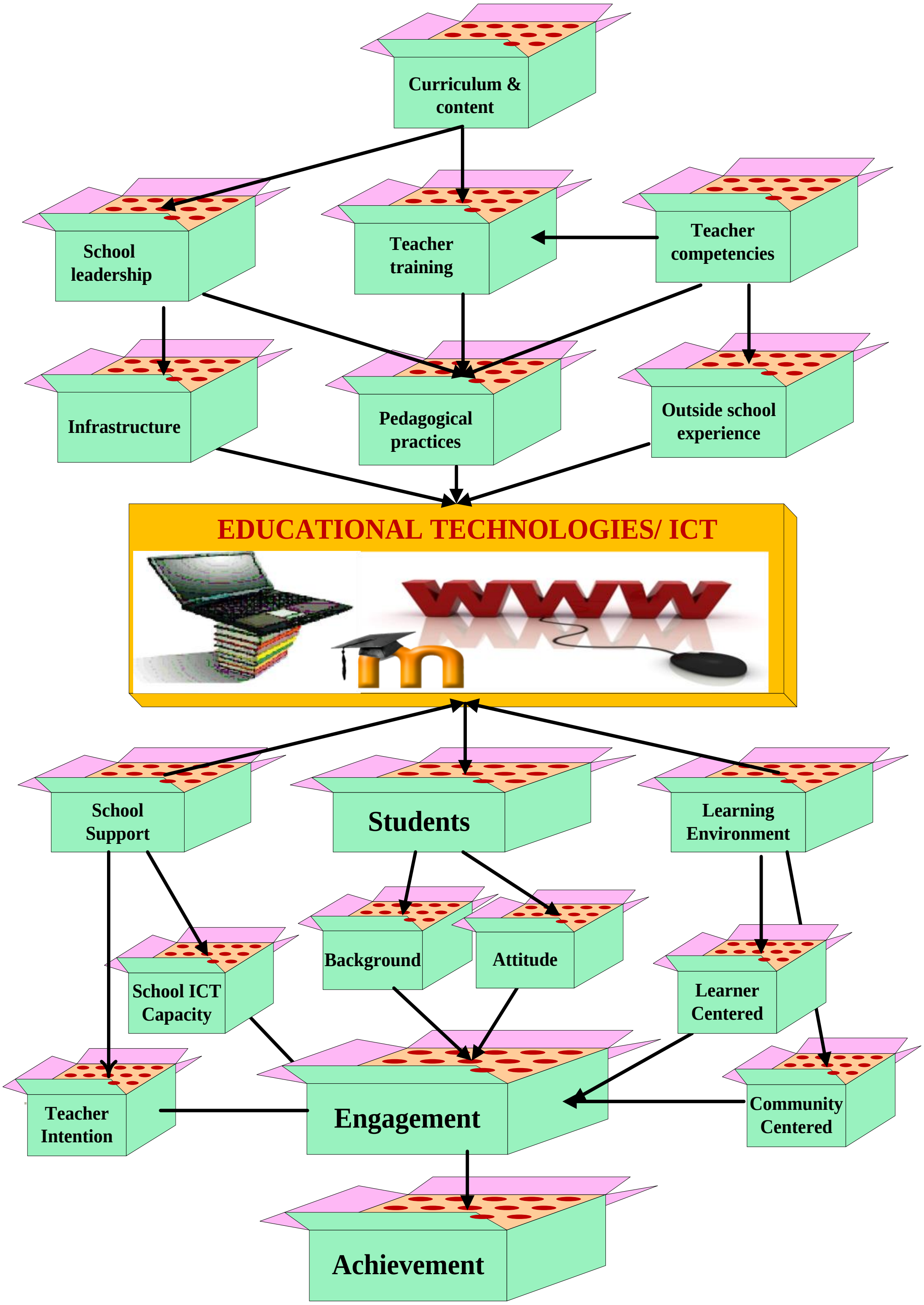

Figure 2 Conceptual Framework for this study

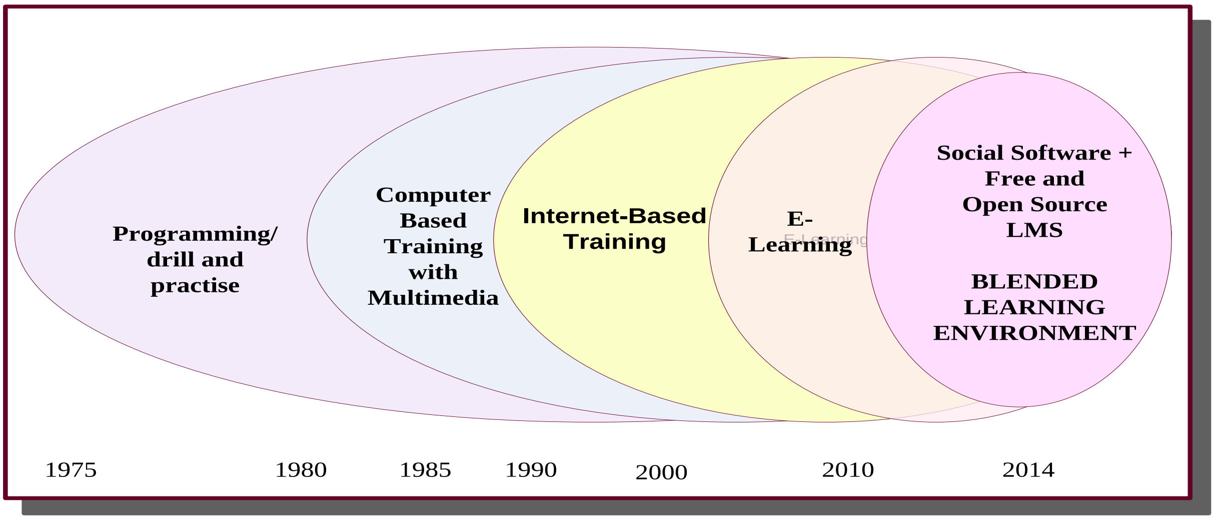

Figure 3 Evolution of ICT.

Adapted from Poss (2012).

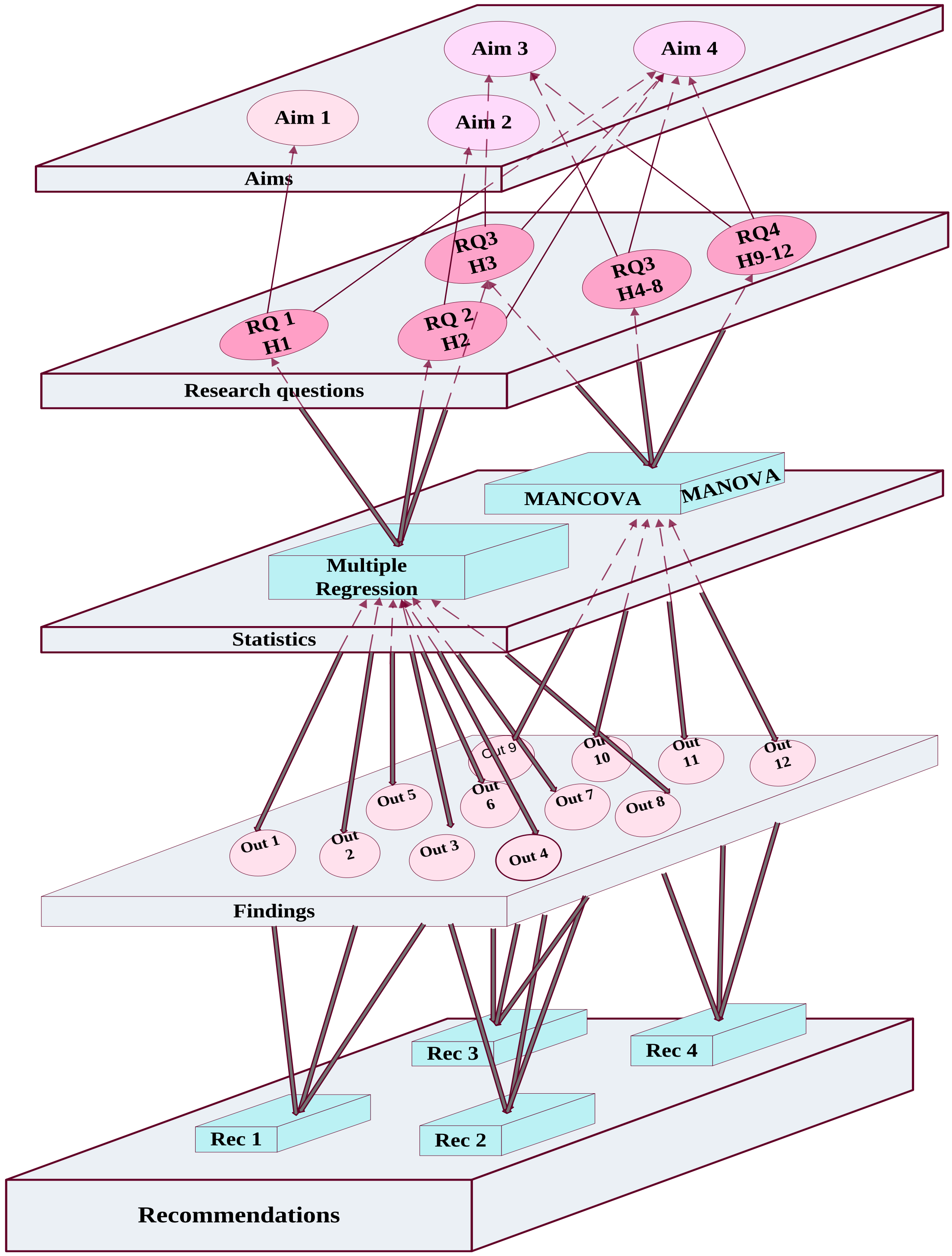

Figure 4. Methodological considerations of Data Analysis

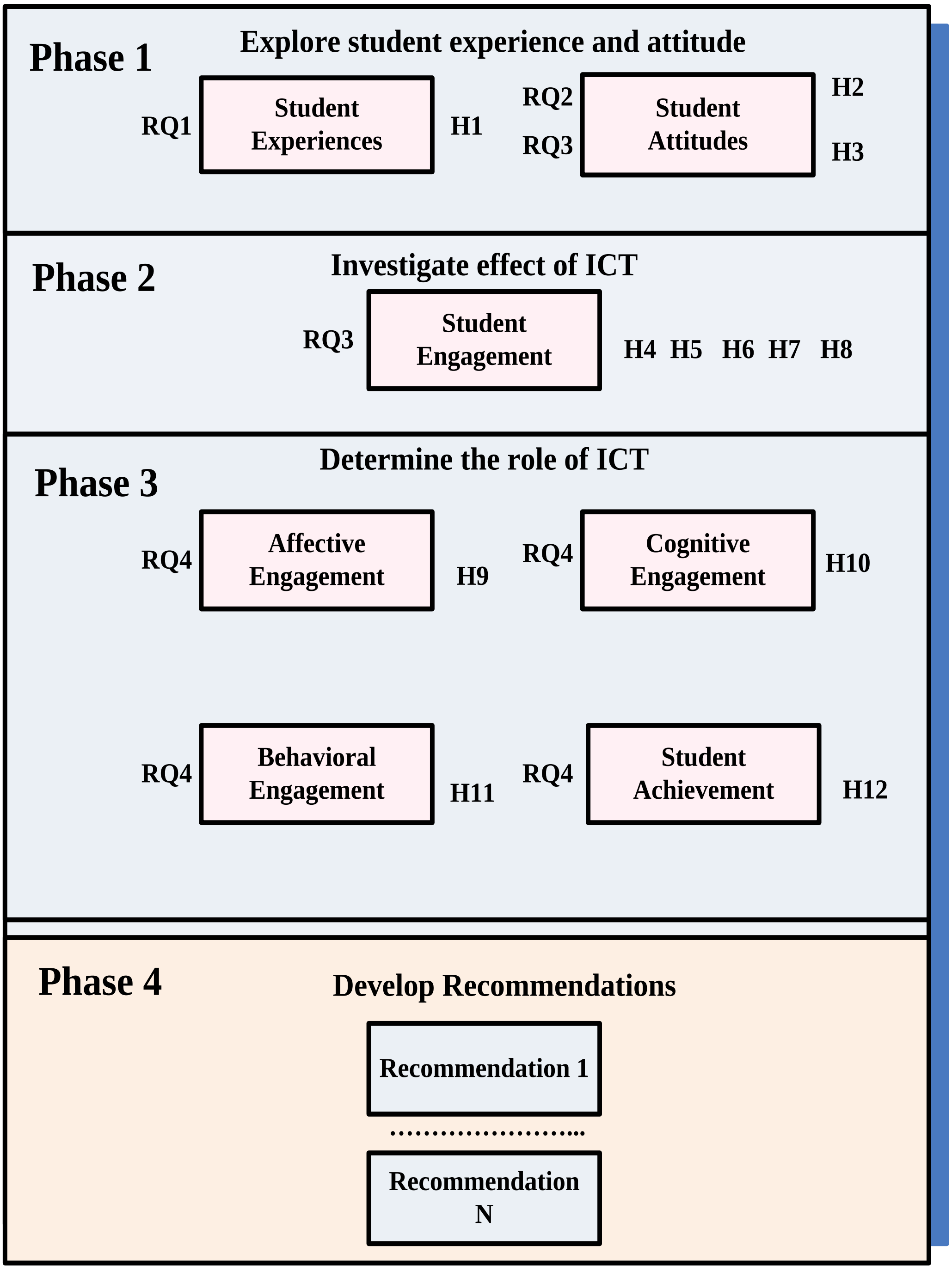

Figure 5 Pictorial Illustration of the Four-Phase Study Design

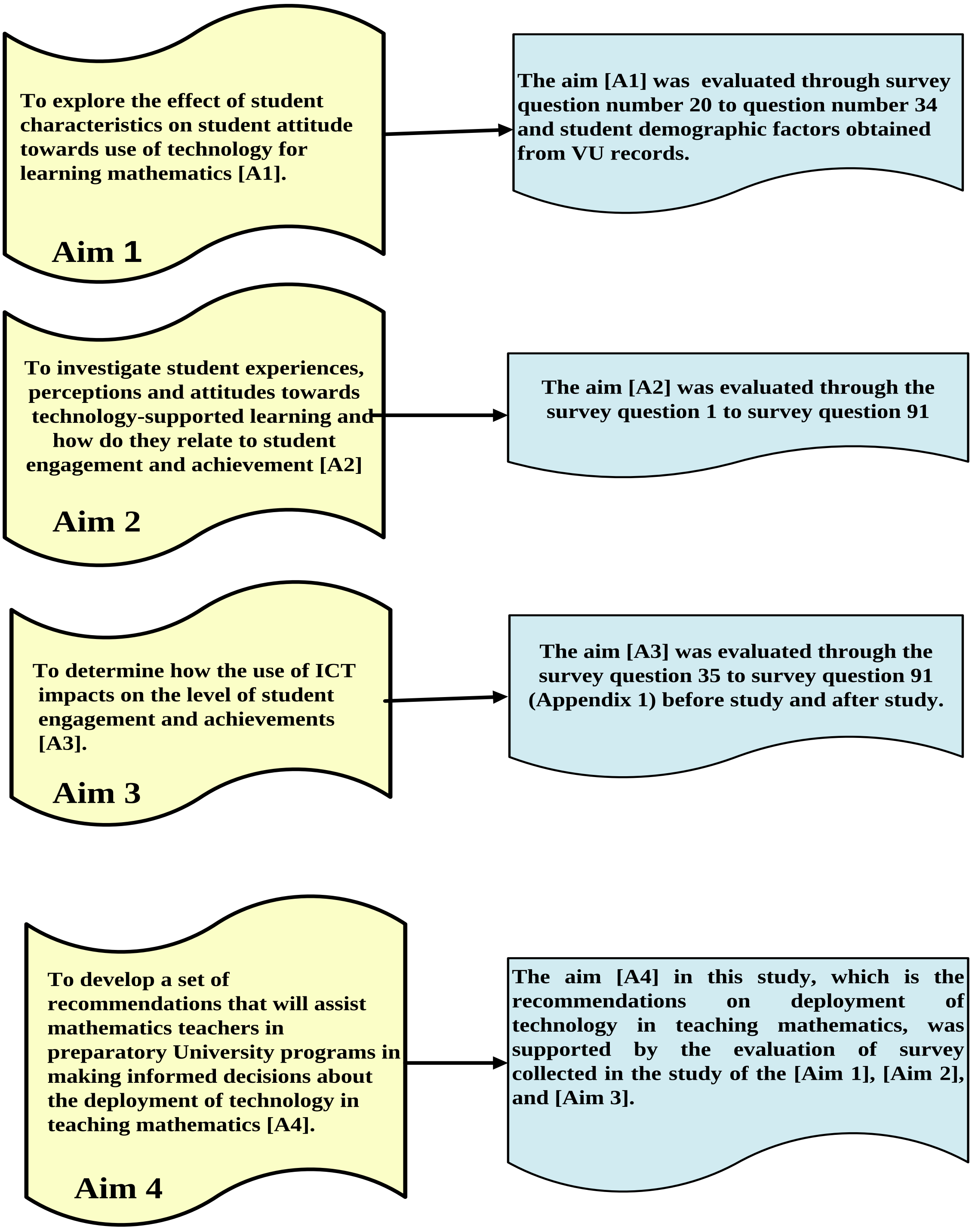

Figure 6 Structural interpretation of study Aims and Meta data evaluation

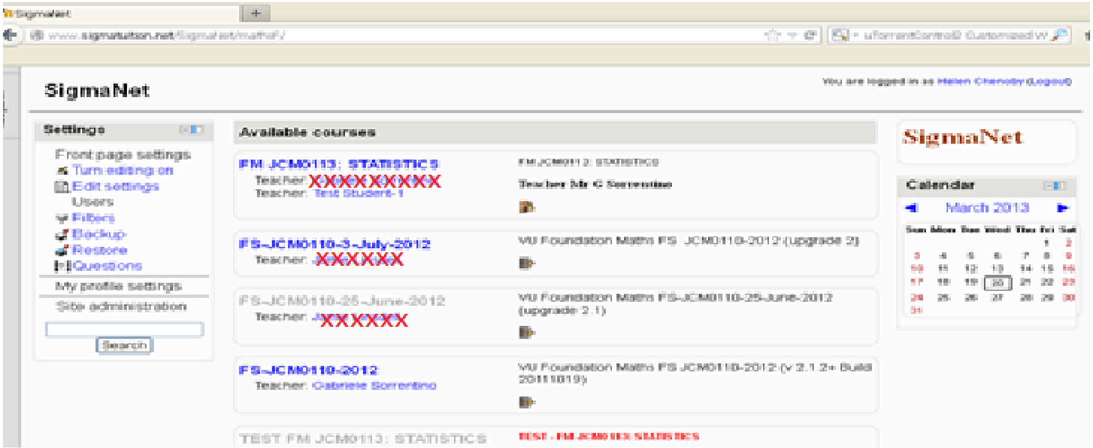

Figure 7 Custom Designed Courses Front page (Moodle 2.4)

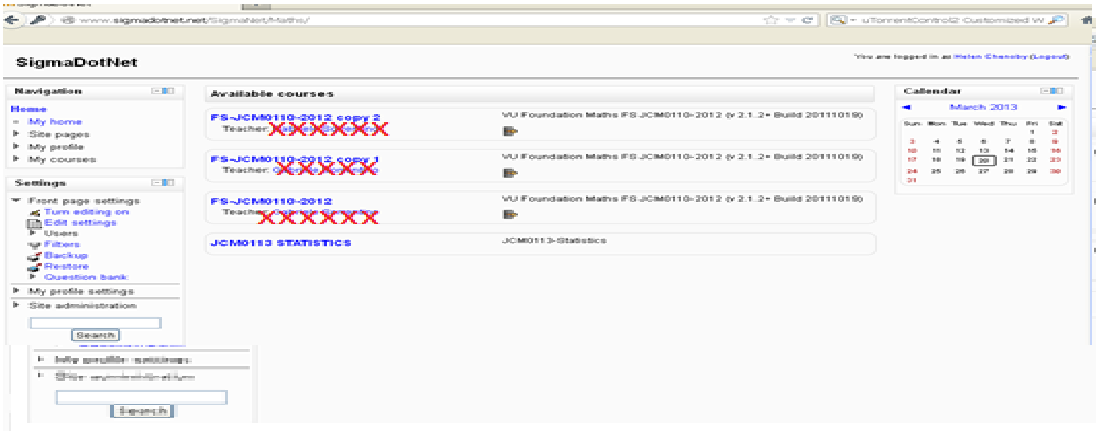

Figure 8 Courses Home Page Designed in Moodle v 1.9

Figure 9 Courses activities

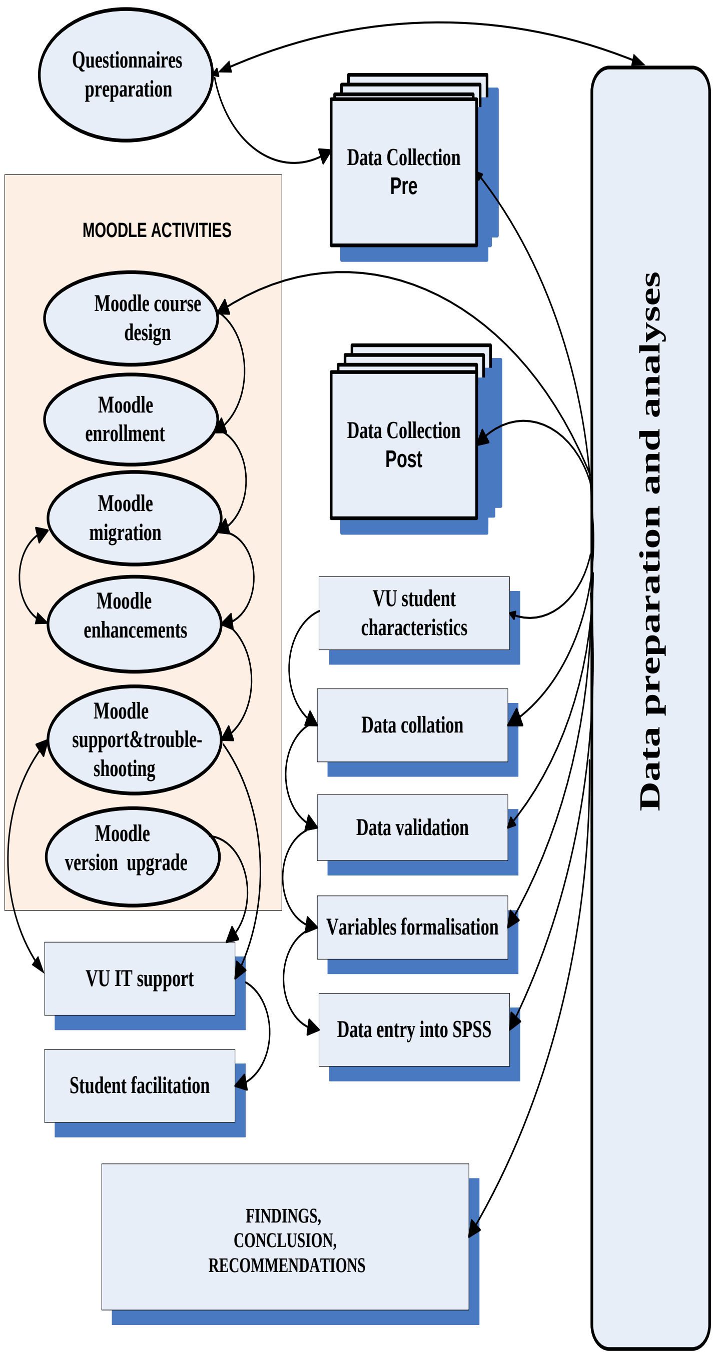

Figure 10 Data collection process and preparation for analysis

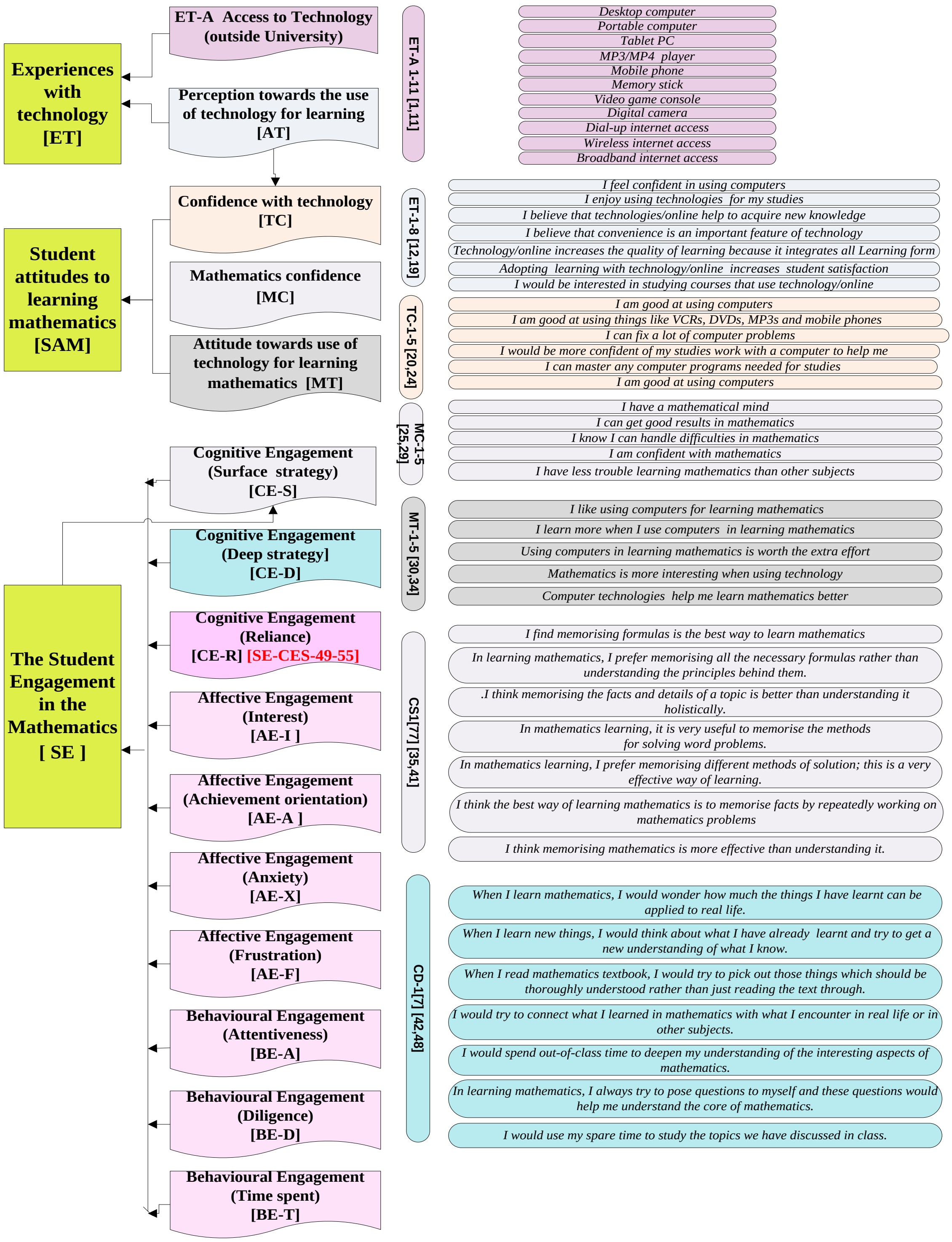

Figure 11 Data Formalisation (Part 1).

For more details refer to Appendices. (Appendix 24)

Continue Figure 11 Data Formalisation (Part 2).

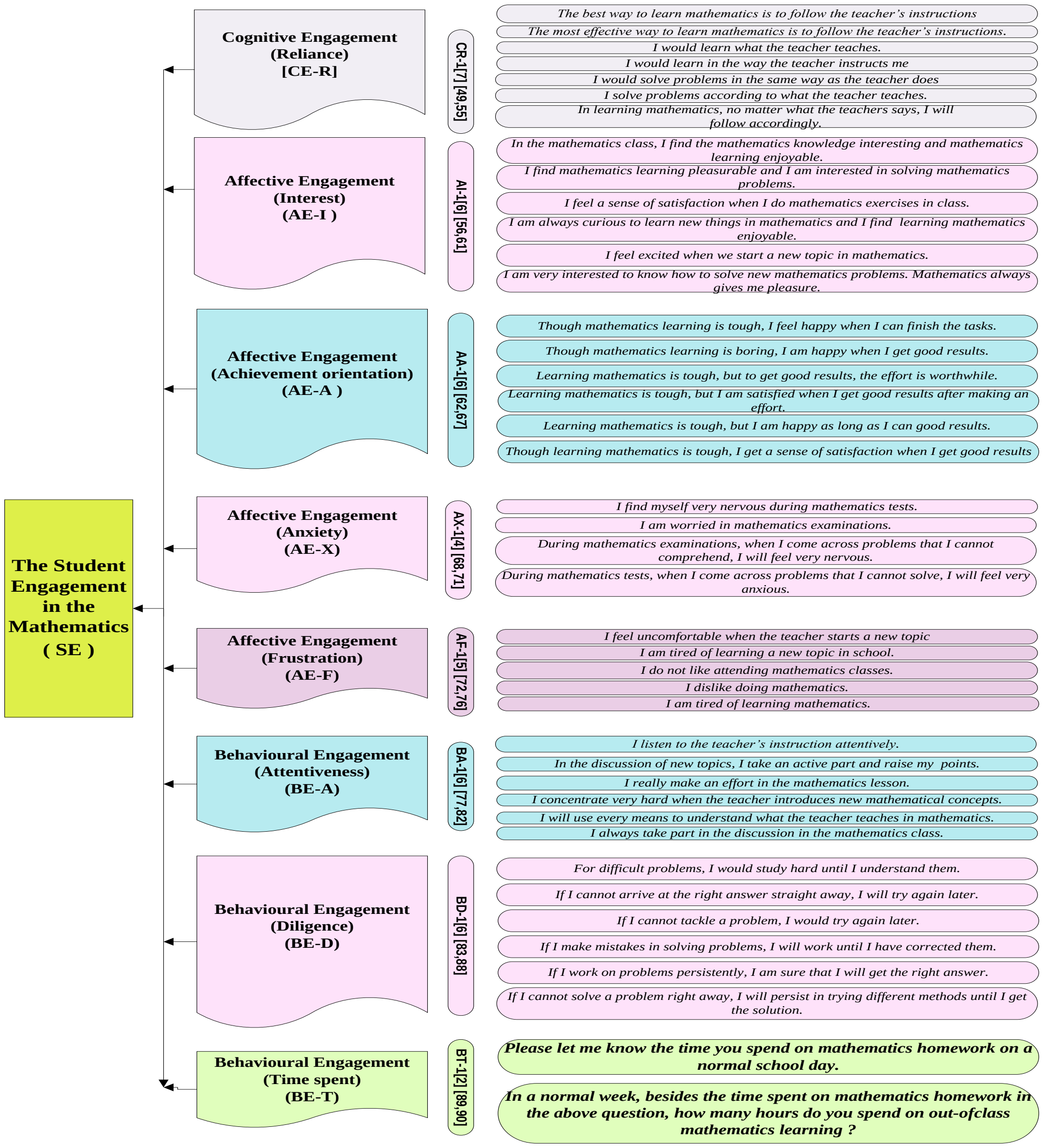

Figure 12 Data Formalisation (Part 2).

For more details refer to Appendix 25 and Appendix 26.

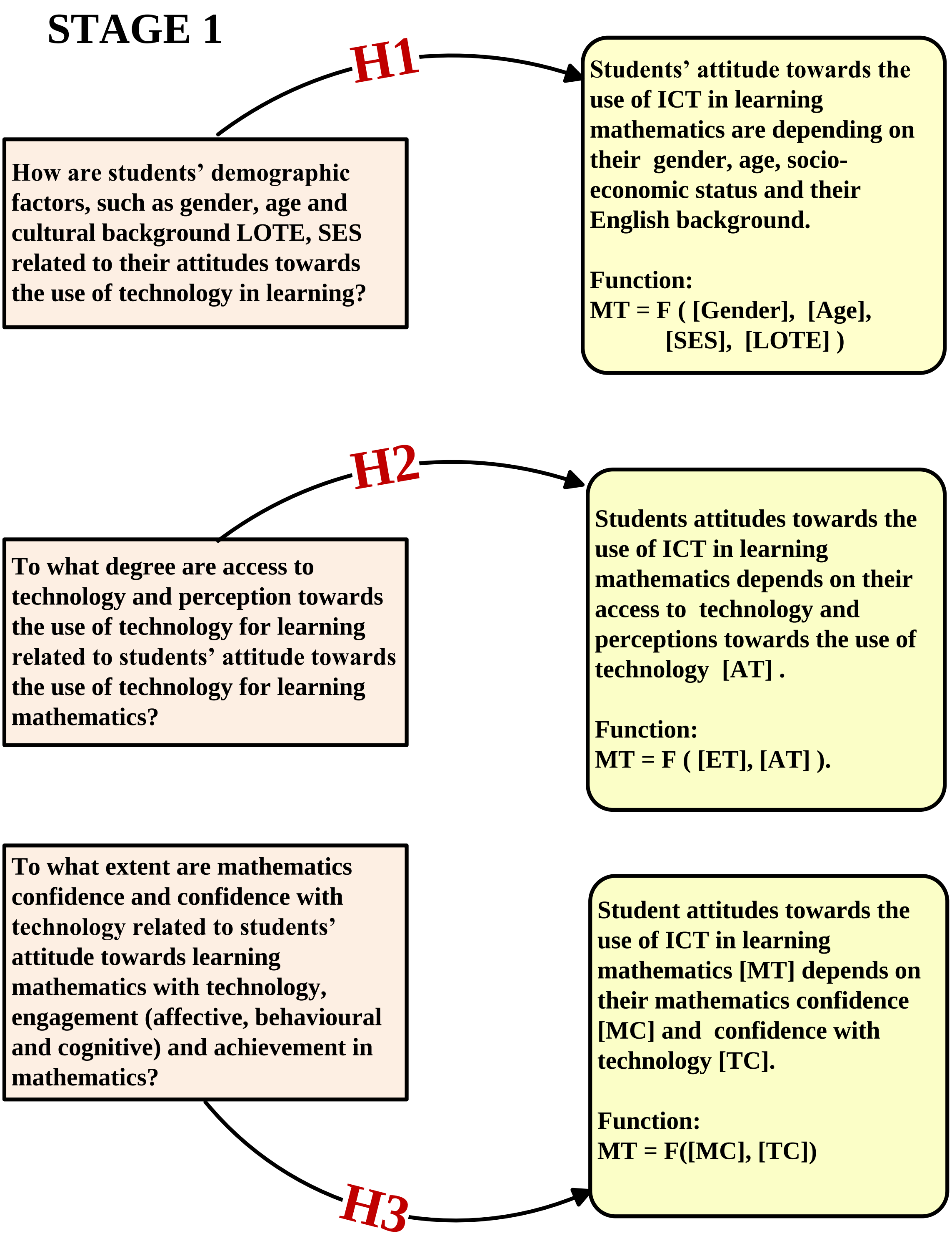

Figure 13 First stage of data analysis (STAGE 1)

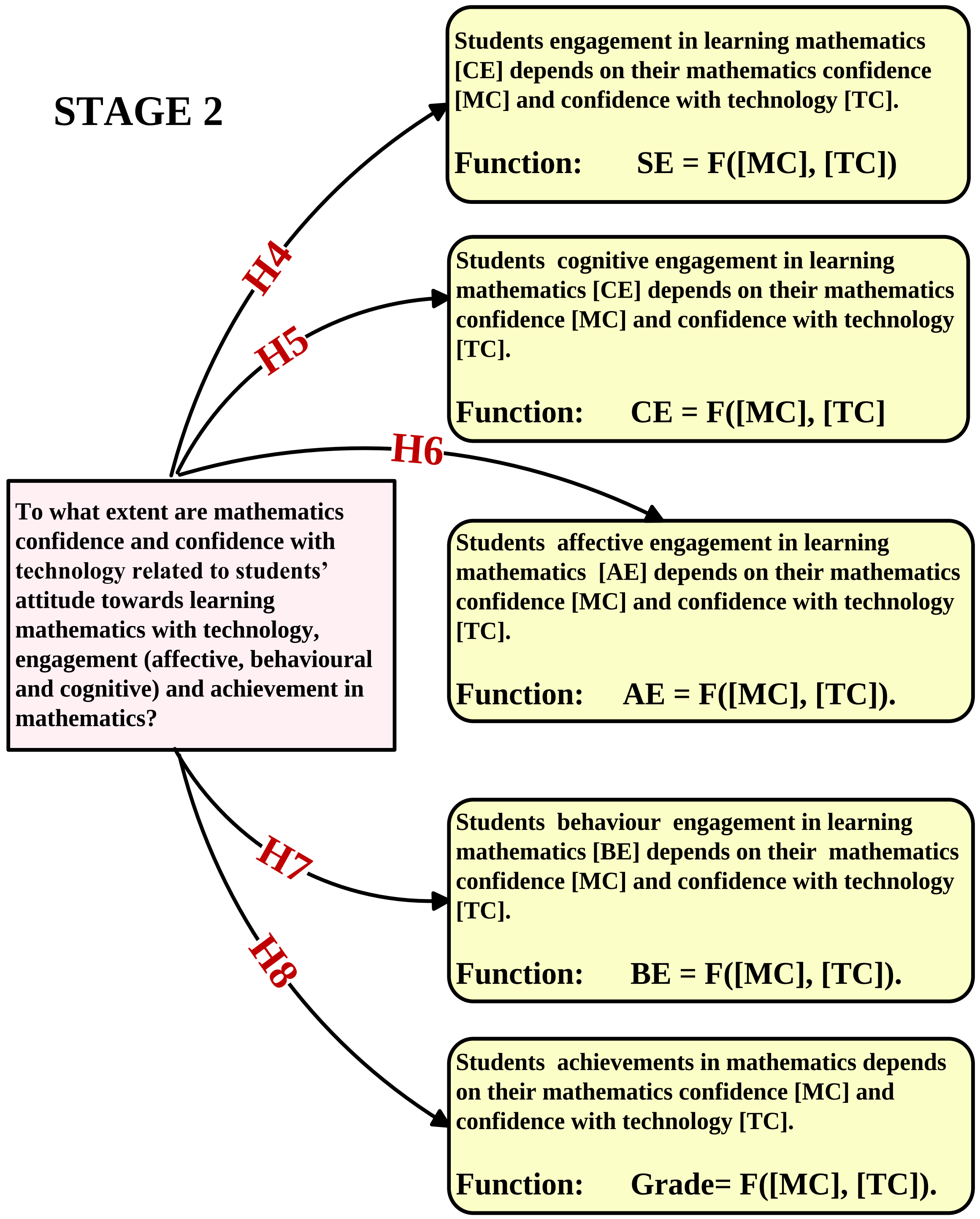

Figure 14 Second stage of data analises (STAGE 2)

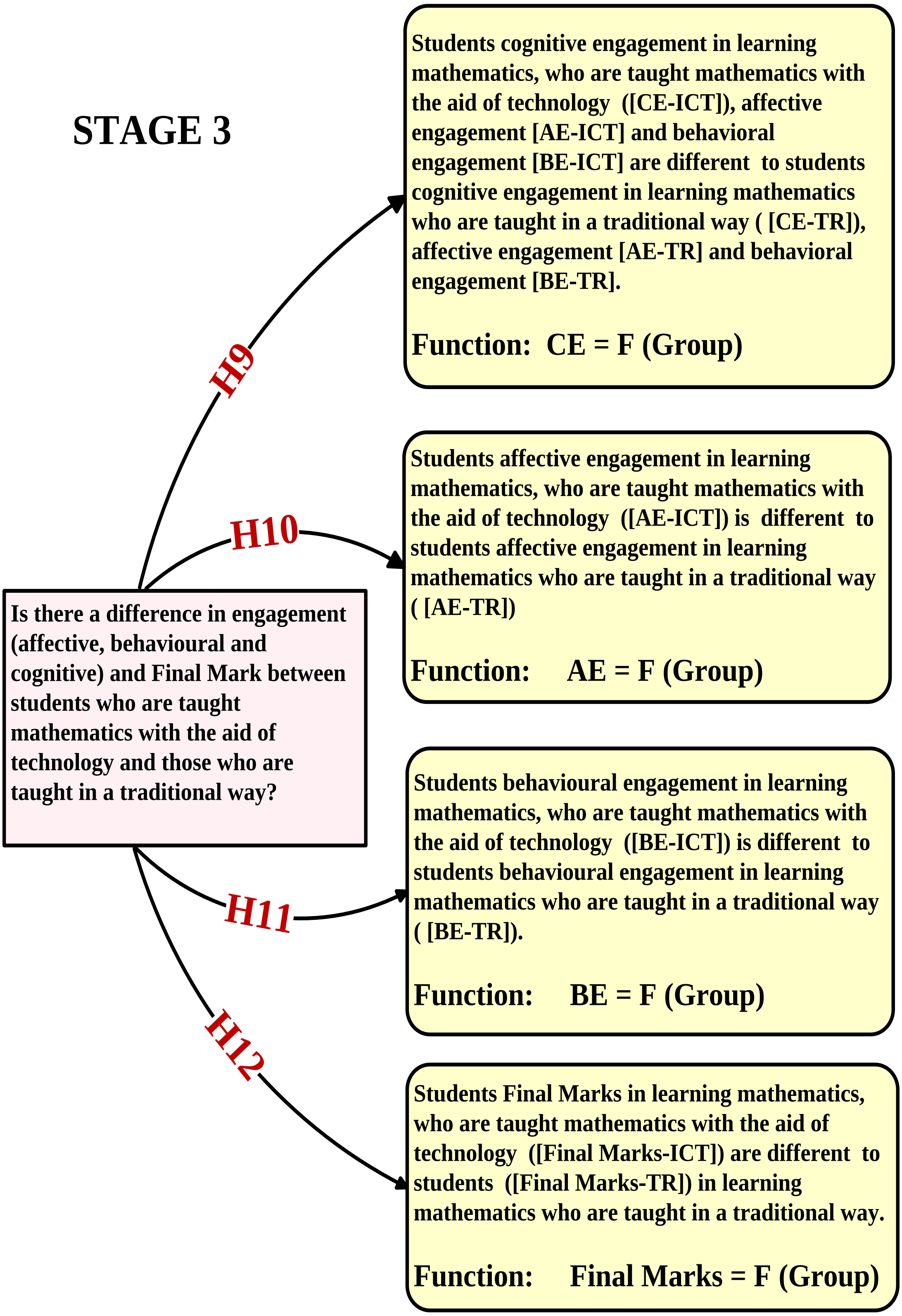

Figure 15 Third Stage of data analysis (STAGE 3)

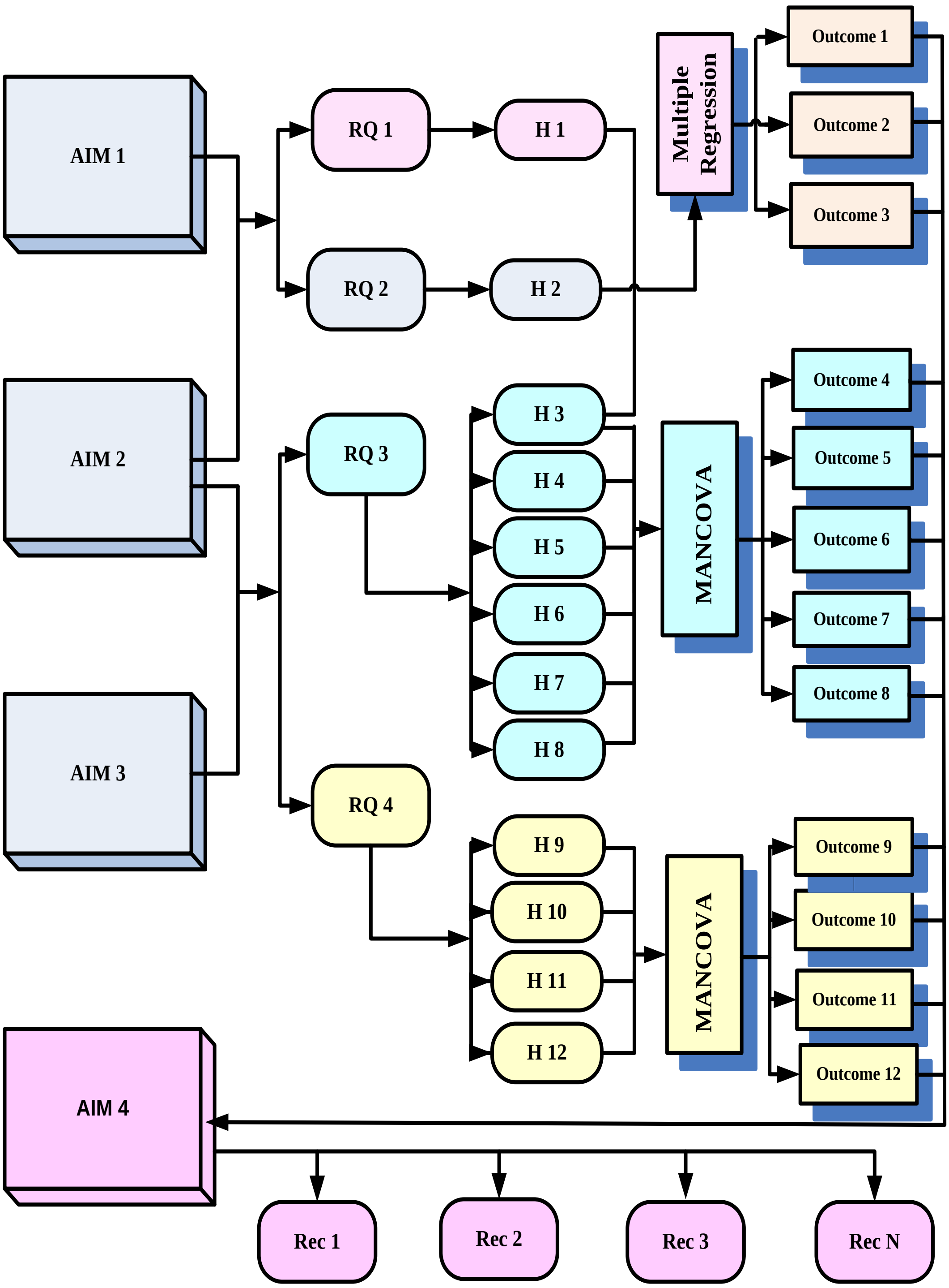

Figure 16 Overall Structure of Data Analysis

Appendix 3 Student Engagement Survey

Student ID: ___________

In each of the following items, please <u>circle only one option</u> (box) that best represents your situation/opinion.

		No Access	Limited	Full Access
1	Desktop computer	❒	❒	❒
2	Portable computer (i.e. laptop or notebook)	❒	❒	❒
3	Tablet PC (e.g. iPAD)	❒	❒	❒
4	MP3/MP4 player	❒	❒	❒
5	Mobile phone	❒	❒	❒
6	Memory stick (e.g. flash drive, USB stick)	❒	❒	❒
7	Video game console (e.g. Xbox, Playstation)	❒	❒	❒
8	Digital camera	❒	❒	❒
9	Dial-up internet access	❒	❒	❒
10	Broadband internet access (ADSL or cable)	❒	❒	❒
11	Wireless internet access	❒	❒	❒

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
12	I feel confident in using computers/Internet	❒	❒	❒	❒	❒
13	I enjoy using technologies for my studies	❒	❒	❒	❒	❒
14	I believe that technologies/online help to acquire new knowledge	❒	❒	❒	❒	❒
15	I believe that technology/online enhances my learning experience	❒	❒	❒	❒	❒
16	I believe that convenience is an important feature of technology/online	❒	❒	❒	❒	❒
17	Technology/online increases the quality of learning because it integrates all forms of media (print, audio, video)	❒	❒	❒	❒	❒
18	Adopting learning with technology/online increases student satisfaction	❒	❒	❒	❒	❒
19	I would be interested in studying courses that use technology/online	❒	❒	❒	❒	❒
20	I am good at using computers	❒	❒	❒	❒	❒
21	I am good at using things like VCRs, DVDs, MP3s and mobile phones	❒	❒	❒	❒	❒
22	I can fix a lot of computer problems	❒	❒	❒	❒	❒
23	I would be more confident of my studies work with a computer to help me	❒	❒	❒	❒	❒

24	I can master any computer programs needed for studies	❐	❐	❐	❐	❐
25	I have a mathematical mind	❐	❐	❐	❐	❐
26	I can get good results in mathematics	❐	❐	❐	❐	❐
27	I know I can handle difficulties in mathematics	❐	❐	❐	❐	❐
28	I am confident with mathematics	❐	❐	❐	❐	❐
29	I have less trouble learning mathematics than other subjects	❐	❐	❐	❐	❐
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
30	I like using computers for learning mathematics	❐	❐	❐	❐	❐
31	I learn more when I use computers in learning mathematics	❐	❐	❐	❐	❐
32	Using computers in learning mathematics is worth the extra effort	❐	❐	❐	❐	❐
33	Mathematics is more interesting when using technology	❐	❐	❐	❐	❐
34	Computer technologies help me learn mathematics better	❐	❐	❐	❐	❐
35	I find memorizing formulas is the best way to learn mathematics	❐	❐	❐	❐	❐
36	In learning mathematics, I prefer memorising all the necessary formulas rather than understanding the principles behind them.	❐	❐	❐	❐	❐
37	I think memorizing the facts and details of a topic is better than understanding it holistically.	❐	❐	❐	❐	❐
38	In mathematics learning, it is very useful to memorise the methods for solving word problems.	❐	❐	❐	❐	❐
39	In mathematics learning, I prefer memorising different methods of solution; this is a very effective way of learning.	❐	❐	❐	❐	❐
40	I think the best way of learning mathematics is to memorise facts by repeatedly working on mathematics problems	❐	❐	❐	❐	❐
41	I think memorising mathematics is more effective than understanding it.	❐	❐	❐	❐	❐
42	When I learn mathematics, I would wonder how much the things I have learnt can be applied to real life.	❐	❐	❐	❐	❐
43	When I learn new things, I would think about what I have already learnt and try to get a new understanding of what I know.	❐	❐	❐	❐	❐
44	When I read mathematics textbook, I would try to pick out those things which should be thoroughly understood rather than just reading the text through.	❐	❐	❐	❐	❐
45	I would try to connect what I learned in mathematics with what I encounter in real life or in other subjects.	❐	❐	❐	❐	❐
46	I would spend out-of-class time to deepen my understanding of the interesting aspects of mathematics.	❐	❐	❐	❐	❐
47	In learning mathematics, I always try to pose questions to myself and these questions would help me understand the core of mathematics.	❐	❐	❐	❐	❐
48	I would use my spare time to study the topics we have discussed in class.	❐	❐	❐	❐	❐

49	The best way to learn mathematics is to follow the teacher's instructions.	❐	❐	❐	❐	❐
50	The most effective way to learn mathematics is to follow the teacher's instructions.	❐	❐	❐	❐	❐
51	I would learn what the teacher teaches.	❐	❐	❐	❐	❐
52	I would learn in the way the teacher instructs me.	❐	❐	❐	❐	❐
53	I would solve problems in the same way as the teacher does.	❐	❐	❐	❐	❐
54	I solve problems according to what the teacher teaches.	❐	❐	❐	❐	❐
55	In learning mathematics, no matter what the teachers says, I will follow accordingly.	❐	❐	❐	❐	❐
56	In the mathematics class, I find the mathematics knowledge interesting and mathematics learning enjoyable.	❐	❐	❐	❐	❐
57	I find mathematics learning pleasurable and I am interested in solving mathematics problems.	❐	❐	❐	❐	❐
58	I feel a sense of satisfaction when I do mathematics exercises in class.	❐	❐	❐	❐	❐
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
59	I am always curious to learn new things in mathematics and I find learning mathematics enjoyable.	❐	❐	❐	❐	❐
60	I feel excited when we start a new topic in mathematics.	❐	❐	❐	❐	❐
61	I am very interested to know how to solve new mathematics problems. Mathematics always gives me pleasure.	❐	❐	❐	❐	❐
62	Though mathematics learning is tough, I feel happy when I can finish the tasks.	❐	❐	❐	❐	❐
63	Though mathematics learning is boring, I am happy when I get good results.	❐	❐	❐	❐	❐
64	Learning mathematics is tough, but to get good results, the effort is worthwhile.	❐	❐	❐	❐	❐
65	Learning mathematics is tough, but I am satisfied when I get good results after making an effort.	❐	❐	❐	❐	❐
66	Learning mathematics is tough, but I am happy as long as I can good results.	❐	❐	❐	❐	❐
67	Though learning mathematics is tough, I get a sense of satisfaction when I get good results	❐	❐	❐	❐	❐
68	I find myself very nervous during mathematics tests.	❐	❐	❐	❐	❐
69	I am worried in mathematics examinations.	❐	❐	❐	❐	❐
70	During mathematics examinations, when I come across problems that I cannot comprehend, I will feel very nervous.	❐	❐	❐	❐	❐
71	During mathematics tests, when I come across problems that I cannot solve, I will feel very anxious.	❐	❐	❐	❐	❐
72	I feel uncomfortable when the teacher starts a new topic.	❐	❐	❐	❐	❐

73	I am tired of learning a new topic in school.	❒	❒	❒	❒	❒
74	I do not like attending mathematics classes.	❒	❒	❒	❒	❒
75	I dislike doing mathematics.	❒	❒	❒	❒	❒
76	I am tired of learning mathematics.	❒	❒	❒	❒	❒
77	I listen to the teacher's instruction attentively.	❒	❒	❒	❒	❒
78	In the discussion of new topics, I take an active part and raise my points.	❒	❒	❒	❒	❒
79	I really make an effort in the mathematics lesson.	❒	❒	❒	❒	❒
80	I concentrate very hard when the teacher introduces new mathematical concepts.	❒	❒	❒	❒	❒
81	I will use every means to understand what the teacher teaches in mathematics.	❒	❒	❒	❒	❒
82	I always take part in the discussion in the mathematics class.	❒	❒	❒	❒	❒
83	For difficult problems, I would study hard until I understand them.	❒	❒	❒	❒	❒
84	If I cannot arrive at the right answer straight away, I will try again later.	❒	❒	❒	❒	❒
85	If I cannot tackle a problem, I would try again later.	❒	❒	❒	❒	❒
86	If I make mistakes in solving problems, I will work until I have corrected them.	❒	❒	❒	❒	❒
87	If I work on problems persistently, I am sure that I will get the right answer.	❒	❒	❒	❒	❒
88	If I cannot solve a problem right away, I will persist in trying different methods until I get the solution.	❒	❒	❒	❒	❒

		Number of Hours
89	Please indicate, how many hours you spend on mathematics homework on a normal school day.	
90	In a normal week, besides the time spent on mathematics homework in the above question, how many hours do you spend on out-of-class mathematics learning?	

91	Have you used any software tools, programs or on-line resources for learning mathematics outside classes this semester?	**Yes**	**No**
	If Yes, please list:	❒	❒
	1.		
	2.		
	3.		
	4.		

Appendix 4 Letter of Consent to Participate in Study

Letter of Consent to Participate in Study

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study entitled: “The role of ICT in student engagement in learning mathematics in a preparatory University program”. This project is being conducted by a student researcher Helen Chenoby as part of Masters research study at Victoria University under the supervision of Professor Iwona Miliszewska, Head of School of Engineering and Science and Dr Ewa Sztendur, Office of PVC (Academic & Students), Victoria University.

This research aims to study and document student perceptions of and experiences with learning mathematics to help determine factors influencing their engagement in learning mathematics. Following the collection of data, set of recommendations for improving student engagement in learning mathematics will be developed.

The research project is expected to exploit how are students’ demographic factors, such as gender, age and cultural background, related to their attitudes towards the use of technology in learning of mathematics, and to what extent are mathematics confidence and confidence with technology related to students’ attitude towards learning mathematics with technology, engagement and achievement in mathematics. The outcomes of this research project will help teachers and learners tap into the power of technologies in order to facilitate learning of mathematics and partake in more engaged learning of mathematics.

As technologies have the potential to engage and motivate learners, it can assist mathematics teachers in making decisions about the deployment of technology in teaching mathematics.

Your permission to access the information from your academic record will be only used for data analyses to address the research questions, all will be anonymous data; there will be no personally identifiable information.

CERTIFICATION BY SUBJECT

I, ...of ....

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study: “The role of ICT in student engagement in learning mathematics in a preparatory University program”, being conducted at Victoria University by Professor Iwona Miliszewska.

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by: Helen Chenoby and that I freely consent to participation involving the use of my student academic record.

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential and I have been given a copy of the document outlining the details of the secure storage of my information.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher:

Professor Iwona Miliszewska

Head of School of Engineering and Science

Phone: (03) 9919 4678 Email: Iwona.Miliszewska@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Research Ethics and Biosafety Manager, Victoria University Human Research Ethics Committee, Victoria University, PO Box 14428, Melbourne, VIC, 8001 or phone (03) 9919 4148.

Appendix 5 Consent Form to Access Student Record

Consent form to access student record

INFORMATION TO PARTICIPANTS:

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....

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study: “The role of ICT in student engagement in learning mathematics in a preparatory University program”, being conducted at Victoria University by Professor Iwona Miliszewska.

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by: Helen Chenoby and that I freely consent to participation involving the use of my student academic record.

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential and I have been given a copy of the document outlining the details of the secure storage of my information.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher:

Professor Iwona Miliszewska

Head of School of Engineering and Science

Phone: (03) 9919 4678 Email: Iwona.Miliszewska@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Research Ethics and Biosafety Manager, Victoria University Human Research Ethics Committee, Victoria University, PO Box 14428, Melbourne, VIC, 8001 or phone (03) 9919 4148.

Appendix 6 Intake 1 Unit of Study JCM110

Tutor's Names: XXXXXXXXXXX

Office: XXXXX

Phone Number: XXXXXXX

<u>Assessment:</u>

Test – Week 2: 10%

Test – Week 5: 10%

Test – Week 9: 10%

Assignment: 10%

Final Exam: 60%

Date	Week	Topic (Contents)
2/5/2011	1	**Arithmetic & Numeracy** (Addition, Subtraction, Multiplication, Division, BODMAS)
9/5/2011	2	**Arithmetic & Numeracy** (Addition, Subtraction, Multiplication, Division, BODMAS, Revision, Test)
16/5/2011	3	**Percentages & Ratios** (Percentages as Fractions and Decimals, Expressing as a Percentage, Percentage of an Amount, Simple Interest, Total Quantity, Definition of a Ratio, Simplification of a Ratio, Comparing Ratios, Simple Applications involving Ratios)
23/5/2011	4	**Percentages & Ratios** (Percentages as Fractions and Decimals, Expressing as a Percentage, Percentage of an Amount, Simple Interest, Total Quantity, Definition of a Ratio, Simplification of a Ratio, Comparing Ratios, Simple Applications involving Ratios)
30/5/2011	5	**Percentages & Ratios** (Percentages as Fractions and Decimals, Expressing as a Percentage, Percentage of an Amount, Simple Interest, Total Quantity, Definition of a Ratio, Simplification of a Ratio, Comparing Ratios, Simple Applications involving Ratios, Revision, Test)
6/6/2011	6	**Algebra** (Collecting Like Terms, Transposition, Expansion, Factorisation)
13/6/2011	7	**Algebra** (Collecting Like Terms, Transposition, Expansion, Factorisation)
20/6/2011	8	**Exponentials & Logarithms** (Exponential Laws, Logarithmic Laws, Logarithmic Equations)
27/6/2011	9	**Exponentials & Logarithms** (Exponential Laws, Logarithmic Laws, Logarithmic Equations, Revision, Test)
4/7/2011	10	**Linear Equations** (Gradients, Forming a Linear Equation, Sketching a Linear Equation)
11/7/2011	11	**Linear Equations** (Gradients, Forming a Linear Equation, Sketching a Linear Equation, Revision, Exam)

Appendix 7 Intake 2 Unit of Study JCM110

Tutor's Names: XXXXXX

Email: (XXXX@vu.edu.au)

Office: XXXX

Phone Number: (9919) XXXX

<u>Assessment:</u>

Test – Week 2: 10%

Test – Week 5: 10%

Test – Week 9: 10%

Assignment: 10%

Final Exam: 60%

Date	Week	Topic (Contents)
2/5/2011	1	**Arithmetic & Numeracy** (Addition, Subtraction, Multiplication, Division, BODMAS)
9/5/2011	2	**Arithmetic & Numeracy** (Addition, Subtraction, Multiplication, Division, BODMAS, Revision, Test)
16/5/2011	3	**Percentages & Ratios** (Percentages as Fractions and Decimals, Expressing as a Percentage, Percentage of an Amount, Simple Interest, Total Quantity, Definition of a Ratio, Simplification of a Ratio, Comparing Ratios, Simple Applications involving Ratios)
23/5/2011	4	**Percentages & Ratios** (Percentages as Fractions and Decimals, Expressing as a Percentage, Percentage of an Amount, Simple Interest, Total Quantity, Definition of a Ratio, Simplification of a Ratio, Comparing Ratios, Simple Applications involving Ratios)
30/5/2011	5	**Percentages & Ratios** (Percentages as Fractions and Decimals, Expressing as a Percentage, Percentage of an Amount, Simple Interest, Total Quantity, Definition of a Ratio, Simplification of a Ratio, Comparing Ratios, Simple Applications involving Ratios, Revision, Test)
6/6/2011	6	**Algebra** (Collecting Like Terms, Transposition, Expansion, Factorisation)
13/6/2011	7	**Algebra** (Collecting Like Terms, Transposition, Expansion, Factorisation)
20/6/2011	8	**Exponentials & Logarithms** (Exponential Laws, Logarithmic Laws, Logarithmic Equations)
27/6/2011	9	**Exponentials & Logarithms** (Exponential Laws, Logarithmic Laws, Logarithmic Equations, Revision, Test)
4/7/2011	10	**Linear Equations** (Gradients, Forming a Linear Equation, Sketching a Linear Equation)
11/7/2011	11	**Linear Equations** (Gradients, Forming a Linear Equation, Sketching a Linear Equation, Revision, Exam)

Appendix 8 Intake 3 Unit of Study JCM0113

Tutor's Names: XXXXX XXXXX.XXXX@vu.edu.au

Contents

Appendix 9 Custom Designed Courses Front page

SigmaNet   You are logged in as   Helen Chenoby   (Logout)

Available courses

[FS-JCM0110-3-July-2012]   Teacher: XXXXXXXXX

VU Foundation Maths   FS   JCM0110-2012 (upgrade 2)

[FS-JCM0110-25-June-2012]   Teacher: XXXXXXXXXX

VU Foundation Maths   FS-JCM0110-25-June-2012 (upgrade 2.1)

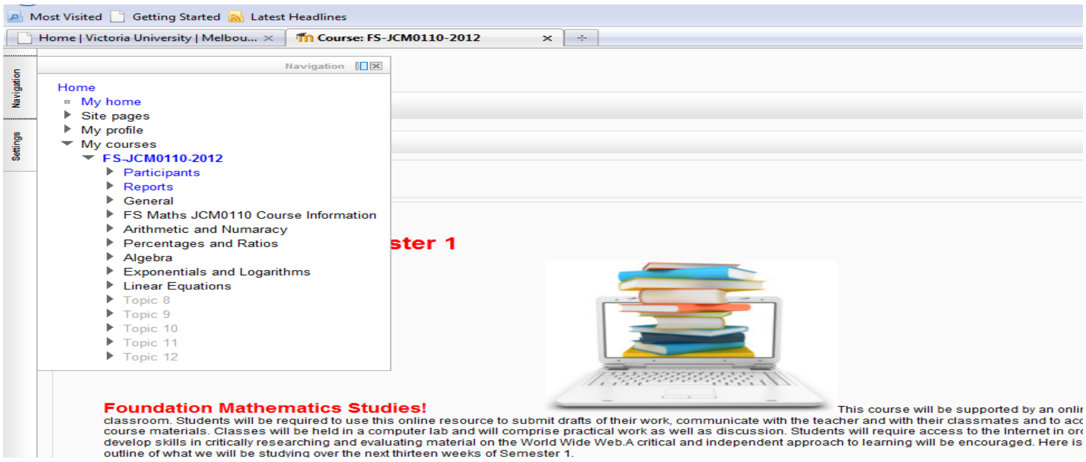
[FS-JCM0110-2012]   Teacher: XXXXXXXXXX

VU Foundation Maths   FS JCM0110-2012 (v 2.1.2+ Build 20111019)

[Copy JCM00110]   Copy JCM00110

[FS-JCM0110-2012 (copy)]   FS-JCM0110-2012 (copy)

An example of how the unit of work has been structured: Conditional assignments have been used to organise different work for different students during the tutorial time



Logarithm laws

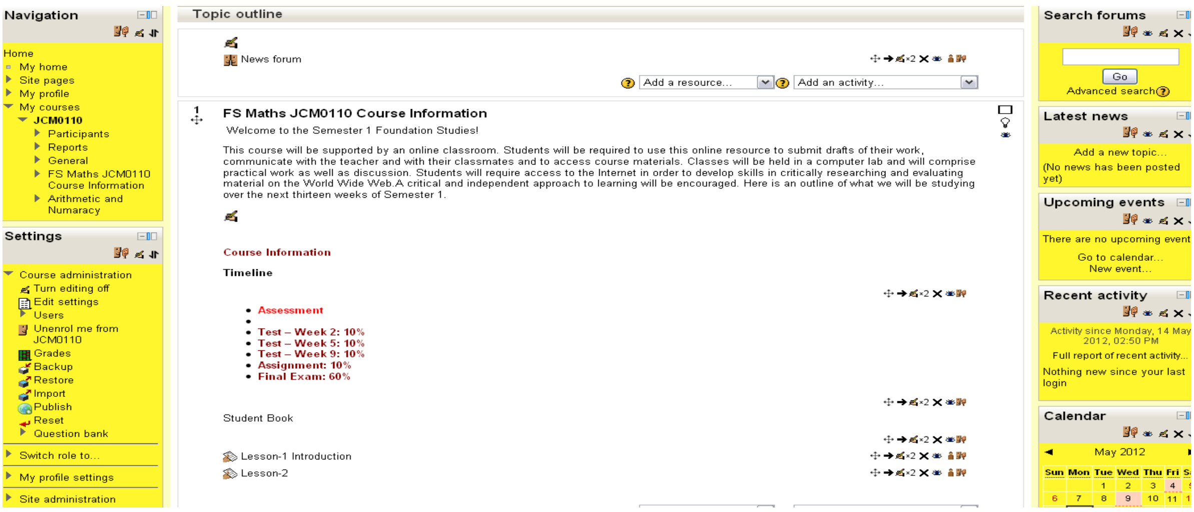
The index laws can be used to establish corresponding rules for calculations involvinglogarithms. These rules are summarised in the following table.

It is important to remember that each rule works only if the base, a, is the same for each term. *Upload: WE 15, WE 16, WE 17.*

- WE 15 Assignment
- WE 16 Assignment
- WE 17 Assignment
- **Class work-1:** StudentBook, p.64
- **Class work-2:** Textbook, Ex. 4A, *7, 8, 9, 14 (Left column)*
- **Class work-3:** Textbook, p.191-192, WE-18, WE-19, WE-20
- **Home work:** Textbook, Ex. 4A, 7, 8, 9, 14 (Right column)
- *Upload your Class work here:*
- Class work-1: Assignment
- Class work-2: Assignment
- Class work-3: Assignment
- **Upload your Home work here:**
- Home work Assignment

Reviewing the outcomes from a “moving target”.

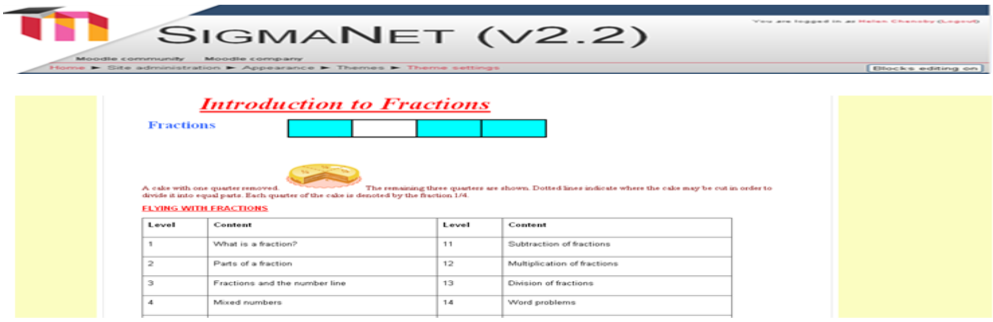
Appendix 10 Moodle participants



All participants: 33

First week of study: Students and teacher were supposed to learn how to use an on-line course and researcher-designer to update the course after every class to cover students’ needs.

Appendix 11 Moodle usage outside of class



Students are enrolled in the Moodle Course and started to use outside of class.

In addition, the study intended to identify how effectively the online course has been designed and what to improve to provide better environment to motivate the current cohort of students to learn mathematics, and also how to make reusable the system to make it available for next intake of students.

Appendix 12 Courses Home Page after migration to new Moodle 2.2 version

Appendix 13 License to use a scale for monitoring students’ attitudes to learning mathematics with technology

Copyright Clearance Center RightsLink®

Title:	A scale for monitoring students’ attitudes to learning mathematics with technology
Author:	Robyn Pierce,Kaye Stacey,Anastasios Barkatsas
Publication:	Computers & Education
Publisher:	Elsevier
Date:	February 2007

Helen Chenoby

Order Completed

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Licensed content title	A scale for monitoring students’ attitudes to learning mathematics with technology
Licensed content author	Robyn Pierce,Kaye Stacey,Anastasios Barkatsas
Licensed content date	February 2007
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Title of your thesis/dissertation	The role of ICT in student engagement in learning mathematics in a preparatory University Program.
Expected completion date	Nov 2012
Estimated size (number of pages)	100
Elsevier VAT number	GB 494 6272 12
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Total	0.00 USD

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

Appendix 14 Procedure on data access and storage

Procedure on the data access and storage

In accordance of Australian Code for the Responsible conduct of research the researcher is responsible for the security of confidential data, including consent forms, academic records, questionnaires collected in the course of the research. The researcher must manage storage of research data and primary materials and provide the security of the data storage according to ethical protocols and relevant legislation of Victoria University, which requires all researchers to adhere to the code and to ensure that their students adopt it as standard practice.

To achieve this:

1. Only the researcher will be responsible for the security of all confidential data, including consent forms, collected in the course of the research.
2. The data will be collected by the researcher from students through survey instruments (Appendix 2).
3. Completed surveys will be collected by the researcher to a special collection box in the tutorial room and will be stored in a locked filing cabinet in room D627a at Victoria University protected behind a secured door.
4. Personal data from student records will be obtained by Dr Ewa Sztendur through VUSIS and Business Objects and will be recorded in a durable form with appropriate references.
5. A catalogue of research data will be maintained in an accessible form.
6. Clear and accurate records of the research methods and data sources, including any approvals granted, during and after the research process will be kept.
7. Confidential information will be used in ways agreed with the students who provided their permission.
8. Student mathematics achievement, obtained at the beginning and the end of semester will be kept in a locked filing cabinet in room D627a at Victoria University protected behind a secured door.
9. Electronic data obtained from student academic records will be kept in password protected storage at Victoria University.
10. Personal data (obtained from student records and consisted of information regarding student demographic characteristics, such as age, gender, socio-economic status, cultural background (e.g. student's country of birth, LOTE identifier) will be coded and the students will not be identified.
11. The information will be kept for 5 years in password protected storage, provided by the faculty.
12. All electronic files will have passwords and disks will be stored in a locked filing cabinet in room D627a at Victoria University protected behind a secured door.
13. Retain research data, including electronic data will be kept indexed and retrievable form.
14. While the students will be required to provide their student IDs (to support the pre- and post- intervention research design), the students will not be identified in any way following the collection of data.
15. The data will be coded and individuals and locations identified only by pseudonym.
16. The information printed as paper files will be shredded and the information stored on computer disks will be overwritten.
17. The notes will be kept under lock and key until the completion of data analysis.
18. The notes will be coded for themes in the comments.
19. It is possible that specific comments will be reported in relation to a particular theme. Real names will not be tied to these comments.
20. The disposal of the data (paper surveys) will be carried out through secure document destruction bin; the disposal service is accredited by the Federal Government for the destruction of classified waste.
21. In the event of publication of this research, no personally identifying information will be disclosed. Upon completion of the analysis, the notes and digital recordings will be destroyed.
22. The principal supervisor Professor Iwona Miliszewska and Dr Ewa M. Sztendur will have access to the data.

Appendix 15 Ethics application approval letter

MEMO

TO	Professor Iwona Miliszewska HES- School of Engineering and Science Victoria University Footscray Park Campus Dr Ewa Sztendur Office of the PVC Academic and Students Victoria University Newport	DATE	5/4/2012
FROM	A/Professor Liza Heslop Chair Health Engineering and Science Human Research Ethics Committee		
SUBJEC	Ethics Application – HRETH 12/43		

Dear Professor Miliszewska and Dr Sztendur,
Thank you for submitting your application for ethical approval of the project entitled:

HRETH 12/43 The role of ICT in student engagement in learning mathematics in a preparatory University program
(HES HREC 12/33)

The proposed research project has been accepted and deemed to meet the requirements of the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007)' by the HES HREC Committee of the Health Engineering and Science Human Research Ethics Committee. Approval has been granted **5 April 2012 to 5 April 2014.**

Continued approval of this research project by the Health Engineering and Science Human Research Ethics Committee (HES HREC) is conditional upon the provision of a report within 12 months of the above approval date (**5 April 2013**) or upon the completion of the project (if earlier). A report proforma may be downloaded from the VUHREC web site at: http://research.vu.edu.au/hrec.php.

Please note that the Human Research Ethics Committee must be informed of the following: any changes to the approved research protocol, project timelines, any serious events or adverse and/or unforeseen events that may affect continued ethical acceptability of the project. In these unlikely events, researchers must immediately cease all data collection until the Committee has approved the changes. Researchers are also reminded of the need to notify the approving HREC of changes to personnel in research projects via a request for a minor amendment. It should also be noted that it is the Chief Investigators' responsibility to ensure the research project is conducted in line with the recommendations outlined in the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007).'

On behalf of the Committee, I wish you all the best for the conduct of the project.
Kind regards,
A/Professor Liza Heslop
Chair
Health Engineering and Science Human Research Ethics Committee

Appendix 16 Student Instruction To create SigmaNet account

Student Instruction To create SigmaNet account

Website Address of SigmaNet

http://www.sigmadotnet.net/SigmaNet/Maths

1. **Create New Account**

   Username <Your First Name>
   Password Student-<Your-ID-Number>
   E-mail VU e-mail address:
   <Your First Name>.<Your Surname>@live.vu.edu.au

   First name <Your First Name>
   Surname <Your Surname>

2. **An email should have been sent to your address at**

   <Your First Name>.<Your Surname>@live.vu.edu.au

It contains easy instructions to complete your registration.

3. **Check VU e-mail address. You will receive a message:**

   Hi < Your First Name > < Your Surname>

A new account has been requested at 'SigmaNet' using your email address.
To confirm your new account, please go to this web address:

http://www.sigmadotnet.net/SigmaNet/Maths/login/XXXXXXX

In most mail programs, this should appear as a blue link which you can just click on. If that doesn't work, then cut and paste the address into the address line at the top of your web browser window. If you need help, please contact the site administrator,
Helen Chenoby xxx@bigpond.com

4. You will get a message: Thanks, <Name> < Surname>
   Registration has already been confirmed
5. Click [Login]
6. Type your Username <Your FirstName>
   Password Student- <Your-IDNumber>

7. Click [Continue]
8. Choose [Courses]

Appendix 17 Moodle First Page Intake 1

04-08-2012

Appendix 18 Moodle Research Conference 2012 notification

MoodleResearchConf2012 notification for paper 21

MoodleResearchConf2012 moodleresearchconf2012@easychair.org

Thu 21/06/2012 2:36 AM

Dear colleague,
We are glad to inform you that your paper entitled Using Moodle to enhance student engagement in learning mathematics in a preparatory university program: A case study (number: 21) has been accepted to be included in the proceedings volume as short paper.
It will be presented in the form of poster at a special session that will be organised during the conference (more details in few weeks).

Please revise your paper according to the reviewers' comments and submit a revised camera ready version till the 9th of July. The submission will be made via the EasyChair conference system. You will upload a revised version of the original manuscript.

Important note: Please format your paper very carefully according to the template given at the section "call for papers" of the conference website.

Moreover, at least one of the authors of the paper should be registered to the conference till the 16th of July which is the Early Bird Deadline in order that the paper is included into the proceedings volume.

We remain at your disposal.

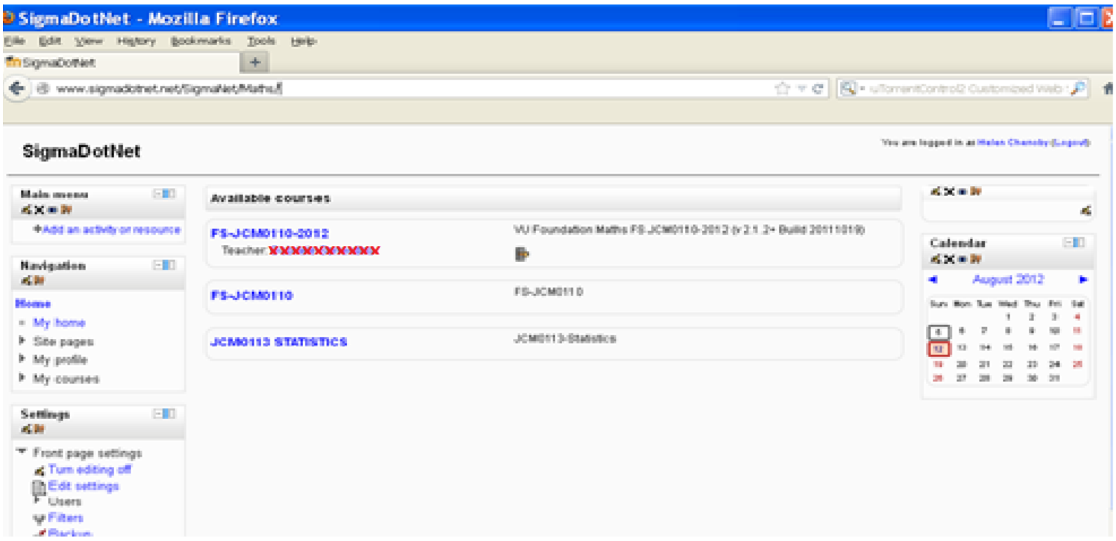
Looking forward to seeing you in Crete.

Best regards,

Simos

Symeon Retalis, Associate Professor
University of Piraeus,
Department of Digital Systems
80 Karaoli & Dimitriou
185 34 Piraeus, Greece
Tel: 0030210 414 2765 & 0030 6945416299
Fax: 0030210 414 2753
Cosy-LLab: http://cosy.ds.unipi.gr/

Appendix 19 Moodle First Page Intake 2



The environment has been redesigned many times to accommodate the dynamics of new students constantly coming in and out.

Appendix 20 Design adapted teacher centred approach

JCM0113: Mathematics 2 (Statistics)

Course Information

Lecture XXXXXX
Office: G522
Phone: 99195227
Email: gabriele.sorrentino@vu.edu.au

Welcome to the Semester 1 This course will be supported by an online classroom. Students will be required to use this online resource to submit drafts of their work, communicate with the teacher and with their classmates and to access course materials. Classes will be held in a computer lab and will comprise practical work as well as discussion. Students will require access to the Internet in order to develop skills in critically researching and evaluating material on the World Wide Web. A critical and independent approach to learning will be encouraged. Here is an outline of what we will be studying over the next thirteen weeks of Semester 1.

Assessment

- **Test 1 – Week 3:** 10%
- **Test 2 – Week 6:** 10%
- **Test 3 – Week 10:** 10%
- **Lab/Tute Exercises:** 5%
- **Assignment:** 5%

Final Exam: 60%

Lab Assignment

- **Lab Assignment 1**
  The first assignment will be available during class time. You will complete the task and upload the file to SigmaNet. The task is to complete Question 5 from the 2011 past test.
  Upload your work here:
- Lab Assignment 1 Assignment (2.2)
- **Lab Assignment 2** **Scatterplot and Correlation**

Your task is to complete the class exercise in chapter 2 (heights vs marks taken) in excel. Using formulae, you are to complete the usual tables to calculate the standard deviation and Pearson's correlation coefficient (follow the instruction in class).

- **Upload your work here:**
- Lab Assignment 2 Assignment (2.2)

4 Additional Lecture Notes Additional Resources:
Mean, Standard Deviation and Variance
Mean, Standard Deviation and Variance
9 Skewed Distributions

Skewed Distributions (Reading the shape of a distribution)

Appendix 21 Design adapted student-centered approach

Print Screen FS-JCM0110-2012

FS Maths JCM0110 Course Information This course will be supported by an online classroom. Students will be required to use this online resource to submit drafts of their work, communicate with the teacher and with their classmates and to access course materials. Classes will be held in a computer lab and will comprise practical work as well as discussion. Students will require access to the Internet in order to develop skills in critically researching and evaluating material on the World Wide Web.A critical and independent approach to learning will be encouraged. Here is an outline of what we will be studying over the next thirteen weeks of Semester 1.

1. **Why on-line?**
2. If you travel, have a busy lifestyle, or just like the idea of not having to lug folders full of paper around all day, please use on-line course.

   a. **Why numeracy is so important?**

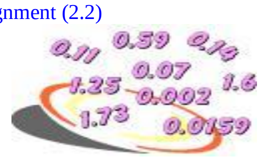
3. Numeracy allows humans to reason with numbers. A human must be numerate to compute various calculations in life, like money, measurement, chance, etc. In mathematics, Arithmetic is the corner stone to Numeracy. The four staples of arithmetic are Addition, Subtraction, Multiplication, and Division.In various university courses, arithmetic without calculators are a requirement. For example, Nurses need to be able to calculate dosages and changes in critical data quickly and without hesitation. Teachers (primary and to a lesser extent, secondary) need to be numerate to pass these skills onto their students in the class room. Students need to be able to do basic mathematics (numeracy) in any course. Time is of the essences and time spent on a calculator, is time wasted.
4. **Beauty-of-mathematics** **Course Information**
5. Timeline

   1. Assessment
   2. Test – Week 2: 10%
   3. Test – Week 5: 10%
   4. Test – Week 9: 10%
   5. Assignment: 10%
   6. Final Exam: 60%

6. Class-2 Exercise Upload your work here:

   a. WSH-1-BODMAS Assignment (2.2)
   b. Home work-2
   c. WSH-2_BODMAS Assignment (2.2)
   d. Solutions WSH-1 & WSH-2 BODMAS

- Upload your work "Revision Arithmetics" here (22 marks):
- Revision Arithmetics (22 marks) Assignment (2.2)



- FLYING WITH DECIMALS
- Upload your class work here:
- Class work 1 Assignment (2.2)
- Class work 2 Assignment (2.2)

Revision "Logarithms "

- **Revision Logarithms SET 11 - SET 14 upload here** (50 marks)
- Revision Logarithms SET 11 (24 marks) Assignment (2.2)
- Revision Logarithms SET 12 (24 marks) Assignment (2.2)
- Revision Logarithms SET 13 (24 marks) Assignment (2.2)
- Revision Logarithms SET 14 (44 marks) Assignment (2.2)
- **Example 3:** Find the linear equation that crosses the points
- **Example 4:** Find the linear equation that crosses the points
- **Class Exercises**

Find the linear equations that crosses the following pair of points.

i. $(2, -3)$ and $(6, 9)$ **ii.** $(-3, 6)$ and $(1, -1)$ **iii.** $(-3, -6)$ and $(2, 4)$

- **Upload your Class Exercises here:**
- Class Exercise (i.) (p.70) Assignment (2.2)
- Class Exercise (ii.) (p.70) Assignment (2.2)
- Class Exercise (iii.) (p.70) Assignment (2.2)

Sketching Linear Equations

To sketch a linear equation on the cartesian plane successfully, we must find the x and y intercepts of the equation. At this moment in time, these intercepts will have no real meaning, other than to sketch the line. In your later studies, these intercepts will represent a major point to your scientific modeling or could assist in explaining a phenomenon in your research.To find the y **intercept** of any mathematical equation involving x and y, we let $x = 0$ and solve for y. If the linear equation is in the form of $y = mx + c$, the y intercept is just c (i.e. $y = c$).To find the x **intercept** of any mathematical equation involving x and y, we let $y = 0$ and solve for x.

- **Example 1:** Sketch the linear equation $y = 2x - 6$.
- **Example 2:** Sketch the linear equation $2y = 3x + 9$.(p.72)
- **Example 3:** Find and sketch the linear equation that intersects the points(p.73)
- **Class Exercises:** Find the linear equations that crosses the following pair of points (p.75)
- **Upload your Class Exercises here:**
- Class Exercises (i) (p.75) Assignment (2.2)
- Class Exercises (ii) (p.75) Assignment (2.2)
- Class Exercises (iii) (p.75) Assignment (2.2)
- Class Exercises (iv) (p.75) Assignment (2.2)

Practice interactive Exercises

Sketching the linear equations

- Sketch the linear equations File
- **Find and Sketch the linear equations**
- Find and Sketch the linear equations File
- **ProblemSheet-6-5 (p.75)**
- **Upload your work Problem Sheet Q-1 here:**
- Problem Sheet Q-1 (a) Assignment (2.2)

- Problem Sheet Q-1 (b) Assignment (2.2)
- Problem Sheet Q-1 (c) Assignment (2.2)
- Problem Sheet Q-1 (d) Assignment (2.2)
- Problem Sheet Q-1 (e) Assignment (2.2)
- Problem Sheet Q-1 (f) Assignment (2.2)
- Problem Sheet Q-1 (g) Assignment (2.2)
- Problem Sheet Q-1 (h) Assignment (2.2)
- Problem Sheet Q-1 (i) Assignment (2.2)
- **Upload your work Problem Sheet Q-2 here:**
- Problem Sheet Q-2 (a) Assignment (2.2)
- Problem Sheet Q-2 (b) Assignment (2.2)
- Problem Sheet Q-2 (c) Assignment (2.2)
- Problem Sheet Q-2 (d) Assignment (2.2)
- Problem Sheet Q-2 (e) Assignment (2.2)
- **Upload your work Problem Sheet Q-3 here:**
- Problem Sheet Q-3 (a) Assignment (2.2)
- Problem Sheet Q-3 (b) Assignment (2.2)
- Problem Sheet Q-3 (c) Assignment (2.2)
- Problem Sheet Q-3 (d) Assignment (2.2)
- Problem Sheet Q-3 (e) Assignment (2.2)
- Problem Sheet Q-3 (f) Assignment (2.2)
- **Additional resources Find and Sketch the linear equations**
- A short video on finding the gradient (slope) of a straight line drawn on a graph
- A short video on finding how the the gradient (slope) of a straight line is connected to the equation of its graph"
- A short video on finding the equation of a straight line through the origin from the gradient (slope) and the *y*-intercept
- A short video on finding the equations of a parallel and perpendicular straight lines

Find the gradient and y-intercept of the following straight lines.

WE -2 (Textbook, p.76)

Sketch graphs of the following linear equations by finding the x- and y-intercepts.

WE -3 (Textbook, p.77)

Sketching linear graphs of the form y = mx

WE -4 (Textbook, p.78)

- Practice Sketching linear graphs
- **Complete Exercises Sketching linear graphs**

Ex.3B (1,2,3,4, left column), (Textbook, p.81)

- **Upload Ex.3B (1,2,3,4, left column) here:**
- Exercises Sketching linear graphs Assignment (2.2)
- **Remember:**

1. The Cartesian plane is a grid, consisting of two axes (*x* and *y*), meeting at the origin (0, 0).

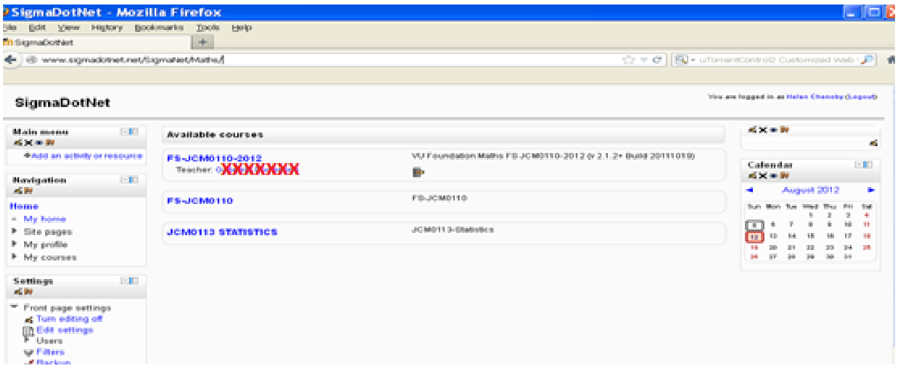
2. A location (point) is specified by its *x*- and *y*-coordinates.

3. A inear graph consists of an infinite set of points that can be joined to form a straight line.

4. To plot a linear graph, the coordinates of only two points are needed, although several points are often plotted as a check.

5. A linear rule or equation can be used to obtain the coordinates of points that belong to its graph.

Appendix 22 Moodle First Page Intake 3



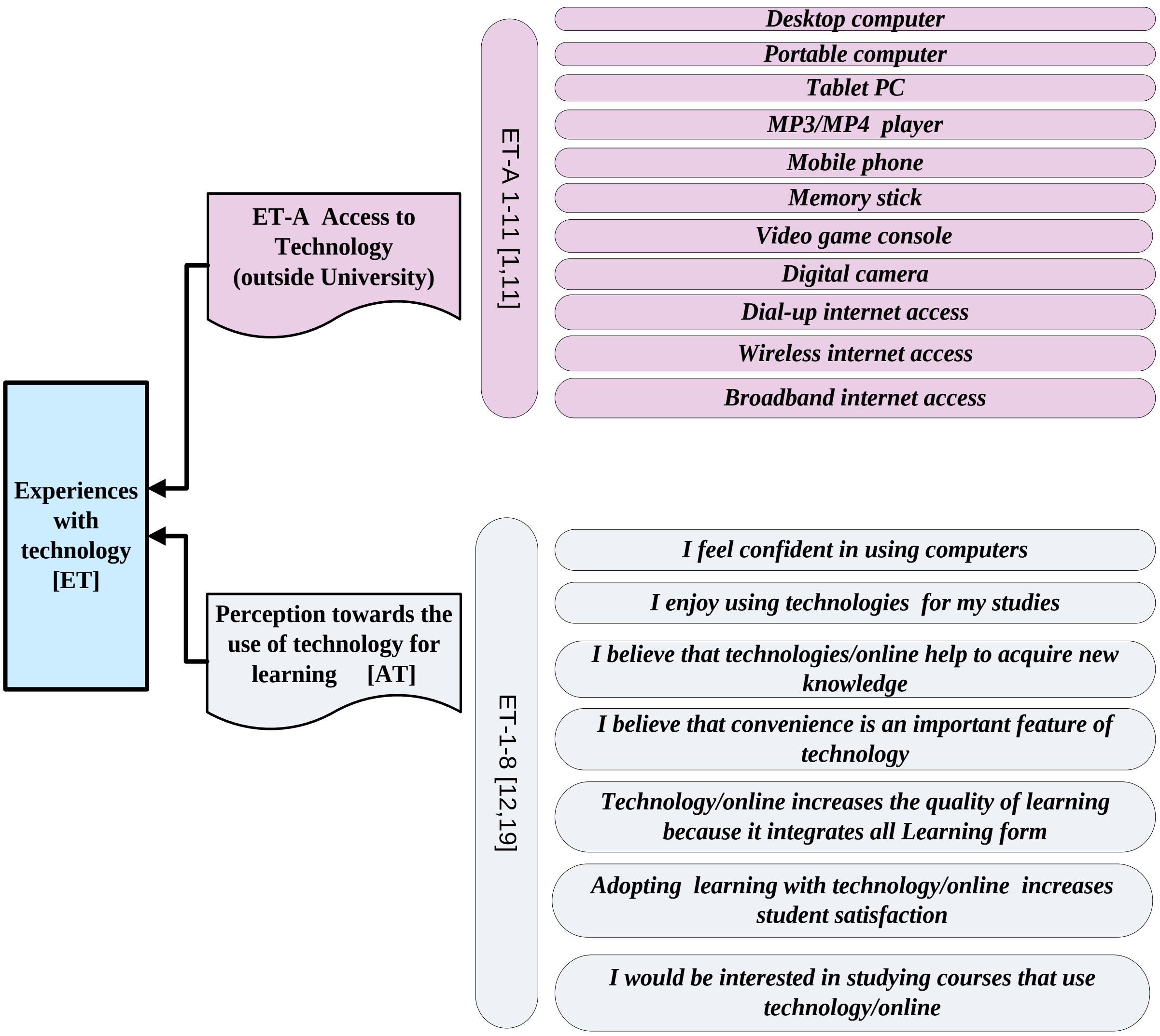
Appendix 23 List of online Courses designed by researcher

Course categories http://www.sigmatuition.net/moodle/course/

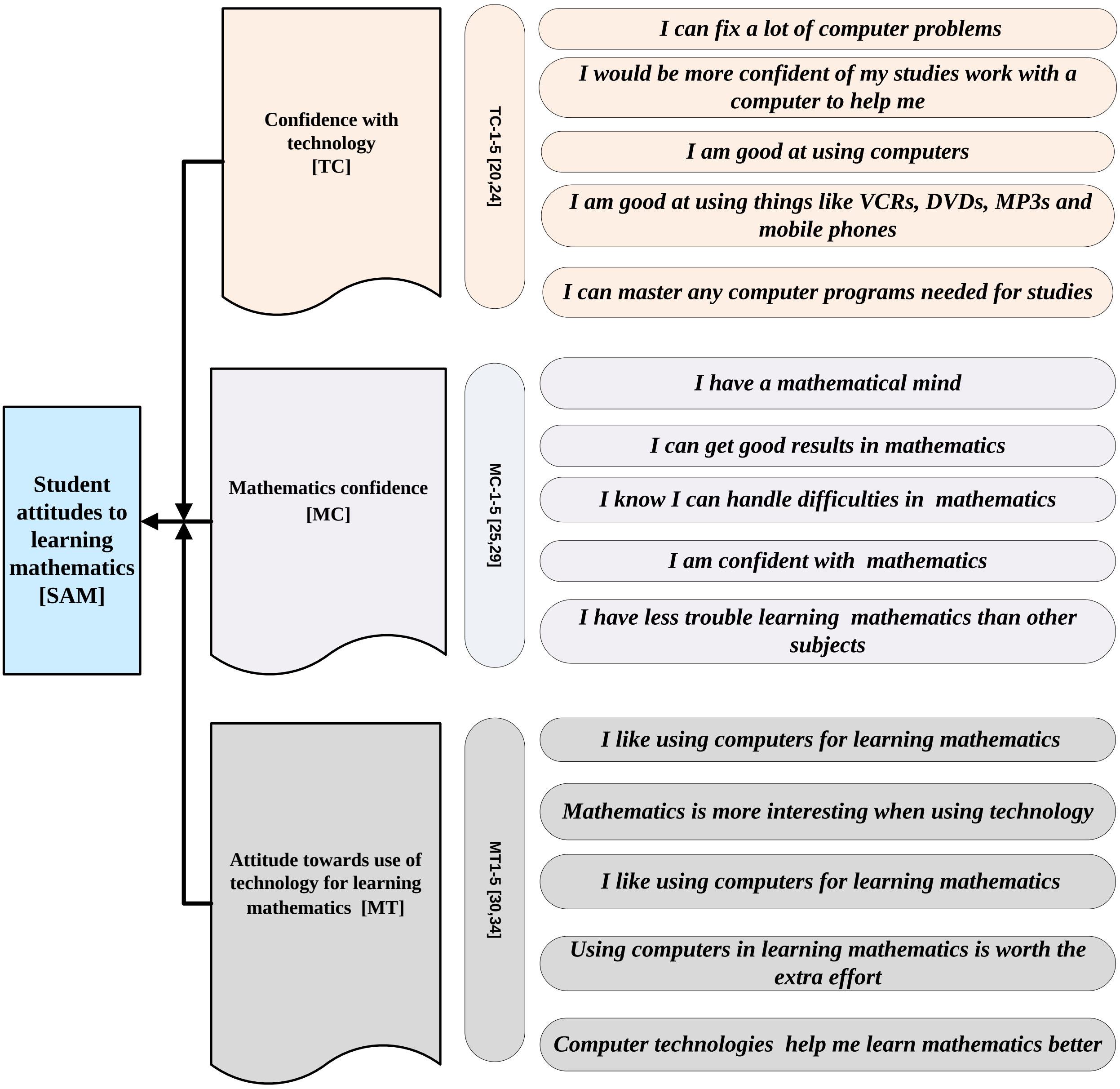
- [Media & Communication]
  - [VCE Further Maths Units 4]
  - [VCE Further Maths Units 3]
  - [Computer Applications (June 2010 Intake)]
    - [Computer Applications Semester B (June 2010 Intake)]
    - [Computer Applications Semester A (June 2010 Intake)]
  - [Computer Applications (February 2011 Intake)]
    - [Computer Applications Semester A (February 2011 Intake Sem A)]
    - [Computer Applications Semester B (February 2011 Intake Sem B)]
  - [Computer Applications (June 2011 Intake)]
    - [COSC1344 June 2011 Sem A]
    - [COSC1345 June 2011 Sem B]
- [ICT]
  - [IT-Year-11-HC]
  - [IT-Year 11-U2]
  - [IT-Year-11-MsChenoby]
  - [IT-Y-10-Multimedia]
  - [Mr Stebbing's Year 11 IT]
  - [Ms Chenoby's Year 12 IT]
- [Maths]

- Further Mathematics
  - GM-A (Business)
    - MATH 1003 (Business Stream)
  - FM MATH 5314
    - VCE Further Maths Units 3
    - VCE Further Maths Units 4
  - Foundation Maths
- TESOL
  - AEM6100-Education Research Design and Methods
- Physics
- test

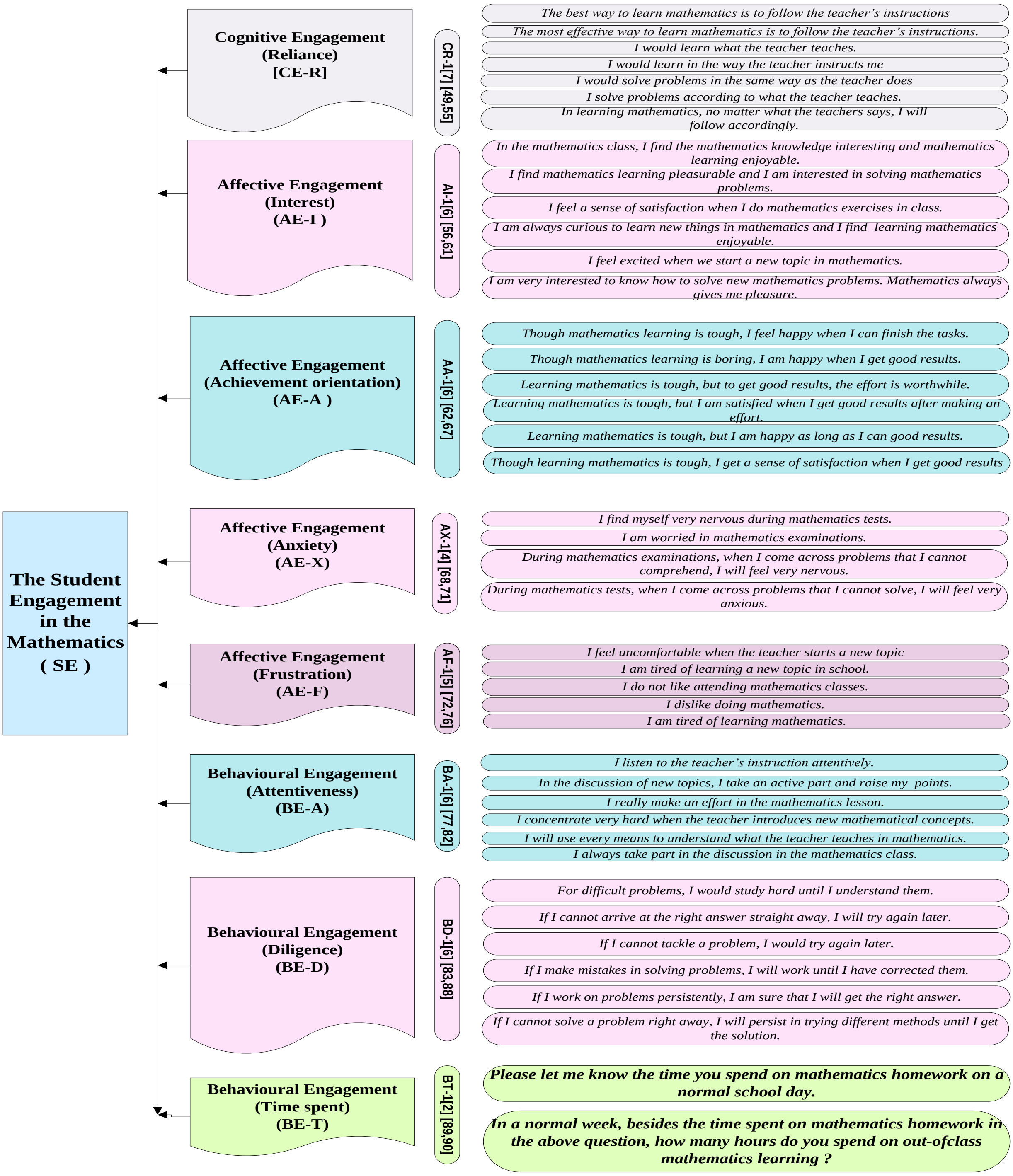
Appendix 24 Data Formalisation (Part 1)



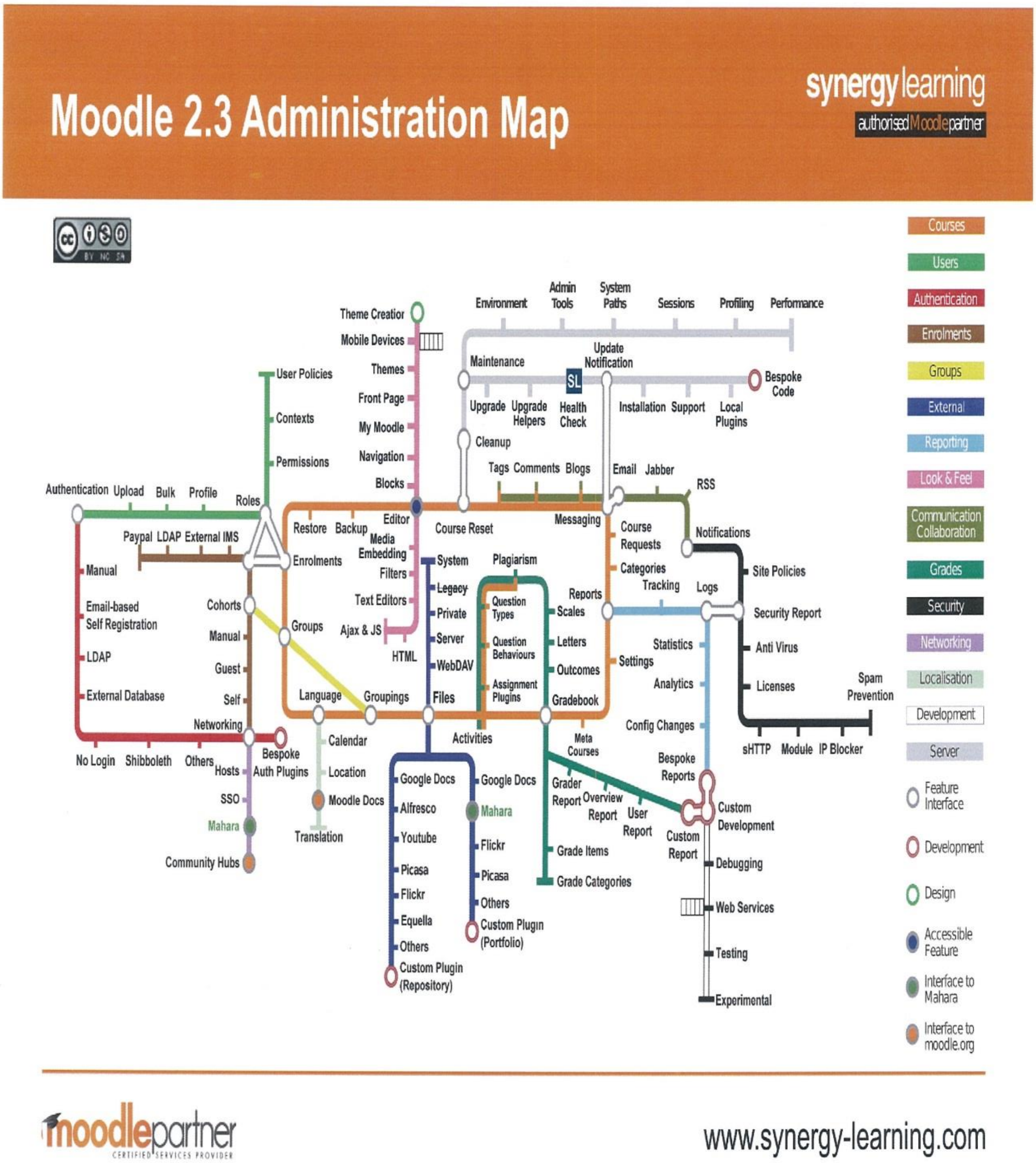
Appendix 25 Data Formalisation (Part 2)



Appendix 26 Data Formalisation (Part 3)



Appendix 27 Moodle 2.3 Administration Map



Appendix 28 Permission to use SMART TEST

Dear Helen

This email has been sent to you after you requested access to SMART test **Addition facts Quiz A** on the website www.smartvic.com
To take the test, your students should:

- go to www.smartvic.com/school
- enter first and last name (this is only for you to identify them – we do not need this) at the top right hand corner
- enter the test code: **hc1619**
- select their school year level (this information is for us to improve the tests)
- look at the sample items to see how they should answer
- work through the test, question by question
- be sure to press the “submit all and finish” button when they have finished.

Results of the test will be available to you immediately when you:

- login by clicking on this shortcut link.
- click on the tab "Quiz Index"
- click on this quiz name on the left side of the screen
- click on "see results" link on the right side of the quiz information line

Alternatively, as a teacher you can login at www.smartvic.com/smart using

- your login name: xxx@live.vu.edu.au
- your password: **xxx**

The smart-test can be reused with this password whenever you like.
You can also switch on or off its availability for students when you wish.

Thanks for using SMART system. We look forward to your feedback.

Smart-test development team

Appendix 29 SMART TESTS

List of Quizzes from SMART TEST available for students free of charge.

Select a quiz from the list below:

- NUMBER
- MEASUREMENT
- SPACE
- ALGEBRA
- CHANCE AND DATA

NUMBER

- Addition facts Quiz A Quiz B
- Multiplication facts (tables) Quiz A Quiz B
- Division facts Quiz A Quiz B
- Meaning of multiplication Quiz A Quiz B
- Multiplication and division with 1 and 0 Quiz A Quiz B
- Multiplication and division by 10, 100, 1000
  Quiz A Quiz B
- Prime, composite and square numbers Quiz A
- Factors and multiples Quiz A Quiz B
- Order of operations Quiz A Quiz B
- Relational thinking Quiz A Quiz B
- Choosing the multiplication and division operations Quiz A Quiz B
- Fractions: models and meanings Quiz A Quiz B
- Fraction operations - concepts Quiz A Quiz B
- Fraction operations - skills Quiz A Quiz B
- Understanding decimals Quiz A Quiz B
- Percentage estimation Quiz A Quiz B
- Percentage type/difficulty Quiz A
- Percentage strategy Quiz A
- Percentage change Quiz A
- Comparing ratios Quiz A
- Calculating with proportions Quiz A
- Readiness for directed number Quiz A Quiz B

MEASUREMENT

- Reading scales Quiz A Quiz B
- Estimation of number Quiz A Quiz B
- Estimation of length Quiz A Quiz B
- Length, area - basic concepts Quiz A Quiz B
- Mass Quiz A Quiz B
- Volume using litres Quiz A Quiz B
- Volume using cubic measure Quiz A Quiz B
- Labelling base, height of triangles Quiz A
- Pythagoras - readiness Quiz A
- Labelling hypotenuse, opposite, adjacent sides for trigonometry Quiz A

SPACE

- Rotation Quiz A
- Reflection Quiz A
- Understanding angle Quiz A Quiz B
- Congruence and similarity Quiz A
- Nets for solids Quiz A Quiz B

ALGEBRA

- Values for letters Quiz A Quiz B
- Letters for numbers or objects Quiz A Quiz B
- Writing expressions involving multiplication, addition and subtraction Quiz A Quiz B
- Formulating expressions Quiz A Quiz B
- Writing expressions using area rules Quiz A
- Expanding brackets using an area model Quiz A
- Writing and solving equations Quiz A Quiz B
- Plotting co-ordinates Quiz A Quiz B
- Representing linear functions Quiz A
- Rates from graphs Quiz A Quiz B

CHANCE AND DATA

- Interpreting pictographs Quiz A Quiz B
- Interpreting Bar Graphs Quiz A Quiz B
- Interpreting Line Graphs Quiz A
- Graphs: choosing the best type Quiz A Quiz B
- Arithmetic average (mean) Quiz A Quiz B
- Stats - Understanding mean, median and mode Quiz A
- Probability - Simple outcome spaces Quiz A Quiz B
- Probability — Long run Quiz A Quiz B

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- SMART test Addition facts Quiz B test code: hc11916
-
- SMART test Multiplication facts (tables) Quiz A test code: hc176
- SMART test Percentage type/difficulty test code: hc2794
- SMART test Multiplication facts (tables) Quiz B test code: hc11894
- SMART test Multiplication and division with 1 and 0 Quiz A test co hc1937
- SMART test Multiplication and division by 10, 100, 1000 Quiz Atest code: hc7672
- SMART test Multiplication and division with 1 and 0 Quiz A test code: hc1937
- SMART test Multiplication and division with 1 and 0 Quiz test code: hc1937
-

Appendix 30 Mapping research parameters to statistical variables

STAGE 1 variables

Demographic variables

[Gender] - Gender,
[LOTE] - Cultural background
[SES] [3] - Social-economic status
[Age] - Age

Descriptive measures

[ET] - Students Access to technology outside university,
[AT] - Students perceptions towards the use of technology for learning

The dependent variables in this study were:

[MT] - Attitude towards use of technology for learning mathematics.
[TC] - Confidence with technology
[MT] - Mathematics confidence

Attitude towards use of technology for learning mathematics was considered as a function of students' confidence with technology ([TC]) and mathematics confidence ([MC]). Formally this relationship was identified as:

[MT] = F ([TC], [MC])

STAGE 2 variables

[SE] - Student Engagement in learning mathematics. It was considered as a Function of student confidence with technology ([TC]) and mathematics confidence ([MC]). Formally this relationship was identified as:

[SE] = F ([TC], [MC])

[SE] - *Student Engagement in learning mathematics with three subscales:*

[CE] **-** Cognitive engagement

[3] *The socio-economic status (SES) distribution of the sample was determined using the Australian Bureau of Statistics Socio-Economic Indexes for Areas (2006) data cubes. The SES standing of students' home suburbs relative to those of Victoria as a whole was rated using the index of relative socio-economic advantage and disadvantage. Suburbs which fell into deciles 1-5 of the index were designated low SES areas, while suburbs in deciles 6-10 were considered high SES areas.

[AE] - Affective engagement
[BE] - Behavioural engagement

Subscales of every dimension of students engagement:

[CE] - *Cognitive engagement*
[CES] - Surface strategy
[CED] - Deep strategy
[CER] - Reliance

[AE] - *Affective engagement*
[AE-I] - Interest
[AE-A] - Achievement orientation
[AE-X] - Anxiety
[AE-F] - Frustration

[BE] - *Behavioral engagement*
[BE-A] - Attentiveness
[BE-D] - Diligence

Formally this relationship was identified as a function of two variables:

[SE] = F ([TC], [MC])
[CE] = F ([TC], [MC])
[AE] = F ([TC], [MC])
[BE] = F ([TC], [MC])

[CE]= F ([TC], [MC])
[CES] = F ([TC], [MC])
[CED] = F ([TC], [MC])
[CER] = F ([TC], [MC])

[AE]= F ([TC], [MC])
[AE-I] = F ([TC], [MC])
[AE-A] = F ([TC], [MC])
[AE-X] = F ([TC], [MC])
[AE-F] = F ([TC], [MC])

[BE] = F ([TC], [MC])
[BE-A] = F ([TC], [MC])
[BE-D] = F ([TC], [MC])

STAGE 3 variables

Student Engagement

[SE-ICT-Pre] – The level of Student Engagement in Learning mathematics in ICT-group before study.
[SE-ICT-Post] – The level of Student Engagement in learning mathematics in ICT-group after study.
[SE-TR-Pre] – The level of Student Engagement in learning mathematics in TR-group before study.
[SE-TR-Post] – The level of Student Engagement in learning mathematics in TR-group after study.

Subscales of Student Engagement

[CE-ICT-Pre] – Cognitive engagement in ICT-group before study.

[AE-ICT-Pre] – Affective engagement in ICT-group before study.

[BE-ICT-Pre] – Behavioural engagement in ICT-group before study.

[CE-ICT-Post] – Cognitive engagement in ICT-group after study.

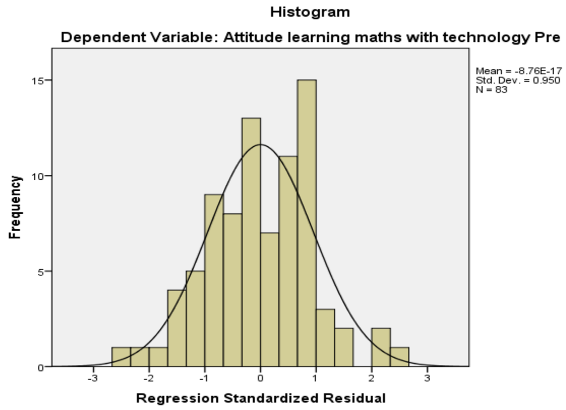
[AE-ICT-Post] – Affective engagement in ICT-group after study.

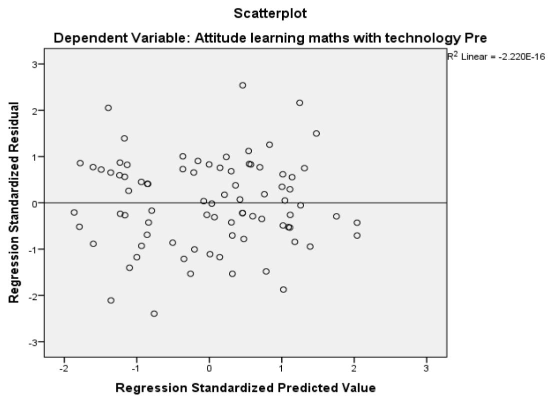
[BE-ICT-Post] – Behavioural engagement in ICT-group after study.

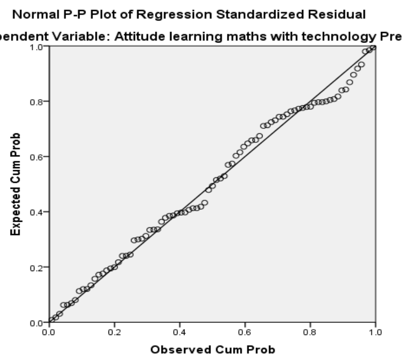
Appendix 31 Multiple Regression Analyses Residual Plots.

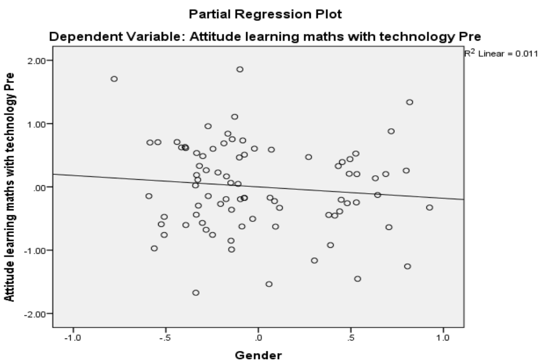
```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS CI(95) R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Avg_MT_Pre
  /METHOD=ENTER Gender Age SES_Low_High LOTE Avg_ET_Pre Avg_AT_Pre Avg_TC_Pre Avg_MC_Pre
  /PARTIALPLOT ALL
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS DURBIN HISTOGRAM(ZRESID) NORMPROB(ZRESID)
  /CASEWISE PLOT(ZRESID) OUTLIERS(3)
  /SAVE PRED COOK LEVER SRESID SDRESID.
```

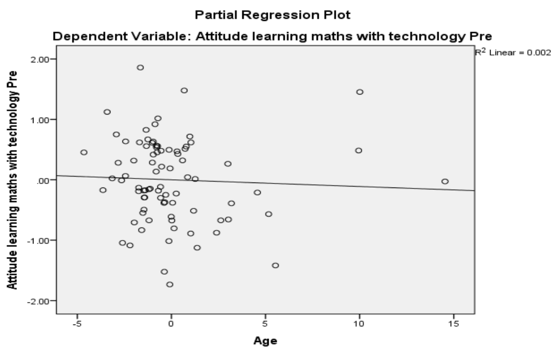
Charts

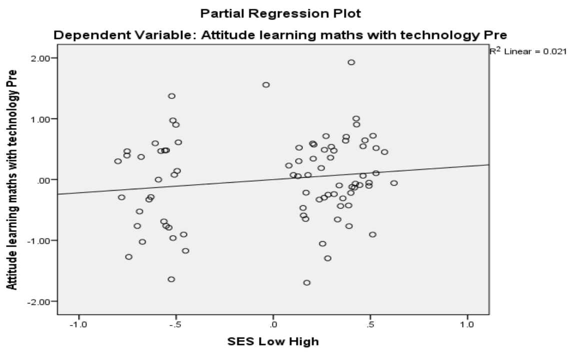


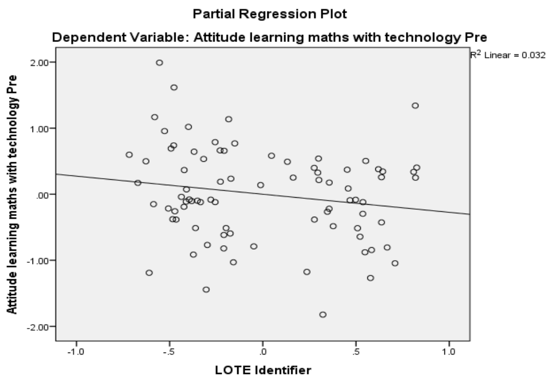


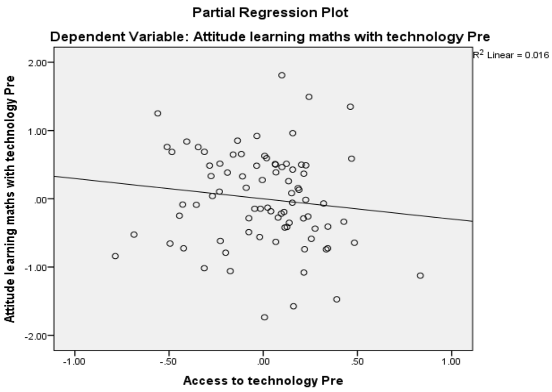


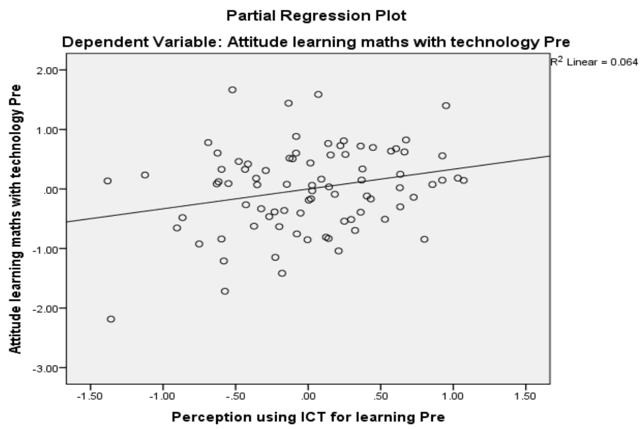


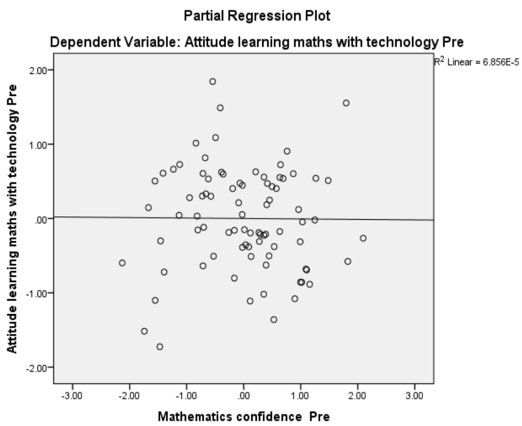


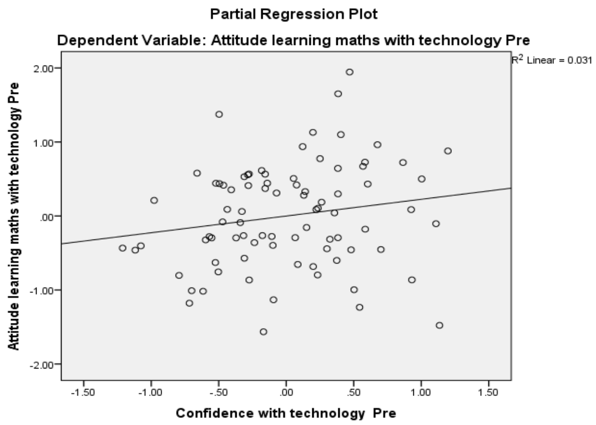



Partial Regression Plot
Dependent Variable: Attitude learning maths with technology Pre
R2 Linear = 0.032
Attitude learning maths with technology Pre
LOTE Identifier


Partial Regression Plot
Dependent Variable: Attitude learning maths with technology Pre
R2 Linear = 0.016
Attitude learning maths with technology Pre
Access to technology Pre


Partial Regression Plot
Dependent Variable: Attitude learning maths with technology Pre
R2 Linear = 0.064
Attitude learning maths with technology Pre
Perception using ICT for learning Pre


Partial Regression Plot
Dependent Variable: Attitude learning maths with technology Pre
R2 Linear = 6.856E-5
Attitude learning maths with technology Pre
Mathematics confidence Pre


Partial Regression Plot
Dependent Variable: Attitude learning maths with technology Pre
R2 Linear = 0.031
Attitude learning maths with technology Pre
Confidence with technology Pre