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Mental Models of First-Year Education Students Studying Information Communication Technologies

Thesis submitted by

Trang Thi Thuy NGUYEN

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DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Signature

Date

DECLARATION OF ETHICS

This research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research council (NHMRC) National Statement on Ethical Conduct in Human Research, 2007. The proposed research study received human research ethics approval from the JCU Human Research Ethics Committee Approval Number H2301 in February 2006 and the report for research or teaching involving humans submitted in 2007.

STATEMENT ON THE CONTRIBUTION OF OTHERS

Nature of Assistance	Contribution	Name, titles, and Affiliations Co-Contributors
Intellectual support	Principal Supervisor	Dr Jo Balatti, James Cook University
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Abstract

The attrition of first-year university students is an important political, socio-economic, educational, and community issue. Surmounting the intellectual challenges associated with transition problems to university, especially in the first six months, is crucial for developing appropriate academic learning habits and strategies. This doctoral thesis investigates mental models of first-year students undertaking a Bachelor of Education degree and how these might be related to their learning practices.

Mental models have been described as an internal, domain-specific representation of an object, system, or event that may be incomplete. Through their mental models, individuals are able to understand and explain the unknown and, with regard to problems, decide what course to follow, and predict consequences. Mental models are successful tools for the acquisition of knowledge, understanding, and problem-solving strategies in order to make such skills available in different situations. Mental models are seen as an important key to students' knowledge, critical thinking skills, and problem solving in learning environments. Mental models are also seen as predictive tools to students' learning performance and results.

The aim of this research was to build a picture of students' mental models in their first semester of first-year using one subject (course) as the context. In particular, the research questions asked were as follows: (1) What are students' mental models of themselves as first-year university students at the beginning and at the end of the subject? (2) What major changes, if any, occurred in the students' mental models across a semester period? and (3) Which mental models, if any, relate to students' learning achievement?

The sample comprised 102 first-year Bachelor of Education volunteer students studying the core first-year subject, *Information and Communication Technologies in Education*, in a regional university in Australia. This thesis employed a mixed-method approach but primarily used quantitative methodology. The data collection tools comprised Likert-scale questionnaires which drew on well-established research about student learning and open-ended questions administered as pre- and post-surveys.

There were 50 items in each questionnaire based on questionnaire items in the research literature and they were categorised into seven mental model subscales. The

seven mental models were: (1) the Sense of Purpose and Expectation Mental Model, (2) the Motivation Mental Model, (3) the Learning Strategy Mental Model, (4) the Collaboration Mental Model, (5) the Poor Coping and Comprehension Mental Model, (6) the Un-motivation and Ineffective Learning Strategy Mental Model, and (7) the Poorly Prepared and Absent Mental Model.

Statistical tests used to identify mental models of students included exploratory factor analysis, correlations analysis, paired sample t-tests, independent sample t-tests, one-way analyses of variance (ANOVA), and stepwise multiple regression analyses. Qualitative data obtained from the open-ended questions was thematically coded and the results were compared with the findings of the statistical analysis.

The five mental models that were identified at the beginning of the subject from the exploratory factor analysis were: (1) the Motivation, Goal, and Academic Engagement Mental Model, (2) the Coping and Expectation Mental Model, (3) the Collaboration Mental Model, (4) the Learning Strategy Mental Model, and (5) the Un-motivation Mental Model. The sample size in this study (102 students) was just within the acceptable range (100) and the Kaiser-Myer Olkin measure of sampling adequacy at pre-test was acceptable. However, the reliability analysis revealed that the Coping and Expectation Mental Model was unusable and the reliability coefficients of four other mental models were modest to acceptable. Therefore a second exploratory factor analysis on the post-test was not performed. To measure changes in the students' mental models at pre-test and post-test in the quantitative data, the seven mental model subscales were used. Three mental models were found in the qualitative data in both at the beginning at the end of semester one: the Difficulty in Coping and Comprehension Mental Model, the Academic Engagement Mental Model, and the Weak Academic Expectation Mental Model. The results of the quantitative and qualitative data analysis were discussed together to investigate students' mental models of learning.

This research determined that by the end of the semester, students' mental models of learning were difficult to change. Either they had not changed or if they had, the changes were generally not indicative of better mental models of learning. Also, differences were found in the mental models of students by gender and school completion time (school leaver/mature age students). Furthermore, there was a relationship between students' mental models and their learning achievement. The results determined that only the Poorly Prepared and Absent Mental Model of students at pre-test was a predictor of the academic grades of students. This mental model negatively impacted student learning achievement.

The findings of the study have implications for university practice. Implementing a program during the semester that helps students to recognise any weaknesses in their mental models of learning is a recommendation. There should be an emphasis on such programs not simply in terms of increasing skills acquisition but in terms of a program which might target students' mental models of learning. For lecturers of subjects that involve information communication technologies, the interventions such as better instructional design could help students to develop their mental models. Effective instruction can motivate and engage students to learn more and retain new knowledge in their long-term memory which enables them to incorporate and organise new information into more complete mental models.

This thesis has contributed to the mental models research of the first-year university experience in particular of pre-service teachers. Future research is needed to further examine mental models with larger groups of students and particularly, to investigate changes in students' mental models not only in the first semester, but also in the second semester of the first-year and possibly in the following years. Further studies of students in other disciplines, especially where a range of ICT tools are used as learning tools, will enable a comparison of results to help produce a clearer picture of the mental models of first-year university students.

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Chapter 1: Introduction

Setting the Context

The retention rate of first-year university students has been of concern to educators and universities worldwide for more than 40 years (e.g., Coates & Radloff, 2013; Cunningham, 2013; Fike & Fike, 2008; Whitehead, 2012; Wintre & Yaffe, 2007; Yorke & Longden, 2007). According to Allen (2010), first-year student retention and academic performance have been studied extensively also in Australia; however, the retention rate of first-year university students in this country continues to be an issue. The most recent report from the federal Department of Education and Training (2013) stated that in 2012, 20 percent of first-year students in Australian universities did not continue with their studies in the following year. This statistic did not account for students who may have changed institutions. In the same year, at the university in which this study took place, the proportion of first-year students who did not continue into their second year was 24 percent. Universities have actively responded to the need to increase retention.

Reasons for student non-completion are complex. Research has highlighted various problems and issues of first-year students and the factors contributing to their drop out (e.g., Baik, Naylor, & Arkoudis, 2015; Donnison & Penn-Edwards, 2012; Krause, Hartley, James, & McInnis, 2005; McInnis, James, & Hartley, 2000). The diverse research contexts of the studies, the differences in the composition of the participant groups, the methodological frameworks, and theoretical frameworks employed have resulted in a range of factors identified. Nevertheless, there are commonalities and overlap across the studies with respect to their findings and recommendations.

The quality of the first-year experience can be influenced by factors such as attendance mode (full-time or part-time students), admission type (school leaver/mature age students), and gender (Derrington, 2006; Kantanis, 2002; McInnis, James, & McNaught, 1995). Key challenges for first-year Australian students include heavy workload, motivation to study, and the ability to work in groups (Baik et al., 2015; James, Krause, & Jennings, 2009; Krause et al., 2005). Learning strategies also have been found to impact student retention (Donnison & Penn-Edwards, 2012; Lizzio, Wilson, & Simons, 2002). The social and the intellectual aspects of the first-year experience are evident in social networks and academic performance being identified as strong predictors of retention of first-year university students (Kantanis, 2002; Krause et al., 2005; McInnis et al., 2000; McKenzie & Schweitzer, 2001).

Larger studies undertaken over ten year periods have provided critical insights into the interconnections among a range of factors that impact the first-year experience. These include student socio-demographics, students' expectations of themselves and of university workload, preparedness, coping with university study, and academic engagement (Baik et al., 2015; Krause et al., 2005; McInnis et al., 2000). A combination of factors, including poor course choice, lack of accurate information about the course, academic difficulty, financial problems, isolation, and the inability to integrate into social networks, is considered a key to understanding students' withdrawal from their first-year course (McInnis et al., 2000).

Also significant to understanding the retention issue of first-year students are university related factors. In a study which surveyed students from 30 universities in Australia, Coates (2010) found that Australian first-year students feel that they are less supported by their universities and are significantly less likely to contact their lecturers and tutors than first-year students in the USA. Early intervention, curriculum design, pedagogy, and assessment are also critical factors to retaining first-year students (Gale & Parker, 2014; Kift, Nelson, & Clarke, 2010; Nelson, 2014).

The federal government has recognised the problems of first-year university students and has devoted significant expenditure to providing institutional academic support (MacNamara, 2007; Sebastian & Zimitat 2007). Since 2009, it has funded the Higher Education Participation and Partnerships Program which aims at increasing access and retention of students of low SES backgrounds (Gale & Parker, 2013). The funding has been used to implement a range of social support programs as well as academic skill development programs. Reporting on a national survey of first-year students in 2000, McInnis (2002) highlighted that support services, academic and learning resources, and campus atmosphere are important issues in helping students be successful during their transition time at university.

Various research methodologies have been employed to explore learning experiences and retention of first-year university students. As well as university databases, studies have used data generated by surveys administered to large populations and interviews with individuals or focus groups. A commonality across the studies that have used student generated data is that they collected data only at one point in time in the students' experience. Theoretical frameworks have also varied.

Research has utilised different theoretical frameworks to explore the learning environment characteristics relating first-year learning engagement and retention of first-year university students. Freeman (2015), for example, utilised Mezirow's Transformational Learning Theory to find evidence of transformational learning for first-year Australian Bachelor of Education students engaged in their learning. Tinto's Theory of Student Departure served as the theoretical framework for the research conducted by LaRocca (2015) to examine the learning experience of first-year students. Klein (2013) applied two frameworks: Astin's Student Involvement Theory and the I-E-O (inputs-environments-outcomes) in her study to investigate the learning environment factors related to first-year student retention. To predict student engagement and retention rate, Barrett (2011) employed the Student Engagement theoretical framework. Hoffer (2010) utilised Astin's Student Involvement Theory, Bandura's Social Learning Theory, and Tinto's Theory of Student Departure to explore academic success and retention rates of first-year students.

While various methodologies and theoretical frameworks have been used to investigate the problems of first-year students, the retention and performance issues still exist. This suggests a new approach could be applied to help understand the problems of first-year students. A thorough search of the literature revealed that mental models have not been used to study the learning performance and achievement of first-year students.

In this study, the mental model framework was selected to investigate students' mental models of learning and of themselves as first-year university students, not only because mental models are one of the best tools (Strauss, 2001) to help educators understand students' minds but also because it allows educators to know which mental models guide students' learning actions (Norman, 1983). Until now, no studies have tackled the relationship between mental models and student learning performance in the specific case of first-year education students.

Mental models are valuable constructs in the consideration of how individuals acquire knowledge and achieve understanding. Mental models are individuals' understandings of given concepts based on earlier and current experiences, beliefs and socio-cultural environments (Halford, 1993; Johnson-Laird, 1983, 1987, 2001; Johnson-Laird & Byrne, 2000). Mental models both modify, and are modified continuously, by incoming perceptions and inputs from external information (Merrill & Gilbert, 2008). The formation of mental models is heavily dependent upon prior conceptualization of attitudes and beliefs with respect to the world around us, of ourselves as learners, of our capabilities and prior experiences, of the issues and problems we face, and lastly of our learning strategies (Goodwin & Johnson-Laird, 2008; Johnson-Laird, 2001; Senge, 2012; Vosniadou, Skopeliti, & Ikospentaki, 2004). Their importance lies in the part they play in learning. Mental models can be correct or incorrect (Greca & Moreira, 2000). According to Jonassen (1994a) and Gentner (2002), understanding the correct and incorrect mental models of students helps educators in the design of the learning environment to create materials and learning experiences which support the construction of correct mental models.

In summary, there is significant worldwide research interest in first-year university students (e.g., Cunningham, 2013; Whitehead, 2012; Yorke & Longden, 2007) and also in mental models (e.g., Askell-Williams, Murray-Harvey, & Lawson, 2005; Jimerson, 2014; Johnson-Laird, 2013; Johnson-Laird & Byrne, 2000; Henderson & Tallman, 2006; Nguyen, 2004; Özcan, 2011, 2013; Richardson, 2007; Wilke, 2008) as a way of understanding students' learning behaviour in specific contexts. However, a review of the literature found that the mental model framework has not been applied to exploring the learning processes of first-year university students.

This study explored the mental models that first-year students hold about their learning. Furthermore, it investigated any changes in mental models of learning that occurred over a timeframe of one semester. In this respect, it differed from other studies of the first-year experience in exploring changes by collecting data twice from the same participants. Exploring change in how students experience their first-year has not attracted research interest. A commonly used approach to studying the first-year experience has been to conduct a once only survey or interview at some time during their first-year (e.g., Bowles, Dobson, Fisher, & McPhail, 2011; Coates, 2010; Donnison & Penn-Edwards, 2012). Some studies have collected multiple sets of data by investigating more than one first-year student cohort in different years (e.g., Baik et al., 2015; Krause et al., 2005). Less attention has been directed to finding out and comparing the conceptions or problems of students at the beginning and at the end of first-year. This thesis adds new knowledge in the literature by investigating and comparing mental models of students at the beginning and at the end of a subject conducted over the first semester of first-year.

This doctoral thesis aims to reduce the gap in the literature by contributing to the body of knowledge linking the First-year Experience with Mental Model Theory. According to Brownlee, Schraw, and Berthelsen (2011), most first-year students enter university showing great naivety. Studying mental models of first-year pre-service teachers provided insights into the way that novice students thought about their learning performance and how they constructed mental models of learning over the semester study. Developing a clearer picture of students' mental models allows educators to understand students' perceptions of the learning strategies that they used, the problems that they faced, and the factors that promoted or hindered their successful achievements in their first-year.

The cohort for this study comprised first-year pre-service teacher education students at an Australian regional university. Retention is an issue for initial education programs as much as it is for first-year students generally. The most recent data, reported in the Initial Teacher Education Data Report by the Australian Institute for Teaching and School Leadership (2014) stated that 23 percent of students who started initial teacher education programs in 2011 dropped out from their study before 2012.

Students who studied the compulsory *Information and Communication Technologies (ICTs) in Education* subject were invited to participate in this study. This subject was delivered in the first semester and according to the subject outline, it targeted high order thinking skills, strategies, and processes relevant to successful university study and lifelong learning. The coordinator/lecturer of the subject adopted a constructivist and social constructivist pedagogical approach in its delivery.

In Australia, the national accreditation process of Initial Teacher Education programs requires providers to integrate ICTs in their teaching and learning programs (Australian Institute for Teaching and School Leadership, 2011). Similar to other universities, the core ICTs subject has been included in the education program of this university to teach students ICTs skills, pedagogical theories, and the integration between ICTs and pedagogies in teaching and learning (Nykvist, 2013). When taught in the first semester of first-year university study, the subject poses particular challenges because some students struggled to see the significance of using ICTs in learning and teaching environment. They could not understand the necessity of undertaking the core ICT subject in their first semester first-year (Nykvist, 2013).

An important contribution that this study makes to the literature on the first-year experience is the use of mental models as predictors of positive or negative learning achievement. Furthermore, discerning the differences between the mental models held at the beginning of the semester and at the end of the semester would help educators to identify areas of learning of first-year students that need to improve. The findings of this study contribute to developing pedagogical strategies to guide the development of mental models.

The significance of the findings of this study pertains to their implications for interventions or changes in practice at the university level and at the subject level. Although the specific context was an ICTs related subject, the mental models obtained have relevance to the first-year experience overall and relevance to other first-year subjects that aim at developing higher order thinking skills and learning strategies for university study and lifelong learning. Furthermore, because the constructivist and social constructivist pedagogical approach used in this particular subject is a common approach across much university teaching, the findings have relevance beyond ICT specific subjects.

The Research Aims and Research Questions

Research Aims

This research aimed (1) to investigate the mental models of learning of first-year Education students studying the core, first semester, first-year subject *ICTs in Education* and (2) to examine what, if any, changes occur in mental models of learning of first-year university students during the first semester of study.

In order to have a clear picture of first-year education students' mental models at the beginning and at the end of their first semester and to thereby focus a different lens on the student learning and achievement, the research questions for this research were as follows.

Research Questions

1. What are students' mental models at the beginning and at the end of their first semester, first-year subject?
2. What major changes, if any, occurred in the students' mental models across a semester period?
3. Which mental models, if any, relate to students' learning achievement?

The methodology allowed further investigation and analysis of mental models of sub-groups of students. Thus, there were a number of sub-questions that needed to be answered in order to achieve the research aim:

a) Do the students' mental models differ in relation to gender and school completion time?

b) If so, what significant differences are there in students' mental models among the identified groups?

Methodology, Scope and Limitations

Methodology

A review of the mental model literature indicated that research on student mental models has predominantly utilised qualitative methodological approaches with a limited number of participants. This study favoured a quantitative methodology in its mixed method design. The design which primarily comprised the statistical analysis of survey responses was utilised to investigate the mental models of learning of a large group of first-year education students (102 students) enrolled in a regional Australian university at the beginning and the end of a core subject in semester one first-year subject. The Likert-scale questionnaires in each pre-survey and post-survey consisted of 50 items. The Likert-scale questionnaires allowed for investigating pre-defined mental models of learning of a large group of students and any changes of their mental models. The items and the pre-defined mental models were established from a review of the relevant literature. Responses to the items were analysed statistically. The qualitative aspect of the design comprised written responses to open-ended questions.

The surveys included two open-ended questions about the students' experience. The responses to the open-ended questions allowed students to describe their own mental models of learning that they constructed by themselves. These responses produced the qualitative data that were analysed thematically to obtain mental models that, unlike those obtained from the survey data, were not pre-defined.

The purpose of obtaining mental models in two ways was to compare the convergence and divergence of the findings of both approaches (Garson, 2008; Tashakkori & Teddlie, 1998). The amount of data generated from the open-ended questions was less than anticipated because some students did not respond to the questions. Specifically, the small qualitative aspect of the methodology was embedded in the quantitative design as a supplement method (Creswell & Plano Clark, 2010) to clarify the mental models of students obtained from the survey data.

The researcher had designed this study to include stimulated recall methodology to obtain students' in-action mental models of learning in the middle of their first semester. The researcher made two attempts to conduct stimulated recall interviews in the tutorial classrooms. However, at the time of conducting this study, volunteer students were concurrently undertaking three other studies so they were reluctant to participate. Hence I was unable to conduct the stimulated recall interviews which would have effectively explored students' mental models in practice. I therefore removed the stimulated recall component from this study and moved forward in analysing the data from the surveys.

Exploratory factor analysis was used to identify mental models of first-year university students at pre-test. Correlational analyses were then performed to investigate the relationship between mental models. To identify significant changes in mental models of students, a series of paired-sample t-tests was also conducted. The utilisation of independent sample t-tests helped to find out the significant differences between mental models of students based on their demographics. One-way analyses of variance (ANOVA) were computed to detect significant influences of mental models on academic achievement of students. Stepwise multiple regression analyses were conducted to predict the relationship between mental models and academic grades of prospective students.

Responses from two open-ended questions were coded and categorised thematically to find any mental models that students constructed in addition to the pre-defined mental models from the surveys. The themes (mental models) were identified based on what emerged from the data. The results of quantitative data were combined with results of qualitative data to provide better understanding of the mental models of first-year university students.

Scope and Limitation

Several limitations to this study exist. Firstly, there was the absence of a pilot study. Although a pilot study would have led to a more reliable questionnaire structure in this research thesis, there was no pilot study because at the time this study was conducted, all universities in Australia started the semester at the same time. The core ICT subject is introduced to pre-service teachers in the first semester, first-year at many universities in Australia (Nykvist, 2013) which is at the same time this study investigated mental models of first-year education students studying the *ICTs in Education* subject. This research did not have the time or funding available to conduct an adequate pilot study.

Secondly, the size of this study's participant group was a limitation. Due to the timing of the data collection, of the 257 students enrolled in this subject, only 102 volunteers participated in this research study. One contributing factor for having fewer than half the students participate was that at the same time that the data were being collected for this study, first-year education students were also being invited to participate in surveys and interviews of three other researchers. The sample size (102 students) in this research was just within the acceptable range (100) for the statistical analyses performed and the Kaiser-Myer Olkin measure of sampling adequacy for the exploratory factor analysis at pre-test was acceptable. Due to the sample size, the results of the exploratory factor analysis should be reviewed with caution. The sample size also meant that a second exploratory factor analysis on the post-test was not performed. The seven pre-defined mental model subscales from the questionnaire instruments were then used for further statistical analyses.

Thirdly, the context of this study was the experience of students in a first-year, first semester subject rather than being the experience of students in their first-year, first semester of university. Therefore a small percentage of the students (10 percent) who participated in this study were not first-year first semester students.

Finally, the amount of qualitative data was limited. This was due to low response rates among participants to the open-ended questions. Many participants in this study did not respond to open-ended questions at the end of the survey. Although interviews, focus group interviews or stimulated recall interviews could provide better data than the open-ended questions, these interviews could not be conducted in this research. The researcher attempted to conduct stimulated recall interviews to find out in-action mental models of learning of pre-service teachers in their tutorial classrooms. Unfortunately, students did not participate because at the same time this study was conducted, many first-year Bachelor students were also participating in three other studies.

Chapter Outline

Chapter 1: Introduction

This introduction chapter outlined the context of the research and the purpose of the study. It included the rationale for the use of the mental model framework. An outline of the study's methodology, scope, and limitation was also presented in this chapter.

Chapter 2: The Problems of First-Year University Students

This chapter reviews the literature about the problems of first-year university students. Factors such as learning and teaching strategies, motivation, academic and social engagement, metacognition, self-efficacy, gender, school/mature age students, metacognition, finance, low social-economic, and secondary school results are discussed. Chapter Two also discusses how educators and universities have responded to challenges of first-year university students.

Chapter 3: Mental Models

This chapter reviews the literature on mental models. The nature, characteristics, functions of mental models, and mental models of learning are reviewed. A section that covers development change in mental models is included because changes in mental models of first-year education students from the beginning to the end of the first semester are examined in the study.

Chapter 4: Methodology

Chapter Four elucidates the research questions. It then outlines the rationale for the embedded mixed methodology approach emphasising the quantitative approach that was used in this study. It then provides a thorough explanation of the research design, the data collection tool, and data analysis employed in this study.

Chapter 5: Mixed Method Results and Analysis

This chapter focuses on data analysis. Students' mental models of learning that were at the beginning and at the end of the semester were identified. It includes evidence of changes in participants' mental models over the one semester period. Also reported are differences in mental models by gender and school completion time (school leaver/mature age students).

Chapter 6: Discussion, Implications, and Recommendation

The chapter discusses the findings of the research to provide a clear picture of mental models and of any changes in first-year students' mental models over the first semester of study. The discussion is followed by a summary of the contribution this study makes to the literature of the First-year Experience. It concludes with the implications the study suggests for proactive strategies that could assist universities and lecturers in improving the learning of their first-year students. It closes with a recommendation for further research.

Chapter 2: The Problems of First-Year University Students

Overview

Chapter Two and Chapter Three comprise the literature review. Chapter Two reviews the research undertaken on the problems of retaining students entering first-year university courses through to graduation which remain critical in many higher institutions internationally. Chapter Three reviews the literature concerning the mental model framework.

There are three sections to this chapter. The first section presents a brief overview of the extent and repercussions of first-year attrition. The second section reviews the factors that have been identified as the causes of this phenomenon. Some personal factors, such as, students' socio-economic and financial status, gender, and age are mostly beyond the control of higher education institutions. However, factors that are linked to the quality of learning and teaching, such as learning and teaching strategies, motivation, academic and social engagement, self-efficacy, and metacognition can be improved through appropriate pedagogical approaches and from support programs. It is in these areas that universities can have a considerable impact on student learning outcomes and retention. The third section discusses how universities/educators have responded to the challenges of the first-year university experience.

Problems of First-Year University Students

The successful transition from work or school to university of first-year university students is critical in relation to student outcomes and retention. Universities are confronted with the recognised problems of first-year students' failure and withdrawal. The retention rate of first-year university students has been an increasingly important personal, institutional, political, social, economic, and educational issue in the international arena for more than 40 years (Baik et al., 2015; DeBerard, Spielman, & Julka, 2004; Drysdale, Ross, & Schulz, 2001; Kift et al., 2010; Krause et al., 2005; Tinto, 1975, 1985, 1998, 2002, 2012; Yorke & Longden, 2007).

Personal Level

At a personal level, high attrition rates mean that students' efforts and talents are wasted and, in many cases, their aspirations are shattered or forced to change.

Australian students who do not complete their degree "gain little economic advantage", but still face "the prospect of HECS[1] re-payment" (Long, Ferrier, & Heagney, 2006, p. 1). In addition to HECS, they (and their families) have to bear the costs of university study, such as, living and travel expenses, books, a computer, and other equipment. A school leaver student in Australia who drops out of university will earn 1.5 million dollars less than the average university graduate student over his or her life time (Milburn, 2012). The statistics from the United States on first-year student retention revealed that those "who fail to graduate are worse off than when they started facing crippling debt and poor job prospects" (King Head, 2009, para. 4).

Institutional Level

At an institutional level, the attrition of first-year students can affect the financial ability of institutions to sustain academic programs given the funding models enforced on them at present. When first-year university students do not continue to their second year, this results in a waste of potential, resources, and skills. The high attrition rate can adversely influence a university's institutional quality reputation, which in turn impacts the financial ability of institutions to offer many support programs. This includes its student support services, such as assistance programs and orientation programs (Long et al., 2006; Vivekananda et al., 2013). Hence, the university's initial enrolment numbers can be further diminished. The attrition rate also represents a loss of income for universities because the Australian government has developed funding mechanisms that rewards institutions on the level of learning and teaching performance, including first-year retention rates and first-year to second-year progression rates (MacNamara, 2007; Sebastian & Zimitat 2007). While the funding of the Australian government rewarding the reduction of attrition rates of first-year university students began in 2008 (Sebastian & Zimitat 2007), attention to the first-year university students has been a priority of educators for more than 40 years (Baik et al., 2015; DeBerard et al., 2004; Drysdale et al., 2001; Kift et al., 2010; Nelson, 2014; Krause et al., 2005; Tinto, 1975, 1985, 1998, 2002, 2012).

National Level

At a national level, the attrition rate means that the projected recruitment of

[1] HECS is an abbreviation of Higher Education Contribution Scheme that is a loan available to eligible students.

human resources to the work force at graduate level may not be achieved, leading to a partial waste of economic resources. Students who do not complete their academic studies may face difficulties in entering the workplace in modern competitive economies (Fike & Fike, 2008)**.** Acknowledging this, the Commonwealth Department of Education, Science and Training [DEST] reviewed the policies of higher education and introduced the Teaching and Learning Performance Fund (TLPE) where student retention rate is one of the performance indicators. The federal government policies have focused on issues of various targeted equity groups to support their transition into university and first-year (Scott, 2006; Scott, Shah, Grebennikov, & Singh, 2008). A media report on retention rates in 2012 stated that the Australian student attrition rate was “worth billions of dollars in lost productivity, earnings and skill levels” (Milburn, 2012). In America, a report by the American Institute for Research (Scheider, 2010) revealed that state governments spent 6.2 billion dollars for education and 1.4 billion dollars to support students who left colleges or universities after their first-year.

In 2008, the Australian government launched a review of the future of the higher education sector (Bradley, Noonan, Nugent, & Scales, 2008). The report indicated that only 28 percent of the Australian people had an undergraduate degree. The Australian government determined that 40 percent of its population from 25 to 34 years old should have an undergraduate degree by 2020 (DEEWR, 2009). Also in 2009, the Australian government responded to the report with a ten-year plan to reform the higher education system and for Australian government and universities to be working to attract more students to higher education. The Higher Education Participation and Partnership Program was implemented to improve retention and completion rates of students (DEEWR, 2009).

In the year 2005, one third of first-year Australian students consider withdrawing from university during their first semester (Krause et al., 2005). However, this national study did not examine the student attrition rate in each faculty. Long et al. (2006) conducted research on first-year students in 14 Australian universities and reported that the attrition rate is higher for the fields of Education (excluding Teacher Education) (19.8%), Engineering (18.5%), Information Technology (17.2%), and Teacher Education (15.6%), and lower for Health (excluding Nursing) (5.3%), Science (9.8%), Law (10%) and Architecture and Building (11.4%).

A 2007 report in the *Higher Education* section in *The Australian* newspaper revealed that: "... of the 300,000 or so first-year students who will arrive on Australian campuses this week, just under 100,000 will be gone by the end of the year" … Ms Bishop [the Australian minster for Education in 2007] said universities with high attrition rates could do more to track why students left the system" (Macnamara, 2007, p. 33). However, the number of first-year university students left universities increased to 35 percent in the year 2008 (Coates & Radloff, 2013).

The 2009 First-Year Experience survey in nine Australian universities published that there were 23 percent of first-year students who seriously thought of deferring or discontinuing (James et al., 2009). However, the findings of the Australasian Survey of Student Engagement (Radloff & Coates, 2009) in which 30 educational institutions from Australia and five from New Zealand participated confirmed that 30 percent of first-year Australian students across the country seriously considered dropping out in their first-year of study. In 2010, the Australian Council for Educational Research (2010) conducted a survey on 55,000 students from 55 Australian tertiary institutions and revealed that 27 percent of first-year students were thinking of leaving their studies.

In 2012, 20 percent of first-year students did not continue with their studies in the second year (Department of Education and Training, 2013). The media in 2015 reported an alert about the number of first-year university students who did not continue their study in their second year (Carter, 2015). Addressing the retention rate issue of first-year university students, Professor Sally Kift stated that she did not "think an easy, seamless transition to university is assured, wherever students come from" (Cited in Carter, 2015, para. 8) in her interview with national radio.

It is worthwhile juxtaposing the Australian attrition rates against those in other economically comparable countries. Garner (2007) asserted that the worst retention rate in the world of first-year university students occurs in the United States, where about 50 percent of young first-year students dropped out of their courses. However, according to American College Testing (ACT, 2007), a more precise average retention rate of first-year students in the United States is 41 percent from first-year to second year, with 34 percent dropping out of degree programmes. The United States Department of Education examined the college attrition rate and found that between 2000 and 2008, 30 percent of students left during, or at the end of, their first-year study and 50 percent of students who enrolled in Bachelor degrees would never graduate

(King Head, 2009). Thus, the United States higher education institutions are encouraged to actively identify students who are at risk of not completing their course and to take appropriate action.

In Canada, Wintre and Bowers (2007) conducted a study of 944 undergraduate students and reported that 57.9 percent of students had graduated, nine percent remained enrolled and 33.1 percent were neither re-enrolled nor graduated. A third of New Zealand students do not complete their degrees (Whitehead, 2012).

It is estimated that 22.4 percent of students in the United Kingdom (Garner, 2007) and 50 percent of students in France (Marshall, 2007) failed to complete their first-year course. The completion rate for Bachelor degrees is approximately 50 percent in the Netherlands (Butts & McNeil, 2003) and in New Zealand (Scott & Smart, 2005). Forty percent of students in South Africa dropped out of their first-year course (Macgregor, 2007).

Proliferation of research into retention and first-year experience has led to the establishment of First-Year Experience conferences around the world. The first Annual Conference on The Freshman Year Experience was held at the University of South Carolina in 1982 entitled *National Resource Centre for the First-Year Experience and Students in Transition* (National Resource Center History, 2014*)*. In addition, the completion rates of first-year university students in Bachelor degree programs in European countries and around the world has led to the foundation of *The European First-Year Experience Conference* that is linked with the United States *National Resource Centre for the First-Year Experience and Students in Transition.*

In Australia, the Pacific Rim - First-Year in Higher Education Conference was first held in 1995 with the theme *Travelling through Transition*. Since then, this conference has continued to be held every one or two years with different themes, for example *Strategies for Success in Transition Years* (1998), *Enhancing the Transition to Higher Education* (2003), *Preparing for Tomorrow Today: The First-Year Experience as Foundation* (2009), and *Aspiration - Access - Achievement* (2010). The theme for the 14th Pacific Rim - First-Year in Higher Education Conference 2011 in Freemantle was *Design for Student Success*. The 15th International FYHY theme, *New Horizons* was in Brisbane in 2012. The 16th International FYHY was in New Zealand in 2013 and the 17th International FYHY was in Darwin, 2014.

High Attrition Causal Factors

Research into attrition rates of first-year students has unearthed a multitude of causal factors. These are reviewed in this section: learning strategies, motivation, academic and social engagement, metacognition, self-efficacy, gender, and mature age and school leaver students. Reviewing these factors helps to find out how previous research have pursued the problems of first-year students in order to build a deeper understanding of these factors which were also investigated in this research. Other factors such as self-efficacy, metacognition, university entry scores, demographics, and financial hardship are not directly investigated in this study; however, they are reviewed here to provide a clear comprehensive picture of factors relating to the retention rates of first-year students.

Learning and Teaching Strategies

Learning Strategies. Learning strategies are important in being successful at university. There is a direct relationship between students' learning strategies and their effect on learning behaviours (Heikkila & Lonka, 2006). First-year university students need to possess certain learning strategies such as critical thinking, metacognition, and self-regulation (Boud & Falchikov, 2006; Facione, 2010; Fagin, Harper, Baird, Hadfield, & Sward, 2006). Some researchers (Haggis, 2004; Haggis & Pouget, 2002) have highlighted that when students are equipped with the learning strategies and skills necessary for them to complete the courses, their transition to university life is easier. Similarly, some writers have contended that attrition is related to learning strategies and that there is a positive correlation between learning strategies and higher grade point average scores (Derrington, 2006; Duff, Boyel, Dunleavy, & Ferguson, 2004; Gijbels, Van de Watering, Dochy, & Van den Bossche, 2005; Richardson, 1997; Zeegers, 1999).

According to some researchers (Donche, De Maeyer, Coertjens, Van Daal, & Van Petegem, 2013), students use different learning strategies when processing their learning. The differences in student learning strategies have been examined as different approaches to learning (Biggs, 1987; Entwistle & McCune, 2004), and learning patterns or mental models (Vermunt & Vermetten, 2004). Vermunt and Vermetten (2004) proposed that learning strategies are closely linked to how students think about learning and teaching (mental models of learning) and motivation. Learning strategies are described in terms of metacognitive and cognitive processing strategies in Vermunt's models of student learning. Cognitive processing strategies are identified by either the use of deep processing activities such as structuring tasks or surface processing activities such as memorising. The mental models of learning by Vermunt and Vermetten (2004) are thoroughly discussed in Chapter Three.

Biggs (1987) used three terms to describe the learning approach of students: surface, deep, and achieving. Two common learning approaches adopted by students are surface and deep learning. The surface approach is described as follows: routinely memorising facts rather than seeking meaning, seeing little value or meaning in the subjects, studying without reflecting on strategies, and often spending minimal time and effort on study (Biggs & Tang, 2007). The deep approach is related to the self-reported development such as lifelong learning, problem solving, analytic skills, ability to plan their own work, and confidence to solve new learning situations (Lizzio et al., 2002). Elaborating this concept, Biggs and Tang (2007) stated that the deep approach is about engaging in assigned tasks and the subjects meaningfully, focusing on underlying meanings, refining ideas, seeing things from different perspectives, using evidence, and applying that knowledge across contexts.

While surface and deep learning approaches define the way students engage in their assigned tasks and study, these approaches do not describe how students organise themselves. Biggs (1987) proposed the achieving approach which is characterised by effectively organising study, time management, and putting forth more effort in order to achieve good grades, whether or not the material is interesting.

Given the discussion above, the approaches to learning by first-year students is of interest to researchers. Donnison and Penn-Edwards (2012) found that many first-year university students adopted the surface approach. School leaver students were more likely to use surface learning than mature age students. In a discussion about the utilisation of surface learning of school leaver students, Wingate (2007) argued that it might be due to their epistemological beliefs which come from prior learning experiences at school. Donnison and Penn-Edwards (2012) also reported that some first-year students use a deep learning approach. However, because of their inexperience in this approach, their learning at university is limited.

Different findings about the relationship between the approach to learning and learning performance have been discussed in the literature. Byrne, Flood, and Willis (2002) discovered that the deep approach has a statistically significant relationship with high academic performance, while a surface approach has a negative relationship with performance. In the same vein, Zeegers (2004) found a positive relationship between a deep approach to learning and academic achievement of first-year science students. Burton, Taylor, Dowling, and Lawrence (2009) indicated surface learning was related to lower grade point averages of first semester, first-year students.

Lizzio et al. (2002) conducted a study of a large, cross-disciplinary sample of undergraduate students in two Australian universities to investigate the association between prior academic achievement, students’ approaches to learning, and academic achievement. Students’ perceptions of heavy workload influenced their choices of surface learning which related to poor learning outcomes. This was not surprising because students who could not handle the workload would aim to memorise or reproduce what they had learnt in order to cope with their academic study. Students who could manage their workload effectively would approach learning at deeper levels.

Lizzio et al. (2002) also found that students’ perceptions of a good teaching environment were the strongest predictors of students working towards the deep approach to learning. Conversely, students’ perceptions of a bad teaching environment and inappropriate assessments such as multiple choice questions led to surface learning. They suggested that the teaching environment and workload should be considered when designing the courses in order to promote a deep approach and good learning outcomes.

Lizzio et al. (2002) discovered that a surface learning approach to learning was a strong predictor of a students’ high grade point average if the nature of the assessments was multiple choice exams which was related to memorisation or procedural knowledge. However, Diseth, Pallesen, Holvand, and Larsen (2006) stated that deep and surface approaches were not significantly related to academic achievement in the form of multiple choice question examinations.

Analysis of the research (Biggs & Tang, 2007; Chan, 2004; Entwistle & Peterson, 2004) suggested that first-year students may benefit from the utilisation of both deep learning and surface learning, but for different purposes. Because the deep learning approach impacts on the skills necessary for self-directed and lifelong learning, Kreber (2003) emphasised that higher education has a responsibility to create a learning environment that promotes deep level learning in students. Although deep learning is preferable, surface learning such as memorising is needed in many disciplines such as language, mathematics, and science (Biggs & Tang, 2007; Chan, 2004; Entwistle & Peterson, 2004). Chan (2004) argued that students can adopt an approach to learning combining aspects of both surface and deep learning as some surface strategies such as memorisation can be used to deepen and develop understanding. According to Donnison and Penn-Edwards (2012), to expect first-year university students to consistently utilise deep learning in their first-year is unreasonable and there is a place in higher education for a surface approach to learning. This thesis did not directly investigate the deep and surface approaches of first-year students. However, by exploring mental models of learning of first-year students, any mental model factors relating to the utilisation of deep or surface approaches are discussed in Chapter Six.

Independent learning. Deficiencies in learning strategies in terms of self-regulation and inadequate time management can inhibit students' independent learning which is an important aspect of higher education (Nelson, Quinn, Marrington, & Clarke, 2012). Independent learning skills are the keys to success at university and are widely acknowledged in Australian universities (Field, Duffy, & Huggins, 2014; Meyer, Haywood, Sachdev & Faraday, 2008).

Given the importance of learning independent skills at higher education, Meyer et al. (2008) conducted a comprehensive review of the international literature and documented a broad agreement that independent learning is "a process during which learners develop the values, attitudes, knowledge and skills needed to make responsible decisions and take appropriate actions in regard to their own learning" (p. 15). Independent learners are able to manage their studies, their time, and themselves (University of New South Wales Learning Centre, 2013).

The term "self-directed learning", "learning how to learn", and "self-regulated learning" are sometimes used interchangeably with independent learning (Meyer et al., 2008, p. 2). The description of self-regulated learning was best addressed by Zimmerman (1986). Zimmerman explained that when students are able to self-regulate their learning they are capable of having an understanding about their learning approach and maximise their study efficiently. Furthermore, students have strong motivation to take responsibility and collaborate with others to improve their learning.

While independent learning skills and critical thinking skills are considered essential factors in higher education, many first-year university students, either school leaver students or mature age students, do not have these skills. School leaver students who come straight from secondary school, where the teachers control the classroom and behaviourist study is commonly the norm, found it difficult to adjust to independent learning at university (Field et al., 2014). At secondary school, students are more reliant on teacher-directed learning while at university, students required to be more self-directed and engage in peer learning (Meyer et al., 2008). The distinguishing feature between learning at school and university has been identified in the Learning Centre at University of New South Wales website in 2013: "…the higher degree of independence expected from uni students. Studying at university allows you far more control over your work than school. However, uni also offers far less supervision". First-year university students in this study were required to learn and complete the *ICTs in Education* subject assignments as well as other subjects independently. Lacking independent learning skills hinder successful transition to university.

Educators (Field et al., 2014; Kift, 2009) emphasised that independent learning skills should be explicitly taught to first-year students because they are important "to optimal achievement and maximizing learning outcomes for all students" (Field et al., 2014, p. 5). Different techniques of training/instructions should be taught to help students be independent learners. For example, independent learning skills should be integrated into the curriculum in a scaffolded way in Australian universities (Kift, 2009) or by facilitating peer study groups (Damon & Phelps, 1989). First-year students need to know that being an independent learner at university does not mean that they are isolated in the teaching and learning environment (Myer et al., 2008). An important characteristic of independent learners is that they are able to recognise their abilities and seek out the assistance through lectures, academic support staff, and tutors (Ashford & Cummings, 1983).

Skills in planning, organisation, self-instruction, self-monitoring, and self-evaluation should be included in the formal curriculum in order to support positive learning outcomes (Zimmerman, 1986; 2008). However, universities rarely teach and develop independent learning skills to first-year university students in the discipline classroom (Field et al., 2014). In their research, Field et al., (2014) indicated that the instruction on how to be an independent learner was not in frequently found in law lectures, physics labs, and the English literature classroom. The lecturers tended to focus on teaching new knowledge, rather than asking if the students understood the learning skills that are required for their learning and success in their first-year and throughout their degree.

Constructivist and social constructivist teaching and learning. Independent learning falls within the field of constructivist teaching and learning. The constructivist approach is based on learner-centred activities and social learning theory (Lave & Wenger, 1991; McInerney & McInerney, 2010; Vygotsky, 1978). Constructivist views of learning have emphasised the active role of learners and "effective learning occurs when individuals construct their own understanding" (McInerney & McInerney, 2010, p. 3). Constructivism, scaffolding, and social constructivism are at least some of the keys for a successful first-year transition at university. Within higher education, the basic tenet of constructivism is that learners study actively by brain storming, critiquing, and solving problems, rather than regurgitating what they have observed or heard (Werth, Southey, & Lynch, 2009). Students are encouraged to become critical thinkers and self-directed learners by applying their prior knowledge in learning situations in which they have to analyse, articulate, and re-evaluate their understanding (Duffy & Jonassen, 1991). In the constructivist teaching and learning environment, students construct their knowledge and understandings while teaching is simply a catalyst for learning (Biggs, 2003).

A constructivist approach is necessary in the teaching of ICTs in distributed learning environments as ICT skills change very quickly because of rapid technological developments (Crawford, 2003). Boyle (2000) suggested that focusing on information memorising is not helpful as both teachers and learners must continuously update and relearn their ICT skills and knowledge. In the *ICTs in Education* subject in this study, students were encouraged to construct their own knowledge in the constructivist and social constructivist learning environments vis-a-vis construction of mental models. Moreover, students study more effectively when engaging with authentic tasks which encourage their curiosity. For example, in this study, when students utilised the ICT cognitive tools, the usefulness of “semantic networks” and “concept maps” (Jonassen, Peck, & Wilson, 1999, p.163) allowed students to construct their ideas spatially and transfer these ideas or mental models to other students.

Engaging students in constructivist learning and teaching activities in their subjects helps to increase the retention rate of first-year students (Tinto, 2005). The educators’ role is to provide effective support to assist students to discover knowledge and guide students towards understanding without telling them the things they need to understand. Scaffolding in the constructivist teaching approach makes the students’ job easier by providing the maximum amount of assistance at the beginning stages of learning and then, as the students’ mastery grows, gradually withdrawing, or fading out the assistance process (Kablan & Kaya, 2014; Puntambekar, & Kolodner, 2005). The gradual release of responsibility is accompanied by a concurrent decrease in the degree of assistance, without the learning task itself being altered by being broken down into simpler subsidiary component tasks (Collins, Brown, & Holum, 1991). This pedagogy promotes student engagement and “substantially enhances student processing skills” (Tinto, 2005. p. 93). These skills would not only help students to understand the core subjects in their first-year, but also in their second and third year at university (Werth et al., 2009). When learners are made to actively and constructively attempt their own solutions, with prompting kept to a minimum, the resulting internalization of procedural knowledge, and importantly, conceptual mental models is both more effective and more permanent than when the correct solutions are broken down and directly taught. When first-year students have done it themselves, or worked it out for themselves, it is much more securely etched in their mental models (Collins et al., 1991).

Educational theory not only emphasises the importance of culture and context in knowledge development and understanding, but also acknowledges the internal mental structures of individuals (Bruner, 1966, 1986, 1996; Piaget, 1963; Vygotsky, 1978). The social interaction between learners with their fellow students, lecturers, tutors, and knowledgeable people plays an important role in the learning process. Learners assimilate the social meanings of significant symbol systems, and study how to use them within learning environments. Learning is a social process in which knowledge develops through interactions and communications within groups (Gredler, 1997; Prawat & Floden, 1994; Mason & Rennie, 2006). In this context, educators play the role of facilitator rather than being the source of knowledge while students take on the active learning role. If group interaction is involved at a high cognitive level such as interactive exchange of ideas and perspectives, especially asking and answering questions, then group interaction influences cognitive thinking (King, 2002; Surowiecki, 2004). Individuals each build their own idealized mental models of a concept and verbalise their mental models to groups of people who mutually recognise and understand that concept. Critical thinking is developed with respect to differing descriptions and perspectives when these are challenged and defended. Cohen et al. (2004) said, after Hutchins (1995), that thinking skills are not only learned in social interaction but continue to be manifested in social contexts. Furthermore, King (2002) and Surowiecki (2004) indicated the critical role of the lecturers/tutors in the learning group. Without the influence of the lecturers/tutors, the high level of cognitive thinking may not be achieved.

Social constructivists promote collaborative learning, which helps students develop multiple perspectives for problem-solving. Working in small groups in the computer lab, or in tutorials, allows students to share different views and help one another. It also gives opportunities for learners to re-examine and be aware of their own knowledge (metacognition) (Spigner-Littles & Anderson, 1999), their mental models (Henderson & Tallman, 2006), and to engage in various metacognitive experiences. When learners share information with groups, they may quickly realise how much they know or do not know, which may further promote their metacognitive awareness. They are also made aware of the difference between understanding and memorising materials (Henderson & Tallman, 2006).

Because metacognition does not develop automatically in all students, some students need support from more knowledgeable people, or from instructional strategies such as modelling and cognitive apprenticeship to achieve effective metacognition (Resnick & Johnson, 1988). Gunstone and Baird (1988) argued that metacognitive abilities are enhanced when they are integrated with the subject content and the learning context. Students are forced to reflect upon their own thinking processes, decide what steps are needed for them to solve problems, and evaluate outcomes. This in turn encourages learners to construct and organize internal mental models in order to reflect effectively and efficiently upon their thinking. Metacognition is facilitated through the process of reflection, and students seem to learn better and solve problems more quickly, especially when a task is complex and conceptual (Chan, Lam, & van Aalst, 2003). Learners take cognitive responsibility for monitoring and evaluating their own and their peers' knowledge. Social constructivist learning promotes the development of metacognition which is important for achieving higher-order, independent thinking (Crawford, 2003; Riedel, 2003). Wenger (1987) argued that within collaborative groups, people access information virtually from someone else's memory. She called this the Transactive Memory System of a group which is "not [sic] traceable to any of the individual alone, nor it can be found somewhere "between" individuals. Rather, it is a property of a group"(Wegner, 1987, p. 191).

Integration of ICTs in education programs. The role of ICTs in education has been emphasised worldwide (e.g., Department of Education USA, 2010; Ministry of Education New Zealand, 2006-07; Ministry of Education Singapore, 2008, 2009). In Australia, it is required that the graduate teacher must "implement teaching strategies for using ICT to expand curriculum learning opportunities for students" and "demonstrate knowledge of a range of resources, including ICT, that engage students in their learning (Australian Institute for Teaching and School Leadership, 2011, focus areas 2.6 and 3.4). To prepare pre-service teachers for their future profession, universities have included the compulsory introductory ICT course in the curriculum to provide students with the necessary ICTs knowledge and skills (Moran, Vozzo, Reid, Pietsch, & Hatton, 2013; Polly, Mims, Shepherd, & Inan, 2010).

In many universities worldwide, educational technologies courses deliver only basic technology skills (Polly & Shepherd, 2007; Mims, Polly, Shepherd, & Inan, 2006; Wang, 2002) and do not teach students the effective implementation of technology in teaching and learning at school (Beyerbach, Walsh, & Vannatta, 2001; Wang, 2002). Polly et al. (2010) emphasised that education faculties should focus not only on the computer skills of pre-service teachers but also facilitate the utilisation of ICT in teaching and learning.

The Technological Pedagogical Content Knowledge (TPCK) framework, now known as TPACK has been introduced and promoted in the curriculum in education programs in many universities (Mishra & Koehler, 2006). The TPACK provides the pre-service teachers with the integration of knowledge fundamentals that they need to effectively teach with ICT, comprising the dynamic interactive relationship between technological knowledge, pedagogical knowledge, and content knowledge (Mishra & Koehler, 2006). Based on the TPACK framework, some researchers (Polly et al., 2010; Tondeu, Roblin, van Braak, & Fisser, 2013) suggested that the ICT should be integrated in the entire curriculum to provide pre-service teachers the opportunities to learn how ICT can support teaching and learning in different subjects. Without integrated ICT in the entire curriculum, the knowledge and skills gained in the ICT course itself are likely to remain inaccessible and untouched (Polly et al.,2010).

According to Gill, Dalgarno, and Carlson (2015), many pre-service teachers may have experience in using technologies in their previous studies and/or their social and personal lives. However, the ICTs skills that they bring to the class room do not help them to implement ICTs in the teaching and learning environment. A plausible explanation is that the “pedagogical application of ICT is new” for the pre-service teachers (Hammond, Reynolds, & Ingram, 2011, p. 192). Pre-service teachers were not aware of the complexities of integrating ICTs in teaching and learning environment (Brown & Warschauer, 2006; Gao, 2006; Gao, Choy, Wong, & Wu, 2009). Kennedy et al. (2006) revealed that many first-year university students had difficulties in using digital technologies effectively in their academic study although they made optimal use of ICT for other personal or social purposes.

Divaharan (2011) conducted research on pre-service teachers in the later years of their education program, studying the core Information and Communication Technology subject over 12 weeks in Singapore. Pre-service teachers were taught the pedagogies, technology skills, and the integration between pedagogies and technology in teaching. During the first four weeks of this subject, pre-service teachers learnt pedagogical theories and principles of integrating pedagogies and technology. In the following eight weeks, students were taught the specific ICT tools and the pedagogical use of the ICT tools. Divaharan (2011)’s findings revealed that pre-service teachers wanted to study the technology skills before studying the pedagogical theories so that they could comfortably integrate the possible pedagogical method with the technology tools in teaching and learning. These pre-service teachers also found that peer learning was useful in gaining technology and pedagogical knowledge. In contrast with Divaharan (2011)’s study, first-year pre-service teachers in this current study were taught a range of information technology software, pedagogies, and how to integrate ICT in teaching and learning simultaneously.

Nykvist (2013) used a mixed method research to conduct a research of 667 first-year pre-service teachers studying a core ICT unit in their first semester. He found that some first-year students indicated that they did not understand the integration of pedagogical approaches and ICT skills in the learning and teaching environment. Because the core ICT subject in Nykvist's study was taught in the first semester, first-year pre-service teachers only learnt about the pedagogies theory and ICT practice but they did not have experience in the integration of ICT with learning pedagogy in the actual classrooms. He further mentioned that some students could not understand the necessity to enrol in the ICT core subject and could not see the significance of using ICT in their future teaching.

Similar to Nykvist's research, the current study conducted research with pre-service teacher students who studied the compulsory *ICTs in Education* subject in their first semester. However, there were differences between the current study and Nykvist's research (2013) which are explained as follows. Nykvist (2013) investigated students' perceptions of the ICT subject, their expectations about utilising ICT in their future teaching, and the ICT skills and knowledge that they brought to the classroom. This current study sought students' mental models of learning and any challenges that students faced. This study also examined changes in students' mental models of learning over a semester which Nykivst did not explore.

The teaching and learning theoretical paradigm of the *ICTs in Education* subject was eclectic with an emphasis on constructivism. The *ICTs in Education* subject combines behaviourist learning (mass face-to-face lectures, workshop demonstrations), constructivist learning (interactive web activities), and social constructivist teaching and learning (tutorial discussion, problem work activity). The constructivist and social constructivist approaches in this subject required students to study actively by brain storming, critiquing, and solving problems. Students were encouraged to become critical thinkers and self-directed learners by applying their prior knowledge in learning situations in the tutorial classrooms in which they had to analyse and articulate their understanding (Duffy & Jonassen, 1991).

Motivation

Motivation has been conceptualized in different ways by a number of theorists. For example, goal theory is one in which goals or goal orientation is central to understanding motivation and achievement (Ames, 1992). On the other hand, expectancy-value theory (Wigfield & Eccles, 2000) is a theory of motivation which proposes that people’s efforts to achieve depend on their expectations of success in the learning activities.

Motivation has been defined as “a student’s willingness, need, and compulsion to participate, and be successful in the learning process” (Bomia et al., 1997, p. 1). Thus, motivation drives students to be active learners, engage with their learning and complete their studies (Pintrich, 2003). Consistent with these ideas, Levy and Campbell (2008) explained that when students are motivated, they are more likely to confront challenges and obstacles when solving problems.

Further support to the notion that motivation and learning goals are important factors in academic success is provided by McKenzie and Schweitzer (2001). Andrews et al. (2005) also found that motivation is a powerful aspect that influences the academic performance of first-year university students.

Hulick and Higginson (1989) used the *Learning and Study Skills Inventory* to investigate learning strategy and motivation of first-year students at Kentucky University. They found that students who were motivated often utilised deep learning strategies and obtained high grades at the end of their first-year course. Motivation and persistence was found to correlate with students’ final grade point average in a study of 300 first-year Mathematics students (MacNamara & Penner, 2005). Comparisons between perceptions of students and faculty staff in relation to academic success of first-year students doing a mathematic subject have been drawn by Anthony (2000). It would appear that both students and staff are in agreement that motivation is a critical factor influencing student success.

It has been observed that motivation is distinguishable in two modes: intrinsic motivation (the need to fulfil an interest) and extrinsic motivation (the need for recognition) (Ryan & Deci, 2000). Students who are intrinsically motivated usually engage with learning tasks, apply a deep learning approach and use a range of strategies to handle challenges. They focus on understanding what they are studying and persist at difficult problems (Nilsen, 2009; Walker, Greene, & Mansell, 2006). In contrast to this, students with extrinsic motivation were found to apply surface learning approaches, such as memorising content details to pass an examination (Nilsen, 2009;

Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004). The reasons why students withdrew from an engineering degree were investigated by Baillie and Fitzgerald (2000) who noted that students who dropped out of the course were more extrinsically motivated by attending a prestigious university rather than intrinsically motivated by an aspiration to learn engineering.

According to Bowman (2007), the motivation students bring to higher education classrooms can be influenced because of something or someone. A university wide study of motivation offered implications for universities: the learning environment is helpful to stimulate students' motivation and educators can directly influence student motivation by providing "development feedback, achievement recognition, student-teacher interaction, and valuable career-based and educational-based outcomes" in their course design (Andrews et al., 2005, para. 3). The influence of educators has also been emphasised by Kwan, Chung, Ho and Leung (2011) who argued that the most significant task for educators is to help students to set their learning goals, and develop self-motivation strategies that lead to academic success.

First-year university students are more likely to be motivated to learn and persist with university study if they engage with their peers, academic staff and the university community (Krause, 2005). She also stressed that educators should (a) create and maintain a stimulating intellectual environment in which learning discussions are stimulated and ideas are debated, (b) encourage students to develop self-regulated strategies that will drive students' engagement and motivation, and (c) encourage first-year university students to commit to their study by emphasising the importance of studying and spending time on academic work. Educators should examine student demographics and develop strategies for maximising the possibilities for engagement. In addition, educators and mentoring teams should let students know that first-year pressures are being noted and that the institution is able to equip them with coping strategies.

Baik et al. (2015) found that over a third of first-year university students revealed that they had difficulty in getting motivated (Baik et al., 2015). As motivation is important for persistence and achievement, low motivation of students can lead to disengagement with study which places first-year university students at greater risk of withdrawing from their studies. The mental models of motivation of first-year education students were explored in this study to determine the significance of motivation on the utilisation of effective learning strategies.

Academic and Social Engagement

First-year student engagement in terms of academic and/or social activities has been the focus of investigation in many studies (e.g., Astin, 1985; Krause et al., 2005; Pascarella & Terenzini, 2005; Yu, DiGangi, Jannasch-Pennell, Lo, & Kaprolet, 2007; Zepke, 2013). According to Wimpenny and Savin-Baden (2013), there were 2,530 articles about student engagement published between 2000-2012. Whilst explanations for the high dropout rate of first-year students are manifold, Yu et al. (2007), basing their assertions on the most accepted model of student retention (Tinto, 1975), argued that "academic perspective, performance, personal development, academic self-esteem, enjoyment of courses, and identification with academic norms and one's role as a student all contribute to a student's overall sense of integration into the university" (p. 3). Their argument is that by being highly engaged in their academic learning, students academically achieve and succeed, and therefore are more likely to complete their degrees. Some studies (Yorke & Longden, 2007; Yu et al., 2007) emphasised student engagement is an internal process and is the role of students in their commitment to learning. However, other researchers (Bradley et al., 2008; Nelson et al., 2012: Tinto, 2009; Zepke & Leach 2010) described that engagement involved not only the commitment of students, but that the institutions, teaching, and support staff have to provide the necessary conditions, opportunities and expectations for such engagement to occur. Nelson and her colleagues (2012) supported this view stressing that engagement involved an institution's curriculum practices.

There are different perspectives of the definition *engagement* in the literature. Student engagement is defined as the "time and effort students devote to educationally purposeful activities" (Australian Council for Educational Research, 2010, p. 1). Interestingly, while tutors think of engagement as cognitive engagement, students see it as predominantly affective engagement (Solomonides & Reid, 2008). Cognitive engagement refers to students' self-regulation, high order thinking skills, and effective use of deep learning process (Fredericks, Blumenfeld, & Paris, 2004) whereas affective engagement concerns motivation, enjoyment, and interest in learning (Furlong et al. 2003). Bryson and Hand (2007) defined student engagement as their sense of belonging to university and the learning community, while Christie, Tett, Cree, Hounsell, and McCune (2008) suggested that emotion is also involved in learning. Fredericks et al. (2004) emphasised that students must invest actively, emotionally, and cognitively in learning in order to succeed.

Taylor (2008) suggested that the initial task for first-year university students is to engage in the course they are undertaking. The ability to engage with and subsequently to complete a course is influenced by social factors (Helland, Stallings, & Braxton, 2001; Krause et al., 2005; Peel, 2000; Tinto, 2002; Yorke & Longden, 2007). The socio-cultural perspective on student engagement focuses on the impact of social context on student learning and engagement. The strength of peer interaction networks and their role in aiding the transition and adjustment of first-year students has been investigated by Kantanis (2002), while McInnis et al. (2000) reported that a peer network is important to the creation and development of successful learning communities. Furthermore, Zepke and Leach (2010) found that teachers are a stronger influence than student motivation in promoting students' engagement.

According to Wimpenny and Savin-Baden (2013), there were 2,530 articles about student engagement published between 2000-2012. However, none of these studies utilised the mental model framework to address the academic and social engagement of first-year university students. This current study built upon other studies by exploring the pre-defined mental models of students including collaboration mental models and academic engagement mental models in the first semester of their first-year study. The correlation between collaboration mental models, academic engagement mental models and other mental models of learning are analysed in Chapter Five.

Gender

Gender differences have been found in relation to university study and academic achievement (Winter & Yaffe, 2000). According to several studies (Dobson, et al., 1996; Lawrence, Ashford, & Dent, 2006; McKenzie & Schweitzer, 2001; Richardson & Woodley, 2003; Smith & Naylor, 2001; Tinklin, 2003), female students perform better than male students. Female students appear to be more serious about education and more conscientious about their learning than their male counterparts (Tinklin, 2003; Warrington, Younger, & Williams, 2000). According to these studies, female students are better prepared and organised, while male students, in contrast, are ill-prepared and less attentive.

The results of studies on gender difference in retention rates are inconsistent. For example, according to Martin, MacLachlan, and Karmel (2001), male students were more likely to withdraw from courses than female students. Other studies have found that gender is not a considerable predictor of academic achievement of first-year university students (Ravenscroft & Buckless, 1992; Turner, Holmes, & Wiggins, 1997). The hypothesis that gender is not significant is also supported by Long et al. (2006).

Research is inconclusive concerning gender differences in cognition, motivation, and achievement among first-year university students. Studies such as that of Gonzaler, Dowson, Brickman, and McInerney (2005) do not support the relationship between gender and academic motivation. In contrast, the Al-Hilawani and Sartawi (1997) research showed that male students utilised a deep learning approach and had extrinsic motivation while females employed a surface learning approach and had intrinsic motivation. Furthermore, a study of first-year university students revealed that male students were more motivated than female students (Baik et al., 2015). On the other hand, Pedaste et al. (2015) found that female students were significantly motivated than male students in their first-year information technology course. Pedaste et al. (2015) stated that although female students have higher motivation than male students, there were no differences between male and female's cognitive abilities and their grade scores.

Studies investigating the relationship between gender and academic achievements also have provided mixed results. Research in American universities found that female students achieved higher grades than male students (Geltner, 1996; McGregor, Reece & Garner, 1997). Similarly, female students performed better than male students in most disciplines in Australian universities (Dancer, 2003; Dobson & Sharma, 1995; Dobson et al., 1996). Several theories have been proposed to explain why female students get higher grades than male students. Archer and Schevak (1998) suggested that the better grades of female students have been linked with the use of cognitive and self-regulatory strategies. Chee, Pino, and Smith (2005) argued that the higher grades of female students probably resulted from the benefits of their social relationship contributing to their attitudes and behaviours for learning. On the other hand, a research on 300 first-year Spanish students (María, Páramo, Martínez, Tinajero, &. Rodríguez, 2014) indicated that gender had no significant effect on first-year academic achievement. However, they found that there are differences between female and male students with respect to the effects of adjustment on their academic achievement. Male students scored higher on personal-emotional adjustment while female students scored higher on academic adjustment. Given these inconclusive findings, this study continues this line of research by examining whether there is any correlation between mental models, gender, and academic achievement in first-year university students.

School Leaver/Mature Age Students

School leaver students. School leaver students require knowledge of, and need to be prepared for, significant differences between school and university expectations. McInnis et al. (2000) and Yorke et al. (1997) showed that school leaver students face intellectual and other challenges associated with the transition from school to university. School leaver students who exit from highly supportive non-government/private school environments may find it difficult to adjust to the independent learning environment of a university (Win & Miller, 2004). During their school years, these students receive a lot of assistance from teachers and parents in order to achieve high Tertiary Entrance scores for the university and the course of their choice. To make the transition from school to university, school leaver students have to make adjustments to accommodate the differences between high school and university levels in terms of learning materials, content, learning conditions, teaching methods, learning styles, and assessment types. Some students may find it difficult to comprehend learning materials at university level, as they are more extensive and complex than those at high school. This, of course, may affect their overall performance.

School leaver students generally utilize a surface learning approach (Burton et al., 2009; Richardson & Newby, 2006). This suggests that school leaver students focus on unrelated parts of the tasks and simply memorize information. Drysdale et al. (2001) and Nelson et al. (1993) found that a deep learning style is a critical component of the learning process which contributes to good academic performance and student persistence. This is because at university level, students are expected to solve problems that do not always have clear cut solutions but require high-order thinking. Therefore, school leaver students need to change their styles of learning (Drysdale et al., 2001; Scanlon, Rowling, & Weber, 2007) because these schema may not be sufficient to master the complexities of academic learning and to be self-motivated, self-regulated, self-directed, and self-managed (Pargetter et al., 1998).

Mature age students. Mature age students returning to university after a time gap find it difficult to adjust to academic study, to the social change, the application of technology, and new learning strategies (Wilson, 2003). In support of this, Barraket, Payne, Scott, and Cameron (2000) demonstrated that mature age students, relative to their school leaver counterparts, had poorer information literacy skills and less confidence in accessing resources as well as in using information technologies (Bird & Morgan, 2003). Limitations in academic practice of mature age students sometimes lead them to position themselves as deficient learners (Clarke, Postle, & Skuja, 1997; Gale & McNamee, 1995; Ramsay, 1994; Webb, 1999). Thus, there is robust evidence from many studies that mature age students lack confidence in their abilities. They experience a great deal of anxiety and self-doubt about academic ability and previous knowledge and this affects their engagement with learning.

The transition experience of mature age students has been commented on by Kantanis (2002) as follows:

> Personality type, state of mind, coping strategies, interpersonal skills and communicative competence, and such factors as intelligence, preferred learning style/s, prior academic achievement, maturity, flexibility, motivation, commitment, desire to succeed and perseverance all play a significant role in determining the type of transition experience that [mature age] students will have and the speed with which adjustment to university will be made (p. 4).

Studies that have compared mature age students with school leaver students have found that mature age students are more committed, persistent and involved than school leavers (Derrington, 2006; McInnis et al., 1995). Furthermore, they appear to be confident, independent, and able to concentrate on academic aspects (Scanlon et al., 2007). Age does not seem to affect their academic performance (Hoskins, Newstead, & Dennis, 1997).

Mature age students have a clear idea about their learning and a stronger sense of purpose for studying than do younger students. Mature age students enter university with an intrinsic motivation to develop personal goals and priorities rather than purely to gain a qualification (Newstead, Franklin-Stokes, & Armstead, 1996; Richardson, 1994). In support of this, Shores and Vivekananda (1997) reported that mature age students adjust significantly better to university life than school leaver students. They find that the transition to university is not as difficult as for school leaver students (Scanlon et al., 2007). Nevertheless, the major challenge for mature age female students is to commit to take up studies and balance their studies with work, personal life and family (Hillman, 2005).

While the Year 12 Equivalent National Tertiary Entrance Rank (ENTER) is considered to be a predictor of success performance for school leaver students in Australia, student self-reported learning strategies are considered a robust predictor of mature age students' performance (McKenzie, 2002; McKenzie & Schweitzer, 2001). Indeed, there is general agreement that mature age students are more likely to employ a deep approach to learning (Derrington, 2006; Duff et al., 2004; Gijbels et al., 2005; Richardson, 1997; Zeegers, 1999). Given this, mature age students develop a more profound comprehension of learning materials than school leaver students who tend to use surface learning (Derrington, 2006; Richardson, 1997; Zeegers, 1999) and to be more academically successful than school leavers (McKenzie, Gow, & Schweitzer, 2004). The findings from a three-year study at an Australian university (Cantwell, Archer, & Bourke, 2001) support these perspectives, emphasizing that mature age students perform much better than school leavers, which, in turn, influences their higher grades. Consistent with this, the use of strategic learning approaches amongst British mature age students relates to their mark (Wilding & Andrews, 2006). A study of first-year university students at the University of Southern Queensland (Burton et al., 2009) reported that mature age students tend to utilize a deep and strategic approach which is associated with positive grade point averages, while school leavers tend to apply a surface learning approach which correlates with their negative grade point averages. In addition, the findings of a study of first-year Biology students (Burke da Silva, Hunter, & Auburn, 2008) stated that mature age students generally utilized a deep learning approach, had strong motivation skills and therefore performed better than school leavers.

Study of mature age students in the Faculty of Arts, Humanities and Social Science of the University of Western Australia revealed that mature age students had higher retention rates than young students (Skene, Broomhall, Ludewig, & Allen, 2009). Some researchers (Cantwell et al., 2001; Derrington, 2006; McInnis et al., 1995; Richardson, 1997; Zeegers, 1999) pointed out that mature age students outperformed young students and that school leavers were more at risk of attrition.

Using the Metacognition Awareness Inventory (MAI), a survey explored self-regulated learning in first-year psychology students and ascertained that mature age students coming to university after many years in the workforce found it difficult to “adequately utilise learning strategies” (Vrugt & Oort, 2008, p. 8). Mature age students who were effective self-regulators were obtaining lower exam scores than school leavers who effectively self-regulated their learning (Vrugt & Oort, 2008). However, the argument that prior education, life and work experiences have positively influenced metacognitive abilities which then enabled mature age students to complete their degree has been put forward by Graham and Donaldson (1999). Similarly, McKenzie and Schweitzer (2001) verified that mature age students, with their work experience, utilised a variety of learning strategies. Taken together, the findings outlined above suggest a need to further investigate the academic performance of mature age and school leaver students. The correlations between mental models of mature age and school leaver students and their academic results were investigated in this study and are presented and discussed in Chapter Five and Chapter Six.

Metacognition

Metacognition is considered a critical factor in successful transition of first-year university students given the importance of metacognition in increasing student engagement (Larmar & Lodge, 2014). Metacognition is the higher order process of troubleshooting in learners’ perceived levels of understanding. It enables students to successfully control their cognitive processes while engaging them in learning and in acquiring new knowledge (Kommers & Aroyo, 2002). Students with high-level metacognition are expected to learn more effectively as they are “self-directed and goal-oriented” (Phelps & Graham, 2004, p. 52). They monitor their progress, use proper strategies, adjust their learning accordingly, and are aware of those capabilities they do not possess (Mumford, Zaccaro, Jacobs, & Fleishman, 2000). Crawford (2003) suggested that the development of metacognition is important for achieving higher-order, independent thinking. However, studies on metacognition have traditionally focused in the domain of educational psychology rather than being found specifically within the higher education literature.

A theoretical framework of metacognition of first-year students was used in studies by Veenman and Beishuizen (2004) and Vrugt and Oort (2008) in order to understand the impact of metacognition on study strategies and of study strategies on academic achievement. They researched first-year psychology students and found that appropriate metacognitive strategies had positive effects on exam scores. Another interesting finding was that female first-year university students who had self-regulated learning strategies, including utilizing metacognitive strategies, obtained higher exam scores than male effective self-regulators.

Comparisons between school leaver students and mature age students on metacognition have been conducted by Derrington (2006). She contended that school leavers "demonstrated more metacognitive ability in their strategy choices" (p. 176), while mature age students demonstrated more metacognitive ability in knowledge and control. Her results also revealed that mature age and school leaver students used alternative approaches (deep or surface learning) and utilised "metacognition in different ways and at different times" (p. 176). Further, she concluded that "the age of the student had no discernible impact on their understanding of, and ability to, utilise metacognitive strategies" (abstract).

Self-efficacy

Some studies have focused on the relationship between retention and self-efficacy (Brainard & Carlin, 1998; Felder, Felder, Mauney, Hamrin, & Dietz, 1995; Margolis & Fisher, 2002; Seymour & Hewitt, 1997). According to these researchers, self-efficacy of undergraduate students in science, technology, engineering and mathematics correlated with their persistence and achievement. Furthermore, students who held self-efficacy beliefs and expectations that they would perform well in a given course have been positively linked with academic success and low attrition rates. In her research of first-year university students in the Netherlands, Olani (2009) discovered that self-efficacy was a positive predictor of first semester first-year academic grade point average for male students in five disciplines: Electrical Engineering, International Trade and Investment Management, Information System Management, Mathematics, and Psychology

Financial Hardship

The impact of financial difficulties on retention in higher education has long been investigated internationally (Krause et al., 2005; Long et al., 2006; McInnis, James, & McNaught, 1995; Yorke & Longden, 2007). Nearly 60 percent of first-year students in the United Kingdom were worried about financing their studies, and nearly 60 percent of young higher education students were in paid work (Yorke & Longden, 2007).

Krause et al. (2005) conducted a national study on first-year students in Australian universities over a decade. Their longitudinal study revealed that 39 percent of first-year students thought seriously of withdrawing from their degree courses because of financial concerns. According to Ballantyne (2000), mature age students thought about withdrawing due to family and/or financial reasons. A study by McKenzie and Schweitzer (2001) found that Australian first-year, full-time students with part-time employment had the poorest grade point average scores. The *University's First-Year Initiative Survey report* (2002) published by Deakin University revealed that 81 percent of students in the Faculty of Education were working at the time of the survey. Callender (2000) argued that students with financial hardship and who undertook long hours of employment during both semesters fell behind in their academic studies. As a consequence, according to Callender (2000) and Long et al. (2006), this cohort of students is far more likely to withdraw from study than university students from more privileged backgrounds.

Baik et al. (2015) raised a concern about the increase in the number of hours that first-year university students work in their paid jobs. Twenty-five percent of working students did not attend their classes in order to work and more than half of working students reported that work interfered with their learning at university. Because these students must work to meet their basic needs, they could not afford to prioritise their study. As a result, these working students: (1) found that the workload of the course was heavy, (2) had difficulties comprehending the learning materials, and (3) could not keep up with the volume of the subjects in their course. These students perceived their academic studies as less enjoyable and 27 percent of the working students considered deferring their studies. These results require critical attention from institutions and the government.

Socio-demographics

A number of studies have examined the relationship between sociodemographic variables and student attrition and have produced different results (Hillman, 2005; Krause et al., 2005; Long et al., 2006; McMillan, 2005). In their research on first-year university students in 35 Australian universities, Long et al. (2006) reported that students from the lowest socio-economic backgrounds were more likely to withdraw from university than those in the higher socio-economic groups. Similar to this, other research (Abbott-Chapman, 2011; Adams, Banks, Davis & Dickson, 2010; Collier & Morgan, 2008) found that students within the low socio-economic and immigrant communities were more vulnerable to the pressure of university study which led to attrition. As Kuh et al. (2008) suggested, universities need to find out what these students expect and how much effort they put in their study in order to find a way to improve the retention rates of first-year university students from lower socio-economic back grounds.

The most recent report from Baik et al. (2015) disclosed that low socio-economic students generally are less prepared for academic studies than high socio-economic students, although the low socio-economic students are clear about their learning goals and purpose in attending universities. Unlike the higher socio-economic students, the low socio-economic students tended to work full time to meet their basic needs and support their family, therefore the stress related to finance and work commitment interfered with their studies.

Findings about the retention rate in the first-year of Non-English speaking background students were different. Although it might be expected that Non-English speaking background students would be disadvantaged at university, McMillan (2005) and Long et al. (2006) revealed that in Australian universities, students from culturally and linguistically diverse backgrounds had a slightly lower attrition rate (15%) than students from an English speaking background (20.5%). This could be because the non-Australian cultural background students were more likely to be positive in learning and coping (Burgess, Crocombe, Kelly, & Seet, 2009). However, the research of Grebennikov and Skaines (2009) was in disagreement with these results, their study found the association between low grade point average and non-English speaking background students. Their study found that the students from culturally and linguistically diverse backgrounds were at more risk of failure. There was a significant higher *Pass* rate for English speaking students compared to non-English speaking background students.

There have been significant debates about the effect of type of enrolment on retention. McMillan (2005) revealed that there was no significant difference in the retention rate between full-time and part-time students. In contrast, other researchers (Grebennikov & Skaines, 2009; Hillman, 2005; Krause et al., 2005; Long et al., 2006; Smith, Therryl, & Whale, 2012) reported that part-time students were more likely to withdraw than full-time students. This raised the question why part-time students are more likely to withdraw from their first-year study than full-time students. It is argued that the higher retention rates of part-time first-year university students could be due to their difficulties in managing work and study and balancing their family commitment with study (Hillman, 2005; Smith et al., 2012).

Secondary School Results

Evidence is mounting to support the attrition literature which claims that there is a positive relationship between previous academic capabilities of students and their performance during the first-year (DeBerard et al., 2004; Murphy, Papanicolaou, & McDowell, 2001; Pike & Saupe, 2002). The guidelines for admission to Australian universities include Year 12 scores as measured by the Equivalent National Tertiary Entrance Rank (ENTER). In Queensland, Overall Position (OP) scores are used by universities for measuring students' academic ability. OP scores range from OP 01(best) to OP 25.

In Australian universities, it is believed that secondary school results are important predictors of academic performance at university and that they are inversely related to student attrition (Cao & Gabb, 2006; McClelland & Kruger, 1993; McKenzie, 2002; McKenzie et al., 2004; McMillan, 2005; Pargetter et al., 1998). Studying first-year university students for two decades from 1994-2014, Baik and his team (2015) found that students with low secondary school results were less prepared for their university study, were less likely to have time management skills to work out their study workload, and had difficulty understanding the lectures and learning materials. There was an association between low secondary school results with low levels of academic engagement. Students with low secondary school results found it hard to be motivated by their studies. Not only did they not actively engage in the orientation program, but they also did not find enjoyment in the intellectual challenge of the subject. As a result, students who had lower school secondary results considered withdrawing from their degree course more than students with higher school secondary results.

Reflecting a similar pattern, in the United States, students with high school grade point averages and scores on standardised tests, such as the Scholastic Aptitude Tests (SAT) or the American College Testing (ACT), were associated with student persistence (Hoffman & Lowitzki, 2005; Kamera, Reuben, & Sillah, 2003; Robbins et al., 2004; Titus, 2004). Like the Australian and American studies, a study of first-year Portuguese students revealed that the higher education access mark (similar to Tertiary Entrance) was the strongest predictor of first-year academic achievement (Soares, Guisande, Almeida, & Fernanda M. Páramo, 2008). In their study of first-year Canadian students, Wintre and Bowers (2007) examined a theoretical model of student persistence to graduation and found that secondary results had a positive relationship with learning performance.

Despite these studies into the relationship between high school results and university performance, Singaporean secondary school results were found unreliable and not valid predictors of tertiary academic performance (Tay, 1994). According to Tay (1994), this is because high school examinations focus only on material being taught rather than on students' abilities.

How Universities/ Educators Have Responded to Students' Challenges

Educators and universities worldwide have been conscious about the need to examine the problems and challenges of first-year university students and provide learning support in order to engage and retain students (Baik et al., 2015; Kift et al., 2010; Krause et al., 2005; Tinto, 1975, 1985, 1998, 2002, 2012; Yorke & Longden, 2007). Acknowledging this, since 2009 the Australian government has funded the Higher Education Participant and Partnership Program to improve the retention rates of students and help the low socio-economic students who have difficulties transitioning to university.

To understand the changing of the research on First-Year Experience, Nelson and her team (2011) conducted a meta-analysis of 398 Australasian empirical reports and conceptual papers produced from the year 2000 to 2010 and divided the decade into three periods (2000-2003, 2004-2007, and 2008-2010). The results of this meta-analysis showed that between 2000 and 2003, educators focused on the "influence of individual and personal characteristics on transition success" (Nelson, 2014, p. 6).

However, by the mid-2000s (2004-2007), researchers had shifted from personal characteristics to concentrating on building capacity and practice.

Since 2009, the federal government has funded the Higher Education Participant and Partnership Program to universities. Between 2008 and 2010, the focus was on the curriculum at a subject level designing good practice in assessment and there was a strong collaboration among universities. There was a substantial increase in the number of reports reflecting on the changes in national policy framework and there was a substantial increase in research on early intervention as a preventative strategy (Nelson, 2014).

Although not time-based and not similar to the meta-analysis of Nelson and her team (2011), The *Good Practice Report* by Gale and Parker (2011) also contributed to knowledge about the First-Year Experience. The *Good Practice Report* was a national report for which Gale and Parker (2011) assembled, analysed, and assessed 19 studies and five Australian Learning and Teaching Council projects between 2006-2009. These projects were selected by the Australian Learning and Teaching Council as examples of good institutional practice in assisting student transition to universities. This report was later extended into another research study by Gale and Parker which drew on sociological and educational theory in the *Studies in Higher Education* journal. Gale and Parker (2014) observed three distinct perspectives of the transition experiences in the literature which inevitably lead to different approaches to transition policy, research and practice in higher education. First was transition as induction: researchers justify an institutional response to student transition by supporting students through intensive programs. Second was transition as being about students' transformation or development from one stage to another or managing transition as part of learning process. Third was again student driven but facilitated by the development of individual identity. This study foregrounds a "transition as development" perspective (Gale & Parker, 2014), viewing the transition of first-year education students as processes of constructing their mental models of learning and of themselves as learners and the changes in their mental models in the constructivist and social constructivist learning context.

Frameworks Enhance Education Practice

Various worldwide frameworks have been used to enhance education practice and are described as follows.

Focusing on the curriculum, Transition Pedagogy (Kift & Nelson, 2005) and the set of six curriculum principles (Kift, 2009) have been presented to almost every university in Australia, New Zealand, the United Kingdom, the United States, and Europe. As a result, the widespread use of first-year Curriculum Principles at subject, program and institutional level is well reported. The six interconnected principles are: (1) Transition, (2) Diversity, (3) Design, (4) Engagement, (5) Assessment, and (6) Evaluation and Monitoring. The six principles support student engagement, success and retention. The Transition principle address issues related to student transition to university such as their previous learning experiences. The Diversity principle emphasise the diversity of students. The Design principle addresses student learning needing to be focussed and scaffolded. The Engagement principle is about engaging and involving pedagogy which enables active and collaborative learning. The Assessment principle highlights that the formative assessment should occur early in the program of study, and assessment should increase in complexity gradually from the first-year to later years. The Evaluation and Monitoring principle addresses that good first-year curriculum design is formatively evaluated to both student progress and the learning program to improve student learning.

While Kift (2009) focused on the curriculum of first-year university students, Lizzio (2006) and Lizzio and Wilson (2004) concentrated on the critical factors for student success. The model *Five Senses of Success* was proposed. The five elements are: capability, connectedness, resourcefulness, purpose and culture. Firstly, students' success at university relies on their sense of capability. Students' sense of capability depends on their understanding of their student role, their proficiency of basic academic skills, and their level of commitment to the learning community. Educators can help students to develop their sense of capability by equipping students with clear university expectations, offering entry level development of academic skills, and engaging students in the learning community. Secondly, students' success at university depends on their sense of connectedness with learning peers, academic staff, and their student identities. Students with strong connections are more likely to be successful at university. Academic staff can help students develop their connectedness by providing opportunities for students to establish their relationships with fellow students and staff. Thirdly, students' success at university depends on their sense of purpose. Students who have a clear sense of purpose and learning goals when starting at university are committed and persistent when facing academic challenges. To help students develop their sense of purpose, educators can provide activities for students to clarify their choice of a degree at university and develop their strengths and talents. Fourthly, students' success at university depends on their sense of resourcefulness which is developed when they proactively navigate the university system to get assistance and information. Universities can help students by providing clear and accessible resources and encouraging students to get help and speak up when they have difficulties in managing and balancing their work, life, and study commitments. And fifthly, students' success at university depends on their sense of academic culture: when students recognise the value of learning and what is valued in new culture, they will be successful at university. Successful students know the value of learning how things are done. According to Lizzio (2006), students' sense of cultural competence depends on their appreciation of the core values and ethical principles of the university and how these will inform their approaches to study and working relationships with fellow staff and students" (pp. 2-3).

In contrast to the set of six curriculum principles (Kift, 2009) and the model *Five Senses of Success* by Lizzio (2006), Tinto (2012) focused on the institutional conditions for student success. Tinto (2012) proposed a framework comprising: expectations, support, assessment, feedback, and involvement. According to Tinto (2012), student success is motivated, in part, by what students expect of themselves and their expectations are shaped by institutional actions. During the critical first-year of university, students need academic and social support in order to be successful. Assessing students' performance and providing frequent feedback enable students to adjust their learning behaviours and promote their success. Furthermore, the more students are academically and socially engaged with educators, academic support staff, and learning peers, the more likely they are to succeed at university. Another framework is the Social Justice Framework.

The Social Justice Framework was developed as resources for the teaching and learning sector and as part of an Australian Government Office for Learning and Teaching project (Creagh et al., 2013; Nelson & Creagh, 2013). The Social Justice Framework for higher education was developed by Nelson & Creagh (2013) in conjunction with educators of ten Australian universities. This framework focused on "good practice for activities that monitor student learning engagement and identify students at risk of disengaging in their first-year" (Creagh et al., 2013, abstract). This framework has the potential to create a learning environment that focuses on success.

There are five principles in this framework for practice: Self-determination, Rights, Access, Equity and Participation. The Self-determination principle is interpreted as students being actively involved in "program design, enactment and evaluation" (Nelson & Creagh, 2013, p. 112). For example, a student survey which gathers feedback from students is used to revise the Monitoring Student Learning Engagement program and advisor training materials. The Rights principle is that all students are treated with dignity and respect. Universities recognise and value students' cultural, social and knowledge system. The advisors' training programs include communication strategies, for example, being able to speak with students from culturally and linguistically diverse backgrounds. The Access principle is designed to make sure all students have access to "social, cultural, political and economic resources" (Nelson & Creagh, 2013, p. 114) to promote students' learning engagement. From the social justice perspective, the Equity principle is expressed as "programs [that] are designed to demystify and decode dominant university cultures, processes, expectations and language for differently prepared cohorts" (Nelson & Creagh, 2013, p. 114). The Participation principle is to make sure that all students have opportunities to participate in university activities and to complete their qualifications. The five principles of the Social Justice Framework establish good practice at universities and develop students' sense of belonging and connectedness to universities.

Focusing on Future Action

One of the models that has been presented in many Australian universities has been the Individual and Institutional Characteristics Influencing Student Retention and Engagement (IICISRE) model (Nelson et al., 2012). Firstly, it takes into account that the institution, teacher, and students themselves are factors impacting the student experience. Secondly, academic, social, and institutional factors have a transformative effect on student experience. And finally, students have brought with them their knowledge, skills, and attitude in their first-year in order to gain success at university.

However, IICISRE did not emphasise about the importance of emotion which was introduced in the Kahu framework. In 2013, in a conceptual framework comprising engagement, antecedents, and consequences, Kahu presented a sophisticated theoretical framework which emphasised six elements: (1) the socio-cultural context; (2) the structural; (3) psycho-social influences; (4) engagement; (5) the proximal; and (6) distal consequences. Kahu (2013) viewed student engagement as a “psycho-social process, influenced by institutional and personal factors, and embedded within a wider social context, integrates the socio-cultural perspective with the psychological and behavioural views” (p. 768). Compared between IICISRE model and Kahu model, Nelson (2014) indicated that both models emphasised in student engagement , however, Kahu models is a more sophisticated model and every universities should apply this model.

In this study, the findings were used to develop a number of recommendations for universities assist students in their first-year academic studies (Chapter Six). These recommendations were consistent with the IICISRE model (Nelson et al., 2012) and the Kahu mental model (Kahu, 2014) that university and the lecturers of the subjects should have learning support program that assist students engage students in their learning.

Conclusion

In this chapter, a review of the problems, issues, and challenges that requires attention of the educators and universities and how educators / universities have responded to these challenges was presented. The first-year transition was reviewed in terms of significant differences in learning and teaching strategies, motivation, academic and social engagement, gender, mature age and school leaver students, metacognition, self-efficacy, socio-economic and demographics, financial hardship, and tertiary entrance results.

Although many variables thought to be contributing to first-year university student retention have been discussed extensively in the literature, factors implicated in the high dropout rate still remain complicated and unresolved. This is not surprising considering the number of very diverse factors which have been discussed in various studies (Bean & Metzner, 1985; Glaser, 1990; King Head, 2009; Krause, 2005; Krause, McInnis, & Welle, 2003; Lawrence et al., 2006; Long et al., 2006; McInnis et al., 1995; McKenzie, 2002; McKenzie & Schweitzer, 2001; Yorke et al., 1997; Yorke & Longden, 2007).

The literature also highlighted how universities/educators have responded to these challenges. Various models that have been used to enhance education practice in first-year curriculum were reviewed. However, this review of the literature found that there is a shortage of research into mental models of first-year education students at the beginning and at the end of their first semester, an area of research to which this study aims to contribute.

Chapter 3: Mental Models

Overview

Chapter Two reviewed the problems of first-year university students and how universities and educators responded to these issues. While there has been a wealth of research into the retention of first-year university students for more than 40 years, there has been no research that has utilised the mental model framework. This thesis developed out of an interest to investigate students' mental models of learning and of themselves as learners in their first semester, first-year at university. This chapter provides an overview of mental model theory.

The concept of mental models in which the mind constructs small models of reality for use in anticipating and predicting events, for reasoning, and for explanations was advanced by Craik (1943)**.** Since then, mental model theory has been utilised internationally in an extensive range of pure and applied research (Henderson & Tallman, 2006; Johnson-Laird & Byrne, 2000). The concept of mental models has been used as cognitive representations that are created and activated in various situations. In 2002, Henderson, Putt, and Coombs examined the mental models of Australian students in a higher education online environment. Five years later, Richardson did similar research with students in the United Kingdom. Also in Australia, Sparkes and Huf (2003) investigated the mental models of personnel during military decision making process. Mental models of obligatory and prohibitory traffic signs held by Spanish psychology students were identified and examined (Castro, Moreno-Ríos, Tornay, & Vargas, 2008). Wilke (2008) investigated the developmental change of mental models of pre-service teachers in learning and instruction in Florida University. Research into mental models of processing mobile phones was conducted in Taiwan (Chang & Wu, 2009). However, surprisingly, it would appear that no study has directly addressed the relevance of the mental model framework in the domain of first-year university students' learning.

This thesis contributes to the body of knowledge in the First-Year Experience research by exploring the mental models relating to learning performance of first-year undergraduate students enrolled in a Bachelor of Education degree. Furthermore, it is important to note that research on pre-service teachers has been dominated by research in beliefs and conceptions (Wilke, 2008). Accessing mental models, especially those of students, may yield valuable information about their conceptual scaffolds (Vosniadou, 1994). According to some researchers (Bao, 1999; Bao & Redish, 2001; Gentner, 2002), by exploring student mental models and any changes during a course of study, educators may be able to identify difficulties and develop better instructional designs for students.

This chapter reviews various perspectives of mental models in order to explore the advances that have been made thus far in this field. The first section reviews definitions of mental models, characteristics of mental models and some functions of mental models: control function, explanatory function, prediction function, and memory function. The second section of the chapter draws on mental models of learning, including mental models of novices and experts. The third section is about the developmental change of mental models. Some factors related to changes in mental models are also discussed in this section.

What are Mental Models?

The father of the mental model theory, the Scottish psychologist and philosopher, Kenneth Craik (1943) defined a mental model as follows:

> If the organism carries a "small-scale model" of external reality and of its own possible actions within its head, it is able to try out various alternatives, conclude which is the best of them, react to future situations before they arise, utilise the knowledge of past events in dealing with the present and the future, and in every way to react in a much fuller, safer, and more competent manner to the emergencies which face it (p. 61).

Another antecedent is Wittgenstein's (1992) who added three main assumptions to the theory of mental models:

1. Each mental model represents a possibility. For example, in this study, the sentence *"Kim was a first-year education student and failed to attend the Education program in the second year"* calls for two mental models to represent the two possibilities: (a) either Kim failed examinations in Education program and dropped out of university or else (b) Kim changed her direction and enrolled in another course, such as Nursing or Business. Where "failed examinations in Education program and dropped out of university" denotes a

mental model of the possibility in which Kim failed examinations and left university, the "changed her direction and enrolled in another course" denotes a model of the possibility in which Kim is still a first-year university student but changed her study direction.

2. Mental models have a rich internal structure. A mental model is constructed with many parts that structurally correspond to the parts of what it represents.

3. Mental models normally represent only "what is true according to the premises, but not what is false" (Johnson-Laird, 2001, p. 434). A mental model represents a truth in the possibility only when it is true. For example, the first mental model in the set above represents the possibility that Kim failed examinations in the Education program and dropped out of university, but it does not represent explicitly that in this case it is false that Kim changed her study direction and enrolled in different course. Similarly, the second mental model does not represent explicitly that, in this case, it is false that Kim failed examinations in Education program and dropped out of university.

Since the 1940s, mental models have been defined in terms of different perspectives. Haycock and Fowler (1996) identified a mental model as "a convenient mechanism" (p. 971) for the acquisition of knowledge, for generalisation of problem-solving skills to make them available to different situations, for developing metacognitive skills, and supporting cognition and metacognition in the learning process. Another description comes from Van Der Veer and Del Carmen Puerta Melguizo (2003) that "mental models are representations in the mind of real or imaginary situations and can be constructed from perception, imagination, or from the comprehension of the discourse" (p.12). Mental models are seen as allowing learners to plan and accomplish tasks, to evaluate results, to interpret unexpected results in the context of the learning environment (even if the learner's perception of the environment is incomplete or incorrect), and to restructure concepts about the environment (Greca & Moreira, 2000; Norman, 1983; Van Der Veer & Del Carmen Puerta Melguizo, 2003). Mental models, according to some researchers (Gentner, 2002; Gentner & Stevens, 1983; Johnson-Laird, 1983, 1987; Norman, 1983; Wild, 1996; Young, 1983), provide learners with the means to conceptualise, remember, interpret, and communicate information, as well as to control their performances and make predictions.

Simply put, individuals have mental models for different aspects, or domain, of their lives. For instance, an individual can have mental models about his or her health, family, career, and /or politics. First-year university students have mental models of aspects such as their learning strategies, learning experience, university teaching modes, mentor program, and examination. They rely on their mental models (Johnson-Laird, 2001) to understand the concepts, reason the theory, solve problems, and make sensible decisions. According to Eckert and Bell (2005), each of these mental models includes related values and beliefs and often, mental models overlap. The formulation and organisation of people's mental models to represent the semantic information of problems are essential elements of the reasoning process (Johnson-Laird, 2001; Van Der Veer & Del Carmen Puerta Melguizo, 2003). Individuals do rely on mental models for reasoning. Seeking to explicate the mechanisms of reasoning, Johnson-Laird (2001) drew attention to the fact that people reason by thinking the circumstances of the problems described in their mental models. People predict the possibilities and focus on what is true for these possibilities in the problems. They look at the semantic content of the problems, not just their syntactic structure. Therefore mental models are not identical with perceptions of situations, but develop from the integration of information from these perceptions with existing mental models (Johnson-Laird, Byrne, & Schaeken, 1992). Johnson-Laird and Byrne (2000) asserted that even though mental models underlie visual presentations, not all theoretical and real environments or situations can be visualised. The incompleteness of mental models is one of their characteristics that is described in the following section.

Characteristics of Mental Models

This section draws on theoretical and empirical studies to do with mental models. It identifies characteristics of mental models that are generally accepted by the researchers in the field.

Mental models are incomplete and simplified. Mental models have been characterised as being an internal domain-specific representation of an object, system, or event that may be incomplete yet useful (Gentner, 2002; Gualtieri, Fowkles, & Ricci, 1996; Henderson & Tallman, 2006). Mental models themselves continuously modify and are modified by incoming information (Lambert & Walker, 1995; Pitts, McGregor, & Stripling, 1995). The idea that a mental model is incomplete is supported by Greca and Moreira (2000), and they also support the idea that mental models can be continuously improved as new information is incorporated, so that, especially with regards to teaching or learning with computer technologies, mental models will always be in a continuous state of flux.

Mental models are unstable over time because people tend to forget or confuse the details of the system or the content of an issue especially when these mental models have not been used for a period of time (Gentner & Stevens, 1983; George, 2000; & Norman, 1983). Mental models are not static but keep developing when the users interact with the target system.

Mental models are flexible and dynamic because mental models change over time during their interaction with the situated environment (Haycock & Fowler, 1996; Henderson et al., 2002; Jones, Ross, Lynam, Peter, & Leitch, 2011). The learning processes are situated fundamentally within the social environments where learners first perceive concepts and then constructively process them to deepen their comprehension (Seel, Al-Diban, & Blumschein, 2000; Seel, 2001). To be able to absorb new information and develop/change their mental models, learners have to use their relevant “semantic knowledge” (Seel et al., 2000, p. 130)in a continuous process of restructuring and updating to accommodate this information into their existing mental models (Seel et al., 2000).

Henderson et al. (2002) utilised a stimulated recall method to examine the flexibility and dynamic of teachers’ mental models studying the post graduate subject called *Teaching and Learning with the WWW.* The pedagogy of this subject drew on a constructivist approach to learning. The teachers in their study had experience in the teaching field. However, they were self-identified as novice users in utilising the web when starting this course. Henderson et al. (2002) found that mental models were dynamic and there were major changes from espoused (pre) mental models that embraced instructivist pedagogy to reflective mental models that incorporated constructivist pedagogy. The instructivist teaching approach is described as teacher-centered. Instructivism places emphasis on knowledge transmission from the teacher to learners (Olufemi, 2008). In this current study, the flexibility and dynamic of mental models were explored through changes that occurred in students’ mental models from experiencing a constructivist and social constructivist teaching learning context in the

ICTs in Education subject over a semester. In contrast to the post graduate students in the Henderson et al. (2002), the participants in this study were first-year pre-service teachers. They were novices in ICTs, the teaching field, and in the integration between ICTs and learning pedagogy in teaching.

Mental models are dynamic representations in which recursiveness is a prominent feature (Johnson-Laird, 1983). Mental models can be "organised recursively, that is, in computational terms a model can call itself during processing, providing both computational power and a mechanism by which the self, and the self-reflective aspects of the self, can be understood" (Power & Wykes, 1996; p. 205). Mental models are recursive domain specific knowledge structures that learners construct and use to reason, explain, and interpret the world around them (Vosniadou et al., 2004). However, mental models are not always accurate (Gentner, 2002; Norman, 1983). Mental models still work even when inaccurate because, as Norman (1983) stated, while "they may not be technically accurate (and usually are not), they still have to be functional" (p. 7). Discussing the inaccuracy of mental models, Gentner (2002) asserted that "if typical incorrect models are understood, then instructors and designers can create materials that minimise the chances of triggering error" (p. 9683). Jonassen (1994a) suggested that understanding learners' effective and ineffective mental models helps in the design of learning environments which support the construction of accurate mental models. Mental models are also characterised as limited, naïve (unscientific) and often include "superstitious" behaviour (Norman, 1983). People persist in their superstitious behaviour even when they know that this behaviour is not needed.

Runnability is postulated as a defining characteristic of mental models (Ehrlich, 1996; Kazdim, 2000; Norman, 1983; Rogers, Rutherford, & Bibby, 1992). The running of a mental model "provides the means by which inferences can be made when having to decide, predict, or interact within various domains" (Rogers et al., 1992, p. 290). People can run multiple mental models at the same time. They activate their mental models in their short-term memory while performing cognitive tasks. Mental models need to be processed and run for each situation to be useful for internal or external actions (Halford, 1993; Henderson & Tallman, 2006). The dynamic process of running a mental model reflects individuals' ability to metacognise and the capacity of their working memory (Haycock & Fowler, 1996; Johnson-Laird, Oakhill, & Bull, 1986). They can run multiple mental models for both the plan of what to do and how to accomplish the tasks (Cohen et al., 1995; Henderson & Tallman, 2006).

For instance, a first-year university student in this study could run multiple or overarching mental models when he/she started his/her first semester of the bachelor of education degree. The multiple mental models could include mental models of being a first-year student, learning goal, learning strategies, motivation, and of the study methods needed become a successful student. Being aware that mental models develop over time during their interaction with the learning environment (Haycock & Fowler, 1996; Henderson et al., 2002; Jones et al., 2011), mental models of first-year universtity students at the beginning and at the end of the subject were examined and compared in this study (see Chapter Five and Chapter Six). This analysis will help inform educators about accurate mental models as well as any non-viable mental models which were constructed due to the pre-conceptions that students held when beginning their unversity journey.

Functions of Mental Models

Mental models have various functions in the cognitive system. Examples of the functions of mental models are: reducing mental effort, recalling information, performing tasks, predicting function, explaining and enabling actions, and troubleshooting. Mental models are also claimed to play an important part in metacognition and act as memory and organisation devices.

The functions of mental models discussed in this chapter are: control function, predictive function, explanatory function, and memory function.

Control function. Individuals' mental models control their behaviour (Henderson &Tallman, 2006) and what they think they can do or cannot do. According to Pfeffer (2005), individuals perform their actions in relation to the mental models that they subconsciously hold, not according to what they claim to believe. The danger of mental models is that people are usually unaware of the accuracy of their mental models. It is therefore logical that whether their mental models are complete or incomplete, accurate or inaccurate, naïve or complex, people use their existing mental models to understand, diagnose, predict, and solve problems (Johnson-Laird, 1983; Norman, 1983). Hence, the question is whether the actions they generate are effective in getting the results they want.

In the field of education, a study examining mental models of librarian teachers (Henderson & Tallman, 2006) utilising stimulated recall method demonstrated that individuals can allow their mental models to manage them or they can manage their mental models. They also stated that the success of changing one's incorrect existing mental models is determined by the ability to be aware of the accuracy of one's mental models.

Mental models are powerful and the control function of mental models plays an important role in our life. Rao (2005) emphasised that: "all transformation begins and ends with mental models. Because these models dictate how you act under different circumstances and how you interpret the events that happen in your life, when you change the model, you change your life." (cited in Mills, 2010, para. 5). Rao (2005) has applied his theory of mental models in his pioneering course *Creativity and Personal Mastery* which is one of the most popular and highest rated courses at the London Business School and the Columbia Business School. In this course, he has emphasised people have many mental models running in their heads, some of these mental models are useful while others are not. If people are aware of their own mental models, discard the unwanted/useless mental models, modify the existing mental models, and adopt new mental models, they will create a change in their life.

In this study, first-year university students were novices so they might not construct accurate mental models of learning. Errors in mental models could occur if the mental models that students brought to university were not precise, elegant mental models, but were anchored in their deeply held beliefs in their memory or based on emotional experience (Henderson & Tallman, 2006). Were students aware of their own incorrect mental models? Did students control their mental models by changing their espoused mental models from incorrect to correct mental models by the end of the subject? Or did mental models control students by retrieving existing information from their long-term memory? The control functions of mental models were uncovered in Chapter Six in this research.

Explanatory function. Johnson-Laird (1983) concisely outlined the explanatory function of mental models through his statement:

> understanding certainly depends on knowledge and belief. If you know what causes a phenomenon, what results from it, how to influence, control,

> initiate, or prevent it, how it relates to other states of affairs or how it resembles them, how to predict its onset and course, what its internal or underlying "structure" is, then to some extent you understand it. The psychological core of understanding, I shall assume, consists in your having a "working model" of the phenomenon in your mind. If you understand inflation, a mathematical proof, the way a computer works, DNA or a divorce, then you have a mental representation that serves as a model of an entity in much the same way as, say, a clock functions as a model of the earth's rotation (pp. 2- 3).

Simply put, the explanation function of mental models involves causal reasoning, that is, reasoning about the factors that cause phenomena and/or trying to establish possible relationships in a particular representation. Henderson and Tallman (2006) utilised the stimulated recall method to investigate mental models of the teacher-librarians. They emphasised that the *explanatory* function helps to understand the situation and select different strategies because mental models "facilitate cognitive and physical interactions with the environment, with others, and with artefacts" (Henderson & Tallman, 2006, p. 25).

The explanatory function of mental models is powerful in conceptual development and conceptual change. It is evident in the studies of mental models in a science study (Vosniadou, Skopeliti, & Ikospentaki, 2005) that mental models help to generate the explanation of theories and the revision of existing theories. Vosaniadou et al. (2005) explored how children's prior knowledge influenced their reasoning in elementary astronomy. Vosaniadou et al. (2005) designed an experiment that investigated the knowledge of primary students about the earth, with or without the presence of a globe. Students were interviewed individually and the interview questions were divided into two parts. Firstly, they were asked (a) to answer the questions, (b) by drawing, and (c) by construction - with play-dough models about the shape of the earth and where people live. Secondly, they were presented with a globe and were told "this is a culturally accepted model of the earth" (Vosaniadou et al., 2005, p. 338) and they were asked a series of questions about the earth and where people live. They used ANOVAs for group comparisons and discourse analyses for analysing the qualitative data. Mental models of children about the earth were based on representations of the earth in their drawing and in their play-dough model. Children used the explanation functions of mental models in their drawing and in their play-dough model to reason the shape of the earth and where people live. The explanatory function of students' mental models helped them to reconcile their previous knowledge and beliefs about the earth. Vosaniadou et al. (2005) suggested that educators should pay attention to students' prior knowledge and internal representations.

The Mental Model Revision View (Chi, 2000) offered the process of self-explanation in enriching a situation model or re-developing a domain model. The Mental Model Revision View starts with the assumption that learners come into a learning situation with pre-existing mental models. The pre-existing domain model is often incorrect but is flawed in a coherent way and students can use their domain model to explain a problem solving situation to predict answers for a problem (Chi, 2000). Some researchers (Calin-Jageman & Horn Ratner, 2005; de Bruin, Rikers, & Schmidt, 2007) stated that self-explanation supports the process of repairing "incorrect but coherent" mental models.

In this study, for example, consider first-year education students who are about to read the teaching and learning theory and pedagogies involved in using technology in the classroom. The assumptions the lecturer makes about the students include that before they start reading, they have a pre-existing mental model about pedagogies (e.g., constructivist, social constructivist, and behaviourist) as well as the information technology software that is currently being used in teaching and learning. The pre-existing mental model is referred to as a domain model. This domain model could be a mix of correct and incorrect knowledge and have a big or small gap when compared with the information presented in the text book or in the lecture notes. Students would use self-explanation in order to explain the parts of this topic that they understood, try to think of related knowledge that might help them to understand the rest of the topic, and make an effort to problem solve the gaps in their understanding.

Predictive function. Mental models enable individuals to predict a situation or a phenomenon, the solutions of a problem, or how a system will work (Birnberg, Luft, & Shields, 2007; Gentner, 2002; Gentner & Stevens, 1983; Henderson & Tallman, 2006; Johnson-Laird, 1983; Muñoz, Glaze, Arthur, Jarrett, & McDonald, 2011; Norman, 1983). For example, meteorologists use a mental model to predict the weather in the field of weather forecasting (Hoffman, Coffey, & Ford, 2000; Trafton et al., 2000). The predictive power of mental models in the field of network security was recognised by Blythe and Camp (2012). In a study of science (Vosniadou et al., 2004), mental models are considered as predictive and explanatory power sources because they can be used as instruments to build theories and suggest new propositions in scientific discovery.

The predictive function of mental models has been elaborated by Henderson and Tallman (2006) in the field of education. If the student's mental model is sufficiently accurate and useful, students can utilise knowledge from prior mental models to predict as new activities are attempted. When a student has already had experience with a given situation, a revised mental model is constructed due to predicting new aspects of the situation (Henderson & Tallman, 2006). The predictive function will be better if a mental model of a student is accurate and complete. If a student does not have the ability to consider all alternative solutions then an erroneous predictive solution can be made (Johnson-Laird, 1983, 2001). It is usually required for students to simultaneously run and link various mental models while solving problems as they predict possible outcomes (Norman, 1983). The linking of multiple mental models will depend on the effectiveness of the storage process and the ability to access and retrieve information form the long-term memory that is discussed in the memory function section.

Memory function. One of the most important functions of mental models is that mental models serve as "memory and organisation devices" and thus help reduce mental effort (Henderson & Tallman, 2006, p. 21). The bimodal existence of mental models is that mental models reside permanently in long-term memory of an individual and are transiently existent in his or her working memory (Doyle, Radzicki, & Trees, 1998; Garcıa-Madruga, Gutierrez, Carriedo, Luzon, & Vila, 2005; García-Madruga, Gutiérrez, Carriedo, Luzón, & Vila, 2007; Henderson & Tallman, 2006; Johnson-Laird, 2001; Johnson-Laird & Byrne, 1991). Mental models depend both on the structure of knowledge stored in long-term memory and on the available capacity of short-term memory (Markovits & Barrouillet, 2002).

The influence of previous knowledge and experience on the construction of mental models has been well documented in the mental model literature (Azevedo, Moos, Greene, Winters, & Cromley, 2008; Cronjea & Fouche, 2008; Johnson-Laird, Girotto, & Legrenzi, 1998; Norman, 1983). According to some researchers (Barrouillet & Grosset, 2007; Cañas, Antolí, & Quesada, 2001; García-Madruga et al., 2007;

Johnson-Laird & Byrne, 1991), mental models are believed to be constructed from prior knowledge or previous experience and are modified as a result of new incoming information and new experiences. Individuals construct mental models in their working memory when they perform new tasks or learn new concepts. The flexibility of mental models allows access, utilisation, and integration of information from previous knowledge or experience in the long-term memory, as well as the incorporation of extracted information from new tasks.

Mental model theory involving reasoning (Johnson-Laird, 1983, 1987, 2001; Johnson-Laird & Byrne, 2000), and the idea that working memory capacity is important for logical reasoning have been advocated by Barrouillet and Grosset (2007). Limited capacity working memory does not affect reasoning, however, working memory capacity limits “the construction of mental models and thereby constrains performance in comprehension and deductive reasoning alike” (Oberauer, Weidenfeld, & Hörnig, 2006, p. 21). When reasoning to understand a problem, an individual either has to construct new mental models for that problem or access his or her mental models in the long-term memory if the problem is similar to a particular representation in the past, and then process the problem in his or her working memory. The reasoning of an individual is mainly constrained by the number of mental models he or she can hold in his or her limited-capacity working memory, as well as by the validity of the knowledge he or she used to construct these mental models. The capacity of working memory relies on resources for retrieving information from long-term memory and maintaining this information for processing. Therefore it can be difficult for those who have insufficient working memory capacities to construct and maintain their mental models (Anderson et al., 1996; Barrouillet & Grosset, 2007; Johnson-Laird,1983; Markovits & Barrouillet, 2002; Newton, 1996). The availability and structure of useful information or previous knowledge stored in the long-term memory may affect the outcomes of the reasoning process, according to Vandierendock, Diercx, and Van der Beken (2007) and Barrouillet and Grosset (2007). If the cognitive resources of an individual are limited and unavailable, he or she is not able to perform the process of activating and retrieving knowledge or information from the long-term memory to reason the problems (Barrouillet & Grosset, 2007; García-Madruga et al., 2007; Halford, 1993; Markovits & Barrouillet, 2002; Newton, 1996).

The relationship between the memory function and the reasoning function of mental models was presented in a study of García-Madruga et al. (2007). They conducted research on mental models, working memory, and reasoning tasks of volunteer university students studying psychology. The participating students in their study neither received the training nor participated in any working memory tests or reasoning tests. For the working memory test, each participant had to read to himself/herself “a series of progressively increasing phrases presented on a screen, and was then asked to recall the last word of each phrase and write each of them down in the correct order” (García-Madruga et al., 2007, p. 382). For the reasoning task, three sets of problems disjunctions were presented to participants, one based on “if then” conditionals, one based on “unless” conditionals, and one based on “A or B, or both”. Each set contained 12 problems. García-Madruga et al. (2007) utilised multiple regression analysis to analyse the data. They concluded that students constructed multiple mental models when reasoning the problems. There were positive correlations between working memory and reasoning responses which required the representation of multiple mental models. In contrast, the negative correlations between working memory and reasoning responses did not require multiple mental models. Their results also showed that some reasoning responses from students were probably obtained by surface strategies that did not load working memory.

In the same vein, the memory function of mental models has been explained in the research by Edwards-Leis (2010) in the field of primary education. Edwards-Leis (2010) conducted a research study on mental models of teaching, learning, and assessments on volunteer students and their teacher in a suburban primary school. Using the stimulated recall methodology to investigate in-action mental models of students studying robotic lessons, Edwards-Leis (2010) showed that some students ran several mental models to compare the effectiveness of different strategies for their learning outcomes. Their working memory was able to retrieve the appropriate mental models and integrate new knowledge of the robotic program to solve the problem. However, some students’ working memory was limited due to their under-developed working memory and this could hinder the ways they searched for alternative solutions to the problems.

An individual can hold one or more mental models simultaneously in his or her working memory to solve problems (Henderson & Tallman, 2006; Johnson-Laird, 1983; Johnson-Laird & Byrne, 1991; Norman, 1983; Payne; 1992). For instance, consider first-year education students studying the *ICTs in Education* subject in which they are required to draw a concept diagram. They can hold one or more mental models simultaneously to analyse a given concept - mapping activity, decide upon its diagrammatic type, and use “Inspiration” software to draw that concept diagram. However, when individuals run and maintain more mental models in their working memory, it is likely they need more time to find out the solutions. Also, during the working process, some information may be lost and some errors may be made (Vandierendock et al., 2007). Therefore the fewer mental models that need to be run, the better (Johnson-Laird, 1983). Long-term memory can influence working memory, as individuals’ perceptions of new incoming information is based partly on their prior knowledge and experiences (Anderson et al., 1996; Bagley & Payne, 2000; Hambrick & Engle, 2002; Hegarty & Just, 1993; Schwartz & Black, 1996). The more prior knowledge students have, the more likely they are able to construct conceptual frameworks that enable them to chunk information, because it reduces the cognitive load of new information claimed (Sweller, 1993). Prior knowledge is found to be the most significant factor in learning and understanding, and, in turn, influences the development of mental models. Students with low prior knowledge have limited conceptual understanding and are therefore less able to discuss the information or solve problems (Dalton, 2003).Learning can be a difficult process when students have low prior content knowledge. For example, first-year education students in this study were required to work on a spreadsheet activity to calculate the maximum, average, and minimum income value for a range of data. On the basis of the conditional premise that when students have no previous knowledge of how to use these formulae, the conclusion is that they could not produce the required information.

Pre-test and post-test tools/instruments have been used to measure mental models of school students to discover that accurate prior knowledge is associated with sophisticated mental models (Azevedo & Cromley, 2004; Tindle & Lincoln, 2000; Zeegers, 2004). The impact of previous domain knowledge on the use of hypermedia has been investigated by some researchers (Azevedo, Cromley, Winters, Moos, & Greene, 2005; Bird & Morgan, 2003; Gale & McNamee, 1995; Webb, 1999), confirming that learners with lower prior domain knowledge have more difficulty in interacting with hypermedia. In this study, the questionnaire items in the pre-test and post-test was utilised to examine mental models of learning that pre-service teachers held while studying ICTs and integrating ICTs into the learning and teaching context. The running of multiple mental models, the accurate or the inaccurate ones, was retrieved from students' prior knowledge and/or experience stored in their long-term memory. Students' previous knowledge or experience has an effect on the choice of their learning approaches. Therefore, students who have well developed prior knowledge are likely to adopt a deep learning strategy, because they self-regulate their learning by activating prior knowledge and linking new information to already known concepts in their long-term memory (Prosser, Trigwell, Hazel, & Waterhouse, 2000).

Mental Models of Learning

According to some researchers (Halford, 1993; Johson-Laird et al., 1986; & Henderson & Tallman, 2006), students can construct mutiple mental models when doing their learning tasks. First-year education students entering university can hold a number of different mental models of learning and of themselves as learners. It is important to understand the learning strategies they use and why they choose particular strategies. The learning approaches of first-year university students were discussed in the section Learning and Teaching Strategies in Chapter 2. Although this study directly focuses on first-year education university students' mental models, this section discusses the literature on methods and findings of other research on the conception and mental models of learning of pre-service teachers in their higher years in education program. This is because it would appear that mental models of first-year university students have not been investigated by research studies in the literature.

Students depend on their mental models of learning to regulate their learning strategies (Vermunt, 1998). According to some researchers (Entwistle & Peterson, 2004; Patrick & Pintrich, 2001), the concepts of learning can be understood through the application of the mental model framework. McNeil (2008) supports this view, suggesting that the way to measure students' learning is to examine their mental models because they can reflect their learning.

Entwistle and Peterson (2004) defined two kinds of mental models of learning: (1) learning as knowledge intake and reproduction, and (2) learning as constructing and transforming knowledge. Vermunt (1996) conducted his interviews with a wide range of university students and identified four mental models:

- Undirected learning style: students co-operated with fellow students, required support from teachers, and were being stimulated by teachers and peers.

- Reproduction directed learning style: students' study goal was to pass the examination. They absorbed knowledge from the course materials for the examination. They did not want to collaborate with learning peers about study topics as they thought it was useless.

- Meaning directed learning style: students took responsibility for their own learning. Students constructed their knowledge to understand concepts and diagnosed problems when they encountered difficulties.

- Application directed learning style: students acquired knowledge in order to apply it in practical situations.

Vermunt (1996) argued that the four mental models of learning were over-arching and that students could adopt different learning styles to meet the demands of the educational learning context.

Vermunt and van Rijswijk (1998) designed an Inventory of Learning Styles to investigate mental models of a large group of students. The initial questionnaire has 241 questionnaire items derived from their interviews with students in the Dutch Open University. There were two sections in this instrument: "the first section concerned the study activities involved in the processing of course content and the regulation of learning and the second section concerned study orientations and conceptions of learning, education and co-operation" (Richardson, 2007, p. 256). Vermunt and van Rijswijk (1998) used the factor analysis to identify the items that were most strongly associated with each of the four components of the Inventory of Learning Styles: processing, regulation, orientations, and conceptions. This yielded a revised version of the questionnaire containing 44 items in 16 scales, including five scales to measure different concepts of learning, education, and the conceptions of: Construction of Knowledge, Intake of Knowledge, Use of Knowledge, Stimulating Education, and Co-operative Learning. The following table presents the extraction of five scales of measuring different concepts of learning from the Inventory of Learning Styles.

Table 3.1

Conceptions of Learning in the Inventory of Learning Strategies

Conception	Description of content
Construction of Knowledge	Learning viewed as constructing one's own knowledge and insights. Most learning activities are seen as tasks of students
Intake of Knowledge	Learning viewed as taking in knowledge provided by education through memorizing and reproducing; other learning activities are tasks of teachers
Use of Knowledge	Learning activities are viewed as tasks of students, but teachers and textbook authors should continuously stimulate students to use these activities
Stimulating Education	Learning activities are viewed as tasks of students, but teachers and textbook authors should continuously stimulate students to use these activities
Co-operative Learning	Attaching a lot of value to learning in co-operation with fellow students and sharing the tasks of learning with them

Source: Vermunt and Vermetten (2004, pp. 365–366).

The Inventory of Learning Style from which Table 3.1 is extracted was evaluated by Richardson (2007) to investigate the mental models of university students taking distance learning courses with the Open University in the UK. The component factor analysis, cluster analysis, and discriminant analysis were used to analyse the data. A principal component factor analysis in Richardson's study identified four mental models: co-operative learning, intake of knowledge, use of knowledge and stimulating Education. These mental models were similar to those identified by Vermunt (1996) and according to Richardson (2007), these mental models are better interpreted as four over-arching learning styles. In the same vein, Law and Meyer (2008), using Vermunt's model, investigated relationships between learning strategies and mental models of learning and students' learning orientation of post-secondary students in Hong Kong. Their findings showed that mental models of learning and students' learning orientations directly influenced their processing strategies.

The studies of Vermunt (1996), Richardson (2007), and Law and Meyer (2008) demonstrated the strength of quantitative research in the study of a large group of students' mental models of learning. The research (Richardson, 2007; Vermunt & Vermetten, 2004) also confirmed the use of factor analysis in identifying mental models of learning. Minor, Onwuegbuzie, Wicher, and James (2002) conducted a mixed methods study, using an open-ended questionnaire and a Likert-scale questionnaire, to examine pre-service teachers' educational beliefs and perceptions of effective teachers. The survey asked students' beliefs about the transmissive views and progressive views of learning. They found that 28 percent of students were categorised holding transmissive views, 13 percent having progressive views, and 59 percent were categorised as eclectic (beliefs that shared characteristics of both transmissive and progressive). They suggested that the reason there was a large number of participants holding eclectic views was due to the fact that the survey was conducted at the beginning of the course. They concluded that the teacher education program must help pre-service teacher students to be aware of and modify their beliefs.

Chan and Elliot (2004) examined Hong Kong pre-service teacher students' conceptions of teaching and learning and their epistemological beliefs, using Likert-scale surveys and correlational analyses. Their work was based on Schommer's (1994) five dimensions of epistemological beliefs: (1) the organisation of knowledge, (2) the certainty of knowledge, (3) the source of knowledge, (4) the control of knowledge acquisition, and (5) the speed of knowledge acquisition. Two concepts of teaching and learning: traditional/transmissive and progressive/constructivist were also included in their survey. The transmissive and constructivist views were explained by Wilke (2008) as follows: "in the transmissive view of learning, learning is the non-problematic acquisition of knowledge by a novice from an expert. In the constructivist view of learning, learning occurs through reasoning and justification of knowledge and teaching becomes a facilitation of this process" (p. 16).

Chan and Elliot (2004) hypothesised that pre-service teachers who had naive epistemological beliefs would apply a traditional/transmissive view of learning. They described a naïve epistemological belief as one in which "knowledge is simple, clear, and specific; knowledge resides in authorities and is certain and unchanging; concepts are learned quickly or not at all and learning ability is innate and fixed" (p. 818). Chan and Elliot (2004) found that the pre-service teachers who had naïve views related to the certainty of knowledge. They explained that this was not unusual because students usually obtain more sophisticated views of knowledge during learning. They suggested that further research should be conducted to explore changes in students' beliefs and conceptions of learning. In response to the recommendations of the research studies above, this current project examined not only mental models of pre-service teachers in their first semester, first-year, but also changes of mental models over a semester.

Mental Models of Experts and Novices

According to Winn (2004), novices' working memory capacity developed when they were confronted with new conditions; whereas experts process other cognitive strategies, such as automaticity, omitting working capacity. Novices were more skilled than experts in utilising their working memories that helped them to recall information based on shallow characteristics.

An expert's mental model is fundamentally different from a novice's. Experts and novices differ according to their levels of conceptual understanding, which is reflected in their mental models (Chi, 2006; Chi, Feltovich, & Glaser, 1981). An expert's mental model is not simply more elaborate, complete, sophisticated or accurate (Gentner & Stevens, 1983; Hsu, 2006; Norman, 1983; Phillips, Klein, & Sieck, 2008) but generally, experts have the resources to elaborate complex mental models to steer and help them perfect their performances (Bradley, Paul, & Seeman, 2006; Ericsson, 2008; Payne, 1988; Phillips et al., 2008).

Experts are therefore better problem solvers and construct more advanced task-related mental models in specific topics than novices do. However, one of the characteristics of mental models is that mental models are almost always incomplete and even though experts' mental models are "stable and integrative, they still possess some fragments that drive them to further acquire knowledge." (Hsu, 2006, p. 5)

The expert's mental model "tends to be hierarchically organised with broad strategies at the top and narrower tactics below. [It also links] useful actions and declarative knowledge to form clusters that tend to be deployed simultaneously" (Newton, 1996, p. 206). According to Norman (1983), experts run their mental models to envisage the states and behaviours of the environment. They have the ability to solve unpredicted problems in new situations, utilising their prior experiences to simulate different or new mental models before carrying out the most appropriate actions for that situation.

Experts are more likely to enjoy the manipulative advantage of having superior cognitive strategies. Experts, having automaticised processes while performing tasks, are left with a larger amount of cognitive capacity within their short-term memory for integrating information, planning, troubleshooting, and for further strengthening their mental models in their specific knowledge domain (Glaser, Lesgold, & Lajoie, 1985). They are also better able to use metacognitive skills to monitor and reflect on their performance, thus continuing to make these skills even more accurate and efficient. On the other hand, a study comparing working memory performance of novice and expert interpreters pointed out that novices, interestingly, outperformed experts (Köpke & Nespoulous, 2006).

Chi, Glaser, and Farr (1988) suggested that experts have the ability to continue strengthening their expertise through a life-long progression within their long-term memory. Their prior knowledge enables them to perform better than novices. This is confirmed by Solomon (2002) who tracked learners' improvement from inefficient, slow, and frustrating to fast, quick, and efficient. Learners' mental models continuously improve with their performances as they take on board conceptual processes that can be handled more efficiently by their working memory. In support of these studies, Clark (2008) stated that not only do experts have a large amount of knowledge in their long-term memory, but they also organise this knowledge in complex mental models. Clark (2008) identified two types of mental models: simple and complex. Simple mental models support cognitive operation such as generalisations while complex mental models focus on problem solving.

In contrast, novices base their mental models on concrete forms of knowledge and superficial understandings of the concepts, reflecting the limitation of their cognitive development and its uncertain links to other declarative, procedural, and conceptual knowledge (Clark, 2008; Fiore, Cuevas, & Oser, 2003; Staggers & Norcio, 1993). This limits novices' skill levels in learning new, or reinstating previous, knowledge (Qureshi, 2004). Novices often start with a narrow scenario, looking for surface details first. They may have trouble processing new information because of having difficulties integrating this with their prior knowledge. Therefore this can place "an increased burden on processing capacity [in their short-term memory] and novices may not make an economical or efficient use of the capacity they have" (Newton, 1996, p. 206). Also, because novices are preoccupied with establishing mental models and attempting to picture and simulate processes in real time, they experience difficulty in envisaging abstract relations and properties (Glaser et al., 1985). Hsu (2006) and Michael (2004) emphasised that novices use their existing mental models to solve problems, but because novices often hold incomplete and erroneous mental models, errors may occur in their solution. In this study, first-year education students were novices who had no prior or little experience in ICTs and pedagogy in teaching field, so it is impossible for all students to construct complete and accurate mental models.

As discussed previously, mental models continuously change when one is involved in the knowledge construction process and through interaction with the world. Therefore, mental models of novices can evolve and become more complete and accurate (Hsu, 2006). Drawing on the belief that novices can become experts, Sebrechts, Marsh and Furstenburg (1990) observed the evolution of individuals' mental models in their study. At the beginning of their study, participants' mental models were unclear and incomplete. However, by providing external learning aids, their mental models improved. Novices' mental models were amended and refined, and thus their performances were enhanced. In the same vein, Hsu (2006) investigated the effects of metaphors on the basic and integrative knowledge acquisition of both expert and novice computer programmers. His research demonstrated that metaphors fostered the development of mental models in both experts and novices. Experts reinforced their mental models and made minor modifications whereas novices learned integrative knowledge better with metaphors.

It follows that educators should consider providing a learning environment which fosters the interaction and development of novices' mental models. Students are required to build upon and reinforce their existing mental models through problem solving, including self-guided and external-guided learning (Clark, 2008; Seel, 2001). Students construct their own knowledge and learn socially by interacting with academic teachers, tutors and peers, and with artefacts such as books or cognitive tools. According to some researchers (Clark, 2008; Darabi, Nelson, & Seel, 2009; Eckert & Bell, 2006; Hsu, 2006; Seel, 2001), problem solving, the learning process, and knowledge exchange are the primary sources for mental models development. In this current study, a distributed learning environment of the *ICTs in Education* subject (e.g., group work, tutorial classes, and informal discussions.), facilitated by constructivist and social constructivist paradigms, could promote individual development. The success or failure of the development of students' mental models in this study is examined in Chapter Six.

Developmental Change in Mental Models

Because the study of mental model development within first-year university students is relatively unexplored, this thesis research will help understand any changes to initially incomplete student mental models over a semester and what factors, if any, caused changes in their mental models. Several theoretical frameworks concerning the factors relating to the developmental change in mental models are discussed in this section.

Mental models are difficult to change. Mental models are often difficult to change because, as Vosniadou (1994) explained, they are tied to everyday experience and years of confirmation. Individuals will readily accept and integrate new information if it fits in with their existing mental models but discard it if they deem it irrelevant or unimportant. In fact, some individuals stick with their existing mental models even though their mental models are dysfunctional and often give deficient results. Some do not recognise the inadequacy of their mental models and still use them in discussion with others or apply them to external events (Duffy, 2003).

As mentioned, mental models are powerful, and learning behaviour of students is influenced by their mental models. Students can hold mental models (for example, to understand the text, diagnose problems, and predict answers) which promote or hinder success in their academic disciplines. Petroski (1992) claimed that people "... tend to hold onto their theories until incontrovertible evidence, usually in the form of failures, convince them to accept new paradigms" (pp. 180-181). Although mental models are difficult to change, it is possible to recognise and change mental models (Pfeffer, 2005, p. 125). Importantly, in order to change mental models, it is required that people be aware of their mental models because if people are not aware of their mental models, they are difficult to change. The ability to ascertain one's own mental models and the capability of changing any faulty mental models is influenced by some factors that are discussed in the following section.

Factors that influence changes in mental models. The incentive for changing mental models is motivation (Gardner, 2006; Martin, 2007). But how can students be motivated to understand their own mental models and develop them? The key factors for changes in students' mental models discussed in this section are (1) the learning process (Alavi, Marakas, & Yoo, 2002; Barker, Van Schaik, & Hudsons, 1998; Driscoll, 1994; Hinsz, 1995; Jonassen, 1994c; Silvan, 1999; Wilke, 2008), (2) the social learning environment including dialogue communication (Gardner, 2006; Martin, 2007; Scott, 2008), and (3) the use of ICT and cognitive tools as a means of learning mediation (Barker et al., 1998; d'Apollonia, Charles, & Boyd, 2004; Driscoll, 1994; Hinsz, 1995; Jonassen, 1994c; Silvan, 1999; Tallman & Benson, 2000). Changing students' mental models is the most powerful and useful way to change their learning behaviour and learning approaches.

Learning process. The learning process is seen as a prominent key for facilitating changes in mental models. Students have evolved their mental models in social-cultural learning environments in which their own ideas are influenced by constructivist and social constructivist pedagogy (Alavi, 2005; Barker et al., 1998; Barker, van Schaik, Hudsons, & Meng Tan, 1998; Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, 2004; Hatano & Inagaki, 2003; Jonassen, 1994a; Vosniadou, 2007).

According to Silvan (1999), constructivism is "connected to mental model change" (p. 16). Studies on mental models (d'Apollonia et al., 2004; Noriaki, King, & Monk, 2000) showed that students benefit from instructional guidance provided by educators. Academic feedback helps students realise their own inadequate mental models or misconceptions. A responsive learning environment allows students to become aware of their existing mental models and knowledge exchange assists students to adjust any misconceptions in their mental models. Any interactive exchange of ideas in the social learning environment, especially asking and answering questions, could be described as shared mental models or distributed cognition (Cole, 1997; Cole & Engeström, 1993; Hutchins, 1995, 2000; Hutchins & Hollan, 1999). Individuals each build their own idealised mental models of a concept and verbalise their mental models to groups of people who mutually recognise and understand that concept. Their critical thinking is developed with respect to differing descriptions and perspectives when these are challenged and defended. This will force students to change their mental models either by constructing new mental models or by revising their existing mental models.

The influence of learning on changing mental models of learning and teaching in education students at Flinders University was investigated by Askell-Williams, Murray-Harvey, and Lawson (2005). They used the problem based learning topic (PBL) that was embedded within the education topic Development Learning and Teaching (DLT). The development of mental models through instructions using self-directed learning, professional collaboration, knowledge building, critical thinking, and theory-practical relationships was examined. The content analysis of students' written reflection on their PBL experiences indicated that the problem based learning topic offered students learning experiences that precipitated change in mental models resulting from the following qualities: "(1) the value of case studies for engaging with subject content, motivating learning and connecting theory with practice, (2) self-reflection and peer collaboration for cognitive and professional growth, and (3) PBL processes of inquiry for developing self-regulated learning practices" (Askell-Williams et al., 2005, abstract).

The developmental changes in pre-service teachers' mental models of learning and instruction at Florida State University were investigated by Wilke (2008) using a qualitative, case study approach. To examine changes in the mental models of pre-service teachers in learning and instruction over time, Wilke collected three types of data for analysis:

- Phase one: Lesson Plan 1, Questionnaire 1, First Interview (January, 2007).
- Phase Two: Second Interview (April, 2007).
- Phase Three: Lesson Plan 2, Questionnaire 2, Third Interview (December, 2007).

The findings showed that pre-service teachers modified their mental models over time and mental models of learning and instructions of pre-service teachers were in a state of flux. Wilke (2008) drew six specific conclusions:

1. Mental model development was incremental and sustained
2. The complexity of mental models increased over time

3. Mental model expansion did not lead to the discarding of earlier conceptions

4. Mental model development progressed toward discipline-specific pedagogical practices

5. Mental models were influenced by a developing understanding of lesson planning and assessment

6. Developing mental models evidenced the acquisition of concept labels (Wilke, 2008, pp. 93-98).

From the findings of his study, Wilke (2008) emphasised that there is a need to design learning environments that facilitate the acquisition of the critical concepts in the teaching field. Furthermore, teacher educators should help pre-service teacher students be aware of deficiencies in their mental models and their roles.

In accordance with the mental model framework, conceptual change theory has been studied by many researchers (Evans, 2000, 2001, 2008; Sinatra, Brem, & Evans, 2008; Vosniadou, 1994, 2007; Vosniadou et al., 2004) who have stated that students have certain conceptions of the world and it is extremely difficult to change or revise these existing models of the world. Their prior knowledge is the obstacle to conceptual change because although prior knowledge contains errors, it still fits neatly within their existing understanding of the world. If students fail to be aware of any mistakes in their conception, they are naturally reluctant to change their misconceptions (Evans, 2000, 2001, 2008). To help students' conceptual change, educators must be aware of students' ideas that they bring to the classroom and design the instruction that foster their deeply thinking about other alternative perceptions (Sinatra et al., 2008). Sinatra et al. (2008) further stated that the degree to which students become involved in the content through discussion and dialogue related to changes in students' conception. Other researchers looked for ways to use motivation, social context, and affect to foster the conceptual change of students (e.g., Gregorie, 2003; Linnenbrink-Garcia & Pugh, 2009; Murphy & Mason, 2006). Linnenbrink-Garcia and Pugh (2009) found that everyday learning experience enriches students' learning and causes students to restructure their learning experiences. They also found that students' learning goals for their learning benefit seem to be conducive to conceptual change. Moreover, the use of higher order thinking skills in these classroom practices such as reasoning, argumentation, and problem-solving could also contribute to the conceptual change (Torff, 2003).

In the same vein, mental model theory states that students' mental models evolve in appropriate ways through knowledge construction in the social learning environment which is described in the following section.

Social learning environment. Applying Vygotskian theory, mental models are socially constructed through interaction with more capable or knowledgeable people (Barker et al., 1998; Henderson & Tallman, 2006; Jonassen, 1999b). Students develop their mental models in the social learning environment, whereby their own ideas are influenced by meaningful pedagogy.

According to Ellis and Maidan-Gilard (1997), mental models are shaped and developed in social contexts because different learners can have different mental models when observing the same event or doing the same task. Within social learning environments such as tutorial classrooms, workshops, and collaborative groups, individuals share their knowledge, insights, and perspectives. In effect, this requires them to consider and explore others' externalised mental models. Learners' knowledge is developed by exchanging assumptions, generalisations, critique, elaborations, and understanding of concepts. Information gathering within and among groups augments the "extensiveness" of the group's mental models as well as at the same time increases the "congruence" of individuals' mental models (Ellis & Maidan-Gilad, 1997, p. 5). Individuals compare their own mental models containing their own ideas with those of others, manipulating incoming information to solve problems (Henderson & Tallman, 2006).

While working in a group and obtaining new information, learners are able to embed mental models of others' concepts within their own mental models in a relevant domain. However, this process is dependent on the capacity of their working memory (Anderson, Reder, & Lebiere, 1996) and their willingness to manage and change their mental models (Henderson & Tallman, 2006). Individuals can reason or form a judgment on their own and others' ideas when pursuing the same goals, thereby enhancing performance (Cannon-Bowers, Salas, & Converse, 1990, 1993; Orasanu, 1990; Porter et al., 2003; Rentsch & Hall, 1994). According to Alavi et al. (2002), changes in students' mental models require the acquisition of knowledge and change in knowledge structure through the distributed cognitive process in the distributed learning environment. It is therefore worth examining the literature about distributed cognition.

Hutchins, well known for his distributed theory (1995) emphasized that since the mid-1980s, rather than being "a solitary mental activity, [cognition is seen as a] distributed phenomenon" (p. xiii) built on the individual's interaction with artifacts and with cultural and social environments. There are three important kinds of distributed cognition which play a major role in understanding human cognition: (i) cognitive processes distributed through social groups; (ii) cognitive processes distributed and integrated between internal and external structures; (iii) cognitive processes distributed, evolved, and transformed through time (Hutchins, 2000). Social and situational environments afford fundamental influences affecting each individual's own cognition (Nardi, 1996). Thus, it is impossible to separate students' cognition (or mental models in this thesis) from the sociocultural learning environment in which they operate and evolve.

Based on the literature on conceptual change and mental model theory (Gregorie, 2003; Linnenbrink-Garcia & Pugh, 2009; Murphy & Mason, 2006; Sinatra et al., 2008), it was hypothesised that the development of students' mental models in this study was likely to occur when they deeply engaged with the learning content through learning discussion with peer students and with the lecturer/ tutors/ demonstrators in the tutorial classes and computer workshops. The changes/no change of students' mental models in the constructivist and social constructivist teaching and learning environment of the *ICTs in Education* subject are analysed and the findings compared to other studies in Chapter Five and Chapter Six.

Communication /dialogue. The concept of dialogue in the collaborative learning is an essential key in helping people to recognise any limitation or dysfunction in their mental models and to modify their mental models (Jacobs & Heracleous, 2005). Individuals can explore, develop, and share understanding, learn new knowledge, and create new shared mental models through a dialogic method which is seen as "the core of the evaluative inquiry" (Duffy, 2003).

It was Vygotsky (1978) who paid particular attention to dialogue as the most common, prevalent, and self-explanatory cognitive tool that amplifies students' thinking and ideas sharing. He asserted that dialogue plays a crucial role in learning and that articulating ideas combined with thinking at one and the same time is equivalent to "a unit of verbal thinking" (Vygotsky, 1978, p. 47). Research by mental model cognitive scientists (Johnson-Laird, 1983; Johnson-Laird & Byrne, 1991; Johnson-Laird, Legrenzi, Girotto, Legrenzi, & Caverni, 1999) demonstrated that the dialogue involved in critical thinking forms the basis of reasoning during which "alternative possible situations are represented by mental models" (Cohen et al., 2004, p. 9). Not only the situation but also the goals and intention to question and plan answers are constructed within individuals' particular mental models. Oliver and Jacobs (2004) maintained that a dialogue process stimulates divergent viewpoints which are important for self-learning and mutual understanding. Different ideas and opinions help to restructure the cognitive process. According to Cohen et al. (2004), dialogue provides a means for people to argue and exchange points of view, provide feedback, and work together to construct new mental models. The more complicated the activity, the more strategic planning and discussion are required from students. This collaborative social interaction process assists and gives people opportunities to develop their own knowledge and skills as well as to guide their peers' participation in situated activities. The process of critical dialogues therefore increases individuals' understanding of the situation and of others' points of view and, when successful, usually improves judgment, decision-making, and a sharing of knowledge and skills. Participation in critical dialogue can be seen as a process of evaluating mental models, learning new knowledge, and constructing new mental models, since it forces people to negotiate or defend their ideas and, in the process, to hopefully modify and add new features to their existing mental models.

In this study, to take an example, critical dialogue had the function of eliciting knowledge in students' mental models that had not been used before when they discussed with one another in tutorial classes/computer workshops. The critical dialogue in the tutorial classes in this study proved useful to answer the research question about changes in students' over a semester. That is, developmental changes in students' mental models could occur if students would have participated in the collaborative learning environment.

Cognitive tools. Cognitive tools refer to the computer devices and environments that facilitate and encourage critical thinking and high order learning. Additionally, cognitive tools engage learners in meaningful cognitive and metacognitive processes (Jonassen, 1994b, 2007).

Norman (1983) suggested that cognitive tools provide students with opportunities to enhance their reflection. Moreover, cognitive tools can be used for fostering the creation of mental models (Resnick & Johnson, 1988). It is believed that when students use cognitive tools, they are able to advance more complex mental models of the content being studied as well as developmental models of the cognitive tool being used (Kim, Elliott, & Holschuh, 2002). Learners construct two kinds of mental models when using a cognitive tool: a mental model of the cognitive tool that they are working with and a mental model of the world represented by the tool (Kim et al., 2002; Payne, 1992). These mental models do not have to be accurate, but they must be "runnable".

Incomplete and inaccurate mental models often lead to limited and inefficient use of cognitive tools (Norman, 1983). Supporting Norman's (1983) perspective, many researchers (Barker et al., 1998; Cronjea & Fouche, 2008; Jih & Reeves, 1992) stated that the existence and value of individual mental models directly influence their task performance. If learners possess adequate mental models of functions and operations of cognitive tools, they are probably more engaged with their learning.

Cognitive tools can be used for fostering the construction and development of mental models (e.g., Barker et al., 1998; Cronjea & Fouche, 2008; Hsu, 2006; Resnick & Johnson, 1988). In this study, the pre-service teachers were taught to use the cognitive tools (ICTs tools) and to integrate the cognitive tools into their learning and teaching. To illustrate, first-year education students used technological tools, such as *Inspiration Software* to create a concept map. Different mental models were constructed to use these cognitive tools, for example, a mental model of using the cognitive tool and a mental model of creating a concept map. Students could not use cognitive tools, such as *Inspiration,* to draw a concept map without actively engaging and deeply thinking. The *Inspiration* cognition tool required students to think in meaningful and careful ways as to how this tool's features could be utilised to present their task, a concept map.

According to many researchers (Bower & Morrow, 1990; Calvin, 1996; Kim et al., 2002; O'Malley & Draper, 1992; Payne, 1992), students' previous mental models can affect their use of cognitive tools. Lack of previous knowledge may lead students to experience difficulties in drawing diagrams. The cognitive tool requires learners to become aware of their existing mental models and acquire external knowledge to construct or modify mental models of working with the software. The cognitive tool supports reflective thinking and facilitates learning through knowledge construction that involves using the appropriate mental models to understand and interpret new information, and then integrating new information into the existing mental models (Jonassen, 1994a). According to Jonassen (1994a) students use their existing mental models to interpret and integrate new information into newly enriched mental models. In the process, they learn new knowledge whose acquisition and restructuring, using cognitive tools, is thus a constructive rather than reproductive process.

Incomplete and inaccurate mental models often lead to limited and inefficient use of cognitive tools (Norman, 1983). Supporting Norman's (1983) perspective, many researchers (Barker et al., 1998; Cronjea & Fouche, 2008; Jih & Reeves, 1992) stated that the existence and value of individual mental models directly influence their task performance. If learners possess adequate mental models of functions and operations of cognitive tools, they are probably more engaged with their learning.

Conclusion

Craik (1943) originally proposed that mental models are "representations in the mind of real or imaginary situations" (p. 12). Since then, mental models have been used as a theoretical framework for explaining how individuals explain, understand, interpret, analyse, and solve anticipated events in different fields (Greca & Moreria, 2000; Norman, 1983). Why are mental models so important? Firstly, mental models control performance and processes. Mental models control how learners think and react. Secondly, mental models allow learners to predict and explain problems and are runnable as they evolve through the learning and teaching interaction (Birnberg et al., 2007; Muñoz et al., 2011). Thirdly, mental models serve as "memory and organisation devices" (Henderson & Tallman, p. 121) and not only help mitigate memory overload, but, by underpinning learner's understanding, help learners solve problems, choose likely solutions, predict outcomes, and achieve results. And fourthly, the powerful predictive function of mental models allows explaining and predicting of the actions/performances and reactions of the learners or the systems (Henderson &

Tallman, 2006).

Cognitive constructivists have believed that students organise their mental models based on their own perceptions, previous knowledge, prior learning styles, and previous learning experience (Henderson & Tallman, 2006; Johnson-Laird & Byrne, 2000). For example, mental models of learning at high school could have influenced the constructions of mental models of some first-year students in this study. For that reason, Sinatra et al. (2008) stated that educators must be aware of any pre-conceptions that students bring to the classroom in the instructional design of the subjects.

Learners learn better or more effectively when they form their own mental models to understand concepts, processing their conceptual knowledge in order to apply their own existing knowledge to new content and to solve problems. However, not every person constructs complete or correct mental models because mental models are not always complete or accurate (Gentner, 2002; Norman, 1983). Although incorrect or inappropriate mental models can be formed, mental models are modified or developed if individuals recognise the inaccuracy in his or her mental models. Because mental models control what learners' think and how they act (Henderson & Tallman, 2006), students are unwilling to change their mental models if they fails to be aware of their own mental models (Evans, 2001; 2008). According to Jones et al. (2011), if the cognition of the learners is limited, incoming information may be rejected and the mental models of learners do not change. Seel (1999) suggested that higher order cognition might be needed in order to facilitate understanding and analysis of instructional material to change mental models.

According to Ellis and Maidan-Gilard (1997), mental models are developed in social constructivist learning setting. Other studies (d'Apollonia, et al., 2004; Noriaki et al., 2000) acknowledged that students benefit from instructional guidance provided by educators. Academic feedback also helps students realise their own inadequate mental models or misconceptions. Learning is measured by changes in mental models (Doyle, 1996). First-year university students are expected to make a commitment to lifelong learning. Lifelong learning is defined as the process of acquiring and updating abilities and knowledge. According to Barker et al. (1998), "lifelong learning involves continuously changing mental models and their adaptation to meet the needs of dynamically changing societies and environments" (p. 314).

A review of the current literature on mental models and on first-year university students indicated that mental models of first-year students have still been unexplored, although the problems of first-year students have been researched for more than 40 years (Baik et al., 2015; DeBerard et al.,2004; Kift et al., 2010; Krause et al., 2005; Tinto, 1975, 1985, 1998, 2002, 2012; Yorke & Longden, 2007). This study builds upon research on first-year students and on mental models by utilising the mental model framework to investigate first-year education students' mental models of learning, any changes of their mental models over a semester, and the relationship between mental models and learning achievement.

Investigating mental models of pre-service teachers not in their first-year but in the higher years of education program, Wilke (2008) used qualitative methods. Other researchers (e.g., Chan & Elliot, 2004; Entwistle & Peterson, 2004; Law & Myer, 2008; Richardson, 2007) utilised the questionnaire survey to explore mental models or conceptions at one point in time. This study builds upon these studies by utilising questionnaire items to obtain the pre-defined mental models of the same pre-service teachers at the beginning and at the end of the semester in their first semester, first-year. The supplemental open-ended questions were added in the survey to clarify and compare mental models with the quantitative analysis. Changes in students' mental models in a subject where the intent was to provide a constructivist and social constructivist learning environment were examined carefully, which fills the gap in the mental model literature and responds to the suggestion in the literature (Chan & Elliot, 2004; Wilke, 2008) that further studies should be conducted to investigate changes in pre-service teachers' mental models.

In using the mental model framework to explore how pre-service teachers constructed in their first-year think about learning and of themselves as learners, this thesis contributes to reducing the gap in the literature on research that has been dominated by studies on beliefs and conceptions (Wilke, 2008). This study also contributes to the literature about the relationship between mental models and learning achievements in which few studies have been conducted that Hsu (2006) stated.

According to Taylor (2008), first-year undergraduate students are novices to learning. Many first-year education students in this research were novice learners. Being novices, they were more likely to respond to surface features and details

(Henderson & Tallman, 2006). Understanding pre-service teachers' espoused (pre) and reflective (post) mental models in their first semester, first-year at university and changes in their mental models over a semester could inform educators so that they tread more confidently in facilitating students' learning. In addition, a mental model perspective would suggest that educators could consider developing pedagogy to promote effective mental models. The next chapter discusses the research questions and the methodology that was employed in this study to investigate mental models of first-year university students.

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Chapter 4: Methodology

Overview

Chapter Three reviewed the theory and educational related studies pertaining to mental models. This chapter presents a detailed description of the research method used in this research. Firstly, it reintroduces the research aims and research questions. Secondly, it discusses the mixed methods approach that emphasised the quantitative method. Thirdly, it describes the context of the project and the participants. And fourthly, it outlines the statistical tests used in the quantitative analysis and the method used for coding the open-ended questions for the qualitative analysis.

Research Aims

This research aimed to (1) investigate the mental models of learning of first-year education students studying the *ICTs in Education* subject core, first semester, first-year subject and (2) examines what, if any, changes occur in mental models of learning of first-year university students during the first semester.

Research Questions

1. What are students' mental models at the beginning and at the end of the subject?
2. What major changes, if any, occurred in the students' mental models across a semester period?
3. Which mental models, if any, relate to students' learning achievement?

The methodology allowed further investigation and analysis of mental models of sub-groups of students. Thus, there were a number of sub-questions that needed to be answered in order to achieve the research aim:

a) Do the students' mental models differ in relation to gender and school completion time?

b) If so, what significant differences are there in students' mental models among the identified groups?

A Mixed Methods Approach to the Research

When choosing between quantitative and qualitative approaches or a combination, investigators face the challenge of identifying a research paradigm that will meet their research aim and questions (Patton, 2002). The use of a mixed method provides a better understanding of issues being investigated (Connelly, 2009; Creswell, 2003, 2010; Creswell & Plano Clark, 2007; Creswell, Plano Clark, Gutmann, & Hanson, 2003; Onwuegbuzie & Dickinson, 2008; Onwuegbuzie & Teddlie, 2003; Patton, 2002; Tashakkori & Teddlie, 1998, 2003). In his promotion for combining quantitative and qualitative approaches, Creswell (1994) stated the purpose of a mixed method was: "to include an examination of overlapping and different facets, to use the methods sequentially, to find contradictions and new perspectives, and to add scope and breadth to a study" (p. 189). A mixed methods research is well defined by Creswell and Plano Clark (2007):

> Mixed methods research is a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone (p. 5).

A mixed method allows for greater flexibility and opportunity for selecting design types and presenting a greater multiplicity of divergent opinions than either approach alone (Burns, 2000; Creswell, 1994, 2003, 2011; Creswell & Plano Clark, 2007; Creswell et al., 2003; Johnson & Turner, 2003; Onwuegbuzie & Dickinson, 2008; Onwuegbuzie & Teddlie, 2003; Tashakkori & Teddlie, 2003; Teddlie & Johnson, 2009; Teddlie & Tashakkori, 2003). The dynamic connection between different approaches in mixed method research provides a greater potential to discuss the complex research questions than either traditional research method alone (Hesse-Biber & Crofts ,2008).

Before discussing the mixed method design of the study, the limitation of the qualitative data is reiterated (this limitation was noted in Chapter One). When designing the methodology for this study, the stimulated recall method was included to explore students' in-action mental models while learning in the social constructivist tutorial classrooms. The stimulated recall methods would have provided the researcher the opportunities to explore students' mental models in depth (Nguyen, 2004). The researcher attempted to attend the tutorial classroom to conduct the stimulated recall method. Unfortunately at this point in the research process, first-year students had been to participate also in three other studies so they were unwilling to increase participation in this study. Consequently, the researcher eliminated the stimulated recall method from the qualitative data collection which impacted the choice of the mixed methodology designs in this study. Furthermore, the number of students who answered the open-ended questions on the survey at the end of the semester was fewer than anticipated. This was due to absence from the face to face teaching or the choice not to complete the questions. Student reluctance to increase their participation led to the intent to include interviews at the end of the semester being dismissed.

To conduct a mixed method research, according to Creswel and Plano Clark (2010), it is important that researchers address:

> different ways that the quantitative and qualitative strands of the study relate to each other. A strand is a component of a study that encompasses the basic process of conducting quantitative or qualitative research such as asking questions, collecting data, analysing data, and interpreting results based on that data (p. 63).

Researchers have to consider four key decisions in choosing a mixed methods design: (1) whether the strands are independent or interactive, (2) whether the strands are equal in the study or have unequal priority for addressing the purpose of the research, (3) whether the strands of the study are implemented concurrently, sequentially, or across multiple phases, and (4) how to mix the strands (Creswell & Plano Clark, 2010). This study utilised the mixed method in which the quantitative methods was emphasised and the qualitative open-ended questions were used in a secondary role (Creswell & Plano Clark, 2010). The “point of interface” (Morse & Niehaus, 2009, p. 25) or the point where the mixing occurs in this study occurred during the data collection and data discussion.

Mixed method designs take a range of forms. Creswell and Plano Clark (2010) further stated that researchers can apply one of six major mixed method research designs: (1) the convergent parallel design, (2) the explanatory sequential design, (3) the exploratory sequential design, (4) the embedded design, (5) the transformative design, and (6) the multiphase design. This study employed the embedded mixed method design. The rationale for utilising the embedded design method is explained below.

Rationale for Utilising the Embedded Design Mixed Method

The embedded mixed method design was utilised in this study, in which researchers can "collect and analyse using quantitative and qualitative data within a traditional quantitative or qualitative research design" (Creswell & Plano Clark, 2010, p. 90). This study used the most common type of embedded design found in the literature where the qualitative is embedded in the quantitative design (Creswell & Plano Clark, 2010). All quantitative items and two qualitative open-ended questions were collected in the same survey.

This research aimed to investigate mental models of a large group of first-year university students. The mixed method approach with primarily quantitative questionnaires was utilised because it allowed for the identification of a number of pre-defined mental models of the large group of students. Data from quantitative questionnaires also allowed for testing significant differences in students' mental models among the groups, and examining any changes in mental models over time.

However, the results of the quantitative questionnaires could not include quotations from volunteered students. There was a need to add a small qualitative component in this research in order to allow students to express their thoughts, emotions, and problems they were facing in this subject, beyond what was asked in the quantitative items. The open-ended questions allowed volunteer students to have the opportunity to respond more elaborately and in greater detail than the quantitative method which required a Likert-scale response (Popping, 2008). The qualitative data also could reveal mental models that were unanticipated. The results gained from the supplemental open-ended questionnaires were then used to support and elaborate the findings from the quantitative analysis.

The embedded mixed method approach in this research helped to check the convergence and divergence of the findings from the analysis of the quantitative items and the responses to the open-ended questions and provided richer details about students' mental models of learning. The embedded mixed method allowed the researcher to extract the dominant findings from both quantification and descriptions and to thus maximise findings about students' mental models. This enhanced the validity of the findings and thereby improved the quality of the data analysis and interpretation (Garson, 2008; Tashakkori & Teddlie, 1998).

The procedures of other mixed method designs are described below to explain why this research could not apply one of those methods. It is recalled that the aim of this study was to explore mental models of students in their first semester, first-year. The researcher had only 11 weeks to collect data.

- The convergent parallel design (also referred to as the convergent design) is the most well-known mixing methods since the 1970s and is the most common research design used across disciplines. The purpose of the convergent parallel design is "to obtain different but complementary data on the same topic" (Morse, 1991, p.122) to best understand the research problem. To conduct a convergent parallel design, the quantitative and qualitative strands must be implemented at the same time of the research process and be prioritised equally. This design could not be applied in this research because of the limited time for equally collecting, analysing, and merging quantitative and qualitative data and results at the one time. Moreover, if the quantitative and qualitative results did not agree then it might require the re-collection and re-analysis of additional quantitative or qualitative data. It was also a challenge to have different samples and different sample sizes in this research (Creswell & Plano Clark, 2010).
- The explanatory sequential design (also referred to as the explanatory design) is conducted when researchers want to use a qualitative strand to explain initial quantitative results (Creswell et al., 2003). The explanatory sequential design occurs in two different interactive phases. Firstly, the researcher starts to collect and analyse the quantitative data. Secondly, the qualitative phase is designed so that it follows from the results of the quantitative phase. The results of the qualitative data are used to explain the results of the quantitative data in more depth. However, in this study, the researcher could not implement the explanatory sequential design because it would require a lengthy amount of time for consecutively implementing two phases of collecting quantitative and qualitative data. It would be also very difficult for the researcher to specify how first-year volunteered students would be selected after the initial findings were obtained.

- The exploratory sequential design uses sequential timing. The qualitative strand has greater priority within the design. Firstly, the qualitative data are collected and analysed. Secondly, based on the results of the exploratory design, a second quantitative phase is conducted to generalise the findings of the qualitative data (Creswell & Plano Clark, 2010). The researcher could not implement this design in this study because of time-constraints. As the exploratory sequential design requires a considerable time to implement while the researcher had only 11 weeks to collect data. Also, the volunteered students refused to participate to the stimulated recall interviews in this study. In addition, it was difficult for the research committee to approve this design because the researcher "cannot specify how participants will be selected for the second phase until the initial findings are obtained" (Creswell, 2013, p. 85)
- The transformative design was not suitable for this research because the purpose of transformative design is a framework of belief systems focusing on improvement of social justice (Creswell & Plano Clark, 2010), and that was not the purpose of this study. The research directly involves people of a culturally diverse group and trust must be built between the researcher and volunteered participants. The mixing methods in the transformation design are for value-based and ideological reasons, rather than methodology design (Greene, 2008). The advantage of the transformative design is the results are useful for communities and the research helps to empower individuals. However, the challenges for the researchers to conduct the transformative design as there is still little guidance in the literature on how to conduct this type of mixed method.
- The multiple phase design is used in program evaluation where quantitative and qualitative approaches are used over multiple years in order to "support the development, adaption, and evaluation of specific programs" (Creswell & Plano Clark, 2010, p. 20). The multiple phase design best addresses investigations of complex health projects and evaluation programs. The multiphase mixed method design was not suitable for this research because phases could not be accommodated in this study. This study investigated mental models of first-year university students in only one semester. Furthermore, some of the challenges in designing the multiple phase design are the researcher include a budget, resources, time, and effort to conduct multiple phases over two semesters or multiple years as

well as the need to effectively collaborate with other researchers. Hence the multiple phase design was not appropriate for this study.

Quantitative Research

The quantitative method is often defined as traditional research, the empiricist paradigm, the positivist/post-positivist paradigm, or post-positivism research (Denzin & Lincoln, 2005; Mackenzie & Knipe, 2006). Discussing the history of quantitative research in the education field, McMillan, Mohn, and Hammack (2015) pointed out that the field of education has utilised quantitative research design since early in the 20^{th} century and it developed from the quantitative research utilised in psychology and the social sciences.

Quantitative research employs a deductive approach. It involves taking a concept or theory and then developing an instrument, such as a survey, in order to observe and test the concept empirically (Creswell, 2003; Johnson & Larry, 2004; Neuman, 2000). Focusing on variables, numerical representation of frequencies, and statistical inference, it involves measurement and analysis of the correlations among, and differences between, variables, and seeks cause and effect relationships (Casebeer & Verhoef 1997; Maxwell & Loomis, 2003; Neuman, 2000). The results of quantitative data are presented numerically in tables. The quantitative research can also be confirmatory and involves verification.

While disagreement among researchers exists, quantitative research has the great strength because the use of statistical techniques de-emphasises individual judgment, thus allowing the researchers to remain “neutral” and “objective” (Hoyt & Bhati, 2007; Newman, 1994). However, with this approach, the context and the setting are often not well understood by the researchers (Creswell, 2003). Whereas, the qualitative approach can provide details about context, students’ emotion, behaviour, and personal characteristics that the quantitative study cannot offer.

Qualitative Research

The qualitative method is seen as naturalistic research, constructivist research, or an interpretative approach (Creswell, 2003). In contrast to quantitative research in education, qualitative research emphasises the processes and events that are not examined in terms of quantity (Maxwell & Loomis, 2003). It has been preferred for investigating people’s experiences, thoughts, and attitudes that are not directly observable. The qualitative method can highlight subtleties in, for instance, student thoughts, behaviours and responses, and can uncover reasons for their actions (Burns, 2000).

Analysis in the qualitative method, with an emphasis on the identification of meaning and processes is based on some events relate to, or influence, other events (Maxwell & Loomis, 2003). Qualitative research usually relies on inductive reasoning processes to interpret and structure the meanings that are derived from data (Creswell, 2003; Johnson & Larry, 2004; Neuman, 2000). The qualitative method can be exploratory, as it is often used when the researcher wants to learn more about the phenomena (Creswell, 2003; Johnson & Larry, 2004).

Combining Quantitative and Qualitative Research Methods

Understanding the characteristics of quantitative and qualitative research helps when a researcher combines these different approaches. A summary of the kinds of distinctions made concerning the use and value of both methods is provided in Table 4.1.

Mixed methods research has been suggested as being the "third methodological movement" (Tashakkori & Teddlie, 2003, p. 679) or the "third research paradigm" (Johnson & Onwuegbuzi, 2004, p. 14). In the past few decades, various researchers have proposed a mixed methods research which combines quantitative and qualitative approaches as complementary to either quantitative or qualitative research (Creswell, 1994, 2003; Creswell et al., 2003; Johnson & Onwuegbuzi, 2004; Johnson et al., 2007; Onwuegbuzie & Teddlie, 2003; Tashakkori & Teddlie, 2003; Teddlie & Johnson, 2009). Tashakkori and Teddlie (2010) emphasised that mixed methods research "has gone through a relatively rapid growth spurt… it has acquired a formal methodology that did not exist before and is subscribed to by an emerging community of practitioners and methodologists across the disciplines" (pp. 803-804).

Table 4.1

Features of Quantitative and Qualitative Research in Education

	Quantitative	Qualitative
Conceptual framework	Variance theories	Process theories
Purposes	Generalisability Accurate computation and comparison of variables Setting up relationships between variables Inference from sample to population	Contextualisation Understanding events and/or single cases in the context setting Uncovering unexpected events and their influences
Type of reasoning	Reasoning is logistic and deductive	Reasoning is dialectic and inductive
Type of question	Pre-specified Outcome oriented	Open-ended Process oriented
Researcher role	Researcher remains objectively separated from the subject matter Researcher knows clearly in advance what he/she is looking for	Researcher becomes subjectively immersed in the subject matter Researcher may only know roughly in advance what he/she is looking for
Data Collection	Prior development of tools: such as questionnaires and/or equipment, to obtain quantitative data Context free Standardisation Collection of numbers and statistics Data is more “efficient”, able to test hypotheses, but may miss contextual detail	Inductive development of strategies: e.g., open-ended question, interviews, stimulated recall method Context dependent Adapting to particular situations Collection of textual and/or visual material Data is more “rich”, time consuming, and less able to be generalised
Data analysis	Less time consuming Numerical descriptive analysis (statistic) Establishes relationships, causation Reports statistical analysis Results are relatively independent of the researcher	Time consuming Textual analysis (coding) and categorizing Describes meaning, discovery Reports rich narrative Basic element of analysis is words/ideas Results are more easily influenced by the researcher’s personal biases
Validity	Statistical validity Generalisations leading to prediction, explanation, and understanding	Descriptive validity Interpretive validity Patterns and theories developed for understanding

Adapted from Creswell, 1994, 2003; Creswell et al., 2003.

The use of mixed methods research is broadly evident in nursing research (e.g., Gilbert, 2001; Lane-Tillerson, Davis, Killion, & Baker, 2005), health research (e.g., Forthofer, 2003; Radhakrishnan, Jacelon, & Roche, 2012), psychology (Powell, Mihalas, Onwuegbuzie, Suldo, & Daley, 2008), and educational research (e.g., Boon, 2006; Cinamon & Dan, 2010; Creswell, 2003; Kitchenham, 2005; Tashakkori & Teddlie, 1998, 2003). Mixed methods research was also used to investigate students' perceptions regarding characteristics of effective teachers (e.g., Greimel-Fuhrmann & Geyer, 2003; Onwuegbuzie et al., 2007; Wang, Gibson, & Slate, 2007; Witcher et al., 2003), teachers' attitudes towards teaching early elementary students in urban schools (Halvorsen, Valerie, & Fernando, 2008), mental models (Alavi, 2005; Freebairn-Smith, 2009), and first-year retention (Waller, 2009).

According to Tashakkori and Teddlie (2003, p. 4), mixed methods research "(a) would incorporate multiple approaches in all stages of the study and (b) would include a transformation of the data and their analysis through another approach". A mixed method approach provides convergent evidence as well as divergent or contradictory aspects about the concepts, ideas, or phenomenon being studied (Johnson & Turner, 2003), Furthermore, the results of quantitative and qualitative approaches may be used to supplement each other and also provide the chance for presenting a greater diversity of perspectives. The fundamental principle of a mixed methods approach is to use the strong points of each type of data collection to adjust for the weaknesses, biases, and limitations in any single approach (Tashakkori & Teddlie, 2003).

A mixed method approach strengthens the validity and reliability of research, as data collection from the qualitative approach is used to explain and interpret results from a primarily quantitative study (Creswell et al., 2003; Frechtling & Sharp, 1997; Johnson & Turner, 2003; Patton, 2002; Shih, 1998; Tashakkori & Teddlie, 2003; Teddlie & Tashakkori, 2003). If the quantitative data has some unanticipated results, the qualitative data can then be utilised to investigate these results in more detail and to interpret the findings more adequately and reliably (Creswell, 2003). This should reduce any inherent biases of the researcher in using one method only. If the results from the two approaches do not contradict each other, this will increase the reliability of each singular-approach conclusion. If the results of both approaches conflict, then the interpretations and conclusions can be modified accordingly (Johnson & Larry, 2004; Johnson & Onwuegbuzie, 2004).

Johnson et al. (2007) distinguished three types of mixed methods research: qualitative dominant, pure mixed, and quantitative dominant. The mixed methods approach in this thesis was quantitative dominant in which the researcher relied on quantitative results, while at the same time sought qualitative data to two open-ended questions that added benefit to the research project.

Although a mixed methods paradigm helps to improve the quality, reliability, and validity of the research, it still has certain weaknesses. Table 4.2 outlines the strengths and weaknesses of a mixed methods research.

Table 4.2

Strengths and Weaknesses of Mixed Research

Strengths	Weaknesses
• Provides quantitative and qualitative research strong points that strengthen the research • Overcomes the weaknesses in one approach by using the strengths of the other • Adds insights and understanding from a second method that might be missed when only a single method is used • Deepens and broadens an understanding of the research topic • Maximizes the interpretation of data in both methods • Increases the generalisability of the results • Allows the research questions and sub-questions to be answered and viewed through different lenses • Allows a broader and more complete range of respondents' answers to be discovered • Offers stronger evidence for the conclusions • Allows implications through convergence and divergence of findings • Produces more complete knowledge necessary to inform theory and practice • Provides visual methods of quantitative data (numbers, tables, charts, and plots) that can be used to add precision to words, pictures, and narrative • Uses words, pictures, and narrative (from observations, interviews, and written responses) in the qualitative research to add meaning to numbers in the quantitative research • Provides graphical material from both approaches that enhance reader comprehension	• It might require a research team to conduct both qualitative and quantitative research, especially if two or more approaches are expected to be used concurrently • A researcher has to learn about qualitative and quantitative research and comprehend how to mix them appropriately • It is more time consuming

Sources: Johnson and Onwuegbuzie (2004), Johnson and Turner (2003), Johnson et al. (2007), Onwuegbuzie and Dickinson (2008), and Onwuegbuzie and Teddlie (2003).

From the perspective that quantitative research is confirmatory and involves verification while qualitative research is exploratory and involves generation, Teddlie and Tashakkori (2003) maintained that the major advantage of a mixed method approach in research is that it enables the researcher "to simultaneously answer confirmatory and exploratory questions, and therefore verify and generate theory in the same study" (p. 15). The rationale for conducting a mixed method research in the research is discussed in the section below.

Purposes of Using a Mixed Methods Research

In the mid-1980s, there was a concern that researchers were using mixed method research without providing a justification (Greene, Caracelli, & Graham, 1989; Rossman & Wilson, 1985). Greene et al. (1989) identified five purposes through an analysis of 57 empirical mixed method evaluations. These are: triangulation, complementarity, development, initiation, and expansion. They have been widely used and recommended by Johnson and Christensen (2010).

- *Triangulation* refers to the use of quantitative and qualitative research within one study. The convergence and corroboration of results from two different approaches investigating the same concepts or phenomenon increases the study's validity (Garson, 2008; Greene et al., 1989; Silverman, 2005). A main rationale for using a mixed method research but primarily quantitative in this thesis was that there would be convergence in the analysis of the results. A methodological triangulation is illustrated by using quantitative Likert-scale questionnaires and qualitative open-ended questions to access volunteer, first-year education students' mental models. Such an approach helps to (a) enhance the richness of findings, (b) improve the analysis of the findings of the quantitative method and qualitative method, simultaneously and independently, in order to check convergence, and (c) provide better opportunities for causal inferences (Garson, 2008; Tashakkori & Teddlie, 1998). According to Migiro and Magangi (2011), the results of qualitative data help to explain the quantitative data and produce a well-validated conclusion.
- In order to increase a study's validity and interpretability, *complementarity* involves "expansion, clarification, enhancement, and illustration of the results

from one method with findings from the other method" (Johnson & Christensen, 2010, p. 439). This provides broader coverage as well as alternative levels of analysis (Greene et al., 1989). In this thesis, quantitative methods, such as exploratory factor analysis, independent sample t-test, and mixed method analysis, identified mental models and groups that had the same mental models. Data from the qualitative results helped to identify other mental models that students constructed in addition to the mental models revealed in the quantitative data. The results of the qualitative data in this research helped to expand the data of quantitative results.

- *Development* uses the "results from one method to help develop or inform the other method" (Greene et al., 1989, p. 259) to advance the effectiveness of the research. This thesis did not cover the development because the mixed method approach in this project was primary quantitative analysis.
- *Initiation* searches for "paradox, contradiction and new perspectives" in order to discover the contradictions of the results (Crump & Logan, 2008, p. 24) or "fresh insight" (Greene et al., 1989, p. 260) to add depth and breadth to interpretations. This research aimed to discover, if any, the inconsistent results in, and across, both the findings in the quantitative research and qualitative research.
- *Expansion* seeks to widen the "breadth and range of the study" (Greene et al., 1989, p. 259) by incorporating data, time, and space (Denzin, 1989). This thesis did not cover the expansion as the time for collecting two sets of data only covered a period of three months.

The straightforward nature of this research's design meant that it was easy to implement. The mixed methods approach at the analysis phase enabled each method to figure separately while permitting them to influence each other. Quantitative and qualitative data were analysed and reported in different sections with a final discussion that brought the results together.

In summary, there are four purposes for using an embedded mixed method design in this research: triangulations, complementarity, development, initiation, and expansion. Using the quantitative method as the dominant approach, the researcher was able to perform different statistical tests to report statistically significant differences between mental models of learning of different groups respectively (female/male and mature age/school leaver students) in this research. The reason for using the open-ended questions was the need to more deeply understand students' mental models of learning and the problems they faced during their studies. Quantitative questionnaires and qualitative responses to the open-ended questions are analysed and reported in Chapter Five with a final discussion in Chapter Six. The mixed methods approach at the discussion phase enabled each method to figure separately while permitting them to be compared. As a result, the findings of both approaches were greater than the results of one method alone and provided more breath, deep, and richness (Creswell & Plano Clark, 2007).

Research Design

Having outlined the rationale for choosing the methodology used in the study, this section now provides a description of the context of the study, the participants, the data collection tools, and the data analysis used.

The Context

The participants were studying in a core first semester, first-year subject *ICTs in Education* in a regional Australian university. At the time this study was conducted, the entrance assessment was not available. Students did not have to attend the entrance assessment about their literacy skills or the computer skills. The *ICTs in Education* subject had been extensively redesigned to introduce the students to theory, content, and the necessary skills for effective instructional design, creation, and pedagogical utilisation of ICTs in the education course, school experience practicum, and classrooms. It also targeted high order thinking skills, strategies, and processes relevant to successful university study and lifelong learning.

The objectives of the subject, as delineated in its outline, were as follows:

- develop hands-on skills in the use of computer technologies and the Internet;
- critique aspects of learning with information communication technologies (ICTs);
- critique important social, gender, disability, and cultural issues relating to the introduction of information communication technologies;
- critique learning theories underpinning educational software and educational web sites;

- create relevant information communication technology products.

This subject specifically targeted the following graduate outcomes set by the university:

- **Using Tools and Technologies**
  - the ability to select and use appropriate tools and technologies;
  - the ability to use online technologies effectively and ethically.
- **Information Literacy**
  - the ability to find and access information using appropriate media and technologies;
  - the ability to evaluate that information;
  - the ability to deploy critically evaluated information to practical ends;
  - an understanding of the economic, legal, ethical, social, and cultural issues involved in the use of information and to communicate it accurately, cogently, coherently, creatively, and ethically;
  - the ability to select and organise information.

The *ICTs in Education* subject presented pre-service teachers with a range of ICT literacy and academic topics, including evaluation and instructional design of information technologies, and the social, economic, educational, and political aspects of ICTs. This subject provided an introduction to the educational significance of electronic communication technologies, such as mind-tools. These include utilising spread sheets, databases, concept mapping, and web authoring in ways that inculcate those critical and reflective thinking skills and strategies needed by tertiary graduates (Jonassen, 1994b, 1996, 2007).

The *ICTs in Education* subject required the constructivist learning (interactive web activities), social constructivist learning (tutorial discussion, problem work activity), and behaviourist learning (mass face-to-face lectures, workshop demonstrations) is included. The subject involved three hours of “contact” time per week: one 50-minute mass lecture, one 50-minute interactive web lecture (student decides own time and place), and a 50-minute tutorial. Due to financial constraints, subjects at the time were funded on two lectures and one tutorial per week. Student attendance at the 50-minute ICT workshop was optional; students could attend one or more workshops, for however long they wished, depending on their perceived skill and assignment interpretation needs. Tutorial sessions utilised constructivist and social constructivist pedagogy whereby the tutor and students discussed and shared their understandings within a particular multiple cultures context. As well as a two-hour final semester examination, assessment for the 13-week subject comprised nine tutorial reaction papers that covered aspects of the face to face mass lecture, the interactive web lecture, and tutorial topics. The ICT workshop project activities were covered in the workshops and one assessed E-Portfolio project.

Participants

The 257 convenience sample (Peterson & Merunka, 2014) of first-year bachelor students enrolled in the compulsory core *ICTs in Education* subject were invited to participate in the study. The demographic characteristics of the volunteer students (N=102) are presented in Table 4.3.

Table 4.3

Demographics Characteristics of the Volunteered Students

Participants	**Number**	**Percentage**
Gender		
Female	78	76.5%
Male	24	23.5%
Student Status		
School Leaver	52	51.0%
Mature Age	50	49.0%
Student Type		
Full time	93	91.2%
Part time	9	8.8%
Age		
17	20	19.6%
18-19	45	44.1%
20-29	17	16.7%
30+	20	19.6%
Returning Uni students		
Yes	10	10.0%
No	84	82.4%
Returning the *ICTs in Education subject* students		
No	99	97.1%
Yes	3	2.9%

One hundred and fifty-three first-year education students returned their pre-survey with their consent forms and parents' consent forms for students who were 17 years old. Of the 153 students who completed the pre-survey, 102 completed the post-survey. Therefore the total number of students who participated in this pre and post study was 102, reflecting a 39.6 percent response rate among all first-year education students and a 66.7 percent response rate among students who completed the pre-test. This sample size allowed a comparison of changes, if any, between students' mental models when they started the subject and their mental models at the end of the subject.

Female students dominated in this research being 76.5 percent of the sample while there were 23.5 percent male students. There were slightly more school leaver students (51.0%) than mature age students (49.0%). Most students studied full time (91.2%) while only 8.8 percent were part time students. Nearly half of the students were in the age group 18-19 (44.1%). Students age 17 made up 19.6 percent; students in the age group 20-29 made up 16.7 percent; and there were 19.6 percent students aged 30 and over. A total of 10 students (10 percent) indicated that this was not their first semester of university. Their data were included in the data set because the focus of the study was on the student mental models and changes in those mentals in the context of a particular subject in first-year. Of the sample, three students (2.9 percent) had enrolled in the *ICTs in Education* subject previously. The data from the three students who had attempted the subject before were included in the data set because they did not appear in the previous year's list of completions. This means that if they had been enrolled the previous year, they had withdrawn early in the semester of their first attempt. If they had been enrolled prior to the previous year, the subject had since undergone extensive changes and thus their data could be included.

Data Collection Tools

Pre and post-surveys. Surveys are an appropriate and practical means of collecting data from a large group because of the time and effort required of participants to complete the questionnaires. The survey process is considered a suitable method of research when the accuracy of information from a large population is required, as items in the survey are consistent across individuals (Burns, 2000; Cohen & Manion, 1994; Cohen et al., 2000). Creswell (2003) stated that "a survey design provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population" (p. 153). Burns (2000) argued that participants' responses from a survey can be honest and precise because the participants are guaranteed confidentiality and anonymity.

The survey is described as a cognitive task to help the researchers to understand the mental process of respondents (Vitale, Armenakis, & Feild, 2008). It was expected that such an approach would provide better insight into the area of investigation, with the intention of comparing particular responses across students and at different times.

Surveys were undertaken to "gather data at a particular point in time with the intention of describing existing conditions" (Cohen & Manion, 1994, p. 83) that related to students' mental models of learning at university at the beginning and the end of their first semester. The responses of students to the pre and post-surveys would reveal the examination mental models of first-year education students as learners and how they changed, if at all, their mental models during the semester.

The research aimed to examine the nature of the existing conditions or the attributes of a particular population through their responses to different questions about their mental models of themselves as university students and mental models of their learning. Likert (1932) developed a summated scale for the assessment of survey participants in which a number of alternatives are open to choice. The Likert-scale questionnaire items provided exact measurements of what is being assessed (Wakita, Ueshima, & Noguchi, 2012).

According to Rea and Parker (1992) the Likert-scale questionnaire items help students to clarify the meaning of the question and to simplify the task of answering a question. This was vital because the likelihood of superfluous and irrelevant content was lessened by providing a standardised choice of responses. However, respondents tend to respond systematically to questionnaire items without considering their contents (Baumgartner & Steenkamp, 2001). Therefore, the use of a mixture of positively and negatively worded items was used to "mitigate both acquiescence and dis-acquiescence" (Harzing, 2006, p. 260), because it requires the respondents to thoroughly study the meaning of the questions; as a result they are more likely to give meaningful responses (Harzing, 2006; Smith, 2003). The surveys in this research contain a mixture of positively and negatively items. Responses to the negative Likert questionnaire items were reverse-coded as positive items in the analysis (Field, 2005; Oppenheim, 1996).

The surveys in this research were developed using a five-point, self-rating response scale starting from a value of 1 (strongly disagree), 2 (disagree), 3 (undecided), 4 (agree), and 5 (strongly agree). It is argued by Kreuger and Neuman (2006) that respondents are forced to choose a more positive or negative response when the scale does not have middle position responses. If a participant consistently chose the middle response, this indicated a lack of attitude, knowledge, or extreme opinions about the questions or issues (Harzing, 2006; Oppenheim, 1996). The Likert-scale questionnaires advance the consistency of responses and ease of data tabulation (Arnon & Reichel, 2009; Kreuger & Neuman, 2006; Neuman, 2000, 2004).

The pre-survey was conducted in the second week of the first semester in order to explore mental models of students at the beginning of the subject, that in turn, reflected their learning performances. Students were advised they had approximately 20 minutes for completion, which is seen to be a sufficient period to complete a survey. An essential part of this research's aim was to focus on students' reflection upon their learning experiences in order to identify any changes in the students' mental models. Therefore the post-survey was conducted in week eleven before the examination of the first semester. Students were requested to read the information letter, invited to ask questions, and to complete and sign the consent form. For students who were under 18 years old, the consent form obtaining their parental consent was given to them in a stamped prepaid self-addressed envelope. Once the researcher received their parent's consent form, then their responses to the surveys were valid to use.

Construction of the Pre and Post-Surveys

Section A: Demographic information. Copies of the data collection instruments are found in Appendix A and Appendix B. Section A in the pre and post-surveys comprised questions about the respondent's gender, age, enrolment type (mature age students or school leavers), enrolment status (part time or full time student), overall position (OP) score or equivalent university entry score, highest previous education level, and whether participants had previously attended university or were a repeat student in the *ICTs in Education s*ubject.

Such demographic data were included because the literature has reported a significant relationship between certain demographic information of first-year students and their academic achievement. These include: gender (Lawrence et al., 2006; Richardson & Woodley, 2003; Smith & Naylor, 2001; Tinklin, 2003); mature age students versus school leavers (Derrington, 2006; McInnis, Harley et al., 2000; McKenzie, 2002; McKenzie & Schweitzer, 2001; Tinto, 1985; Yorke et al., 1997; Zeegers, 1999); and high school results (Overall Position score or equivalent) (Cao & Gabb, 2006; McClelland & Kruger, 1993; McMillan, 2005; Pargetter et al., 1998). The findings about the relationships between mental models and gender and mental models and school completion time are reported in Chapter Five. There were not any associations between mental models and Overall Position scores in this research.

Section B: Likert-scale questionnaire items. Fifty Likert-scale questionnaire items were designed, with most items taken verbatim or adapted/reworded from different sources to meet the study's goals.

There were 50 questionnaire items in the survey. The 18items were utilised from the scales of First-Year Experience in Australian universities (Krause et al., 2005). These questionnaire items had been used for ascertaining the attitudes and learning experiences of first-year university students in seven national universities. These questionnaire items have been proven robust and reliable because they were developed through three national studies that spanned a decade (1994, 1999, and 2004).

Krause and the team (2005) conducted three studies to investigate the changes taking place in first-year students' "attitudes, expectations, study patterns and overall experiences on campus" (Krause, 2005, p. 1). Questions in the 1994 survey concentrated on first-year students' university expectations, how their initial experiences differed from their school experiences, how well they adjusted to academic learning, and how their universities responded to students' needs. The project team included additional questions in their 1999 survey to explore and compare any changes in student transition problems and adjustment experiences over the intervening years. Changes in student goals, study habits, and level of commitment as well as any notable changes in the quality of experience for diverse groups identified in the 1994 study were investigated. Furthermore, evidence of the impact of changes in institutional policies and practices on first-year students with respect to the quality of the first-year experience were explored.

In order to compare 2004 first-year student responses with 1994 and 1999, Krause and her team (Krause et al., 2005) decided to discard a small number of items that failed to provide useful information, and the questionnaire items were subsequently revised. Many questions such as “student identity and sense of belonging to a learning community” (p. 16) and “the role of orientation programs in fostering a sense of connectedness to the university” (p. 16) were included in the 2004 survey. Several items were designed to investigate first-year student engagement with learning, a peer group, and academic staff as well as their use of ICTs and how such technologies enhanced their learning. There was also a commitment strategies section for students who took a part-time or casual job.

In summary, Krause et al. (2005) focused on and reported six key areas covering the first-year experiences of students:

1. aspirations, change and uncertainty in the first-year;
2. student expectations and adjustments to university study;
3. engaging with learners and learning at university;
4. managing commitments in the first-year;
5. perceptions of teaching and satisfaction with courses; and
6. the first-year experience of significant student groups (Krause et al., 2005, abstract).

In this research, the items in Krause et al. (2005) pertaining to academic application, academic orientation, sense of purpose, student identity, comprehending and coping, prepared and present, peer engagement, and peer collaboration were used.. However, some of the adopted items were slightly reworded in order to suit the context of the education research field and the *ICTs in Education* subject. Examples of the rewording items are shown in Table 4.4.

Table 4.4

Modifications to the Questionnaire Items (Krause et al., 2005)

Scale (Krause et al., 2005)	Original	Modification
Sense of purpose	I know the type of occupation I want	I really want to be a teacher
	I am clear about the reasons I came to university	I have a clear idea of what is expected of me in this subject
Comprehending and coping	I find it hard to keep up with the volume of work in this course	I find it really hard to keep up with the volume of work in the *ICTs in Education* subject
Prepared and present	I can miss a lot of classes in this course because most notes and materials are on the web	I can miss most of the mass lectures in first-year because most notes and materials are on the web

Questionnaire items modelled on the WIHIC (Fraser, Fisher, & McRobbies, 1996) were included as shown in Table 4.5 below.

Table 4.5

Modifications to the WIHIC (Fraser et al., 1996)

Scale (Fraser et al., 1996)	Original	Modification
Cohesiveness	In this class, I get help from other students	I ask other students for help when I encounter difficulties in problems in the *ICTs in Education* subject
Involvement	I give my opinions during class discussion	I give my opinions during tutorial discussion
Cooperation	Students work with me to achieve class goals	Other students work with me to achieve the *ICTs in Education* subject's learning goals
Task Orientation	I know what I am trying to accomplish in this class	I know what I am trying to accomplish with my learning

The 50 item survey used in this research also included four questions from

What is Happening in this Classroom (WIHIC) (Fraser et al., 1996). This instrument has been proven to be robust and reliable. It has been used in many studies in different disciplines, with different age levels, and in different countries (Aldridge & Fraser, 2000; Allen & Fraser, 2007; Dorman, 2001, 2003; Dorman, Aldridge, & Fraser, 2006; Khine & Fisher, 2001; Kim, Fisher, & Fraser, 2000; Margianti, Fraser, & Aldridge, 2001).

In addition to 18 questionnaire items borrowed from Krause et al. (2005) and four questions from WIHIC (Fraser et al., 1996), the researcher added 28 items that were not covered in Krause et al. (2005) and WIHIC (Fraser et al., 1996) in order to clearly understand a picture of mental models of first-year graduate students as learners. Examples of questionnaire items that the researcher added were shown in the table below.

Table 4.6

Examples of Questionnaire Items that Were Added by the Researcher

Scales	Questions
Learning strategy	I give my opinions during tutorial discussions I am willing to change my ideas when evidence shows that my ideas are weak
Collaboration	I ask other students for help when I encounter difficulties in solving the *ICTs in Education* subject
Un-motivation and ineffective learning strategy	I sit back when working with other students in activities during class When writing, I am more likely to paraphrase an author's words rather than use my own words

The 50 questionnaire items were categorised into seven mental model subscales: (1) Sense of Purpose and Expectations Mental Model; (2) Motivation Mental Model; (3) Learning Strategy Mental Model; (4) Collaboration Mental Model; (5) Un-motivation, and Ineffective Learning Strategy Mental Model; (6) Poor Comprehending and coping Mental Model; and (7) Poorly Prepared and Absent Mental Model (Appendix C). These questionnaire items were intended to help define mental models of learning of first-year university students, any changes in students' mental models, and their strategic approaches since students built their mental models based on their experiences and prior learning over time (Costello & Osborne, 2005).

Section C: Open-ended questions. Given the research aims and questions, it was crucial to include the open-ended questions that offered opportunities for students to express in their own words anything else about their learning time for the *ICTs in Education subject,* learning experiences as first-year university students, and any problems they thought they would face (pre-survey) and did face (post-survey).

There were two open-ended questions included in each survey. The first question asked students to "*List some adjectives (e.g., committed or scared) that describe you as a learner".* The second question asked students to write down "*What problem do you think you may have in studying this subject?"* in the pre-survey and "*What problems did you have in studying this subject?"* in the post-survey.

Responses to two open-ended questions offered the possibility to produce unexpected answers for further analysis. As demonstrated in the research on mental models by Fazio, Battaglia, and Di Paola (2012), a small qualitative approach conducted after students completed the questionnaire could clarify some aspects which emerge from the quantitative analysis and validate the results. In this research, mental models obtained from the open-ended questions were *pure* mental models because they were not predefined as in the quantitative method.

Analysis of Data

Onwuegbuzie and Teddlie (2003) suggested that a mixed method analysis offers a more comprehensive analytical technique for researchers to understand concepts or phenomena better and, thereby, enhance the explanatory quality of the data. According to these authors, data are analysed based on a seven-stage conceptualisation of the mixed methods analysis: (1) data reduction, (2) data display, (3) data transformation, (4) data correlation, (5) data consolidation, (6) data comparison, and (7) data integration.

Data in this research were analysed following seven stages (Onwuegbuzie & Teddlie, 2003), as described in the following sections.

1. Data reduction, whether quantitative or qualitative, "sharpens, sorts, focuses, discards, and organises data in such a way that final conclusions can be drawn and verified" (Miles & Huberman, 1994, p. 11). Onwuegbuzie & Teddlie (2003) defined data reduction as reducing the dimensionality of the quantitative data. In this thesis, prior to the analysis,

quantitative data were checked for accuracy of data entry and missing values. Descriptive statistical analysis allows an interpretation of demographic data that provides information and relationships between mental models of participants and demographic data (such as gender, type of enrol). The inferential statistical analysis of the quantitative data in this research included exploratory factor analysis, correlations analysis, paired-sample t-tests, independent samples t-tests, and stepwise multiple regression analyses.

2. The process of analysing qualitative data was based on data “reduction” and “interpretation” in which respondents’ statements were systematically reduced by searching for themes among the responses before being interpreted (Marshall & Rossman, 1995, p. 113). Onwuegbuzie and Teddlie (2003) stated that data reduction in qualitative data includes coding and case studies. In this thesis, students’ responses to the open-ended questions were coded and grouped into different mental models for interpreting.
3. Data display: The analysed quantitative data (e.g., descriptive statistics, exploratory factor analysis, t-tests, correlations analysis, and stepwise multiple regression analyses) were organised in tables and charts.
4. Data transformation: According to Johnson and Onwuegbuzie (2004), transformative design that changes qualitative to quantitative data occurs most often in the literature, than transforming from quantitative to qualitative data. The transformation process also requires an understanding of systematic information and how to perform such transformative analytic designs. The data transformation stage was conducted in this study. The number of students (female/male, school leaver/mature age) who constructed mental models from the qualitative data were presented in tables (Chapter Five).
5. Data correlation: Data analysis was conducted separately for the quantitative and qualitative data. The results from the quantitative data could then be correlated with the findings in the qualitative data. In this thesis, a pre and post 5-point Likert-scale questionnaires was designed to investigate students’ pre and post mental models. Students were classified into groups based on their similar or different mental models, using mixed

method analysis. The open-ended questions asked students to reflect on the semester's learning journey. The responses of students in the qualitative data were analysed with the results of quantitative data for better understanding of first-year education students' mental models.

6. Data comparison: Data collected and analysed in the pre and post-surveys were compared. Mental models identified in the statistical tests were compared with mental models reported from students in the open-ended questions in order to document the convergent mental models and divergent mental models of learning. Any differences or changes in students' mental models between the beginning of the subject and the end of the subject were also compared and documented in the discussion phase.

7. Data integration: This is a final stage in which data are consolidated and integrated into either a coherent whole or two separate sets of comprehensible wholes in order to present a holistic picture of students' mental models. In this research, the findings of quantitative questionnaires and the open-ended questions were integrated in the interpretation stage in order to provide better understanding of first-year university students' mental models. Integrating the results in both approaches helped to confirm (complement) similar mental models or explain mismatched mental models of learning between pre-and post-surveys.

Quantitative data analysis. The Statistical Package for Social Science (SPSS) Version 18 .0 was used to analyse the quantitative data. Statistical analyses of survey data sought to identify students' mental models as reported in the pre and post-surveys. To answer the research questions, different statistical tests were utilised in this research including exploratory factor analysis, correlations analysis, paired sample t-tests, independent sample t-tests, and stepwise multiple regression analyses.

Factor analysis. Principal component analysis was conducted to investigate the organisation of students' questionnaire responses in order to discover how many mental model factors could be identified. This is a technique that allows a large number of interrelated variables to be reduced into small sets or factors, with all of the variance in the variables being used (Tabachnick & Fidell, 2007; Williams, Brown, &

Onsman, 2010). There are two types of factor analysis: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The exploratory factor analysis is often used in the early stages of research when the researcher has no expectations of the number of components or factors or nature of the variables in each component/factor. This method is exploratory in nature and allows the researcher "to explore the main dimension to generate a theory, or model from a relatively large set of latent construct often represented by a set of items" (Williams et al., 2010, para. 1). Whereas, Confirmatory Factor Analysis is often used later in the process of research to test a proposed theory when the researcher often has assumptions about the number of factors and which factors are the best fit (Tabachnick & Fidell, 2007; Williams et al., 2010).

Factor Analysis has been used in educational psychology studies and educational research and is considered the method of choice for interpreting questionnaires completed by participants (Hogarty, Hines, Kromrey, Ferron, & Mumford, 2005; Williams et al., 2010). Examples include the investigation of high school students' anger (Boman, Curtis, Furlong, & Smith, 2006); the identification of the cornerstones of personal bests in an educational context (Martin, 2006); and to ascertain self-managed learning groups in higher education (Lizzio & Wilson, 2005). Examples of research related to first-year university students include a study identifying Australian first-year university students' self-regulation of academic motivation (Gonzalez, Dowson, Brickman, & McInerney, 2005) and an investigation of first-year Japanese university students' beliefs about learning English (Riley, 2006). More pertinent to the investigation of mental models in this research, the factor analysis was used to find out the similar and different mental models in the case of learning through distance education (Richardson, 2007).

Williams et al., (2010) provides a five step exploratory factor analysis protocol: (1) testing the adequacy of sample size and factorability, (2) extracting of factors, (3) applying criteria to determine factor extraction, (4) rotating the factors, and (5) interpreting and naming factors.

1. *Testing the acceptability of sample size and factorability.* There are varying opinions about the sample size of the exploratory factor analysis. Tabachnick and Fidell (2007) suggested at least 300 participants are needed for factor analysis, while Pett, Lackey, and Sullivan (2003) proposed the sample size as

follows: 100 as poor, 200 as fair, 300 as good, and 500 as very good. However, Coakes and Steed (2001), Hair et al. (2006), and Hair et al. (1995) maintained that a minimum size of 100 subjects is acceptable. With 102 volunteer students, the current study satisfied this criterion.

A factor with fewer than three items is considered weak and unstable; five or more loading items are desirable. According to statisticians (Costello & Osborne, 2005; Fabrigar, Wegener, MacCallum, & Strahan, 1999), there should be at least four variables in each factor. Bartlett's Test of Sphericity, the Kaiser-Meyer-Olkin measure (KMO), and inspection of the anti-image matrix have been proposed for testing the adequacy of sample size and factorability of the correlation matrix.

Prior to the extraction of the factors, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (Kaiser, 1974) and Bartlett's Test of Sphericity (Bartlett, 1950) were examined to check the suitability of the data for factor analysis. The Kaiser-Meyer-Olkin measure is considered the common rule for dropping the least important and uncorrelated items from the analysis. The accepted values of KMO is 0.5 or greater (Kaiser, 1974; Williams et al., 2010). Nevertheless, recent statisticians (Coakes & Steed, 2001; Field, 2005) proposed the minimum acceptable level of 0.60 for the KMO measures. The KMO values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great, and values above 0.9 are superb. A small KMO statistic (less than 0.6) is considered acceptable for exploratory factor analysis. This is because the correlations between pairs of observed variables cannot be explained by other observed variables and factors. Bartlett's Test of Sphericity should be significant ($p < 0.05$) for factor analysis to be suitable.

2. *Extracting of factors*. Numerous extraction methods commonly used in factor analysis are: Principal component analysis (PCA), principal axis factoring (PAF), maximum likelihood, alpha factoring, image factoring, and canonical (Meyers, Gamst, & Guarino, 2013; Pett et al., 2003; Tabachnick & Fidell, 2007; Williams et al., 2010).

   In this research, principal component analysis (PCA), which is basically concerned with the total variance, is the main extraction method. Principal component analysis is the default method in most statistical software and is commonly used in exploratory factor analysis (EFA) (Pett et al., 2003; Thompson, 2004). Variables are formed into linear combinations, and principal components are identified with respect to the amount of variance that the combination of items can explain for the total variance of the sample. The first component has the largest amount of variance. The second component is correlated with the first component and has the next largest variance, and so on (Fabrigar et al., 1999).

3. Applying criteria to determine *factor extraction*. Many extraction methods exist including Kaiser's criteria (eigenvalue > 1 rule), the Scree test, the cumulative percent of variance extracted, and parallel analysis. It is suggested that multiple extraction methods should be used to identify factors.

   The use of eigenvalues and the scree plot to determine the number of factors is utilised in this research. The eigenvalue represents the variance of all the variables in a given factor. Those factors with eigenvalues greater than one can be kept and used.

   A scree plot shows the percentage of total variance accounted for by each extracted factor. There are two ways to identify how many factors result from the scree analysis. One way requires researchers to look at the plot to find the point at which the curve becomes nearly parallel to the horizontal axis. The second way is to draw a series of straight lines through the points, and where the line clearly changes slope is the best approximation of the number of factors. According to Tabachnick and Fidell (2007) and Thompson (2004), interpreting the Scree plot requires the judgment of the researcher. However, the eigenvalues and the scree plot should be compared in order to identify the best representation of the data.

   Despite the benefits of these techniques, Fabrigar et al. (1999) emphasised that the key criterion to determine the most appropriate factors for further analysis is the extent to which those factors can be interpreted clearly with regard to the theory and conceptualization of the study.

   Factor rotation. Initial factor solutions are often difficult to interpret as some variables may have high cross loadings on more than one factor. Rotation methods are used to make results more interpretable by generating linear combinations of variables in such a way that every variable has a high loading on only one factor (Abdi, 2003). There are two types of rotation: “orthogonal when the new axes are also orthogonal to each other, and oblique when the new axes are not required to be orthogonal to each other” (Abdi, 2003, p. 978). Before rotation, all factors are independent. Orthogonal rotation (quartimax, equamax, and varimax) was developed by Thompson (2004) and ensures that the factors are uncorrelated. Varimax rotation is the most common method used in factor analysis (Meyers et al. 2013; Thompson, 2004; Costello & Osborne, 2005). In contrast, oblique rotation (oblimin and promax) allows the factors to be correlated and is seen as a technique that produces more precise results for studies relating to human behaviour, or when data does not meet a priori assumptions (Costello & Osborne, 2005). Promax oblique rotation is most widely used (Meyers et al., 2013). Regardless of which rotation method is used, the results must be easy to interpret and produce factorial suitability (Williams et al., 2010). For meaningful interpretation of the factor, variables loading at and above 0.3 are interpretable (Costello & Osborne, 2005). Comrey and Lee (1992) recommendation is that no variable that loads less than 0.3 should be used in a factor because less than 9% (0.30^2) of that item’s variance is shared with the factor.

4. *Interpreting and naming the factors.* Once the factors are determined, the researcher studies the variables in each factor and gives the factors an appropriate label. Interpretation and naming of factors should be subjective, theoretical, and an inductive process. The researcher examines the items’ loadings in each factor, not only to consider the strengths of the loadings of the variables, but also to ascertain whether the items’ loading are consistent with the concept of the research (Henson & Roberts, 2006). Variables with the highest loadings on a factor are more important when interpreting and labelling factors. An inappropriate name can mislead in the interpretation of the factors. If the items for the principal component analysis were derived from a theory, it is essential that factors should be interpreted in terms of that theory in order to ensure the validity of theoretical constructs (Pett et al., 2003).

The reliability statistics for each factor in this thesis were computed after identifying and labelling the factors. Reliability is a computation of the degree to which multiple measurements of variables are consistent with each other. Cronbach's alpha coefficient of internal consistency has been widely used to ensure that the items in a factor produce a reliable scale (Coakes & Steed, 2001; Downing, 2004; Field, 2005; Yusoff, 2011). There are different opinions about the value of Cronbach's alpha. Values of 0.6 are acceptable (Downing, 2004; Yusoff, 2011) while values of 0.7 and 0.8 are considered good for Cronbach's alpha (Coakes & Steed, 2001; Field, 2005). However, reliability coefficients below 0.5 are seen as unreliable, measures between 0.5 and 0.7 modest, and coefficients above 0.7 indicate acceptable levels (Boermans & Kattenberg, 2011).

The removal of items from the scales in this thesis was guided by a number of criteria, including the following:

- Some researchers and statistics (Downing, 2004; Field, 2005; Yusoff, 2011) suggested that no item that loads less than 0.3 should be used in a factor because less than 9% (0.30^2) of that item's variance is shared with the factor
- An item may reduce the reliability of the whole data or contribute little to it. If so, it should be eliminated from the data. Either the item has (a) low Cronbach's alpha, (b) low correlation with other items in the correlation matrix, or (c) corrected item scale correlation, indicating poor reliability
- If an item has low loading, it reduces the reliability of the data and should be deleted.

After factors were determined from the exploratory factor analysis, factor scores were calculated for each participant on each of the factors comprising the final solution, based on the items loading on each factor. The score of each factor was computed by calculating the average means of the items loading which is greater than 0.3 (Field, 2005).

Correlations analysis. The Pearson correlation coefficient, a bivariate parametric test, was conducted to examine the relationship between mental models identified in the exploratory factor analysis at pre-test. The Pearson correlation compares actual scores (raw scores) of independent and dependent variables. The purpose of the Pearson correlation coefficient is to examine whether an increase in the independent variable is associated with an increase or decrease in the dependent variable (Abu-Bader, 2006).

The coefficient of determination (*r)* measures strengths of the association between two mental models and was computed by squaring the Pearson correlation coefficient *r.* The correlation between two mental models is considered strong if r^2 is greater than or equal 0.64, moderate if r^2 is greater than 0.25 and less than 0.64, and weak if r^2 is less than or equal to 0.25 (Abu-Bader, 2006).

The Spearman rho coefficient, the non-parametric equivalent of the Pearson correlation, accounts for any deviations from normality and was conducted to examine the relationship between mental model factor subscales at pre-test with mental model subscales at post-test. The researcher ran the Pearson correlation coefficient of one mental model identified from exploratory factor analysis at a time with the post-test mental model subscales.

T-test. The paired sample t-test and independent sample t-tests are parametric tests used at the bivariate level and each compares means between two groups.

Paired sample t-test. A paired sample t-test is a parametric test determining the differences between mean scores of two dependent groups on two different occasions/times. Therefore a series of paired sample t-tests was conducted on the theoretically constructed mental models from the original instruments to determine if significant differences existed between mental models that students constructed at the beginning of the subject versus mental models that they built at the end of the subject.

The alpha level for the paired samples t- test was set at .05 to establish statistical significance. Due to the number of t-tests performed, a Bonferroni correction was utilized to control for family-wise error. The Bonferroni correction divides the established p-value by the number of tests, and is considered a conservative approach (Abu-Bader, 2006). The Eta squared was used to calculate the effect size for independent-sample t test. The guidelines proposed by Cohen (1988) were used for interpreting the value of the effect size: .01=small effect, .06=moderate effect, .14=large effect.

Independent samples t-test. The independent sample t-test is the most commonly used bivariate statistical test and widely used in social science research

(Abu-Bader, 2006). The independent sample t-test, also known as independent t-test, is a bivariate parametric test that is used to investigate the difference between the means of two independent groups at the same time to see if the group mean difference is statistically significant.

A series of independent samples t-tests were utilised to compare the differences in means of mental models between two demographic groups: gender and school completion time. The independent t-test assumes that the dependent variables are normally distributed within each demographic group and that the variation of scores in the two groups is not significantly different, referred to as homogeneity of variance (Weinbach & Grinnell, 2007). The Levene's test for equality of variances was used to check this assumption, with the probability value set at .05 to determine whether this assumption was not met. However, the independent t-test is robust to violations of homogeneity of variance with large enough sample sizes. The alpha level for the independent samples t- test was set at .05 to establish statistical significance. Similar to the paired- sample t-test, a Bonferroni correction was utilized to control for family-wise error (Abu-Bader, 2006). Similar to independent sample t-test, the Eta squared was used to calculate the effect size for the independent-sample t-test. The guidelines proposed by Cohen (1988) for interpreting the effect size value were used: .01=small effect, .06=moderate effect, .14=large effect.

One-way analysis of variance (ANOVA). One-way analysis of variance is a bivariate parametric test to compare the mean scores of more than two groups (Abu-Bader, 2006). The term one-way analysis of variance is used because the sample data are separated into groups according to one characteristic. The sample size of one-way ANOVA must be 30 participants or more in order to be sufficient to run ANOVA. The shape of the distribution of the dependent variable must approximate the shape of normal curve.

The one-way ANOVA produces a test statistic called the F ratio to measure the distance of the means of the groups. Abu-Bader (2006) indicated that "the larger the F ratio is, the more likely that the difference between the group means is statistically significant" (p. 170). An alpha level of .05 is used for the established significant value in one-way ANOVA to determine the significant difference among the mean scores. The post-hoc tests is utilised to investigate whether there is a statistically significant difference of each pair within the groups (Abu-Bader, 2006). The Eta squared is calculated to determine the effect size statistics. The guidelines (proposed by Cohen, 1988) for interpreting the value of effect size are: 0.01=small effect, 0.06=moderate effect, .014=large effect. One-way ANOVA were examined to identify significant differences between mental models of students with their educational variables that had three or more levels of academic grades.

Stepwise multiple regression analysis. A stepwise multiple regression analysis, a multivariate statistical technique was utilised. Multiple regression is considered the most used analysis in social science research (Abu-Bader, 2006). The stepwise method combines the forward method as well as the backward method. Its purpose is to inspect the effect of multiple independent variables (two or more) on one independent variable. Regression analysis estimates a "model of multiple factors that best predicts the criterion" (Abu-Bader, 2006, pp. 243-244).

In this research, a stepwise multiple regression analysis was computed to examine the relationship of students' mental models and their academic grades in the *ICTs in Education* subject. A prediction of which mental models affect prospective first-year students' academic grades can help educators to plan intervention strategies in advance.

The multiple regression analysis in this research was checked to meet the following assumptions:

- The independent variables are linearly related to the dependent variable.
- Normality: to examine the assumption of normality in this research, a histogram with a normal curve for the residual scores was inspected to see if the shape of the distribution of the residuals was normal.
- Homoscedasticity: to inspect the assumption of homoscedasticity, the normal probability scatterplot was checked examining the residuals against the predicted values. If the distribution is normal, the data will form a straight diagonal line. Put more simply, a test of homoscedasticity determines whether a regression model's ability to predict a dependent variable (mental models in this study) is consistent across all values (students' examination grades in this study) of that independent variable (Abu-Bader, 2006).

In summary, the quantitative analyses described above include the statistical tests used to identify mental models of students. The exploratory factor analysis was performed to find how many mental models there were in the pre-survey and post-survey. To examine the relationship between mental models identified in the exploratory factor analysis, the Pearson correlation coefficient was performed. The paired sample t-test was utilised to determine the significant differences between mental models of students at the beginning and at the end of the course. A series of independent samples t-tests were conducted to compare the differences in means of mental models between two demographic groups: gender and school completion time. To examine significant differences between mental models of students with their educational variables, one-way ANOVAs were performed. The stepwise multiple regression analyses were then conducted to find out the key predictor for students' learning achievement in this research. A detailed discussion of qualitative data analysis is presented below.

Qualitative data analysis. The qualitative data method allowed for the coding and categorisation of the written responses from first-year university students. According to Richards and Morse (2007), coding leads the researcher from data to ideas, and from the ideas to the data relating to that idea. Coding is a method that allow the researcher to organise and group similar coded data (ideas) into categories because they share some characteristic (Bernard, 2006). When codes are applied and reapplied to qualitative data, the researcher perform codifying, a process that permits data to be "segregated, grouped, regrouped, and linked in order to consolidate meaning and explanation" (Grbich, 2007, p. 21).

The development of categories required the examination of the patterns in the coded data. Some researchers (Hatch, 2002; Saldana, 2009) proposed the characteristics of a pattern that were used in this analysis:

- Similarity: ideas or perception are similar, (or mental model) occur the same way
- Difference : ideas (or mental models) arise in predictable and different ways
- Frequency: the numbers that ideas (mental models) happen
- Sequence: the certain order to ideas / perceptions (or mental models)
- Correspondence: ideas or perceptions (mental model) relate to other ideas,

activities, or events

- Causation: the idea /perception (mental model) appears to cause another

In this research, the purpose of the two qualitative questions in the pre-and post-survey was to enable students to describe their mental models of learning in their own words, rather than asking them to choose answers from a predetermined set of response categories. The first question was designed to make explicit students' thinking about the adjectives that describe themselves as university students. The second question invited students to write down the problems that first-year education students had while studying the *ICTs in Education* subject.

Students' answers to the open-ended questions included a great diversity of responses about their feelings and problems although there were a few students who did not respond. The analysis of data sources followed the inductive coding. Coding is the transition process between data collection (what volunteered students wrote about their perceptions of being first-year university students and their university experiences) and extensive data analysis (Bernard, 2006). The analysis of data utilised the inductive approach allowed the research findings to emerge from the frequent or significant themes from the raw data (Thomas, 2006). The findings in this study arose directly from the analysis of the written responses of students, not from a priori models. The process of inductive coding in this study is described as follows:

1. Prepare the raw data files: students' responses to Question [1] and Question [2] in each survey were entered into a spreadsheet
2. Close reading of text: Once both sets of responses were prepared, the researcher read the text a few times to gain an understanding of the themes covered in the text. The researcher searched for the patterns (e.g., similarity/differences and regularity) in the data and for "ideas that help explain why those patterns are there in the first place" (Bernard, 2006, p. 452)
3. Create the categories: The researchers identified and defined categories. The most similar and frequent responses from students were grouped together. During the data analysis, the categories were created from actual phrases from students' responses. For example, many of the respondents mentioned one of the difficulties that they had in their first-

year was “comprehending the content”. The category “difficulties in comprehending the content” came from the direct quotation of many students, such as “too much content to comprehend”, or “difficult to understand the content”. Another example was the category “workload”

4. Check any overlap or redundancy among the categories
5. Continue revision of categories. Select the appropriate quotations of students that convey the core theme of each category
6. Create the major themes (mental models) incorporating the most important and related categories. Categories that pertained to the same issue or concern were grouped together to form themes. The labels given to the mental models captured the themes.

In addition, the researcher performed coding of the responses to ascertain a frequency count. In this way the researcher was able to see how frequently a particular mental model occurred (Saldana, 2009). Ultimately this frequency would be quantified so that the number of students (female/male and mature age/school leaver students) in each theme (mental model) at the beginning and at the end of the semester were reported and compared.

The themes (mental models) found in the qualitative data at the beginning of the semester were compared with themes (mental models) at the end of the subject. A qualitative analysis was used to compare the results with the quantitative analysis. Implications of this joint use of quantitative and qualitative analysis are discussed in Chapter 6.

Ethical Considerations

In this research there were no physical and/or psychological risks for the participants in the surveys. An information page explaining the study (Appendix D) together with the consent form (Appendix E) and the ethics approval (H2301) from the university ethics committee were given to students before administrating the pre-survey in the second week of classes. A letter, including an information page, a consent form and a stamped return-address envelope, was posted to parents/carers of students who were under 18 years of age. Parents/carers were asked to return the signed consent form if they permitted their children to participate in the survey

(Appendix F). Students and parents/carers were informed that all information would be kept confidential. Students' names and identification numbers or any identifying information were not used in the thesis or other published material.

The completed surveys were locked in a filing cabinet that only the researcher could access. The principal supervisor and co-supervisor only accessed non identifiable student data (SPSS and printed transcripts) after the student number was deleted. The lecturer and tutors did not, and would not see any of the students' comments or personal data. They only have access to the completed thesis and publications. Such ethics procedures reassured participants that their responses would be respected and valued.

Conclusion

Chapter Four described the mixed methodology in this research which primarily employed a quantitative approach to address the research aim and questions. A description of the mixed methodology, the context of the study, the participants, data collection tools, quantitative data analyses, and qualitative data analysis utilising in this research was described. The results of the research are presented in the following chapter along with the analysis that addresses the research questions.

Chapter 5: Mixed Method Results and Analysis

Overview

Chapter Four described the methodology employed in this study. This chapter presents the findings of the mixed methods analysis to answer the research questions and sub-questions outlined in Chapter One. The results of this research are presented in two sections. The first section presents the quantitative analysis. In this section, the results and analysis of Research Question One and Research Question Two are presented. The exploratory factor analysis was conducted to identify mental models of first-year education students at pre-test. Bivariate correlations were then performed to investigate the correlation between mental models. To find out significant changes in mental models of students, a series of paired-samples t-tests were also conducted. The results and analysis of Sub-Research Question [a] and Sub-Research Question [b] are then presented. A series of independent sample t-tests were performed to find out the significant differences in students' mental models among the identified groups. Finally, the results and analysis of Research Question Three are presented. To find out which mental models relate to learning achievement, ANOVAs and stepwise multiple regression analysis were conducted. The second section presents the qualitative findings from the open-ended questions. These support the findings of the quantitative analysis.

Quantitative Results and Analysis

Mental Models of First-Year Education Students

This section presents the results of Research Question One: *What are students' mental models at the beginning and at the end of the subject?* and Research Question Two: *What major changes, if any, occurred in the students' mental models across a semester period?*

To answer these research questions, exploratory factor analysis using principal component analysis, Pearson correlations, paired-sample t-tests, and independent samples t-tests was conducted. The section is divided into three main parts. The first section presents the procedures to identify mental models of first-year education students at the beginning of the subject. The second section outlines mental models of students at the end of the subject. The third section describes changes in students' mental models.

Mental models of students at pre-test.

Exploratory factor analysis at pre-test. Exploratory factor analysis was performed to answer Research Question One: *What are students' mental models at the beginning and at the end of the subject?*

Out of a total possible 257 students studying in this subject, as shown in Table 5.1, 102 (39.6 percent) participated in this research. An exploratory factor analysis using principal components as an extraction method was conducted on 50 items with 102 cases in order to examine the component structure and internal consistency of these items. Fourteen items (28 percent) had missing data (Q9, Q11, Q13, Q25, Q32, Q37, Q38, Q39, Q41, Q42, Q43, Q45, Q46, and Q50). The number of missing values in each variable was well below 10 percent, with often only 1 or 2 missing values per variable. Missing data were handled using the option of replacing the missing values with the mean for that item. Any case containing a missing value on any items was replaced by calculating the mean for the variable from the individuals who did have scores on it (Field, 2005; Schlomer, Bauman, & Card, 2010).

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity indicated that the distribution of the sample was sufficient for running factor analysis (Table 5.1).

Table 5.1

KMO and Bartlett's Test of Sphericity at Pre-test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.579
Bartlett's Test of Sphericity	Approx. Chi-Square	2032.726
	Df	1225
	Sig.	.000

The KMO at pre-test was .579. Kaiser (1974) and Field (2005) recommended values greater than .5 are acceptable for exploratory factor analysis, though according to George and Mallery (2006), this KMO value is still poor. The Bartlett's Test of Sphericity in this research was significant ($p <. 05$) indicated that the exploratory factor analysis in the pre-survey is suitable (Williams et al., 2010).

Principal component extraction revealed the presence of 16 components with eigenvalues exceeding 1 (Appendix G). As the Eigenvalue overestimates the number of components, the Scree Plot was inspected to determine the point at which the last significant drop or break takes place (Figure 5.1).

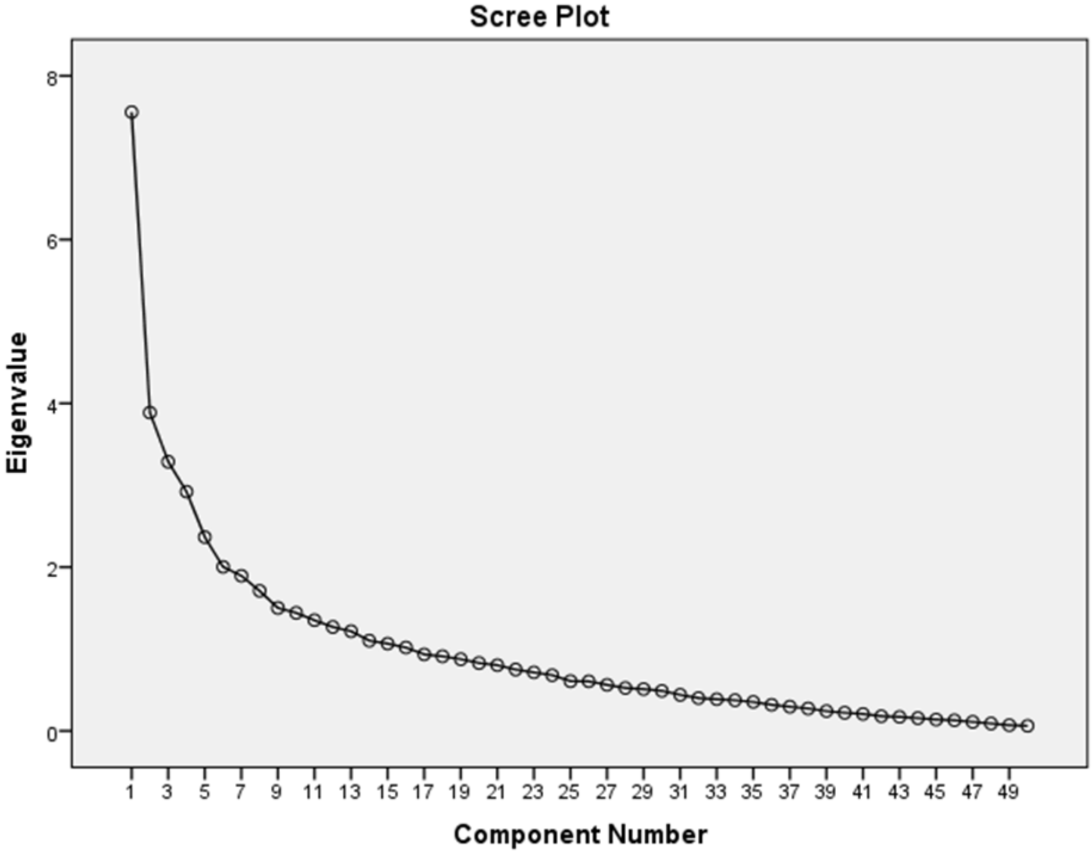

Figure 5.1 The Scree Plot of Exploratory Factor Analysis at Pre-test

The plot is unclear and presents two possible cut-off points between five and six components (Figure 5.1). According to Pallant (2005), it is up to the researcher to determine the number of components that are best for describing the relationships among variables. Thus, it was decided to retain five components for further investigation.

For further analysis, the five components were rotated using principal component analysis with both non-orthogonal (Promax), and orthogonal (Varimax) rotations. The Varimax rotation assumes that the components are not correlated with one another; this method accounted for 45 percent of the variance with 5 components (Appendix H). However, this rotation method did not seem appropriate given the higher correlations among two pairs of components (Component 1 and Component 2 had a correlation of $r = .295$, and Component 1 and Component 5 had a correlation of r = -.220. Therefore, the appropriate results of the principal component analysis using Promax rotation was used. This is a form of oblique rotation when the components are correlated with each other. This accounted for 40 percent of the variance with 5 components. Therefore, only the results from the principal component analysis with promax (oblique) rotation are discussed (Table 5.2).

Table 5.2

Principal Component Factor Analysis with Oblique Rotation

		Components				
Mental Models	Questionnaire Items	1	2	3	4	5
Motivation, Goal, and Engagement Mental Model (15.1% of variance) (19 items)	Q1. I keep trying until I succeed	**.691**	.238	.058	.220	-.199
	Q47. If I do not have my tutorial reaction paper completed, I do not attend the tutorial for that topic	**-.634**	-.139	-.065	.109	.166
	Q15. I keep thinking about information or an issue until I understand	**.625**	.081	-.084	.080	-.210
	Q45. I can miss most of the Mass Lectures in first-year because most notes and materials are on the web	**-.602**	-.067	-.059	.169	.065
	Q31. I have a strong desire to do well in this subject	**.582**	.177	.069	-.088	.013
	Q12. I give my opinions during tutorial discussions	**.564**	.122	-.034	.336	-.237
	Q3. I really want to be a teacher	**.560**	.030	.130	.155	-.157
	Q18. I really enjoy a task that involves coming up with new solutions to problems	**.554**	.409	.122	.051	-.069
	Q5. I know what I am trying to accomplish with my learning	**.534**	.470	.009	.293	-.346
	Q7. I get a lot of satisfaction from studying	**.525**	.383	.029	.076	-.446
	Q48. I usually do an assignment just before it is due	**-.505**	-.093	.052	.295	.277
	Q37. I ask myself questions in order to make sure I understand the content I have been studying	**.505**	.204	.269	.270	-.274
	Q21. I prefer to agree with other people's ideas than formulate my own opinions	**-.481**	.046	.269	-.109	.434
	Q6.I enjoy the intellectual challenges of this subject	**.467**	.335	.050	.147	-.083
	Q46. I only read what I have to do in the *ICTs in Education* subject Web Lecture Topic in order to answer the question	**-.455**	-.143	.263	.346	.101

	Q42. I am willing to change my ideas when evidences show that my ideas are weak	**.400**	.265	.398	-.184	-.010
	Q39. I try to remember solutions to similar computer problems in order to solve a computer problem	**.390**	.108	.015	.040	-.182
	Q19. I value opinions that differ from mine	**.366**	.205	.277	-.145	-.197
	Q38. When writing, I am more likely to paraphrase an author's words rather than use my own words	**-.363**	.079	.216	.189	.111
Poor Coping and Expectation Mental Model (7.77% of variance) (9 items)	Q43. I feel overwhelmed by all I have to do	-.033	**-.683**	.124	-.065	.233
	Q42. I find it difficult to comprehend a lot of the *ICTs in Education* subject material I am supposed to understand	-.030	**-.662**	-.157	.110	.168
	Q4. I have a clear idea of what is expected of me in this subject	.169	**.646**	-.039	.107	.052
	Q40. I find it really hard to keep up with the volume of work in the *ICTs in Education* subject	-.074	**-.604**	-.284	.087	099
	Q1. I know what is required of a first-year university student	.219	**.555**	-.149	.332	-.176
	Q44. I have difficulty adjusting to the style of teaching at university	-.161	**-.554**	.144	-.084	.336
	Q2. I really like being a university student	.440	**.528**	.208	.084	-.096
	Q41. My other university workload is not as heavy	-.163	**-.445**	-.001	.035	-.139
	Q31. I prefer finding answers by myself rather than getting help	.362	**.394**	.028	.309	-.088
Collaboration Mental Model (6.57% of variance) (6 items)	Q27. I ask other students for help when I encounter difficulties in solving the *ICTs in Education* subject	-.015	-.064	**.756**	-.054	-.016
	Q24. I work with classmates outside of class	-.020	.119	**.726**	-.266	.237
	Q28. Other students work with me to achieve the learning goals of the *ICTs in Education* subject	.158	.082	**.658**	-.042	.239
	Q22. I study with other students	.056	.175	**.618**	-.159	.219
	Q26. I learn through discussion with other students	.181	-.059	**.584**	.033	-.272
	Q25. Working together can help me gain a deeper understanding the *ICTs in Education* subject	-.234	-.163	**.542**	.007	-.077
Learning Strategy Mental Model	Q35. If I forget the answer, I can usually think my way through	.288	.184	-.092	**.600**	.010
	Q9. When I try, I generally succeed	.448	.135	-.130	**.549**	-.115

(5.84% cumulative of variance) (10 items)	Q29. I do not need to use a variety of strategies to be an effective learner	-.270	.012	-.078	**.533**	.010
	Q49. When I spend a lot of hours on my assignment, I will get a very good mark	-.116	.003	-.006	**.515**	.110
	Q34. I automatically recall relevant information when solving problems	.095	.009	-.132	**.504**	-.111
	Q17. Learning new ways to learn doesn't excite me	-.411	-.237	-.122	**.458**	-.281
	Q14. I prefer complex to simple questions	.104	-.010	-.234	**.408**	-.271
	Q32. When solving problems, I identify unexpected results as well as expected ones	-.014	.284	-.039	**.379**	.138
	Q50. When it comes to the exam, I usually try to memorise the content	.014	-.034	.219	**.373**	.017
	Q8. If I do not enjoy the subject, I do not want to learn	-.015	-.084	-.130	**.345**	.309
Un-motivation Mental Model (4.74% cumulative of variance) (4 items)	Q10. I find it is difficult to get myself motivated to study	-.095	-.185	.029	.030	**.819**
	Q33. I find out answers to questions by relying on the subject materials	-.324	-.203	.016	-.074	**.816**
	Q16. I would rather do something that requires little thought	-.395	-.036	.126	-.034	**.581**
	Q23. I sit back when working with other students in activities during class	-.407	-.159	.163	.009	**.510**

The component structures for each component (or mental model), including rotated factor loadings, variance, and names of each mental model are shown in Table 5.3. Two items (Q36 (when reading, I try to connect things I am reading about with things I already know) and Q30 (I regularly seek the assistance of teaching staff)) loaded below 0.3 and were discarded from the study (Beavers et al., 2013; Costello & Osborne, 2005; Fabrigar et al., 1999). Coakes and Steed (2001) stated that the names of the components were given based on the highest loadings of the items in each component. According to statisticians (Beavers et al., 2013; Pett et al., 2003), the higher the factor loading, the more the factor reflects the underlying meaning of the component.

In the first factor, the five items that had the highest loadings (Q1, Q47, Q15, Q45, and Q31) were consistent with motivation and engagement with their learning. This first factor could be labelled as “motivation and engagement mental model,” but because this factor had 19 items and also conveyed the concept that students were motivated and engaged with their learning to achieve their goal, the first factor was named the Motivation, Goal, and Engagement Mental Model.

The four items that had the highest loading in the second factor (Q43, Q42, Q4, and Q40) were related to students' coping with their learning and their expectations about the subject *ICTs in Education*. Therefore the second factor was identified as the Poor Coping and Expectation Mental Model.

There were six items (Q27, Q24, Q28, Q22, Q26, and Q25) loaded in the third factor. The concepts of these items were consistent with collaborative learning so the third factor was named the Collaboration Mental Model.

The three items (Q35, Q9, and Q29) that had the highest loadings in the fourth factor were related to students' learning strategy. The fourth factor was named Learning Strategy Mental Model**.**

And finally, the four items in the fifth factor (Q10, Q33, Q16, and Q23) were all related to the concept of un-motivation and disengagement. The fifth factor was named the Un-motivation Mental Model.

The five components accounted for 40.0 percent of the variance in this data set, with component 1 (the Motivation, Goal, and Engagement Mental Model) contributing 15.1 percent, component 2 (the Poor Coping and Expectation Mental Model) contributing 7.77 percent, component 3 (the Collaboration Mental Model) contributing 6.57 percent, component 4 (the Learning Strategy Mental Model) contributing 5.84 percent, and component 5 (the Un-motivation Mental Model) contributing 4.74 percent.

Reliability analysis. Reliability analysis was then conducted to test the validity and reliability of the components (Coakes & Steed, 2001). The reliability values of the components are presented in Table 5.3.

Cronbach's alpha coefficient was used as an index of internal consistency for each factor. Reliability coefficients below 0.5 are seen as unreliable, measures between 0.5 and 0.7 modest, and coefficients above 0.7 indicate acceptable levels (Boermans & Kattenberg, 2011).

Table 5.3

The Reliability Values (Cronbach's alpha)

Components	Cronbach's Alpha
1. Motivation, Goal, and Engagement Mental Model	0.53
2. Poor Coping and Expectation Mental Model	0.08
3. Collaboration Mental Model	0.77
4. Learning Strategy Mental Model	0.67
5. Un-motivation Mental Model	0.75

Table 5.3 revealed that the reliability of component 1 (the Motivation, Goal, and Engagement Mental Model) was modest (0.53), while component 3 (the Collaboration Mental Model), component 4 (the Learning Strategy Mental Model), and component 5 (the Un-motivation Mental Model) were all acceptable. The reliability of factor 2 (the Poor Coping and Expectation Mental Model) was unacceptable (0.08), rendering this factor essentially unusable.

In summary, the results of exploratory factor analysis answered part of Research Question One: "*What are students' mental models at the beginning of the subject?*" Five mental models were found: (1) the Motivation, Goal, and Engagement Mental Model, (2) the Poor Coping and Expectation Mental Model, (3) the Collaboration Mental Model, (4) the Learning Strategy Mental Model, and (5) the Un-motivation Mental Model.

Correlations between mental models. First-year education students held different mental models of learning so it is important to understand any significant correlations between the scores in the five mental models at pre-test. Therefore Pearson correlations were analysed to measure the strength of the relationship between metal models (Table 5.4). It examined whether an increase in the high scores of one mental model led to an increase or decrease in the scores of other mental models.

The results of Pearson correlations indicated that there was a significant positive relationship between the Motivation, Goal, and Engagement Mental Model with the Collaboration Mental Model ($r = .197$, $p < .05$), indicating that students who scored higher on the Motivation, Goal, and Engagement Mental Model had the tendency to score higher on the Collaboration Mental Model. The Collaboration

Mental Model explained 3.8 percent ($r^2 = .197^2 = .038 = 3.8\%$) of the variance in the Motivation, Goal, and Engagement Mental Model. More than 96 percent of the Collaboration Mental Model was unaccounted for. Thus, although the Motivation, Goal, and Engagement Mental Model and the Collaboration Mental Model had a significant relationship, this correlation was considered weak ($r^2 \leq .25$).

Table 5.4

Correlations between Mental Models identified from Exploratory Factor Analysis at Pre-test

	Motivation, Goal, and Engagement	Poor Coping and Expectation	Collaboration	Learning Strategy	Un-motivation
Motivation, Goal, and Academic Engagement	1	.063	.197*	.197*	.032
Poor Coping and Expectation	.063	1	-.006	.059	.104
Collaboration	.197*	-.006	1	-.237*	.163
Learning Strategy	.197*	.059	-.237*	1	.024
Un-motivation	.032	.104	.163	.024	1

*Correlation is significant at the 0.05 level (2-tailed).

Also, the Motivation, Goal, and Engagement Mental Model and the Learning Strategy Mental Model had a positive correlation ($r = .197$, $p < .05$). The Learning Strategy Mental Model accounted for 3.8 percent ($r^{2 =}.197^{2 =}$ $.038 = 3.8\%$) of the variance in the Motivation, Goal, and Engagement Mental Model. This indicated that as students scored higher on the Motivation, Goal, and Engagement Mental Model, they tended to score higher on the Learning Strategy Mental Model. The correlation between them was weak ($r^2 \leq .25$).

There was a moderate significant relationship between the Collaboration Mental Model and the Learning Strategy Mental Model ($r = -.237$, $p < .05$). The Learning Strategy Mental Model accounted for -5.6 percent ($r^{2 =} -.237^{2 =} -.056 = -5.6\%$)

of the variance in the Collaboration Mental Model. The correlation between them was moderate ($.25 < r^2 < .64$). This indicated that when students tended to collaborate in learning, they had the tendency to score lower on the Learning Strategy Mental Model. This could be interpreted that some students could not see collaboration as part of their learning strategy.

The Poor Coping and Expectation Mental Model was not correlated with any of the other mental models. This is not surprising as the Cronbach's alpha of this mental model was very low. The Un-motivation Mental Model was also not associated with any of the other mental models.

Mental models of students at post-test. The researcher planned to use principal component factor analysis to identify mental models of first-year education students through their responses to the questionnaire items at the beginning and at the end of the subject. There were 257 students who studied the *ICTs in Education* subject; however, only 102 students participated in this research. This could be explained by the fact that at the time the researcher conducted this research, there were two other researchers also investigating students' learning, therefore a number of students who volunteered for this research dropped out.

Though the number of students participating in this research was greater than 100, which satisfied the required sample number in the exploratory principal component analysis, after having performed the analysis, it was found that the results of the five factors were insufficient. The KMO test was 0.59, just above the accepted level of 0.5. Cronbach's alpha was then used to obtain a measure of reliability of each component (mental model). This reliability analysis revealed that component 2 was unusable and the reliability coefficients of component 1, 3, 4 and 5 were modest to acceptable. Therefore a second factor analysis on the post-test was not performed.

The seven subscales of mental models that were pre-defined from the questionnaire instruments in the methodology chapter were then used for further analysis at pre-test and post-test. Seven mental models of learning were: (1) the Sense of Purpose and Expectation Mental Model, (2) the Motivation Mental Model, (3) the Learning Strategy Mental Model, (4) the Collaboration Mental Model, (5) the Poor Coping and Comprehension Mental Model, (6) the Un-motivation and Ineffective Learning Strategy Mental Model, and (7) the Poorly Prepared and Absent Mental

Model.

Correlations between mental models. Correlations analyses were conducted on the seven pre-defined mental models for both pre-test and post-test to understand the associations between mental models. Also, there was a need to investigate any relationship between the five mental models identified from the exploratory factor analysis at pre-test and the seven pre-defined mental models at post-test to confirm the correlations between mental models. Three correlation analyses between mental models were conducted: (1) the correlations between seven mental models at pre-test, (2) the correlations between seven mental models at post-test, and (3) the correlations between five mental models identified from the exploratory factor analysis at pre-test and seven pre-defined mental models at post-test. Pearson correlations were conducted on the first and the second items listed above. Spearman's Rho correlations, the non-parametric equivalent of Pearson's correlations to account for any deviations from normality, was conducted on the third one.

Correlations between mental models at pre-test. The Pearson correlation coefficient measured the relationship between seven pre-defined mental models at pre-test. The results of the Pearson correlations are presented in Table 5.5. It is noted that the Collaboration Mental Model was not related to any of the other mental models at pre-test. The remaining six metal models were associated with each other.

The results in Table 5.5 determined that there was a significant positive relationship between the Sense of Purpose and Expectation Mental Model and the Motivation Mental Model ($r = .520$, $p < .01$), indicating that students who scored higher on the Sense of Purpose and Expectation Mental Model also scored higher on the Motivation Mental Model. The Motivation Mental Model explained 27 percent ($r^2 = .520^2 = .27.04 = 27.0\%$) of the variance in the Sense of Purpose and Expectation Mental Model. The correlation between these two mental models was moderate ($.25 < r^2 < .64$).

Table 5.5

Correlations between Mental Models at Pre-test

	Sense of Purpose and Expectation	Motivation	Learning Strategy	Collaboration	Poor Coping and Comprehension	Un-motivation and Ineffective Learning strategy	Poorly Prepared and Absent
Sense of Purpose and Expectation	1	.520**	.470**	.006	-.444**	-.188	-.317**
Motivation	.520**	1	.484**	-.032	-.197*	-.272**	-.381**
Learning Strategy	.470**	.484**	1	.047	-.234*	-.091	-.352**
Collaboration	.006	-.032	.047	1	.001	.080	.018
Poor Coping and Comprehension	-444*	-.197*	-.234*	.001	1	.086	.117
Un-motivation and Ineffective Learning Strategy	-188	-.272**	-.091	.080	.086	1	.420**
Poorly Prepared and Absent	-317*	-.381**	-.352**	.018	.117	.420**	1

**Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the level of 0.05 (2 tailed).

The Sense of Purpose and Expectation Mental Model was positively correlated with the Learning Strategy Mental Model ($r = .470, p < .01$). The Learning Strategy Mental Model explained 22 percent ($r^2 = .470^2 = .22.0 = 22\%$) of the variance in the Sense of Purpose and Expectation Mental Model, indicating a weak correlation ($r^2 \leq .25$). This indicated that when students scored higher on the Sense of Purpose and Expectation Mental Model, they tended to score higher on the Learning Strategy Mental Model.

There was a negative significant relationship between the Sense of Purpose and Expectation Mental Model and the Poor Coping and Comprehension Mental Model ($r = -.444, p < .01$). As the Sense of Purpose and Expectation of students increased, the Poor Coping and Comprehension Mental Model decreased. However, the relationship between them was weak ($r^2 \leq .25$) as the Poor Comprehending and Coping explained 19.7 percent ($r^2 = -.444^2 = .197 = 19.7\%$) of the variance in the Sense of Purpose and Expectation Mental Model.

The Sense of Purpose and Expectation Mental Model was negatively associated with the Poorly Prepared and Absent Mental Model ($r = -.317, p < .01$). This indicated that students who scored higher on the Sense of Purpose and Expectation Mental Model tended to score lower on the Poorly Prepared and Absent Mental Model. The Poorly Prepared and Absent Mental Model explained 10 percent ($r^2 =-.317^2 =-.10=10\%$) of the variance in the Sense of Purpose and Expectation Mental Model, indicating a weak correlation ($r^2 \leq .25$).

A significant positive correlation was evident between the Motivation Mental Model and the Learning Strategy Mental Model ($r = .484, p < .01$). This indicated that students scored higher on the Motivation Mental Model, they tended to score higher on the Learning Strategy Mental Model. The Learning Strategy Mental Model explained 23.4 percent ($r^2 = .484^2 = .234= 23.4\%$) of the variance in the Motivation Mental Model, indicating a weak correlation ($r^2 \leq .25$).

The Motivation Mental Model was negatively correlated with the Poor Coping and Comprehension Mental Model ($r = -.197, p < .05$). This was a weak negative correlation ($r^2 \leq .25$) as the Poor Coping and Comprehension Mental Model explained 3.8 percent ($r^2 = -.197^2 =-.038 = 3.8\%$) of the variance in the Motivation Mental Model. When students scored higher on the Motivation Mental Model they had the tendency to score lower on the

Poor Coping and Comprehension Mental Model.

As expected, there was a negative correlation between the Motivation Mental Model and the Un-motivation and Ineffective Learning strategy Mental Model ($r = -.272$, $p < .01$). This explained 7.4 percent ($r^2 = -.272^2 = -.074 = 7.4\%$) percent of the variance of students who had the Un-motivation and Ineffective Learning strategy Mental Model accounted for the Motivation Mental Model. The correlation between them was weak ($r^2 \leq .25$).

The Motivation Mental Model and the Poorly Prepared and Absent Mental Model also had a significant but weak negative correlation ($r = -.381$, $p < .05$). The Poorly Prepared and Absent Mental Model explained 15 percent ($r^2 = -.381^2 = -.15 = 15\%$) of the variance in the Motivation Mental Model. Students who scored higher on the Motivation Mental Model had the tendency to score lower on the Poorly Prepared and Absent Mental Model.

There was a negative correlation between the Learning Strategy Mental Model and the Poor Coping and Comprehension Mental Model ($r = -.234$, $p < .05$). The Poor Coping and Comprehension Mental Model explained 5 percent ($r^2 = -.234^2 = -.05 = 5\%$) of the variance in Learning Strategy Mental Model. When the scores of the Learning Strategy Mental Model increased, the scores of the Poor Coping and Comprehension Mental Model decreased. The correlation between them was weak ($r^2 \leq .25$).

A significant weak negative correlation ($r = -.352$, $p < .05$) between the Learning Strategy Mental Model and the Poorly Prepared and Absent Mental Model was found. Twelve percent ($r^2 = -.352^2 = -.12 = 12\%$) of the variance of the Poorly Prepared and Absent Mental Model accounted for the Learning Strategy Mental Model. When students tended to score higher on the Learning Strategy Mental Model, they also tended to score lower on the Poorly Prepared and Absent Mental Model.

There was a positive correlation between the Un-motivation and Ineffective Learning Strategy Mental Model and the Poorly Prepared and Absent Mental Model ($r = -.420$, $p < .05$). The Poorly Prepared and Absent Mental Model account explained 17.6 percent ($r^2 = -.420^2 = -.0.176 = 17.6\%$) of the variance of the Un-motivation and Ineffective Learning Strategy Mental Model. This indicated when students scored higher on the Un-motivation and Ineffective Learning Strategy they tended to scored higher on the Poorly Prepared and Absent Mental Model. The correlation between them was weak ($r^2 \leq .25$).

Correlations between mental models at post-test. The Spearman's Rho correlations, was conducted on seven mental models at post-test (Table 5.6). Similar to the pre-test, the Collaboration Mental Model was not related to any of other mental models at post-test.

At post-test, the findings identified a significant but weak positive correlation ($r^2 \leq .25$) between the Sense of Purpose and Expectation Mental Model and the Motivation Mental Model ($r = .422$, $p < .01$). This indicated that when students had stronger sense of purpose and clear expectations about academic study they tended to be motivated than students who did not. The Motivation Mental Model explained 17.8 percent ($r^2 = .422^2 = .178 = 17.8\%$) in the variance of the Sense of Purpose and Expectation Mental Model.

A significant positive correlation between the Sense of Purpose and Expectation Mental Model and the Learning Strategy Mental Model was found ($r = .401$, $p < .05$). This indicated that when the scores of the Sense of Purpose and Expectation Mental Model increased, the scores of the Learning Strategy Mental Model increased. The Learning Strategy Mental Model explained 16.1 percent ($r^2 = .401^2 = .161 = 16.1\%$) of the Sense of Purpose and Expectation Mental Model. The correlation between them was weak ($r^2 \leq .25$).

Conversely, the Sense of Purpose and Expectation Mental Model was negative correlated with the Poor Coping and Comprehension Mental Model ($r = -.330$, $p < .01$). This indicated students who scored higher on the Sense of Purpose and Expectation Mental Model tended to score lower on the Poor Coping and Comprehension Mental Model. The Poor Coping and Comprehension Mental Model explained only 10.9 percent ($r^2 =-.330^2 = -.109= -10.9\%$) in the variance of the Sense of Purpose and Expectation Mental Model. This correlation was weak ($r^2 \leq .25$).

Table 5.6

Correlations between Mental Models at Post-test

	Sense of Purpose and Expectation	Motivation	Learning Strategy	Collaboration	Poor Coping and Comprehension	Un-motivation and Ineffective Learning Strategy	Poorly Prepared and Absent
Sense of Purpose and Expectation	1	.422**	.401**	-.099	-.330**	-.239*	-.184
Motivation	.422**	1	.566**	-.021	-.056	-.271**	-.437**
Learning Strategy	.401**	.566**	1	.054	-.165	-.173	-.200*
Collaboration	-.099	-.021	.054	1	.083	.024	-.037
Poor Coping and Comprehension	-.330**	-.056	-.165	.083	1	.093	.000
Un-motivation and Ineffective Learning Strategy	-.239*	-.271**	-.173	.024	.093	1	.345**
Poorly Prepared and Absent	-.184	-.437**	-.200*	-.037	.000	.345**	1

**Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the level of 0.05 (2 tailed).

A significant correlation between the Sense of Purpose and Expectation Mental Model and the Un-motivation and Effective Learning Strategy Mental Model was found ($r = -.239$, $p < .05$). The Un-motivation and Effective Learning Strategy Mental Model explained 5.7 percent ($r^2 = -.239^2 = -.057 = -5.7\%$) of the Sense of Purpose and Expectation Mental Model. This indicated that when students scored higher on the Sense of Purpose and Expectation Mental Model, they tended to score lower on the Un-motivation and Effective Learning Strategy Mental Model. The correlation between these two mental models was weak ($r^2 \leq .25$).

There was a significant association between the Motivation Mental Model and the Learning Strategy Mental Model ($r = .566$, $p < .05$). The Learning Strategy Mental Model explained 32 percent ($r^2 = .566^2 = .320 = 32.0\%$), indicating that when students were motivated they tended to utilise different learning strategies. The correlation between them was moderate ($.25 < r^2 < .64$).

As expected, the Motivation Mental Model showed a weak negative relation with the Un-motivation and Ineffective Learning Strategy Mental Model ($r=-.271$, $p <.01$). The Un-motivation and Ineffective Learning strategy Mental Model explained -7.3 percent ($r^2 = -.271^2 =-.073= -7.3\%$) of variance in the Motivation Mental Model. The relationship between them was weak ($r^2 \leq .25$).

There was a negative correlation between the Motivation Mental Model and the Poorly Prepared and Absent Mental Model ($r = -.437$, $p < .05$). Nineteen percent ($r^2 = -.437^2 = .190= 19.0\%$) of the Poorly Prepared and Absent Mental Model accounted for the Motivation Mental Model. When students scored higher on the Motivation Mental Model, they tended to score lower on the Poorly Prepared and Absent Mental Model. This correlation was weak ($r^2 \leq .25$).

A weak negative association existed between the Learning Strategy Mental Model and the Poorly Prepared and Absent Mental Model ($r = -.200$, $p < .05$). Only four percent of the Poorly Prepared and Absent Mental Model ($r^2 = -.200^2 = -.04= 4.0\%$) account for the Learning Strategy Mental Model. Students who had a good learning strategy did not have the tendency to score higher on the Poorly Prepared and Absent Mental Model.

A positive relationship between the Un-motivation and Ineffective Learning Strategy Mental Model and the Poorly Prepared and Absent Mental Model was found ($r = .345$, $p < .01$, $r^2 = .12$). The Poorly Prepared and Absent Mental Model was account for 12 percent ($r^2 = .345= .12= 12.0\%$) of the Un-motivation and Ineffective Learning Strategy Mental Model. When students scored higher on the Un-motivation and Ineffective Learning Strategy Mental Model, they also tended to score higher on the Poorly Prepared and Absent Mental Model. This correlation was weak ($r^2 \leq .25$). Correlations between mental models identified from exploratory factor analysis at pre-test and pre-defined mental models at post-test.

To investigate in greater depth the use of multiple mental models of students, the Spearman's Rho correlations between five mental models identified in the exploratory factor analysis at pre-test with seven mental models was performed (Table 5.7).

Table 5.7

Correlations between Mental Models identified from Exploratory Factor Analysis at Pre-test and Pre-defined Mental Models at Post-test.

Pre-test (Exploratory factor analysis)	Post-test						
	Sense of Purpose and Expectation	Motivation	Learning Strategy	Collaboration	Poor Coping and Comprehension	Un-motivation and Ineffective Learning Strategy	Poorly Prepared and Absent
Motivation, Goal, and Academic Engagement	.151	.298**	.439**	.135	-.130	-.009	-.071
Coping and Expectation	.081	.139	.069	.049	.353**	.044	-.076
Collaboration	-.109	-.118	-.111	.485**	.094	.067	.096
Learning Strategy	.057	.104	.161	-.269**	-.177	.035	.091
Un-motivation	-.132	-.198*	-.169	.164	.142	.438**	.207*

**Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

The results show a weak significant positive relationship ($r = .298$, $p < .01$) between the Factor 1- Motivation, Goal, and Engagement Mental Model at pre-test and the Motivation Mental Model at post-test, indicating that students who were motivated, engaged with their learning to pursue their learning goal at the beginning of the subject tended be motivated at the end of the subject. The Motivation Mental Model at post-test explains 8.8 percent ($r^2 = .298^2 = .09 = 8.8\%$) of the variance in the Factor 1- Motivation, Goal, and Engagement Mental Model at pre-test.

The Pre Factor 1- Motivation, Goal, and Engagement Mental Model was also weakly significantly associated with the Learning Strategy Mental Model at post-test ($r = .439$, $p < .01$), indicating students who were motivated and engaged with their learning at the beginning of the semester had the tendency to use different learning strategies at the end of the semester to meet their learning goals than those who were un-motivated and disengaged in learning. The Learning Strategy Mental Model at post-test explained 19.2 percent ($r^2 = .439^2 = 1.92 = 19.2\%$) of the variance in the Pre Factor 1- Motivation, Goal, and Engagement Mental Model.

The Pre Factor 2- Poor Coping and Expectation Mental Model had a significant but weak correlation with the Poor Coping and Comprehension Mental Model at post-test ($r = .353$, $p < .01$), indicating students who could not cope with the requirements of the subject and did not quite understand the requirements of being a first-year university student also were not be able cope with their learning and with reading comprehension at the end of semester one. The Poor Coping and Comprehension Mental Model at post-test explained 12.4 percent ($r^2 = .353^2 = 12.4 = 12.4\%$) of the variance in the Pre Factor 2- Poor Coping and Expectation Mental Model

The Pre Factor 3 - Collaboration Mental Model had a significant but weak correlation with the Collaboration Mental Model at post-test ($r = .485$, $p < .01$), indicating students who scored higher on the Collaboration Mental Model at the beginning of the subject tended to score higher on the collaboration the end of the subject. The Collaboration Mental Model at post-test explained 23.5 percent ($r^2 = .485^2 = 0.24 = 23.5\%$) of the variance in Pre Factor 3 - Collaboration Mental Model.

The Pre Factor 4- Learning Strategy Mental Model had a significant negative association with the Collaboration Mental Model at post-test ($r = -.269$, $p < .01$). This indicated that as students at the beginning of the subject would have utilised more different learning strategies in learning at pre-test they had the tendency to score lower on collaboration learning at post-test. The Collaboration Learning Mental Model at post-test explained 7.2 percent (r^2 = -.269^2 = -.072 = 7.2%) of the variance in Pre Factor 4- Learning Strategy Mental Model, indicating a weak but significant association.

As expected, the Pre Factor 5- Un-motivation Mental Model had a weak significant negative association with the Motivation Mental Model at post-test (r = -.198, $p < .05$). This indicated that students who had higher score on Un-motivation Mental Model at pre-test scored lower on motivation at post-test. The Post Motivation Mental Model explained 3.9 percent (r^2 = -.198^2=-.039 = 3.9%) of the variance in Pre Factor 5- Un-motivation Mental Model.

The Pre Factor 5- Un-motivation Mental Model was significantly positively associated with the Un-motivation and Ineffective Learning Strategy Mental Model at post-test (r = .438, $p < .01$). This indicated that students who scored higher on un-motivation at pre-test also scored higher on Un-motivation and Ineffective Learning strategy Mental Model at post-test. The Un-motivation and Ineffective Learning strategy Mental Model at post-test explained 19.1 percent (r^2 = -.438^2 = -0.191 = 19.1%) of the Pre Factor 5- Un-motivation Mental Model, indicating a weak but significant association.

Additionally, the Pre Factor 5- Un-motivation Mental Model was positively relationship with the Poorly Prepared and Absent Mental Model at post-test (r = .207, $p < .0.5$). This indicated that students who scored higher on Un-motivation at pre-test also scored higher on Poorly Prepared and Absent at post-test. The Post - Un-motivation and Ineffective Learning Strategy Mental Model explained 4.2 percent (r^2 = .-.207^2 = 0.42 = 4.2%) of the Pre Factor 5- Un-motivation Mental Model, indicated a weak but positive association.

Summary of students’ mental models. Research Question One: *“What are students’ mental models at the beginning and at the end of the subject?”*

There were five mental models of students identified from the exploratory factor analysis at the beginning of the subject.

1. The Motivation, Goal, and Academic Engagement Mental Model

2. The Poor Coping and Expectation Mental Model
3. The Collaboration Mental Model
4. The Learning Strategy Mental Model
5. The Un-motivation Mental Model

The Poor Coping and Expectation Mental Model was unusable because the reliability was unacceptable (0.08) therefore seven pre-defined mental models were used for both pre-test and post-test. Seven mental models were:

1. The Sense of Purpose and Expectation Mental Model
2. The Motivation Mental Model
3. The Learning Strategy Mental Model
4. The Collaboration Mental Model
5. The Poor Coping and Comprehending Mental Model
6. The Un-motivation and Ineffective Learning Strategy Mental Model
7. The Poorly Prepared and Absent Mental Model.

The seven mental models were further analysed to produce more in-depth findings on mental models of first-year Bachelor of Education students.

Changes in Students' Mental Models

To answer Research Question Two: "*What major changes, if any, occurred in the students' mental models across a semester period?",* measures of central tendency (mean and standard deviation) and a series of paired samples t-tests for within subject differences was conducted to find any significant changes between mental models of students in the beginning of the subject and at the end of the subject.

Before conducting the measures of central tendency and the t-tests, the researcher carefully examined the data. Many individual students missed scoring items on either the pre-test or the post-test. Therefore, the missing data in each item was replaced within the mean of that item. In the pre-survey there were 14 missing questionnaire items (Q9, Q11, Q13,Q 25, Q32, Q37, Q38,Q 39, Q41, Q42, Q43, Q45, Q46, and Q50) and in the post-survey there were 24 missing variables (Q2, Q7, Q8, Q15, Q16, Q17, Q21, Q28, Q29, Q31,Q32, Q33, Q34, Q35, Q36, Q37, Q38, Q39, Q40, Q41, Q42, Q43, Q46, and Q49). However, the number of missing items in each question was low, with most questions were missing from one to three responses.

Questions in each mental model subscale were examined carefully in order to reverse the coding of questions to make sure appropriate interpretation was given to the seven mental model subscales in this research. A total of five items (Q30, Q33, Q39, Q49, and Q50) were reverse coded. In the subscale Un-motivation and Ineffective Learning Strategy Mental Model, there were positively coded items that were needed to be reversed. These were: Q30, I regularly seek the assistance of the teaching staff; Q33, I find out answers to questions by relying on the subject materials; and Q39, I try to remember solutions to similar problems in order to solve a computer problem. The remaining items, Q49, when I spend a lot of hours on my assignment, I will get a very good mark and Q50, when it comes to the exam, I usually try to memorise the content, were in the subscale Poorly Prepared and Absent Mental Model.

Paired sample t-tests. Prior to conducting inferential statistics to determine whether a statistically significant difference was present between first-year education students' mental models at pre and post-test, checks were performed to determine the extent to which the data of the seven subscales were normally distributed. The histogram charts of the seven subscales were produced and visually checked and showed that they were normally distributed. Additionally, the standardized skewness coefficients (i.e., the skewness value divided by its standard error) and the standardized kurtosis coefficients (i.e., the kurtosis value divided by its standard error) were examined. Six subscales were within the limits of normality, +/- 3 (Onwuegbuzie & Daniel, 2002). The mental model subscales that exceeded +/-3 were the Collaboration Mental Model at pre-test and the Collaboration Mental Model at post-test. The Standardized Kurtosis Coefficient of the Motivation Mental Model at pre-test was 3.42, over the limit of normality (Table 5.8).

Table 5.8

Standardized Skewness Coefficients and Standardized Kurtosis Coefficients for Mental Models at Pre-test and at Post-test

Mental Models	Pre-test		Post-test	
	Standardized Skewness Coefficient	Standardized Kurtosis Coefficient	Standardized Skewness Coefficient	Standardized Kurtosis Coefficient
Sense of Purpose and Expectation	-1.00	0.44	-1.12	-0.71
Motivation	-1.17	3.42	0.56	-0.88
Learning Strategy	-0.31	-0.69	0.78	-1.45
Collaboration	-4.28	5.26	-1.81	0.84
Poor Coping and Comprehension	-0.12	0.13	-1.71	-0.15
Un-motivation and Ineffective Learning Strategy	-0.30	-0.09	-0.10	-0.69
Poorly Prepared and Absent	-0.51	-0.63	-1.24	-1.10

Because the mental model subscales, except the Collaboration Mental Model, were normally distributed, paired samples t-tests were conducted on the seven mental models to answer Research Question 2. Results are presented in Table 5.9. The probability value to determine a significant difference between mental models at pre-test and post-test is alpha is equal to or less than 0.5. The Eta squared for each mental model subscale was calculated to determine the effect size statistics. The guidelines (proposed by Cohen, 1988) for interpreting the value of effect size are: 0.01= small effect, 0.06= moderate effect, and .014= large effect. When running this many t-tests, the family-wise error rate is increased. To account for this, the Bonferroni correction can be applied. A Bonferroni correction was applied to the pre/post samples t-tests, rendering a corrected significance value of .007 (.05/7 tests = .007).

Table 5.9

Results of Paired-Samples t-Tests on Students' Mental Models at Pre-test and at Post-test

Mental Models	Pre-test M(SD)	Post-test M(SD)	M df	95%CI	T	Df	Sig	Eta Squared
Sense of Purpose and Expectation	19.52 (2.58)	18.84 (2.40)	.68	[.18, 1.18]	2.73	101	.006	.07
Motivation	25.84 (3.31)	25.06 (2.73)	.78	[.13,1.13]	2.39	101	.001	.05
Learning Strategy	35.56 (3.72)	35.88 (3.47)	-.32	[-1.02, .38]	-.90	101	.365	.01
Collaboration	20.64 (3.69)	20.39 (4.04)	.25	[-.51, 1.02]	.65	101	.514	.00
Poor Coping and Comprehension	15.33 (3.41)	17.56 (3.90)	-2.22	[-2.96, -1.47]	-5.90	101	.000	.26
Un-motivation and Ineffective Learning Strategy	29.93 (3.31)	31.15 (3.84)	-1.22	[-1.99, -.45]	-3.16	101	.002	.09
Poorly Prepared and Absent	14.02 (2.70)	15.01 (2.96)	-.99	[-1.61, -3.6]	-3.15	101	.002	.09

The results of the paired-samples t-tests identified significant changes between students' mental models at pre-test and post-test. Each of the mental models was examined as follows.

Sense of Purpose and Expectation Mental Model. Statistical analysis of the paired-samples t-tests revealed a significant difference between the scores of the Sense of Purpose and Expectation Mental Model at pre-test and post-test ($t = 2.73$, $df = 101$, $p = .006$). Students scored higher at pre-test ($\overline{x} = 19.52$) than post-test ($\overline{x} = 18.84$). The Eta squared statistics (0.07) indicated a moderate effect size. The Sense of Purpose and Expectation Mental Model at the end of the subject decreased 0.68 points on the scale that was utilised. In other words, at the beginning of the subject first-year education students had stronger desire to become teachers and had higher expectations about the requirements of university study and the *ICTs in Education* subject than at the end of the semester.

Motivation Mental Model. The Motivation Mental Model was significantly different between the pre-test and post-test ($t = 2.39$, $df = 101$, $p = .001$). It was surprising that students' motivation at the end of the subject ($\bar{x} = 25.06$) decreased compared to their motivation at the beginning of the subject ($\bar{x} = 25.84$). The Eta squared statistic was 0.05, indicating a small effect size. This illustrated that at the end of semester one, first-year education students were less motivated than when they started their first-year of study.

Learning Strategy Mental Model. There was no significant difference between the scores of the Learning Strategy Mental Model at pre-test ($\bar{x} = 35.56$) and post-test ($\bar{x} = 35.88$; $t = -0.90$, $df = 101$, $p = .365$). Their scores did not change at post-test and remained high. In short, students who utilised different learning strategies at the beginning of the semester also preferred to use effective learning strategies at the end of the subject.

Collaboration Mental Model. There was no significant difference between the scores of the Collaboration Mental Model at pre-test ($\bar{x} = 20.64$) and post-test ($\bar{x} = 20.39$; $t = 0.65$, $df = 101$, $p = .514$). The Eta squared was 0.00. This could be interpreted as students were satisfied with the level of their collaborative learning and therefore there was not a need to change it.

Poor Coping and Comprehension Mental Model. The results showed a significant difference between the scores of the Poor Coping and Comprehension Mental Model at pre-test ($\bar{x} = 15.33$) and post-test ($\bar{x} = 17.56$; $t = -5.90$, $df = 101$, $p < .000$). The Eta squared statistic was 0.26 indicating a large effect size. At the end of the subject, students scored higher on the Poor Coping and Comprehension Mental Model than they had at the beginning of the subject. On average, the scores of this mental model increased 2.22 points on the scale that was utilised. It can be concluded that at the end of the subject first-year education students found that they were less able to cope with the workload of the subjects and had more difficulties in reading comprehension than at the beginning of the subject.

Un-motivation and Ineffective Learning Strategy Mental Model. There was a significant difference between this mental model at pre-test ($\bar{x} = 29.93$,) and post-test ($\bar{x} = 31.15$; $t = -3.16$, $df = 101$, $p = .002$). The Eta squared statistic was 0.09 indicating a moderate effect size. Students scored higher on the Un-motivation and Ineffective Learning Strategy Mental Model at post-test than pre-test. This clearly shows that after semester one, first-year education students were less motivated and used less effective learning strategies compared to the beginning of the subject.

It could be said that, because the *ICTs in Education* subject was a compulsory subject, some students were not interest in learning this subject. At the end of this subject, students were still academically unmotivated. The absence of motivation to study led to students' cognitive disengagement and discouraged students to utilise the effective learning strategies. These amotivated students thus might invest little effort or energy in their learning and tended to use the ineffective learning strategies to acquire the marks and complete this subject.

Another possible explanation for this result could be that students' amotivation resulted from a lack of ability to regulate their learning. Lack of motivation due to students' low ability and low effort could display the negative relationship with students' academic performance and ultimately, academic achievement.

Poorly Prepared and Absent Mental Model. A significant difference between this mental model at pre-test ($\bar{x}$ = 14.02) and at post-test ($\bar{x}$ = 15.01; t = -3.15, df = 101, p = .002) was found. Students scored higher at post-test. The Eta squared statistic was 0.09 indicating a moderate effect size. In other words, at the end of the semester students were less prepared than at the beginning of the semester.

Results summary of paired-sample t-tests. The findings of the paired-samples t-tests answered Research Question 2: "*What major changes, if any, occurred in the students' mental models across a semester period?"*

Mental models of learning of first-year education students changed across a semester period. However, changes in students' mental models were not in the expected direction. Eleven weeks after commencing the *ICTs in Education* subject, students scored lower on the Sense of Purpose and Expectation Mental Model. It could be assumed that, students' mental models included misplaced high expectations about academic study in higher education because they had experienced such learning for only one week (the pre-survey was administered in the second week). According to Spray, Scevak, and Cantwell (2013), university education traditionally is content-heavy. In this research, students might not have been clear about how the university's learning environment was different from that of high school and that they were required to face challenges in order to accomplish their learning tasks. The findings suggested that most first-year students have great naivety about academic learning when entering university. The findings also suggested that further research should be done to understand the expectations of first-year university students.

The scores on the Motivation Mental Model at the end of the subject were lower than at the beginning of the semester which is consistent with the findings of Baik et al. (2015) that first-year students found it was difficult for them to be motivated. Because motivation drives students to engage with their learning and confront challenges and obstacles when solving problems, it was not surprising that students scored higher on the Poor Coping and Comprehension Mental Model, the Un-motivation and Ineffective Learning Strategy Mental Model, and the Poorly Prepared and Absent Mental Model at post-test than pre-test.

The lower scores on the Sense of Purpose and Expectation Mental Model and the higher scores on the Poorly Prepared and Absent Mental Model and the Un-motivation and Ineffective Learning Strategy Mental Model indicated that students' self-perceived preparedness and expectations associated with their approaches to learning, which supported the previous study (Byrne & Flood, 2005). These mental models could negatively affect students' learning achievement because they were naive and inaccurate.

Two mental models were considered as accurate mental models: the Learning Strategy Mental Model and the Collaboration Mental Model, and these remained un-change during the semester. Students may not have changed their Learning Strategy Mental Model perhaps they were less motivated at the end of the subject. This could be because learning strategies and motivation are closely linked together (Vermunt & Vermetten, 2004). Recall that the Collaboration Mental Model was not associated with any other mental models in the correlational analysis; this could have prevented students from being motivated. According to Krause (2005), students are more likely to be motivated to learn if they engage with their learning peers and academic staff. Here, students were less motivated and the peer interaction networks were not strong.

Taken together, the results from these five mental models: (1) the Sense of Purpose and Expectation Mental Model, (2) the Motivation Mental Model, (3) the Poor

Coping and Comprehension Mental Model, (4) the Un-motivation and Ineffective Learning Strategy Mental Model, and (5) the Poorly Prepared and Absent Mental Model indicated that students' mental models were naïve, incomplete, and inaccurate. These mental models were constructed properly based on previous beliefs or learning experience at school (Wingate, 2007). The results from these mental models suggest why students were less effective in the performance of their tasks in their first-year.

The Relationship between Students' Mental Models and their Demographics

Consideration of gender and school completion time (school leavers/mature age students) particularly in the First-Year Experience could contribute significantly to the research. Different opinions exist on whether gender is a strong predictor in first-year students' academic achievement (e.g., Coates & Radloff, 2013, Lau & Yuen, 2010; Krause et al., 2005, Long et al., 2006). Research on school leaver and mature age students has also shown different results (Cantwell et al., 2001; Derrington, 2006; Duff et al., 2004; McKenzie et al., 2004; Richardson, 1997; Zeegers, 1999). The mixed results from these studies called for the investigation between mental models and gender, school completion time, and Overall Position results (high school results) in this research. No significant differences by Overall Position scores were found on the seven mental models in this research.

In order to answer Research Sub-Question [a]:*"Do the students' mental models differ in relation to gender and school completion time?*" and Research Sub-Question [b], "*If so, what significant differences are there in students' mental models among the identified groups?"* a series of independent samples t-tests were utilised to compare the differences in the mean scores of mental models between two demographics characteristics: gender and school completion time.

Independent samples t-tests. The independent sample t-tests were conducted to find out the significant differences by gender and by school time completion at pre-test and post-test on mental models. A Bonferroni correction was applied to the pre-test and post-test for gender and school completion time, rendering a corrected significance value of .003 (.05/14 tests = .003). This corrected alpha level was used to identify the significant differences in each t-test. The effect size using guidelines from Cohen (1988) to interpret the value were: 0.01= small effect, 0.06 = moderate effect, and 0.14= large effect.

The findings revealed there were no significant differences by gender and by school completion type on the Sense of Purpose and Expectation Mental Model, the Collaboration Mental Model, and the Learning Strategy Mental Model. Significant differences by gender and by school completion time were found on the Motivation Mental Model, the Un-motivation and Ineffective Learning Strategies Mental Model, and the Poorly Prepared and Absent Mental Model. There were significant differences by gender on the Poor Coping and Comprehension Mental Model. The SPSS results of the independent sample t-tests by gender are presented in Appendix I and the SPSS output of the independent sample t-tests by completion time are presented in Appendix J. The results of significant differences by gender and by school completion time on mental models at pre-test and post-test are presented as follows.

Motivation Mental Model. The results of the independent samples t-tests by gender and by school completion time at pre-test and post-test for the Motivation Mental Model are presented in Table 5.10.

Table 5.10

Results of Independent t-Tests - Motivation Mental Model by Gender and by School Completion Time

		N	M (SD)	t(100)	Sig. (2 tailed)	95%CI	Eta Squared
PRE	Female	78	26.24 (3.06)	2.23	.002	(.19, 3.20)	0.04
	Male	24	24.54 (3.96)				
POST	Female	78	25.18 (2.65)	.79	.420	(.75,.19)	0.006
	Male	24	24.67 (3.00)				
PRE	School leaver	52	24.23 (3.62)	-2.1	.003	(-2.54,.03)	0.03
	Mature Age	50	26.48 (2.85)				
POST	School leaver	52	23.26 (2.58)	-3.1	.002	(-2.66,.60)	0.09
	Mature Age	50	25.90 (2.65)				

Gender differences. A significant difference was found between female and male students at pre-test (t[100] = 2.23, p = .002) for the Motivation Mental Model (Table 5.10). Females scored higher than males at pre-test. The effect size was small (Eta squared = 0.04). There was no significant difference between female and male students at post-test (t[100] =.79, p = .42) for the Motivation Mental Model. Even so, the mean for the female respondents ($\bar{x}$ = 25.18) was slightly higher than male students ($\bar{x}$ = 24.67). Levene's test was not significant for both comparisons, indicating the variances were equal. This indicated that female students were more motivated than male students.

School time completion. There was a significant difference at pre-test by school time completion (t[100]= -1.9, p= .003) for the Motivation Mental Model. Mature age students scored higher ($\bar{x}$ = 26.48) than school leaver students ($\bar{x}$ = 24.23). The effect size was small (Eta squared = 0.03).

The findings also determined a significant difference between school leaver and mature age students at post-test (t[100 = -3.1, p = .002). Mature age students also scored higher ($\bar{x}$ = 25.90) than school leaver students ($\bar{x}$ = 23.26) and the effect size was moderate (Eta squared = 0.09) (Table 5.10). Levene's test was not significant for both comparisons, indicating the variances were equal. In short, mature age students were more motivated than school leaver students at both pre-test and post-test.

Poor Coping and Comprehension Mental Model. The results of the independent samples t-tests determined a significant difference by gender at post-test for the Poor Coping and Comprehension Mental Model (Table 5.11). There were no significant differences by school completion time on this mental model at both tests.

Gender differences. There was no significant difference between female and male students at pre-test (t[100] = .88, p = .93). Females scored higher ($\bar{x}$ = 15.35) than males ($\bar{x}$ = 15.28) at pre-test. There was a significant difference by gender at post-test (t[100] = 2.31, p = .003) for the Poor Coping and Comprehending Mental Model. Females scored higher ($\bar{x}$ = 18.12) than males ($\bar{x}$ = 15.35) at post-test. The effect size was small (Eta squared = 0.05). This indicated that male students, on average, self-reported better coping and comprehension about the aspects of the subject they were doing than female students. Levene's test was not significant for both comparisons, indicating the variances were equal.

Table 5.11

Results of Independent t-Tests - Poor Coping and Comprehension Mental Model by Gender

		N	M(SD)	t(100)	Sig. (2 tailed)	95%CI	Eta Squared
PRE	Female	78	15.35 (3.53)	.88	.93	(1.51, 1.66)	0.01
	Male	24	15.28 (3.06)				
POST	Female	78	18.12 (3.49)	2.31	.003	(.28, 4.48)	0.05
	Male	24	15.73 (4.66)				

Un-motivation and Ineffective Learning Strategy Mental Model. The results of the independent samples t-tests determined a significant difference between female and male students at pre-test for the Un-motivation and Ineffective Learning Strategy Mental Model. Significant differences between school leaver and mature age students at both pre-test and post-test for this mental model were also found (Table 5.12).

Table 5.12

Results of Independent t-Tests - Un-motivation and Ineffective Learning Strategies Mental Model by Gender and by School Completion Time

		N	M (SD)	t(100)	Sig. (2 tailed)	95%CI	Eta Squared
PRE	Female	78	28.48 (3.27)	-2.56	.002	(-3.37, -.39)	0.06
	Male	24	31.37 (3.11)				
POST	Female	78	30.83 (3.65)	-1.51	.13	(-3.12, .41)	0.02
	Male	24	32.18 (4.35)				
PRE	School leaver	52	30.73 (3.40)	2.55	.003	(.36, 2.90)	0.06
	Mature Age	50	29.09 (3.03)				
POST	School leaver	52	32.18 (3.56)	2.85	.003	(.63, 3.55)	0.08
	Mature Age	50	30.08 (3.87)				

Gender differences. A significant difference was found between female and male students at pre-test ($t[100] = -2.56$, $p = .002$) for the Un-motivation and Ineffective Learning Strategy Mental Model. The magnitude of the differences between the means was moderate (Eta squared = 0.06). Male students scored higher ($\bar{x}$

= 31.37) on this mental model than female students ($\bar{x}$ = 28.48).

However, no significant difference was found between female and male students at post-test (t[100]= -1.51, p =.13) for the Un-motivation and Ineffective Learning Strategy Mental Model. Even so, male students also scored higher ($\bar{x}$ = 32.18) than female students ($\bar{x}$ = 30.83) at post-test. Levene's test was not significant for both comparisons, indicating the variances were equal. This indicated that male students, on average, were more un-motivated and used more ineffective learning strategies than female students.

It is noted that female scores higher on the Un-motivation and Ineffective Learning Strategy Mental Model at post-test ($\bar{x}$ = 30.83) than pre-test ($\bar{x}$ = 28.48). It could be concluded that there were more female students at the end of the subject constructed the Un-motivation and Ineffective Learning Strategy Mental Model than at the beginning of the subject.

School completion time. There was significant differences between school leavers and mature age students at pre-test (t[100] = 2.55, p = .003) and post-test (t[100] = 2.85, p = .003) for the Un-motivation and Ineffective Learning Strategy Mental Model. Levene's test was not significant for both comparisons, indicating the variances were equal.

School leaver students scored higher ($\bar{x}$ = 30.73) than mature age students ($\bar{x}$ = 29.09) at pre-test. At post-test, school leaver students scored higher ($\bar{x}$ = 32.18) than mature age students ($\bar{x}$ = 30.08). The magnitude of the differences in the means was moderate, with Eta squared = 0.06 at pre-test and Eta squared = 0.08 at post-test. It can be concluded that school leaver students were less motivated and used more ineffective learning strategies than mature age students.

Poorly Prepared and Absent Mental Model. The results of the independent samples t-tests by gender and by school completion time at pre-test and post-test for the Poorly Prepared and Absent Mental Model are presented in Table 5.13.

Table 5.13

Results of Independent t-Tests - Poorly Prepared and Absent Mental Model by Gender and by School Completion Time

		N	M (SD)	t(100)	Sig. (2 tailed)	95%CI	Eta Squared
PRE	Female	78	13.48(2.61)	-4.1	.002	(-3.47, 1.11)	0.14
	Male	24	15.78 (2.25)				
POST	Female	78	14.60(3.06)	-3.5	.002	(-3.7, -.39)	0.11
	Male	24	16.32(2.21)				
PRE	School leaver	52	14.08(2.72)	.21	.80	(-.95, 1.1)	0.00
	Mature Age	50	13.96(2.72)				
POST	School leaver	52	15.84(2.70)	3.0	.003	(.57,.28)	0.08
	Mature Age	50	14.14(3.01)				

Gender differences. A significant difference was found between female and male students at pre-test (t[100] =- 4.1, p = .002) and at post-test (t[100] = -3.5, p = .002) for the Poorly Prepared and Absent Mental Model. At pre-test, males scored higher ($\bar{x}$ = 15.78) than females ($\bar{x}$ = 13.48) at pre-test. Also, male students scored higher ($\bar{x}$ = 16.32) than female students ($\bar{x}$ = 14.60) at post-test. The magnitude of the differences in the means at pre-test was large, with Eta squared = 0.14, while the effect size at post-test was moderate (Eta squared = 0.11). Levene's test was not significant for both comparisons, indicating the variances were equal. This indicated that male students were less prepared and less attended in the lectures/tutorials than female students.

School completion time. School leaver students scored higher ($\bar{x}$ = 14.08) than mature age students ($\bar{x}$ = 13.96) at pre-test on the Poorly Prepared and Absent Mental Model. However, this difference did not reach the level of statistical significance (t[100]= .21, p = .80).

There were significant differences between school leaver and mature age students at post-test (t[100] = 3.00, p= .003) for the Poorly Prepared and Absent Mental Model. School leaver students scored higher ($\bar{x}$ = 15.84) than mature age students ($\bar{x}$ = 14.14) at post-test. The effect size was moderate (Eta squared = 0.08). Levene's test was not significant for both comparisons, indicating the variances were equal. This indicated that school leaver students were less prepared and less attended the lectures/tutorials than mature age students.

The relationship between gender and learning achievement. A Chi-square test was computed to investigate the relationship between gender and the academic grades. The significant value in the chi-square test is less than .05. There was a significant relationship between gender and the academic grades $\chi^2(3) = 8.114$, $p = 0.044$. Table 5.14 below revealed the relationship between gender and the academic grades. While female students had the highest number of *High distinction and Distinction* grades (33.3%) male students had the lowest number (12.5%).

Table 5.14

Relationship between Gender and Academic Grades

		Academic Grades				
		HD & D	C	P	F	Total
Female	Count	26	22	21	9	78
	% within female	33.3%	28.2%	26.9%	11.5%	100.0%
Male	Count	3	4	11	6	24
	% within male	12.5%	16.7%	45.8%	25.0%	100.0%

There were 26.9 percent of female students who had *Pass* grade comparing to 45.8 percent of male students. Regarding to the *Fail* grade, there were 11.5 percent of female students who did not pass this subject compared to 25.0 percent of male students. There were 28.2 percent of female students who obtained *Credit* grade whereas there were only 16.7 percent of male students. In summary, female students obtained higher grades than male students.

The relationship between school completion time and learning achievement. To investigate the relationship between school completion time and the academic grades, a Chi-square test was computed. The significant value in the chi-square test was less than 0.05. There was a significant relationship between school completion time and the academic grades $\chi^2(3) = 9.199$, $p = 0.027$. Table 5.15 below reveals the relationship between school leaver/mature age students and their academic grades.

Table 5.15

Relationship between School Leaver/Mature Age Students and Academic Grades

		Academic Grades				
		HD & D	C	P	F	Total
School leaver students	Count	8	15	19	10	52
	% within school leavers	15.4%	28.8%	36.5%	19.2%	100.0%
Mature age students	Count	21	11	13	5	50
	% within mature age Students	42.0%	22.0%	26.0%	10.0%	100.0%

Mature age students achieved the highest number of *High Distinction and Distinction* grades (42.0%) while school leaver students had the lowest number (15.4%). Fewer mature age students gained *Credit* grade (22.0%) than school leaver students (28.8%). Twenty-six percent of mature age students passed this subject compared to 36.5 percent of school leaver students. Ten percent of mature age students failed the subject compared to 19.2 percent of school leaver students. In summary, mature age students obtained higher grades than school leaver students.

Results summary. The independent sample t-tests and Chi-square tests addressed Research Sub-Question [a]: *"Do the students' mental models differ in relation to gender and school completion time?*" and Research Sub-Question [b], "*If so, what significant differences are there in students' mental models among the identified groups?"*

The findings revealed significant differences by gender and by school completion time on the Motivation Mental Model, the Un-motivation and Ineffective Learning Strategies Mental Model, and the Poorly Prepared and Absent Mental Model. There were significant differences only by gender on the Poor Coping and Comprehension Mental Model.

In this research, female students were more motivated than male students. Female students utilised different learning strategies while male students preferred surface learning approach. Female students had better learning results than male students. In contrast, male students were underprepared and often skipped the lectures, tutorial classes and computer workshops. Nevertheless, male students coped better than female students and had better understanding the learning materials.

Mature age students were more motivated than school leaver students and they also used more effective learning strategies than school leaver students. School leaver students were less prepared and less often attended the lectures than mature age students. School leaver students were low achievers.

These findings on differences by gender and by school completion time on the four mental models: the Motivation Mental Model, the Poor Coping and Comprehension Mental Model, the Un-motivation and Ineffective Learning Mental Model, and the Poorly Prepared and Absent Mental Model, contribute to the debate in the literature of first-year students.

The Relationship between Mental Models and Learning Achievement

This section presents the findings of Research Question Three: "*Which mental models, if any, relate to students' learning achievement?"*

To examine the relationship between mental models and students' learning achievement, a series of ANOVAs and step-wise regression analyses were conducted in this research. A series of ANOVAs aimed to understand the effect of mental models on students' examination results and academic grades. Step-wise regression analysis was utilised to predict which mental models of prospective first-year education students will influence their learning achievement. This also filled the gap in the literature that there are not many research investigations on the relationship between mental models and learning performance and learning outcomes (Hsu, 2006).

One-way Analysis of Variance (ANOVA). One-way ANOVAs were conducted on the seven mental models at both pre-test and post-test and the students' examination results. The examination results were grouped into three groups: 12-20 marks, 21-25 marks, and 26-35 marks.

In terms of students' academic grades, universities assign five main academic grades namely High Distinction, Distinction, Credit, Pass, and Fail. In this research, only10 students obtained *High Distinction* grades. The group of students who obtained *High Distinction* grades and the group of students who had *Distinction* grades were combined together namely *High Distinction and Distinction*. There were only four groups in this research*: High Distinction and Distinction, Credit, Pass, and Fail*. One-way ANOVAs were computed on the seven mental models at both pre-test and post-test among the academic grade group. An alpha level of .05 is used to establish significant value in determining the significant difference in one way-ANOVAs.

There were no significant interactions at pre-test and post-test between four mental models and (1) students' examination results and (2) their academic grades. These four mental models were the Sense of Purpose and Expectations Mental Model, the Learning Strategy Mental Model, the Collaboration Mental Model, and the Poor Coping and Comprehension Mental Model.

At post-test, the findings determined significant differences (1) between the scores of Motivation Mental Model among examination groups; (2) between the scores of the Un-motivation and Ineffective Learning Strategy Mental Model among examination groups and academic grade groups; and (3) between the scores of the Poorly Prepared and Absent Mental Model and academic grade groups. At pre-test, there were no significant differences between the above mental models and (1) the examination results and (2) academic grades.

The following section presents the significant interactions of examination results and academic grades in each mental model. Full details of SPSS output of ANOVAs are presented in Appendix K (examination results) and Appendix L (academic grades).

Motivation Mental Model. The results of ANOVA determined a significant interaction between the Motivation Mental Model at post-test and students' examination results. The findings showed an overall significant difference between the scores of the Motivation Mental Model at post-test among the examination groups ($F(df=2,93) = 4.47$, $p < 0.05$) at post-test (Table 5.16).

Table 5.16

Results of One-way ANOVA - Post-test Motivation Mental Model by Examination Results

		N	M (SD)	Df	F	Sig.
Motivation Mental Model	Exam Results	96		2,93	4.47	.01
	12-20	21	24.20 (2.40)			
	21-25	39	24.39 (4.28)			
	26-35	36	25.97 (3.00)			

The Bronferroni post hoc test was then conducted to determine which groups were significantly different. The results showed that the 26-35 exam mark group ($\overline{x}$ = 25.97) had significant higher scores on the Motivation Mental Model than the scores of the 21-25 exam mark group ($\overline{x}$ = 24.39). The 26-35 exam mark group ($\overline{x}$ = 25.97) also had significant higher scores on the Motivation Mental Model than the scores of the 12-20 exam mark group ($\overline{x}$ = 24.20). There were no significant differences between the scores of the 21-25 exam mark group and the scores of the 12-20 exam mark group (Table 5.17 and Figure 5.2).

Table 5.17

Results of Post Hoc Bronferroni - Post-test Motivation Mental Model by Examination Results

	Exam Results		Mean Difference	Std. Error	Sig.	95% CI
Motivation Mental Model	12-20	21-25	-0.20	.70	1.00	(-1.92, 1.53)
		26-35	-1.77*	.71	.04	(3.52, .017)
	21-25	12-20	0.20	.70	1.00	(-153, 1.92)
		26-35	-1.57	.60	.03	(-3.05, -.10)
	26-35	12-20	1.77*	.71	.04	(.01, 3.52)
		21-25	1.57*	.60	.03	(.10, 3.05)

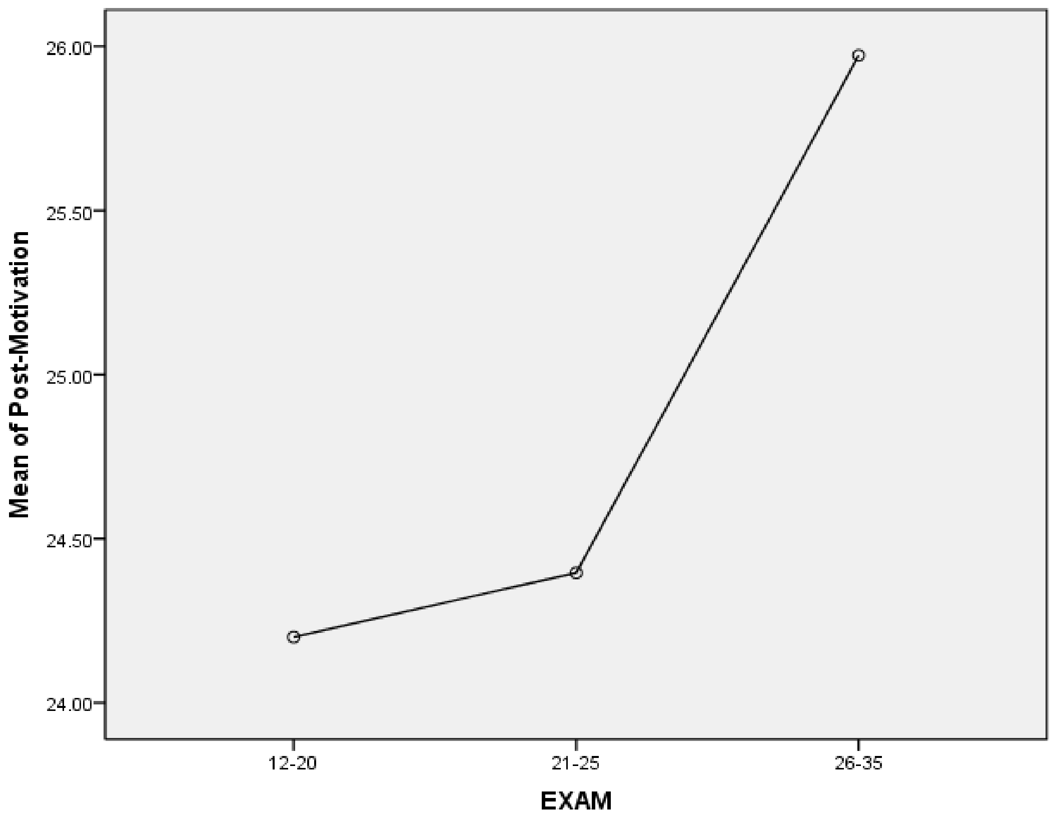

Figure 5.2 The Mean Plot at Post-test- Mean Scores of Motivation Mental Model by Examination Results

The results of the one-way ANOVA and the Bronferroni post hoc test indicated that students who achieved the highest marks (26-35 mark) in their examination were more motivated than other groups. The results provide statistical evidence that Motivation Mental Model is related to students' examination results.

Un-motivation and Ineffective Learning Strategy Mental Model. The results of ANOVAs revealed the significant interactions between the Un-motivated and Ineffective Learning Strategy Mental Model and (1) students' examination results; and (2) students' academic grades at post-test.

Examination results. There were significant differences among the examination groups with regards to the scores of the Un-motivation and Ineffective Learning Strategy Mental Model. The results showed an overall significance in the mean scores of the Un-motivation and Ineffective Learning Strategy Mental Model ($F(df = 2,93) = 3.87$, $p < 0.05$) (Table 5.18).

Table 5.18

Results of One-way ANOVA- Post-test Un-motivation and Ineffective Learning Strategies Mental Model by Examination Results

		N	M (SD)	Df	F	Sig.
Un-motivation and Ineffective Learning Strategy Model Mental Model	Exam Results	96		2,93	3.87	.02
	12-20	21	33.00 (3.63)			
	21-25	39	30.77 (3.31)			
	26-35	36	30.17 (4.28)			

The Bronferroni post hoc test was then conducted to determine which examination groups were significantly different. The results of Bronferroni post hoc test (Table 5.19) showed that the 12-20 examination group had significant higher scores on Un-motivation and Ineffective Learning Strategy Mental Model than the 26-35 examination group (mean difference = 2.83). There were no significant differences between 21-25 examination group and 12-20 examination group (mean difference = 0.59).

Table 5.19

Results of Post Hoc Bronferroni - Post-test Un-motivation and Ineffective Learning Strategy Mental Model by Examination Results

	Exam Mark		Mean Difference	Std. Error	Sig.	95% CI
Un-motivation and Ineffective Learning Strategy Mental Model	12-20	21-25	2.22	1.01	.09	(-.26,4.71)
		26-35	2.83*	1.03	.02	(.29, 5.31)
	21-25	12-20	2.22	1.01	.09	(-4.71, .26)
		26-35	.59	.87	1	(-1.52, 2.72)
	26-35	12-20	2.83*	1.03	.02	(-5.34, -.29)
		21-25	.59	.87	1	(-2.72, 1.52)

Overall, the results of the one-way ANOVAs and the Bronferroni post hoc tests indicated that the 12-20 examination group had higher scores ($\overline{x}$ = 33.00) on the Un-motivation and Ineffective Learning Strategy Mental Model than the 26-35 examination group ($\overline{x}$ = 30.17). The 21-25 examination group and the 12-20 examination group had similar scores on the Un-motivation and Ineffective Learning Strategy Mental Model. The mean scores of these groups were shown in Figure 5.3 below.

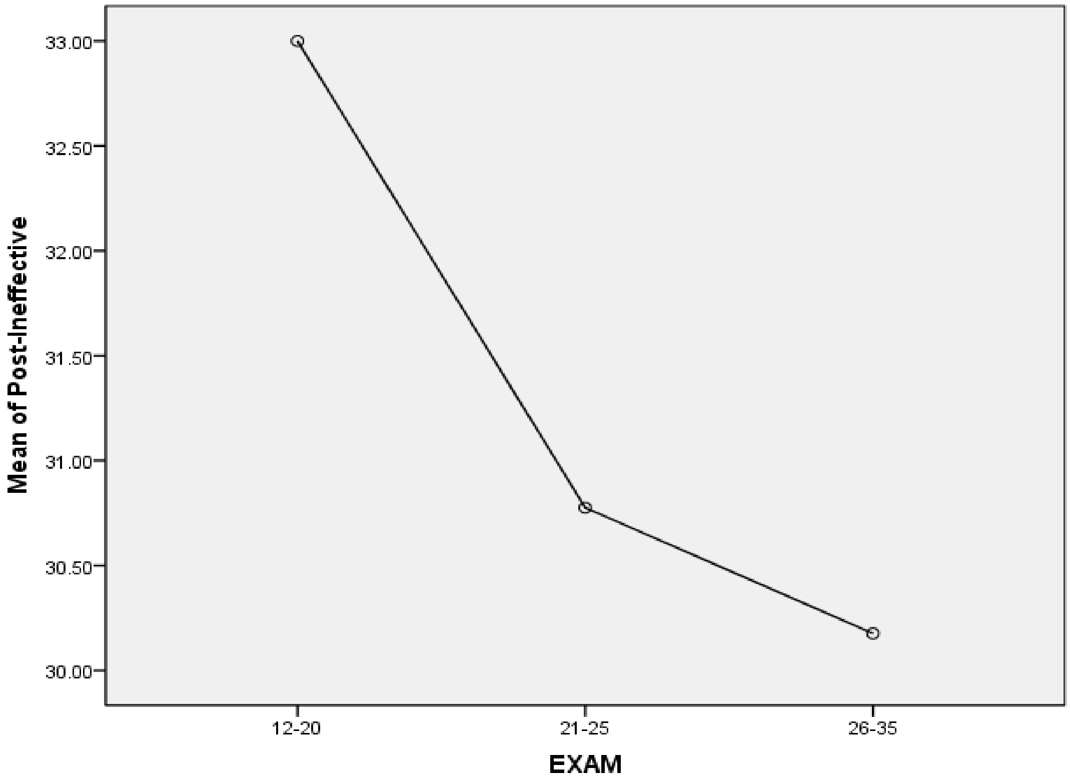

Figure 5.3 The Mean Plot of Post-test Un-motivation and Ineffective Learning Strategy Mental Model by Examination Results

The results of the one-way ANOVA and the Bronferroni post hoc test indicated that the lowest achiever students (having 12-20 mark in their examination) were less motivated and utilised effective learning strategies less than the highest achievers (achieving 26-35 marks in their examination). This indicated that the Un-motivation and Ineffective Learning Strategy Mental Model was correlated to students' examination results.

Academic grades. A significant interaction between the Un-motivation and Ineffective Learning Strategy Mental Model and students' academic grades was detected. The results showed an overall significance in mean scores of the Un-motivation and Ineffective Learning Strategy Mental Model in at least two academic grade groups (F(df = 3,98) = 4.96, $p < 0.05$) at post-test (Table 5.20).

Table 5.20

Results of One-way ANOVA - Post-test Un-motivation and Ineffective Learning Strategy Mental Model by Academic Grades

Mental Model		N	M (SD)	Df	F	Sig.
Un-motivation and Ineffective Learning Strategy Mental Model	Academic Grades	102		3, 98	4.96	.003
	High Distinction & Distinction	29	30.02 (3.92)			
	Credit	26	29.72 (3.62)			
	Pass	32	32.43 (3.55)			
	Fail	15	33.06 (3.23)			

The Bronferroni post hoc test was then conducted to determine which academic grade groups were significantly different. The results of Bronferroni post hoc test (Table 5.21) showed that the *Credit* group had significant lower scores on this mental model than the *Pass* group (mean difference = 2.71). The *Credit* group also had significant lower scores on this mental model than the *Fail* group (mean difference = 3.34). There were no significant differences between the *High Distinction and Distinction* group and the *Credit* group (mean difference = 0.30), and between the *Pass* group and the *Fail* group (mean difference = 0.63) on the scores of the Un-motivation and Ineffective Learning Strategy Mental Model.

Table 5.21

Results of Post Hoc Bronferroni Post-test Un-motivation and Ineffective Learning Strategy Mental Model by Academic Grades

Mental Models			Mean Difference	Std. Error	Sig.	95% CI
Un-motivation and Ineffective Learning Strategy Mental Model	High Distinction and Distinction (HD & D)	Credit	0.30	0.98	1.00	(-2.34, 2.95)
		Pass	-2.41	0.93	0.07	(-4.92, .11)
		Fail	-3.04	1.16	0.06	(-6.16, .08)
	Credit	HD & D	-0.30	0.98	1.00	(-2.95, 2.34)
		Pass	-2.71*	0.96	0.03	(-5.3, -.12)
		Fail	-3.34*	1.18	0.03	(-6.52, -.16)
	Pass	HD & D	2.41	0.93	0.07	(-0.11, 4.92)
		Credit	2.71*	0.96	0.03	(0.12, 5.30)
		Fail	-0.63	1.14	1.00	(-3.70, 2.44)
	Fail	HD & D	3.04	1.16	0.06	(-0.08, 6.16)
		Credit	3.34*	1.18	0.03	(0.16, 6.52)
		Pass	0.63	1.14	1.00	(-2.44, 3.70)

Overall, the results of the one-way ANOVAs and the Bronferroni post hoc tests indicated that the *Credit* group had the lower scores ($\overline{x}$ = 29.72) on the Un-motivation and Ineffective Learning Strategy Mental Model than the *Pass* group ($\overline{x}$ = 32.43) and the *Fail* group ($\overline{x}$ = 33.06). The *Credit* group and the *High Distinction and Distinction* group had similar scores on the Un-motivation and Ineffective Learning Strategy Mental Model. The mean scores of these groups were shown in Figure 5.4 below.

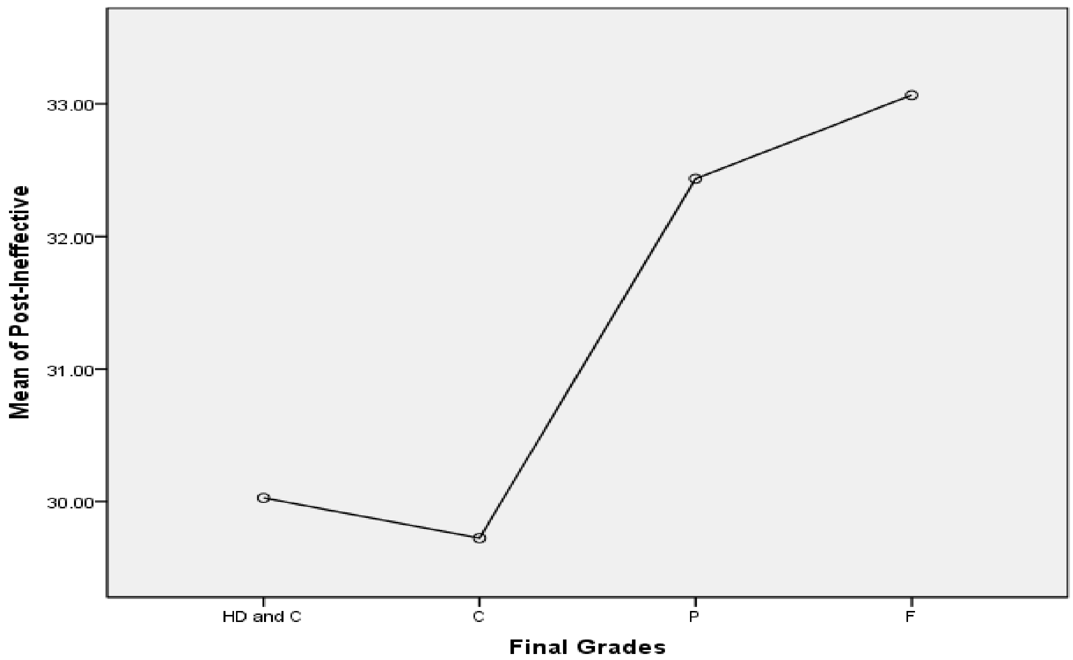

Figure 5.4. The Mean Plot of Post-test Un-motivation and Ineffective Learning Strategy Mental Model by Academic Grades

The results of one-way ANOVA and the Bronferroni post hoc test revealed that there was an association between the Un-motivation and Ineffective Learning Strategy Mental Model with students' academic grades.

Poorly Prepared and Absent Mental Model. Significant interactions between the Poorly Prepared and Absent Mental Model and students' academic grades were detected.

Academic grades. The one-way ANOVA was utilised to examine the significant differences among the academic grade group with regards to their scores on the Poorly Prepared and Absent Mental Model at post-test. The results showed an overall significance in the mean scores of the Poorly Prepared and Absent Mental Model in at least two academic grade groups ($F(df = 3,98) = 3.68$, $p < 0.05$) (Table 5.22).

Table 5.22

Results of One-way ANOVA- Post-test Poorly Prepared and Absent Mental Model by Academic Grades

Mental Models		N	M(SD)	Df	F	Sig.
Poorly Prepared and Absent Mental Model	Academic Grades	102		3,98	3.68	.015
	High Distinction and Distinction	29	13.75 (2.92)			
	Credit	26	14.68 (2.73)			
	Pass	32	16.00 (2.86)			
	Fail	15	15.86 (2.94)			

The Bronferroni post hoc test was then conducted to determine which academic grade groups were significantly different. The results of Bronferroni post hoc test (Table 5.21) showed that the *High Distinction and Distinction* group had significant lower scores on the Poorly Prepared and Absent Mental Model than the *Pass* group (mean difference = 2.24). The *High Distinction and Distinction* group also had significant lower scores on this mental model than the *Fail* group (mean difference = 2.11). There were no significant differences between the *High Distinction and Distinction* group and the *Credit* group (mean difference = 0.93), and between the *Pass* group and the *Fail* group (mean difference = 0.13).

Overall, the results of the one-way ANOVAs and the Bronferroni post hoc tests indicated that the *High Distinction and Distinction* group had lower scores ($\overline{x}$ = 13.75) on the Poorly Prepared and Absent Mental Model than the *Pass* group ($\overline{x}$ = 16.00) or *Fail* group ($\overline{x}$ = 15.86). The *High Distinction and Distinction* group and the *Credit* group both had similar scores on this mental model. The mean scores of these groups were shown in Figure 5.5 below.

Table 5.23

Results of Post Hoc Bronferroni - Post-test Poorly Prepared and Absent Mental Model by Academic Grades

Mental Models			Mean Difference	Std. Error	Sig.	95% CI
Poorly Prepared and Absent Mental Model	High Distinction & Distinction (HD & D)	Credit	-0.93	0.77	1.00	(-3.01,1.15)
		Pass	-2.24^{*}	0.73	0.02	(-4.22,-.27)
		Fail	-2.11	0.91	0.14	(-4.56,.34)
	Credit	HD & D	0.93	0.77	1.00	(-1.15,3.01
		Pass	-1.31	0.76	0.51	(-3.35, 0.72)
		Fail	-1.18	0.93	1.00	(-3.68, 1.32)
	Pass	HD & D	2.24^{*}	0.73	0.02	(0.27, 4.22)
		Credit	1.31	0.76	0.51	(-0.72, 3.35)
		Fail	0.13	0.90	1.00	(-2.28, 2.54)
	Fail	HD & D	2.11*	0.91	0.14	(-0.34, 4.56)
		Credit	1.18	0.93	1.00	(-1.32, 3.68)
		Pass	-0.13	0.90	1.00	(-2.54, 2.28)

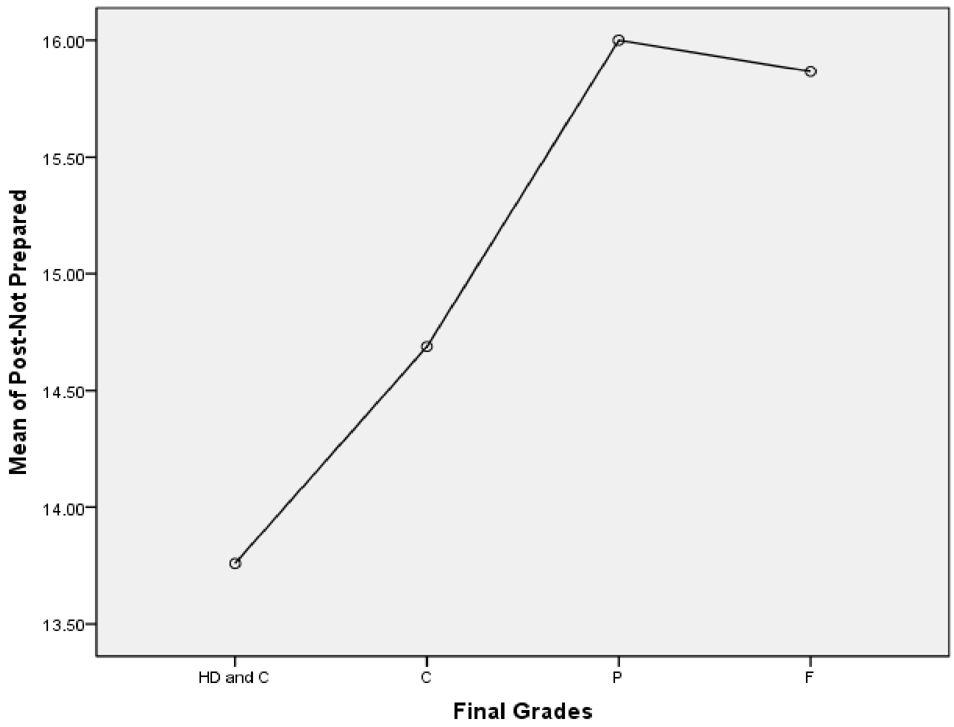

Figure 5.5 The Mean Plot of Post-test Poorly Prepared and Absent Mental Model by Academic Grades

Stepwise multiple regression analysis. Correlations and multiple regression analyses were conducted to examine the relationship between students' academic grades and their mental models at pre-test and post-test. The results of correlations showed that there was only a significant positive correlation between the Poorly Prepared and Absent Mental Model at pre-test and the academic grades. No positive correlations were found between the other mental models and academic grades.

The results of the stepwise multiple regression analysis revealed the Poorly Prepared and Absent Mental Model at pre-test is a significant predictor of prospective first-year education students' academic grades ($F = 5.87$; $p < .05$). With a beta of -.237 ($p < .05$), the Poorly Prepared and Absent Mental Model accounted for 4.7 percent of the variance in students' academic grades (Table 5.24).

Table 5.24

Results of Multiple Regression Analysis - Predictors of Academic Grades

Factors	R	R^2	Adjust R^2	B	T	P	F	P
Poorly Prepared and Absent Mental Model	.273	.056	0.47	-.237	10.25	.000	5.87	.017

Figure 5.6 below shows the histogram chart with a normal curve for the distribution of standardized regression residuals. The shape of the distribution of the residuals approaches the shape of a normal curve, which indicates that the assumption of normality was met.

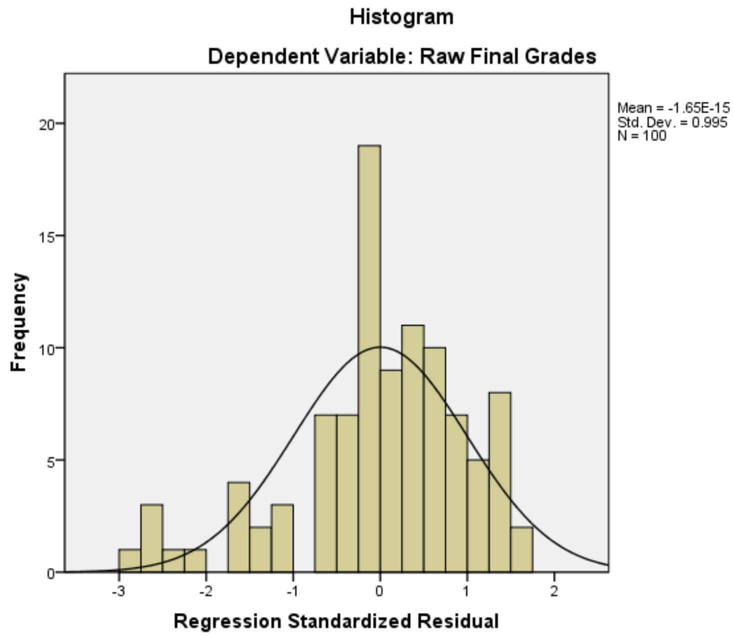

Figure 5.6 Histogram - Normal Probability of Plot of Standardized Residuals

To assess the assumption of homoscedasticity, the normal probability scatterplot for the standardized residuals in Figure 5.7 below is examined. The y axis represents the predicted scores and the x axis represents the observed scores. The assumption of homoscedasticity is met. Figure 5.7 below shows a diagonal line, with minor deviations.

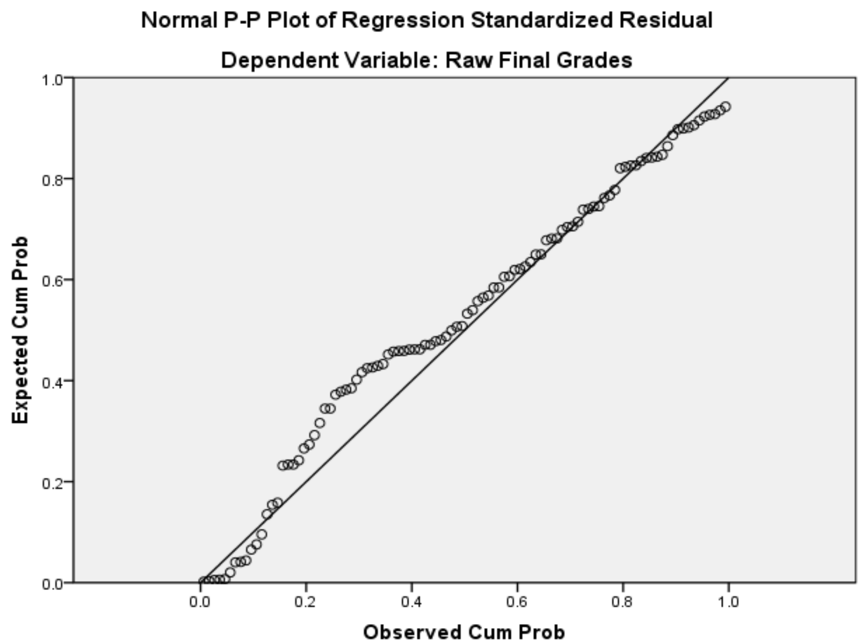

Figure 5.7 Normal Probability Plot of Standardized Residuals

The results indicated that the Poorly Prepared and Absent Mental Model at pre-test as a significant predictor of students' academic grades. If prospective first-year students score higher on the Poorly Prepared and Absent Mental Model they are not getting higher academic grades.

Results summary. The One-way ANOVAs and Stepwise Multiple Regression Analysis answered Research Question One: *"What are students' mental models at the beginning and at the end of the subject?"*

The results of one-way ANOVAs determined the relationship between mental models and academic results of first-year Bachelor or Education students:

- The Motivation Mental Model was found to have a strong effect on getting the higher marks in the examination.
- The Un-Motivation and Ineffective Learning Strategy Mental Model had strong effects on examination results and academic grades. Students who scored higher on this mental model were those who got the lower results in the examination, and failed in this subject.
- The Poorly Prepared and Absent Mental Model was found strongly correlated with students' academic grades. Students who had higher scores on this mental model were those who had the lower marks in their examination and failed in this subject.

Based on the findings, it is concluded that there were strong correlations between mental models and academic success of pre-service teachers in higher education. Motivation is the key for achieving higher results. Two inadequate mental models of students were the Un-Motivation and Ineffective Learning Strategy Mental Model and the Poorly Prepared and Absent Mental Model played an important role in students' negative academic achievement.

The results of Stepwise Multiple Regression Analysis indicated the Poorly Prepared and Absent Mental Model is a predictor of prospective pre-service teachers' learning achievement.

Summary of Quantitative Analyses

In this section, exploratory factor analysis, correlation analyses, paired-sample t-tests, independent sample t-tests, chi-square tests, one-way ANOVAs, and stepwise multiple regression analysis were conducted to address research questions and sub-research questions. The insights gained by the quantitative analyses will contribute to the mental models literature and first-year experience, which are discussed in Chapter 6. This will assist educators in making decisions regarding assistance programs to help students recognise any weaknesses in their own mental models and modify their mental models. The following section presents the results of qualitative data.

Qualitative Data Results and Analysis

This section focuses on students' mental models presented in the qualitative data. It analyses the responses to the open-ended questions in the pre-survey and post-survey to establish a clearer picture of first-year education students' mental models.

As discussed in Chapter Four - Methodology Chapter, two open-ended tasks were included in both surveys to allow students (1) to list adjectives that describe themselves as university students and (2) to identify difficulties they anticipated facing/did face during their first semester. Students could give more than one response. The qualitative data of both surveys were coded and categorised for the purpose of responding to the research questions. The data were coded inductively and then compared to themes (mental models) that were identified.

Mental Models of First-Year Education Students in the Pre-Survey and Post-Survey

Three mental models were identified from students' responses: (1) the Difficulty in Coping and Comprehension Mental Model, (2) the Academic Engagement Mental Model, and (3) the Weak Academic Expectation Mental Model at both pre-survey and post-survey. Responses of students to the open-ended questions were quite similar in both surveys therefore the results of each mental model in both pre-survey and post-survey were analysed together.

Difficulty in Coping and Comprehension Mental Model. The most common mental model that almost all students constructed was the Difficulty in Coping and Comprehension Mental Model. There were 91 students (89.2% of the sample) at the beginning of the subject and 93 students (91.1% of the sample) at the end of the subject who had this model. The categories that formed this mental model were lack of time management skill, workload, difficulty in comprehending the content, and utilising computer skills.

The transition from school and work to university was a great challenge for first-year education students. At the beginning of the subject, students were aware of having difficulties in coping with their academic study. They realised that they did not have time management skills which is one of the important skills that related to keeping up with study tasks. Other transition challenges for first-year students were reading comprehension and utilising the ICTs tools. Examples of students' responses at the beginning of the subject are presented in Table 5.25.

Table 5.25

Difficulty in Coping and Comprehension Mental Model: Examples of Pre- Survey Student Responses

What problems do you think you may have in studying this subject?	Time management	• Time to study • Not enough time • Not enough time to do preferred study requirements or to complete weekly activities • Time management skills
	Comprehending	• Collating information. A lot of reading, a lot of activities to do, a lot of self-directed learning • Confusion, understanding the content • Difficulty understanding • Concentrating • Keeping it up in the lectures • Feeling unsure about what I am doing when I don't feel confident about what I am doing. It takes me 2-3 times as long to do as I get scared that I will break something.
	Computer skills	• Using computers, understanding computer language • Computer skills • Lack of IT skills

In addition to the existing problems that they had anticipated above, students at the end of the semester indicated that they had difficulty in coping with the workload of academic study. In the table below (Table 5.26) a selection of student comments are provided.

Table 5.26

Difficulty in Coping and Comprehension Mental Model: Examples of Post- Survey Student Responses

Questions	Category	Examples of students' responses at post-survey
What problems did you have in studying this subject?	Time management	• Finding time to sit on the computer to read web lectures • Not enough time • Time management • Develop time management skill
	Workload	• Big workload, need to be motivated • Spending too much time on this subject, seeing connections in content • Other work for other subjects, large assignment • Other subject being hard, difficulties handling so much
	Comprehending	• Too much content to comprehend, find the word confusing, understand lectures and tutors • A lot of reading, a lot of activities to do, a lot of self-directed learning • Confusion, understanding the content • Difficulty understanding • Concentrating, putting all I have • Keeping it up in the lectures
	Computer skills	• Lack of IT skills • Computer skills • Lack of computer awareness

At the end of the subject, students admitted that they had difficulties in time management and needed to develop their time management skills. Because students lacked of time management skills, they found it was very hard to cope with the workload not only with the *ICTs in Education* subject but also with the workload of other subjects. They clearly stated their problems in comprehending the learning content which required self-directed learning and self-explanation. Students also re-stated that they lacked computer skills.

The number of responses from the 91 students in the pre-survey and the 93 students in the post-survey in each category are presented in Table 5.27. In this research, students could refer to more than one difficulty that they had in the *ICTs in Education* subject.

Table 5.27

Responses forming the Difficulty Coping and Comprehension Mental Model

Difficulty in Coping and Comprehension Mental Model	Number of Responses (Pre-survey)	Number of Responses (Post-survey)
Time management skills	80	81
Workload	-	40
Comprehending the content	40	50
Computer skills	30	28
Total number of difficulties	150	199

Table 5.27 reveals that while the total number of students who responded in each survey was almost the same, the list of difficulties increased from 150 to 199. The difficulties with workload was the category that substantially increased the number of difficulties followed by an increase in the comprehending the content category.

The following section presents the analyses of each category that formed the Difficulty Coping and Comprehension Mental Model.

Time management skills. Pre-service teacher faced challenges in managing their time. In the second week of the semester, 80 students indicated that they had difficulties in "time management" or "develop time management skills". Some of these students also indicated that they also had difficulties in comprehending the content or IT skills which are discussed later in this chapter.

By the end of the subject, 81 students gave responses that confirmed their time management issues. In addition, their responses included comments such as "Not enough time to do preferred study requirements or to complete weekly activities"; "Did not spend enough time on this subject because my other subjects required more time"; and "Not enough time to do everything that required each week". Therefore, time management was considered a concern. It can be argued that these students did not figure out how to organise their study at university. They might not have the study skills to plan their time in effective ways. Yorke and Longden (2007) highlighted that time management of first-year students was an issue, thus lacking time management skills of first-year university students was not unique to this study. However, the findings in this study were helpful in understanding the differences in time management skills among demographic groups. To illustrate the number of school leaver and mature age students who need to develop their time management skills, Table 5.28 is presented below.

Table 5.28

Number of Students (School Leaver/Mature Age) Anticipated/Needed to Develop Time Management Skills

	School Leaver	Mature Age	Total
	N	N	N
Pre-Survey	37	43	80
Post-Survey	46	35	81

At the beginning of the subject, among the 80 students who anticipated that they would need to develop their time management skills there were more mature age students (N=43) than school leaver students (N=37). However, by the end of the subject, considering the extra commitment that many mature age students had (“family commitments”, “children responsibilities”, and “work”), it was surprising that less mature age students (N=35) than school leaver students (N=46) who indicated that they needed to develop their skills in managing time. A possible explanation for this could be that while struggling between study and family and work, mature age students developed self-management. Their maturity and life experiences might give mature age students advantages such as daily planning and how to use their time effectively that school leaver students may have not developed.

School leaver students, on the other hand, indicated they had difficulties in “trying to find a balance between study and social events”, “motivation”, “commitment”, and “procrastination”. Motivation and commitment were important aspects in driving effectiveness of time management. Lacking motivation and not having engagement with their learning were possibly important determinants of time management development in school leaver students. School leaver students who procrastinated would have had a greater likelihood of being behind the schedule of their study.

Table 5.29 below presents the number of female and male students who reported their difficulty in time management skills.

Table 5.29

Number of Students (Female /Male) Anticipated/Needed to Develop Time Management Skills

	Female	Male	Total
	N	N	N
Pre-Survey	66	14	80
Post-Survey	62	19	81

The results showed that there were more male students (N=19) at the end of the subject stating that they needed develop their time management skills than at the beginning of the subject (N=14). There was a very slight change in the number of female students in the pre-survey (N=66) and the post-survey (N=62).

Some female mature age students noted that they had difficulties in studying because of their commitments to family, children, and the elderly in their families. The common comments from female, mature age students about their difficulties in studying were "family commitments", "children", and "family situations". Only one student indicated that she had "sporting commitment". In contrast, some male mature age students mentioned having to balance between study and work.

In general, it was a challenge for mature age students (female and males students) to combine their higher education with family responsibilities or work because it required their time, commitment, and a higher degree of flexibility. Although universities have general support programs to assist all students with time management skills, the findings in this study suggest the need to have a support program for mature age cohort, especially woman, to develop timetable planning, time management skills and practical information.

Workload. At the end of the subject, students expressed that they had difficulties in coping with the workload of this subject as well as three other subjects. It is surprising that students did not mention about the workload at the beginning of the subject when they did the pre-survey in week two of the semester, even though they expressed their lack of time management skills. There were 40 students who mentioned difficulty with coping with the workload of the *ICTs in Education* subject as well as other subjects. Students' difficulties in studying this subject included

“Coping with workload”; “Spending too much time on this subject”; “Other work for other subject, large assignment”; “Other subject being hard, difficulties handling so much”, “Too much assessment workload”, “A lot of reading”, “Time to study everything that is required each week”, “A lot of activities to do”, and “I won’t spend enough time on this subject because my other subjects require more time”.

It could be said that students did not express their challenges in coping with their study workload at the beginning of the semester because they did not realise the workload until they experienced it. Another reason could be that students might not have been well-informed about the workload that was associated with full time study in the Orientation week.

According to some researchers (Crisp, 2006; Crisp et al., 2009), students had unrealistic expectations about workload at university and thought that they would easily get help from their lecturers similar to they received it at high school. Based on these studies, it is possible that some students in this study acknowledged the workload of academic study. However, they supposed that they could simply use their old strategies at high school, such as asking the lectures/tutors to review their work and seek feedback for the drafts of their learning tasks.

As presented above, many students mentioned that they did not have good time management skills. These students therefore could not cope with the volume of fulltime workload at university. Poor time management and workload appeared to be related. Table 5.30 presents the data of school leaver students and mature age students who expressed their difficulty in workload at the end of the subject.

Table 5.30

Difficulty in Workload between School Leaver and Mature Age Students

	School leaver	Mature Age	Total
	N	N	N
Pre-Survey	-	-	
Post-Survey	27	13	40

The results showed that 13 mature age students commented about the study workload they faced compared to 27 school leaver students who did. This could be explained by school leaver students having difficulties adjusting their study habits to university requirements while mature age students seemed to adjust well to university learning and teaching.

Some school leaver students expressed their lack of motivation to cope with the university workload. Examples of their written responses are: “Need to find motivation to cope with workload”, “I need to be motivated”, “I have stress because too much info in this subject to remember and work for other subjects” and “Motivation to cope with workload”. The lack of motivation could partially stem from their low capability to regulate study behaviour to cope with study workload. Because of lacking motivation, these school leaver students were less likely to make the efforts required to study or solve problems.

Tale 5.31 below displays the number of female and male students who mentioned the study workload they were encountering.

Table 5.31

Difficulty in Workload between Female and Male Students

	Female	Male	Total
	N	N	N
Pre-Survey	-	-	-
Post-Survey	32	8	40

In this research, male students were more comfortable with their study workload than female students. Thirty-two female students reported that the volume of workload in their first-year study was heavy. Given that female students had responsibilities at home, such as family, and in some cases, paid work, they might not have had much time left for studying or attending class. This could be a stressful time for female students who must balance between study, family, and probably a work commitment. It appears that students’ outside commitment impacted upon study workload. Some male students expressed reasons they could not cope with their workload: “Too many abstract thoughts”, “Slow study skills’, and “Lack of study skills”.

The findings suggest learning community programs for mature age students should be implemented and be different for males and females. In these programs, in addition to the advice and resources of academic skills needed at university, female mature age students can support and share their experience or techniques of managing time for study at home.

Comprehending the content. Because the pre-survey was conducted in the second week of the first semester, students already had attended lectures and had accessed the web lectures of the *ICTs in Education* subject. They had a sense of the content of the subject. At the pre-survey, 40 students expressed that they had problems in understanding the content of the subject. They expressed difficulty in "Understanding the content as it is new to me"; "Understanding the content and putting in my own words"; "Understanding the terminology"; "Finding my ways to understand"; "Lack of understanding, reading other content picking up the content"; and "Understanding the content, making sure that I don't fall behind". The most common expression of difficulty was in "understanding the content". It could be argued that students were challenged by the amount of academic reading of the *ICTs in Education* subject that they had not encountered to the same degree at high school or at work. Another reason could relate to their time management issues. Because most students lacked time management skills they would not be able to allocate enough time for effective reading and understanding the content.

At the end of the subject, 50 students commented on their challenges in comprehending the content of this subject. Their comments included "Too much content to comprehend, find the words confusing, not understanding lecturers and tutors"; "A lot of reading, a lot of activities to do, a lot of self-directed learning"; "Confusion, understanding the content"; and "Understanding the content, handling how much content we have". Similar to the pre-survey, the most common difficulty was "understanding the content". It could be that many students were yet to sufficiently develop the enabling concepts and strategies to concurrently learn the content of this subject including theory of various aspects of ICTs, pedagogy learning, and the integration of the contemporary software and pedagogy in teaching and learning.

Motivation seemed to be a problem. This may partially explain why these students had difficulties in comprehending the content by the end of the subject. Some students stated: "Not being motivated to study"; "Difficult in getting motivated"; "Lack of interest, motivation", and "Not very interesting topics, too much work". Levy and Campbell (2008) emphasised that students' motivation to learn has a profound impact on their choice of approaches to learning. In this study, because some students were not motivated to learn the subject, they did not engage with their learning and tried harder to comprehend the content. Some students found the content of the subject very difficult resulting in the loss of motivation.

The *ICTs in Education* subject was a core, first-year subject for education students therefore all students had to do it. Some students had considerable difficulty in understanding the content of the subject because they did not like the subject. Some students expressed their dislike as follows: “Dislike the subject”; “Reluctant to study”; “Studying the wrong thing, not very interested in this subject”, and “Boredom subject”.

According to Spray et al. (2013), universities and educators are responsible for scaffolding first-year students’ metacognition abilities and study skills in their transition phase. In light of the subject’s results, it is suggested that the lecturers of this subject and any ICTs related subjects should pay attention to the effective design and delivery of the subject content. Intervention at the beginning of the semester may be effective in helping students like those in this study to comprehend the learning content. Support programs such as extra tutorial classrooms and workshops in the first few weeks of this subject should be designed to motivate students to engage in this subject and scaffold students with their metacognition abilities.

Table 5.32 below revealed the number of school leaver students and mature age students in both surveys.

Table 5.32

Difficulty in Comprehending the Content of School Leaver and Mature Age Students

	School leaver	Mature Age	Total
	N	N	N
Pre-Survey	28	12	40
Post-Survey	32	18	50

There were more school leaver students than mature age students who expressed that they had difficulty in comprehending the content in both surveys. Some mature age students expressed their “lack of knowledge in this area”, “difficult to understand”, and “do not have effective learning styles”. Among school leaver students who stated that they had difficulty in comprehending the learning material, there were seven school leaver students in both surveys who commented that “nothing to do with the actual content”. In their written responses, they stated that they had difficulty in reading comprehension because they were “lazy” and “procrastinated”.

For other school leaver students and mature age students, it could be said that the volume of reading academic texts that they faced made it difficult for them to comprehend the subject matter. Another reason could be that reading comprehension at university level is more sophisticated than at school level and required that they had to read independently. If students did not have good literacy skills when attending this subject they might find it challenging to read the texts as well as to foster their analysis, critique, and evaluation in order to comprehend the content.

Table 5.33

Difficulty in Comprehending the Content of Female and Male Students

	Female	Male	Total
	N	N	N
Pre-Survey	32	8	40
Post-Survey	40	10	50

By the end of the subject, more than a half of female students and less than half of male students reported their difficulties comprehending the content of the subject. Both genders had difficulty comprehending the content perhaps they did not have extra time for the subject. Comments of some female students included “extra time needed”; “managing work, uni and family”, and “not enough time”, while some male students stated “work”. It could be said that, female mature age students did not have more privileged time for their studies than male mature age students. Study time for female mature age students was filled with their responsibilities of family and paid work.

Although some female students reported their difficulties in balancing between family, study, and other commitments, they retained their motivation for self-improvement in comprehending the content. This was evident through the written responses from female students such as: “Some issues with content wording but improving each day”.

Universities need to take into account the challenges between work, family, and study that mature age students like those in this study were facing. It is suggested that a study support program should be provided in order to assist mature age students in developing their time management skills, reading comprehension skills, and motivation.

Computer skills. One of the problems that some students faced during the semester was insufficient computer skills. Because one-third of the *ICTs in Education* subject related to the teaching and learning of ICT learning products, students were required to use computer skills to complete the E-portfolio. In addition, students had to utilise and foster various cognitive processes while working with cognitive tools in order to produce quality ICT learning materials.

At the beginning of the subject, there were 30 students who anticipated that they would have difficulty in working with the computers. At the end of the subject, 28 students in the post-survey reported problems in using the ICT tools. Table 5.34 shows the number of school leaver and mature age students who lacked computer skills in this subject.

Table 5.34

Lacking Computer Skills of School Leaver and Mature Age Students

	School leaver	Mature Age	Total
	N	N	N
Pre-Survey	9	21	30
Post-Survey	9	19	28

More than twice as many mature age students as school leavers anticipated that they would have difficulties in computer skills in the pre-survey. At the end of the subject, the same nine school leavers who had expressed concern at the beginning of the semester reported that they had had difficulty in using the cognitive tools. Nineteen of the 21 mature age students again reported difficulty at the end of the semester. The difference in experience between mature age students and school leavers may be explained by appreciating that the school leaver students have been raised in a globalised and ICT world and it was not difficult for them to use the ICT tools. In contrast, some mature age students who left school many years earlier, might not have had substantial experience with technologies.

Table 5.35

Lacking Computer Skills of Female and Male Students

	Female	Male	Total
	N	N	N
Pre-Survey	24	6	30
Post-Survey	24	4	28

There was also very little change in the difficulty with computer skills by gender (Table 5.35). More female students experienced the difficulties with ICT tools than male students. There were no differences in the number of female students in both surveys with regards to their difficulties in computer skills. There were comments from female students such as “the software *Inspiration* is very difficult to use” and “I hate *Inspiration*”. It could be said that some of those female mature age students who returned to university after years to look after their family did not have an advantage of keeping up with the new technology. However, there were also school leaver females who had difficulty. In contrast, few male students commented on having difficulty with the ICT tools.

Academic Engagement Mental Model. The Academic Engagement Mental Model was derived from the pre-service teachers’ answers to the qualitative question: *“List some adjectives that describe you as a learner”* in both surveys. Some students wrote down many adjectives which convey the same meaning. For example one student listed two adjectives such as “enthusiastic” and “excited”. Because these words conveyed the similar meaning “positive emotion” then the researcher only choose one adjective. The adjectives that had the same meaning and were listed more than once were discarded so the total number of students who had the Academic Engagement Mental Model was accurate.

At the beginning of the subject, the results of this research revealed that 57 (55.9% of the sample) students in the pre-survey had the Academic Engagement Mental Model. However, the number of students who constructed this mental model decreased at the end of the subject (N=47, 46.1% of the sample). Student responses in both surveys were similar and are presented in Table 5.36.

Table 5.36

Academic Engagement Mental Model: Examples of Student Responses in the Pre/Post-Survey

Questions	Category	Examples of students' responses in pre/post-survey
List some adjectives that describe you as a learner	Commitment	• Committed • Hard working • Diligent • Responsible • Keen • Willing • Capable • Dedicated
	Positive emotion	• Excited • Enthusiastic
	Motivation	• Motivated

It is noted that a little less than 50 percent of the students in the sample did not express having commitment or motivation in the pre-survey and more than half did not in the post-survey. Instead, few students described themselves as being "annoyed", "stressed", "lazy", "incompetent", "unconfident", "lazy, confused", "lazy, stressed", "unsure", "not confident", "not committed", "unmotivated" and "losing interest". These responses seem to suggest that first-year education students need to be assisted to promote their motivation and confidence. It could be that their difficulties in coping with this subject reduced their motivation to empower themselves to be engaged learners.

Table 5.37 shows the number of school leaver and mature age students who constructed Academic Engagement in this subject.

Table 5.37

Academic Engagement Mental Model: School Leaver and Mature Age Students

	School leaver	Mature Age	Total
	N	N	N
Pre-Survey	22	35	57
Post-Survey	18	29	47

More mature age students constructed their Academic Engagement Mental Model than school leaver students in both surveys. Mature age students engaged with their learning and expressed their commitment and motivation. In contrast, some school leaver students were more likely to report that they were un-motivated. Examples of the expressions that some school leaver students stated in this research were “not being motivated to study”, “need to find motivation to study”, and “studying the wrong thing, not very interested in this subject”.

Table 5.38 below presents the data of female and male students who reported their engagement in this subject.

Table 5.38

Academic Engagement Mental Model: Female and Male Students

	Female	Male	Total
	N	N	N
Pre-Survey	46	11	57
Post-Survey	37	10	47

At the end of the subject, the number of female students who constructed the Academic Engagement Mental Model decreased while changes in male students were very minimal. It is noted that among 11 male students who reported their academic engagement, only one male was a school leaver student. Instead of expressing their commitment or engagement with the subject, male school leaver students commented that they were “slow, uncomfortable”, “unadapted”, “un-motivated”, “lazy”, and “worried”. Similarly, in their writing some female school leaver students at the end of the subject stated that they were “lazy”, “frustrated”, and “worried about exam”.

Weak Academic Expectations Mental Model. The Weak Academic Expectation Mental Model was derived from the answers to the qualitative question: “*What problems do you think you may have in studying this subject”?* in the pre-survey and “*What problems did you have in studying this subject”?* in the post-survey. Examples of the problems that students wrote down in the pre-survey and post-survey are documented in Table 5.39.

Table 5.39

Academic Expectation Mental Model: Examples of Student Responses in the Pre/Post-Survey

Question	Expectations	Examples of students' responses at pre-survey
What problems do you think you may have in studying this subject?	Understanding what is required	• Understanding what is required • Learning what is expected in the assessment and examination • Understanding the volume of this subject • Volume of this subject
		Examples of students' responses at post-survey
What problems did you think you have in studying this subject?	Understanding what is required	• Not knowing what is required, • Confused about examination • Understanding what exactly it is we are required to do • Subject organisation • Workload of this subject and three other subjects • Not understanding • Confused, never know what they want • Identify what is required in this subject

In the second week of the semester, 38 (37.3% of the sample) students entered the first-year education program without fully understanding the requirements of the *ICTs in Education* subject. They mentioned that the problems they were anticipating were "Understand what is required"; "The volume of this subject"; and "What is expected in the assessment and examination". These responses were somewhat surprising because students had to attend the Orientation week that prepares them for academic learning before starting their first-year education subject. Orientation week takes place the week prior to the start of the lecturing semester. It is made up of academic advisory meetings, campus tours, and activities with staff and students. Lecturers are given the opportunity to give an overview of their subject.

It is recognised in the literature that most Australian universities have well developed Orientation week activities to help new students adapt to university culture (Krause, 2006; 2005; Tinto, 2002). In this study, all students were invited to participate in Orientation week. Therefore, there is a tacit assumption that the first-year education students in this study should have had a clear understanding of the educational course and career goals, subject organisation, workload, and time to study for this subject as well as other subjects.

An explanation for the reasons 38 students did not have clear expectations of university study at the beginning of the subject include the following. It is possible that some of these 38 students did not attend Orientation week. Probably those who attended Orientation week paid more attention to the social activities rather than the academic events. Therefore, they did not have a clear understanding of the requirements of this subject.

According to McKenzie and Schweitzer (2001), many students go to university during Orientation week to attend social activities, have fun, and consume alcohol. These fun social activities in fact may hinder students' comprehension about the requirements of university study and may not promote their interest in academic achievement. The findings in this current project suggest that universities and lecturers could help students to understand clear expectations of university study and gain academic achievement by emphasising study groups (as opposed to social groups) in the Orientation week.

After semester one, the number of students who expressed their weak academic expectations slightly increased over the semester (N=42, 41.2% of the sample). Their problems included "[Being] confused, never know what they want"; "Not knowing what is required"; "Confused about examination"; and "Workload of this subject and three other subjects". These problems may have been in part due to their confusion or misapprehension about the constructivist and social constructivist approach to teaching and learning in this subject, the use of ICTs in the learning and teaching environment, and the volume of tutorial papers and ICT assignments. This leads to the question of the pedagogy that educators use in the design and delivery of their subjects.

According to O'Shea, Vincent, Calder and Hanley (2009), many commencing students struggle with their university study because they do not have the necessary knowledge to negotiate the "hidden curriculum" (p. 1). In this study, it could be that many students might lack ICTs skills in order to utilise ICT for pedagogical practices. They might struggle when studying a range of computer software and pedagogical learning concurrently.

In the same vein with this study, Van der Meer, Jansen, and Torenbeek (2010) stated that just over 50 percent of students in his study were clear about the course expectations by the end of a course. The findings are of interest to those who teach this subject as well as those who teach first-year students and those who design degree programs.

Table 5.40 shows the number of school leaver and mature age students who constructed Weak Academic Expectation in this subject.

Table 5.40

Weak Academic Expectation Mental Model: School Leaver and Mature Age Students

	School leaver	Mature Age	Total
	N	N	N
Pre-Survey	20	18	38
Post-Survey	24	18	42

At the beginning of the subject, there were 20 school leaver students and 18 mature age students who were uncertain of what was expected of them. At the end of the subject, the number of school leaver students slightly increased while there were no changes in the number of mature age students. The Weak Academic Expectation of school leaver students and mature age students could be the gap between their expectations and their learning experience at university. It seems reasonable to conclude that there is a need to provide a clear understanding of academic expectations at university for all students, not just school leaver students.

Table 5.41 reveals the data of female and male students who constructed the Weak Academic Expectation Mental Model.

Table 5.41

Weak Academic Expectation Mental Model: Female and Male Students

	Female	Male	Total
	N	N	N
Pre-Survey	28	10	38
Post-Survey	32	10	42

The results showed that there were more female students (N=32) at the end of the subject constructing the Weak Academic Expectation Mental Model than at the beginning of the subject (N=28). There was no change in the number of male students in the pre-survey (N=10) and the post-survey (N=10).

Summary of Qualitative Analysis

The qualitative results in this research identified that students' mental models of learning did not change during the semester. It was evident that three mental models : (1) the Difficulty in Coping and Comprehension Mental Model, (2) the Academic Engagement Mental Model, and (3) the Weak Academic Expectation Mental Model were constructed at both the beginning and at the end of the study. The differences between female and male students and between school leaver students and mature age students were also found. The findings of the qualitative analysis are integrated with the results of the quantitative data to build a clearer picture of students' mental models.

Conclusion

This chapter presents the results of the quantitative and qualitative research of this study. The findings of the qualitative open-ended questions helped to support the discussions of the quantitative results in Chapter Six. Discussion, implications, and recommendations are presented in the next chapter.

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Chapter 6: Discussion, Implications, and Recommendations

Overview

In the preceding chapter, the data were analysed to identify and explore mental models of learning that 102 first-year Bachelor of Education students undertaking the first semester subject *ICTs in Education* had. This chapter presents the summary and discussion of the most significant results to address the research questions and research aims. It also discusses the contribution this research makes to the literature, its implications for university practice, and some recommendations for future research.

Findings and Discussion

Mental Models of First-Year Education Students

The findings pertinent to the first research question *What are students' mental models at the beginning and at the end of the subject?* are discussed here in two parts: the mental models students had at the beginning of the semester and those they held at the end of the semester.

Mental models of students at the beginning of the subject. At the beginning of the subject (data collected in Week 2), there were five mental models identified from the exploratory factor analysis from the analysis of the questionnaire data at pre-test and three mental models from the analysis of the qualitative open-ended questions.

The five mental models identified at the beginning of the subject from the exploratory factor analysis were: (1) the Motivation, Goal, and Engagement Mental Model, (2) the Coping and Expectation Mental Model, (3) the Collaboration Mental Model, (4) the Learning Strategy Mental Model, and (5) the Un-motivation Mental Model. Correlation analysis showed that the Motivation, Goal, and Engagement Mental Model positively correlated with the Learning Strategy Mental Model. This relationship was expected and has been well documented in the research using other methodologies and frameworks (Krause, 2005; Levy & Campbell, 2008; Pintrich, 2003). In this research, learning strategy had the highest scores and students did not score highly on motivation. The importance of motivation and engagement in promoting first-year university students to commit to their learning and utilise different learning strategies to achieve their learning goals has been identified (Krause, 2005; Levy & Campbell, 2008). Motivation has been associated with the drop out of first-year university students in research studies (Krause, 2005; Levy & Campbell, 2008). For students to learn and perform effectively in their first-year, students must be motivated. Motivation is required for students to develop their independent learning. The motivation and goals of first-year students could impact students' adjustment to academic study and their choice of the learning approach.

There was a very weak positive association between the Motivation, Goal, and Engagement Mental Model and the Collaboration Mental Model. Although students were motivated, goal oriented, and engaged with their learning, they did not strongly collaborate with their learning peers. The findings did not agree with the results of Krause and her team (2005) that there were significant relationships between learning engagement and academic social study.

It is surprising that the Collaboration Mental Model was negatively correlated with the Learning Strategy Mental Model. In other words, students who utilised effective learning strategies did not score a higher level in the Collaboration Mental Model. Although many researchers (Hutchins, 2000, Porter et al., 2003) argued that educational advantages can be derived from collaborative activities among learners, students in this research did not consider working with their learning peers. This was evident by the mean score of the Collaboration Mental Model not being high ($\bar{x}$ = 20.64) at pre-test. It could be some students in this study were uninterested in working with other students. This may be because some students did not believe that collaboration was part of their learning. Another reason for the low mean score of the Collaboration Mental Model could have been that some students might have found it difficult to have spare time to study with their learning peers outside the classrooms. Their responses to the open-ended questions indicated that they had difficulties in managing their time to cope with study workloads. Mature age students, in particular, might fail to incorporate collaborative learning into their university studies because they not only needed to cope with their workloads but also had to balance their study, family, and work.

The Un-motivation Mental Model was not significantly associated with any of the other mental models. Students who were not motivated did not tend to utilise effective learning strategies or study with their learning peers. According to Baik et al. (2015), low motivation of first-year students can lead them to a greater risk of dropping out of their courses.

Results of the analysis of the qualitative data revealed three mental models: (1) the Difficulty in Coping and Comprehension Mental Model, (2) the Academic Engagement Mental Model, and (3) the Weak Academic Expectation Mental Model. The Difficulty in Coping and Comprehension Mental Model was the most common mental model that first-year education students constructed. The pre-service teachers expressed many problems that they had to cope with such as time management, workload, comprehending the content, and utilising the ICT tools.

Only a little more than a half of the pre-service teachers (N = 57; 55.9%) constructed the Academic Engagement Mental Model. According to some researchers (Helland et al., 2001; Krause et al, 2005; Peel, 2000; Tinto, 2002; Yorke & Longden, 2007), social factors influence students' ability to engage with and subsequently to complete their course in their first-year. Therefore, based on the weak correlation between the Motivation, Goal, and Engagement Mental Model and the Collaboration Mental Model in the quantitative results, it could be explained that many students who did not strongly collaborate with their learning peers also did not strongly engage with their learning.

The results of the qualitative data indicated more than a third of pre-service teachers (N = 38, 37.3%) constructed the Weak Academic Expectation Mental Model. In this study, many students struggled to understand academic expectations at the higher education level in their second week of first semester. Based on the findings of Dobozy and Gross (2010) that first-year university students who are new to university life need to be self-motivated in order to orient themselves to a new learning at university, it is suggested that the Un-Motivation Mental Model that students constructed in the quantitative data impacted the construction of the Weak Academic Expectations Mental Models in the qualitative data. Students who had low motivation might not try hard to understand the requirements of university. Baik et al. (2015) emphasised that most, if not all, universities devote energy, time, and resources into orientation programs to ensure students are aware of academic expectations and the academic skills needed to study well at university. Baik et al. (2015) further emphasised that very little is known about the effectiveness of the orientation program in helping students transition smoothly into academic study. Baik et al. (2015) found that one third of university students did not fully understand the academic demands of university while there was a little more than a third of students in this study did not.

Mental models of students at the end of the subject. As stated in Chapter Five, the exploratory factor analysis was not conducted at post-test. At the end of the subject (data collected in Week 11), the seven pre-defined mental models (Appendix C) were used at pre-test and post-test for further analysis. The seven mental models were: (1) the Sense of Purpose and Expectation Mental Model, (2) the Motivation Mental Model, (3) the Learning Strategy Mental Model, (4) the Collaboration Mental Model, (5) the Poor Coping and Comprehension Mental Model, (6) the Un-motivation and Ineffective Learning Strategy Mental Model, and (7) the Poorly Prepared and Absent Mental Model.

The three same mental models identified from students' responses to the open-ended questions at the beginning of the semester were produced again from the analysis of the qualitative data by the end of the subject. They were: (1) the Difficulty in Coping and Comprehension Mental Model, (2) the Academic Engagement Mental Model, and (3) the Weak Academic Expectation Mental Model.

The seven mental models from the questionnaire data and the three mental models from the qualitative data produced by responses to the open-ended questions were considered as the over-arching mental models (mental models that were running simultaneously) (Henderson & Tallman, 2006; Vermunt, 1996) that students used to meet the demands of academic study.

The findings of the correlation analysis revealed a moderate positive relationship between the Motivation Mental Model and the Learning Strategy Mental Model at post-test in comparison to their weak correlation at pre-test. This indicated that at post-test, there were more students who had strong motivation than at pre-test. Students who were motivated tended to utilise effective learning strategies, which is consistent with the results of other studies (Nilsen, 2009; Walker et al., 2006).

The correlation analysis indicated that the Sense of Purpose and Expectation Mental Model of students was positively correlated with their Motivation Mental Model at pre-test and post-test. However, the relationship between the two mental models was weak at post-test while it was moderate at pre-test. This weak correlation might be attributable to a slight increase in the number of students constructing the Weak Academic Expectations Mental Model by the end of the semester of the qualitative analysis. Because many students at the end of the subject still did not completely understand the requirements of the subjects and the workload of other subjects, they were less motivated in learning. Clarifying expectations could help students to maintain their interest and motivation.

There was a weak positive correlation between the Sense of Purpose and Expectations Mental Model and the Learning Strategy Mental Model at post-test. The results of the qualitative analysis supported this finding. There were a slight increase in the number of students (42, 41.2%) who expressed their Weak Academic Expectations Mental Model and a slight decrease in the number of students (47, 46.1%) who constructed the Academic Engagement Mental Model at the end of the first semester compared to the number of students at the beginning of the subject. A possible explanation for this result is that because this subject is a core compulsory subject, students had to attend this subject even though they did not like it. In order to pass this subject, students were required to complete the tutorials, the e-portfolio, and a final examination. Therefore some students had poor understandings about the subject requirement probably because they did not understand what the subject expected of them. It could be said that, some students who had family and work commitments may have had unrealistic expectations about what was manageable in terms of the work-study balance. Another reason for the relationship between the Sense of Purpose and Expectations Mental Model and the Learning Strategy Mental Model could have been that the ICTs components of this subject not only required students to work with a range of different software but also required students to utilise and apply the ICTs in learning and teaching. This might have been beyond the capabilities of some students in this study. Students in this study did not change their expectations of learning by the end of the subject. A strong contributing factor may have been the lack of ICTs skills which they expressed in the Difficulty in Coping and Comprehension Mental Model in the qualitative analysis. The results are of concern to those who teach this subject and those who teach first-year students. There is a need to help students like those in this study to fully understand the requirements of subjects which help them to engage with learning and utilise different learning strategies.

As a result of the weak positive relationship between the Sense of Purpose and Expectations Mental Model and the Learning Strategies Mental Model at post-test, there was a weak negative correlation between the Sense of Purpose and Expectation Mental Model and the Un-motivation and Ineffective Learning Strategies at post-test.

This was not the case at pre-test. In other words, at the end of the subject, few students who had a clearer understanding of university study requirements and had strong teaching goals were motivated and used different effective learning strategies to complete learning tasks.

The Sense of Purpose and Expectation Mental Model was weakly negatively correlated with the Poor Coping and Comprehension Mental Model at post-test. The analysis indicated that students who had clear goals and understood academic requirements were prepared to cope with university life and put in more effort to comprehend the learning material. No significant correlations were found between the Sense of Purpose and Expectation Mental Model and the Poorly Prepared and Absent Mental Model at post-test. Positive Expectations do not guarantee students' preparation and attendance.

Most importantly, results from the questionnaire data revealed an absence of correlations between the Collaboration Mental Model and any other mental models at pre-and post-test. According to many studies in mental models (Duffy, 2003; Henderson & Tallman, 2006; Jonassen, 1999), students adjust, change and develop their existing mental models in the social learning environment from learning collaboratively with their peers. In this research, students did not see collaboration as part of their learning; therefore, they were unlikely to benefit from more competent peers.

Changes in Mental Models of First-Year Education Students

This section discusses the findings for the second research question *What major changes, if any, occurred in the students' mental models across a semester period?*

According to mental model researchers (Johnson-Laird, 1983; Greca & Moreira, 2000; Henderson & Tallman, 2006; Hsu, 2006; Norman, 1983; Van Der Veer & Del Carmen Puerta Melguizo, 2003), mental models are often incomplete or inaccurate. However, even though mental models are incomplete or inaccurate, mental models are functional and guide students' learning behaviour. Students can build mental models that can either promote or hinder success in their study. Importantly, research has found that mental models are resistant to change (e.g., Johnson-Laird, 1983, Duffy, 2003, Henderson & Tallman, 2006; Norman, 1983; Vosniadou, 2007; Vosniadou et al., 2004, 2005). The reasons were summarised in Chapter Three. It is difficult for students to change their mental models because they are using them in their everyday learning experience and practices. However, because mental models are flexible and dynamic, any mental models that prove ineffectual can be discarded (Johnson-Laird, 1983; Henderson & Tallman, 2006), if individuals are able to recognise their mental models and restructure their mental models. This will be discussed further in the

Because the exploratory factor analysis was not conducted in the post-test, this thesis did not examine changes in the five mental models from the exploratory factor analysis at the beginning of the semester. Changes in the seven pre-defined mental models from the quantitative questionnaires and three mental models from the open-ended questions are presented in Table 6.1.

Table 6.1

Changes in Students' Mental Models

Data source of mental models	**Mental models**	**Change at the end of the subject**
Quantitative	1 Sense of Purpose and Expectation Mental Model	Change for the worse (moderate effect size)
Quantitative	2. Motivation Mental Model	Change for the worse (small effect size)
Quantitative	3. Learning Strategy Mental Model	No change and remained high scores
Quantitative	4. Collaboration Mental Model	No change
Quantitative	5. Poor Coping and Comprehension Mental Model	Change for the worse (large effect size)
Quantitative	6. Un-motivation and Ineffective Learning Strategy Mental Model	Change for the worse (moderate effect size)
Quantitative	7. Poorly Prepared and Absent Mental Model.	Change for the worse (moderate effect size)
Qualitative	8. Difficulty in Coping and Comprehension Mental Model	Change for the worse (slightly change)
Qualitative	9. Engagement Mental Model	Change for the worse
Qualitative	10. Weak Academic Expectation Mental Model	Change for the worse

The two mental models that remained unchanged were the Learning Strategy Mental Model and the Collaboration Mental Model. The Learning Strategy Mental Model had the highest mean scores among the seven mental models in both questionnaires. This mental model was considered a viable mental model. Many students had deep-rooted, pre-existing mental models of actively constructed knowledge to utilise different learning strategies rather than passively accumulate knowledge from lecturers. The mean scores of the Learning Strategy Mental Model in both questionnaires remained unchanged indicating that the number of students who constructed this mental model did not change. It could be said that, those students who did not possess the Learning Strategies Mental Model at the beginning of the subject still did not construct this effective mental model. A possible explanation is that there were students who only wanted to absorb knowledge from the course materials to pass the examination so they therefore did not value the importance of learning strategies. In contrast, there were incremental changes for the worse in the Un-motivation and Ineffective Learning Strategy Mental Model which are discussed later in this section.

The mean scores of the Collaboration Mental Model were not high in both questionnaires indicating that many students who did not collaborate with their learning peers at the beginning of the semester also did not want to work with other students by the end of the subject. This could be explained by many students in this study not believing in the value of collaboration or not wanting to collaborate with their learning peers or they did not have time to participate in the learning group outside the classrooms. This was evident by the increment of the mean scores for the Poor Coping and Comprehension Mental Model and the Un-motivation and Ineffective Learning Strategy Mental Model.

There were incremental changes for the worse in five mental models at post-test. They were: the Sense of Purpose and Expectation Mental Model, the Motivation Mental Model, the Poor Coping and Comprehension Mental Model, the Un-motivation and Ineffective Learning Strategy Mental Model, and the Poorly Prepared and Absent Mental Model. Similarly, the mental models derived from students' responses to the open-ended questions also showed changes for the worse. In the post-survey, there were more students who constructed the Difficulty in Coping and Comprehension Mental Model and the Weak Academic Expectations Mental Model than in the pre-survey. On the other hand, there were fewer students who built the Engagement Mental

Model at the end of the subject than at the beginning of the subject. In total, the analysis revealed that students kept eight mental models of learning but they had changed marginally for the worse. Interventions may then be required to guide the learner to modify their mental models

Possible explanations for these results are now presented. A discussion follows that draws on the empirical literature concerning the memory function (Azevedo, Moos, Greene, Winters, & Cromley, 2008; Cronjea & Fouche, 2008; Johnson-Laird, Girotto, & Legrenzi, 1998; Norman, 1983) and on the theoretical literature about the control function of mental models (Johnson-Laird, 1983; Henderson & Tallman, 2006; Pfeffer, 2005; Rao, 2005) that may explain why there was an incremental change for the worse in the mental models.

A theoretical explanation for the retention of mental models is found in the nature of their functions. According to research, the memory function of mental models (e.g., Anderson & Henderson, 2004; Cronjea & Fouche, 2008; Eckert & Bell, 2005; 2006; Zhang, 2008; Zhang & Chignell, 2001) means that mental models reside in the long-term memory. In this research, when students came to university, they already had mental models of learning that they had constructed in their schooling years or in the workplace. They did not start with a blank slate. It could be argued that by the end of the subject, students still relied on their pre-existing mental models for their learning rather than having formulated new mental models.

The control function of mental models (e.g., Johnson-Laird, 1993; Henderson & Tallman, 2006; Norman, 1983) explains why mental models are resistant to change. Mental models control individuals' behaviour. According to Pfeffer (2005), the danger of mental models is that individuals are not usually aware of anything that is incorrect or incomplete in their mental models.

In this research, it appears that the pre-service teachers did not recognise the inaccuracy and ineffectiveness of their mental models over the duration of the subject. Or if they did, they unconsciously continued to use their existing mental models in their learning (Pfeffer, 2005). The first-year education students in this research were considered as novices in learning in the higher education environment and held onto their existing mental models which were in the form of incorrect mental models. It could be very difficult for novice students to abandon or become alert to the weaknesses in these mental models unless they became aware of it or were taught more useful mental models (Pfeffer, 2005). Based on the theory that mental models of novices can develop and become more accurate and complete (Hsu, 2006; Sebrechts et al., 1990), in this study it is suggested that if first-year university students were taught how to recognise the weakness in their novice mental models and the association between mental models and learning outcomes, they could manage to change their mental models to better ones. This calls for the appropriate interventions for students to develop their mental models.

To shift students past their existing ineffective mental models into developing better mental models, educators have to construct learning environments which focus on the stimulation of new ideas and on problem solving in challenging situations and in social contexts (Henderson & Tallman, 2006). Examples of social contexts are lecturer-students, tutors-students, workshop demonstrators-students, mentor-students, and students-students sets of interactions. The *ICTs in Education* subject includes interaction between lecturer-students, tutors-students, and workshop demonstrators-students. In these learning situations, students use mental models for interpreting, analysing, and solving concepts and problems in specific situations, guided by educators, tutors, mentors, or peers. By working in a group, students share different views and help each other. In theory, the subject gives opportunities for students to compare their own mental models with others, re-examine and be aware of their own mental models. When students are able to realise any weaknesses in their own mental models, they can embed mental models of others within their own mental models, and modify their own mental models. Yet, for many students these social contexts did not provide the stimulus to modify their mental models.

It is to be recalled that the mean score of the Collaboration Mental Model was not high in both questionnaires and the quantitative analysis showed that the Collaboration Mental Model did not correlate with any other mental models at pre-test and post-test. In addition, the results of this study found that many students constructed the Poor Prepared and Absent Mental Model. Therefore many students in this study missed the opportunities available to share and discuss their mental models of learning with other students and with more knowledgeable people in order to recognise any weaknesses or deficiencies in their mental models which may have led to a small change for the worse in students' mental models by the end of the subject.

Understanding changes in first-year education students' mental models of learning is important in developing programs. Because the study of mental model development of first-year university students remains relatively under-investigated, the findings of this research are compared with studies which use the mental model framework to investigate subjects other than first-year students. This study is also compared with studies which use the conceptual change theory to examine the conceptions of pre-service teachers. The findings of this research are consistent with many studies of the pre-service teachers which used conception and beliefs framework (Evans, 2000, 2001, 2008; Patrick & Pintrich, 2001). Those studies showed that students did not change or replace their previously held beliefs or conceptions about learning during their teacher education program, but carried on with their old beliefs. In this study, students kept their existing mental models but with incremental changes for the worse.

This research was in contrast with the qualitative studies on mental models of pre-service teachers in their fourth-year (Askell-William et al., 2005; Wilke, 2008) which indicated there was an incremental development in their mental models. In this study, many students did not develop their mental models because they did not strongly collaborate with other students and were also absent from the lectures and tutorial classes. Wilke (2008) indicated that pre-service teachers' mental models of learning develop in the discipline-specific pedagogical practices. Although the findings in the Wilke (2008) study showed there was a development in pre-service teachers' mental models, he also suggested there is a need to help pre-service teachers to be aware of the deficiencies or weakness in their mental models. The study of Askell-William et al. (2005) showed that embedding the problem based learning approach (PBL) required for self-regulated learning practices in the education subjects, and self-reflection and peer collaboration were contributors to assisting students to realise the inadequacies in their mental models and modify them.

The differences between this research and the two qualitative studies of Askell-William et al. (2005) and of Wilke (2008) were that these two studies investigated mental models of pre-service teachers who already had passed through their first-year and second year at university. In contrast, this research investigated "pure" mental models of pre-service teachers who were in their first semester, first-year education program studying the *ICTs in Education* subject. These students were novices to university study and were at the transition stage from school/work to university. It could be these students found it hard to abandon their existing mental models of learning that were built in their high school unless they were taught to recognise the weakness or inaccurate in their mental model.

Some prior research (Gardner, 2006; Martin, 2007; Scott, 2008) suggests that the constructivist and social constructivist learning environment can help students become aware of their existing mental models and develop them. However, although the constructivist and social constructivist approaches were embraced in the *ICT and Education* subject, the results in this research found that many first-year university students did not modify their mental models of learning for the better. It is likely that insufficient scaffolding was included in the teaching-learning design of the subject.

One of the interventions necessary to promote changes in effective mental models of first-year university students is scaffolded learning. Scaffolding has been described as the way “teachers or peers supply students with the tools they need in order to learn” (Jacobs, 2001, p. 125). Scaffolding makes the learner’s job easier by providing the maximum amount of assistance at the beginning stages of learning and then, as the learner’s mastery grows, the assistance process is gradually withdrawn, or faded out. When students are made to actively and constructively attempt their own solutions, with prompting kept to a minimum, the resulting internalization of procedural knowledge, and importantly, their mental models are both more effective and more permanent than when the correct solutions are broken down and directly taught (Collins et al., 1991). Most importantly, educators should only assist students to understand the content or problems but not to tell them what they need to understand. When students have done it themselves, or worked it out for themselves, it is much more securely etched in their mental models. This research suggests that educators should implement the scaffolding process for this subject.

Factors that Hinder Students’ Changes of Mental Models

There were two mental models in this research that could hinder the development of other mental models. They were the Collaboration Mental Model and the Poorly Prepared and Absent Mental Model.

Collaboration Mental Model. Many researchers have emphasised that collaboration is related to changes in mental models (Duffy, 2003; Henderson &

Tallman, 2006; Jonassen, 1999). When collaborating in learning, students develop their mental models because their own mental models are influenced by those of others.

In this research, there was an absence of correlation between the Collaboration Mental Model and other mental models. This could hinder changes in students' mental models. Because most pre-service teachers did not work together with their learning peers, they did not have opportunities to judge their own mental models or compare them with other students' mental models. They could not recognise the weaknesses in their own mental models and were not able to embed mental models of others within their own mental models or modify their mental models of learning (Anderson et al., 1996).

Poorly Prepared and Absent Mental Model. According to some researchers (Alavi, 2005; Barker et al., 1998; Hatano & Inagaki, 2003; Jonassen, 1994a; Vosniadou, 2007), the learning process is one of the important keys to facilitating changes in students' mental models. In theory, a constructivist and social constructivist pedagogy should generate changes in mental models. In the constructivist learning environment, students are encouraged to continuously construct and reconstruct their knowledge, to develop and change their mental models, in response to the feedback and suggestions of the lecturer, tutors, and learning peers. It is argued that although changes in students' mental models are influenced by learning, the boundaries of mental models change depend upon the expertise of the student (Park & Gittelman, 1995). That is, students must have the ability to evaluate the weakness or inadequacies in their mental models. Changes in students' mental models can be seen in terms of recognising the weakness in mental models, evaluating mental models of their own and others, and restructuring mental models.

In this research, the constructivist and social constructivist pedagogy employed in the *ICTs in Education* subject had the potential to promote positive changes or re-construction of mental models (Eckert & Bell, 2006; Hsu, 2006). The constructivist pedagogy of this subject required students to play a central role in constructing their knowledge. In the *ICTs in Education subject,* the social constructivist learning context was the tutorial classrooms. The constructivist environment was interactive web activities and problem activities. According to Henderson and Tallman (2006), students can identify the weaknesses in their own mental models when they use their various mental modes of learning in the constructivist and social constructivist learning context. However, in this study, many students were often absent from the face to face component of the subject.

Given the fact that many first-year university students often skipped face-to-face lectures, tutorial classrooms, and computer workshops, these students may not have had good learning opportunities to critically process and share with others their knowledge or mental models of learning. This is especially important for the students' development of mental models. If students do not discuss their understandings with more knowledgeable others and with their learning peers, they may be less likely to develop shared understandings. Some students who constructed the Poorly Prepared and Absent Mental Model missed the opportunities to engage with the constructivist and social constructivist learning and teaching context of the *ICTs in Education* subject. Because students were absent from the tutorial classrooms or workshops they were less likely to evaluate their learning strategies in light of their performance. They may have been unable to recognise any limitations or dysfunction in their mental models and therefore they could not reflect on what they could have done to improve their learning or change their mental models.

Differences in Mental Models of Students

This section presents the discussion of the sub research question [a] *Do the students' mental models differ in relation to gender and school completion time?* and sub research question [b], "*If so, what significant differences are there in students' mental models among the identified groups?*

The analysis showed significant differences in students' mental models between female and male students and between school leavers and mature age students. There are two parts in this section. The first part presents the differences between the mental models of female and male students. The second part outlines the differences between the mental models of school leavers and mature age students.

Differences in mental models of female and male students. There were 78 female students compared to 24 male students. Females dominated in this research due to the course being Education in which most students are female. The quantitative results showed that there is a relationship between mental models and gender at pre-test and post-test. Male students significantly scored higher on the Poorly Prepared and

Absent Mental Model at both pre-test and post-test. This research found that first-year female students were better prepared and organised than male students which supports the findings of other researchers (Coates & Radloff, 2010; Krause et al., 2005; Richardson & Woodley, 2003; Radloff, & Coates, 2009; Smith & Naylor, 2001; Tinklin, 2003). It is noted that the differences between female and male students in learning preparation had a large size effect (r = 0.14) in this research while there was a small size effect in the study of Coates and Radloff (2010). The findings in the report of Krause and her team (2005) show that male students were underprepared but the differences in gender were very small.

Male students also scored significantly higher than female students on the Un-motivation and Ineffective Learning Strategy Mental Model at pre-test. Although there were no significant differences on the scores between male and female students on the Un-motivation and Ineffective Learning Strategy Mental Model at post-test, male students also scored higher on this mental model. In contrast, female students scored significantly higher on the Motivation Mental Model at pre-test. Females also scored higher than males on motivation at post-test, however, this difference did not reach the level of statistical significance. The findings of the qualitative analysis agreed with the results of the quantitative analysis that there were more female students who constructed the Academic Engagement Mental Model than male students in both surveys. In summary, these results indicate that female students were more motivated, more engaged with their learning, applied more effective learning strategies and were better prepared than male students.

In terms of motivation and engagement, this research does not support findings from some other studies. The findings to do with motivation do not support the Gonzaler et al. (2005) study that found that gender is not associated with motivation. With respect to the disengagement of first-year students, the quantitative analysis in this research found that the disengagement differences between females and males were moderate size (r = 0.06), while the Coates and Radloff's (2010) study produced similar scores of engagement for females and males. The difference between the results of this research and those of the others might be explained by the nature of the subjects in the studies. Unlike these two studies in which first-year students from a range of disciplines were surveyed, this research only surveyed students from Education.

Furthermore, female students scored significantly higher on the Poor Coping and Comprehension Mental Model than female students at pre-test and post-test. This finding is consistent with the report of Krause and her team (2005) that female students were less likely to cope and comprehend the learning materials than male students. The finding to do with comprehension showed that male students in this research were better at comprehension than females. It appeared that male students translated the learning content and the terminology of learning and teaching in the *ICTs in Education* subject into their own words. It is suggested that male students used the explanatory function of mental models (Chi, 2000, Henderson & Tallman, 2006) to self-explain the aspects or parts of the learning content in order to help them to better understand them.

The analysis of the Poor Coping and Comprehension Mental Model showed that female students coped less well than male students. The findings of the qualitative analysis in both surveys were consistent with the quantitative analysis. More female students had the Difficulty in Coping and Comprehension Mental Model than male students. The mental model derived from the qualitative analysis was based on the difficulties that students thought they would have and had in this research. This could be explained by noting that female students in the qualitative data had the opportunity to express that they had more demands on their time - they not only had to cope with the academic study but they also needed to balance their time between study and the demands of raising their children and their family relationships. In terms with coping, this research supports the research on gender differences in the coping strategies of first-year students studying in sport science (Lawrence et al., 2006) that male students had better coping. This finding is consistent with the results of Hillman (2005) and the report of Krause et al. (2005) that it is a challenge for female mature age students to cope with their academic learning while juggling their family responsibilities because it requires time, commitment, and a higher of flexibility.

The findings in the qualitative data showed that female students had poorer information technology skills than mature age students. Nevertheless, the lack of using cognitive tools in this subject did not stop them to become high achievers.

The final finding from this research regarding gender difference is that, females had better learning achievement than male students. This research confirmed results of many studies showing that gender is related to academic achievement and that female students perform better than male students (Dobson et al., 1996; Lawrence et al., 2006;

McKenzie and Schweitzer, 2001; Richardson & Woodley, 2003; Smith & Naylor, 2001; Tinklin, 2003). In contrast, this finding is not consistent with the result of Dalziel and Peat's (1997) on first-year students in the Science discipline. Research on first-year Bachelor of Science students (Dalziel & Peat, 1997) has suggested that male students perform better than females do. However, there are other studies that have found that gender is not a considerable predictor in first-year university students' academic achievement (Long et al., 2006; Ravenscroft & Buckless, 1992; Turner et al., 1997).

Differences in mental models of school leavers and mature age students. Mature age and school leaver students were almost equally distributed (50 mature age and 52 school leavers) in this research. These two groups entered university with different mental models of their learning which subsequently influenced their learning results. Their previous learning styles from schooling and/or from work may have had a significant impact on their mental model construction.

The quantitative analysis determined significant differences in the relationship between mental models and school leaver/mature age students at pre-test and post-test. School leaver students scored significantly higher than mature age students on the Un-motivation and Ineffective Learning Strategies Mental Model at both pre-test and post-test. School leaver students also significantly scored higher than mature age students on the Poorly Prepared and Absent Mental Model at post-test. Although there was no significant difference between school leaver students and mature age students on the Poorly Prepared and Absent Mental Model at post-test, school leaver students scored higher than mature age students on the Poorly Prepared and Absent Mental Model at pre-test.

Consistent with their scores in the Un-motivation and Ineffective Learning Strategies Mental Model, mature age students scored higher on the Motivation Mental Model than school leaver students at both tests. Their mental models of learning indicated that mature age students were more motivated, more engaged with their learning, used more effective learning strategies, and were better prepared than school leaver students.

The findings of the qualitative analysis were consistent with those from the quantitative analysis. They showed that more school leaver students than mature age students had the Difficulty in Coping and Comprehension Mental Model and the Weak Academic Expectation Mental Model in both surveys. More mature age students had the Academic Engagement Mental Model than school leaver students in both surveys.

The findings in this research do not agree with the Bird and Morgan (2003) study. That study suggests that mature age students face a range of obstacles in returning to university and that they lack academic abilities. The difference may be explained by important differences in the nature and size of the student groups. The sample in Bird and Morgan's study (2003) comprised 20 mature age students who were studying by distance learning while in this research there were 102 students (half mature age) studying on campus.

In terms of school leaver and mature age student learning strategy, this research is in line with various studies (Burton et al., 2006; Cantwell et al., 2001; Derrington, 2006; Duff et al., 2004; Gijbels et al., 2005; McKenzie, 2002; McKenzie & Schweitzer, 2001; Richardson & Newby, 2006). These studies found that school leaver students generally utilised a surface learning approach or ineffective learning strategies. Mature age students utilised metacognitive strategies, and engaged with their learning which positively impacted upon their grade results.

In terms of comprehending the content, the finding in the qualitative analysis is consistent with many research studies (Derrington, 2006; Richardson, 1997; Zeggers, 1999). The results of those studies found that school leaver students are less likely to develop deep comprehension of the learning materials due to their ineffective learning strategies. In this research, mature age students had better content comprehension than school leaver students.

In terms of school leaver and mature age student coping and comprehension, the finding in the quantitative data is similar to findings by James et al. (2009) that school leaver students coped less well and had more difficulties in comprehending the learning materials.

Nevertheless, there were more mature age students than school leaver students who lacked computer skills. This finding is in line with the study of Bird and Morgan (2003) that mature age students had poorer computer skills than school leaver students. However, the result does not agree with various studies (Clarke et al., 1997; Gale & McNamee, 1995; Ramsay, 1994; & Webb, 1999) that the limitation in using cognitive tools, such as *Inspiration Software,* of mature age students led them to become under-performing learners.

The final finding indicated that mature age students achieved better results than school leaver students. This research supports many studies of first-year university students in Australia (Burton et al., 2009; Cantwell et al., 2001) that show mature age students achieve better results than school leaver students. In this research, motivation played a key role in mature age students' performance. Two incomplete, naïve, and inadequate mental models in the quantitative analysis (the Un-motivation and Ineffective Learning Strategies Mental Model and the Poorly Prepared and Absent Mental Model) of many school leavers did not help them to achieve better learning results. Consistent with the quantitative analysis, the qualitative analysis showed that many school leaver students were unmotivated and less engaged with their learning. Their un-motivation and disengagement in learning could relate to their ineffective learning strategies which then impacted to their learning achievement.

Mental Models and Student Learning Achievement

This section presents the finding of the third research question *Which mental models, if any, relate to students' learning achievement?* There are two parts in this section. Firstly, the relationship between mental models and student learning achievement are presented. Secondly, the discussion about the Poorly Prepared and Absent Mental Model as a predictor of students' learning achievement

The relationship between mental models and student learning achievement. The findings in this research revealed three mental models relating to students' learning achievement. They are: the Motivation Mental Model, the Un-motivation and Ineffective Learning Strategy Mental Model, and the Poorly Prepared and Absent Mental Model.

The Motivation Mental Model positively related to students' final examination results while the Un-motivation and Ineffective Learning Strategy Mental Model had negative correlations with their examination results and academic grades. Students having the highest scores on the Motivation Mental Model obtained the highest marks in their final examination results. In contrast, students who had the highest scores on the Un-motivation and Ineffective Learning Strategy Mental Model got the lowest results in their examination results and failed this subject. Students who got higher scores on the Poorly Prepared and Absent Mental Model were also the low achievers.

The findings in this research indicated that motivation is an important factor in students' interest in their learning at university and can be conceptualised as students' energy and drive, encouraging students' deep learning strategies and learning commitment (Cunningham, 2013; Martin, 2008; Batmanian, Lingard, & Prosser, 2006). The findings in this research are consistent with the research on first-year Mathematic students (MacNamara & Penner, 2005) that found that motivation is related to students' final grade point average. This research also supports the results of Hulick and Higginson (1989) that students who are motivated often utilised effective learning strategies.

In terms of the relationship between the Poorly Prepared and Absent Mental Model and low achievement, the findings in this research are consistent with the study of James et al. (2009). In their study, students who came to class without preparing and skipped classes were those who did not obtain high achievement and seriously thought of deferring their study. This research also confirms studies (James et al, 2009; Krause et al., 2005) concerning mature age students which reported that they were more prepared and less likely to skip class than school leaver students.

It could be said that, the inaccurate or incomplete mental models (the Un-motivation and Ineffective Learning Strategies Mental Model, and the Poorly Prepared and Absent Mental Model) of many students did not help them to achieve better learning outcomes and attain higher grades in their final examination. Given the importance of the first-year, there is a need to implement programs to help students, develop appropriate mental models of learning at the beginning of the subject.

The Poorly Prepared and Absent Mental Model as a predictor of prospective students' learning achievement. Students construct mental models that guide their learning which, in turn, impacts their learning outcomes (Anderson, 2000; Gentner, 2002; Henderson & Tallman, 2006; Savage, 2001; Senge, 2012; Slone, 2002). One of the power functions of the mental models is the predictive function (e.g., Birnberg et al., 2007; Blythe & Camp; 2012; Gentner, 2002; Gentner & Stevens, 1983; Henderson & Tallman, 2006; Johnson-Laird, 1983; Muñoz et a., 2011; Norman, 1983; Vosniadou et al., 2004). Mental models enable educators to predict how students learn in the following semesters. To predict which mental models of prospective first-year education students influenced learning achievement, a stepwise multiple regression analysis was conducted. An early prediction of the outcome can help educators to plan intervention strategies in advance.

Results of stepwise multiple regression analysis indicated the Poorly Prepared and Absent Mental Model at pre-test was a predictor of prospective first-year education students' learning achievement. As detailed in Chapter Five, with a beta of -.237 ($p < 0.5$), the Poorly Prepared and Absent Mental Model accounted for 4.7 percent of the variance of students' academic grades. The Poorly Prepared and Absent Mental Model identified at pre-test guided students' intentions and plans during the semester which, in turn, led to their learning actions. The analysis indicated that this mental model influenced their academic grades at the end of the subject.

The importance of student learning engagement and achievement is well recognised by Krause and her team (2005), and it is believed that first-year students' success at university is maximised by their involvement and participation in group learning and thinking processes. However, the Poorly Prepared and Absent Mental Model of students in this subject included the intention of avoiding most of the lectures and the tutorial classes if they did not have their weekly tutorial reaction paper completed. It is argued that for new learning to occur, students must construct, distribute, and examine their own and others' mental models on specific topics in tutorial classes (Putnam & Borko, 2000). That is, they need to be active by applying their critical thinking in order for effective learning to occur. In this research, some students determined that they would not attend the tutorial classes. As a result, they missed the opportunities to construct and distribute their ideas or mental models of a specific topic and to get feedback from learning peers and the tutors/lecturer within the social learning environment.

Some researchers have suggested that students enter university with pre-determined learning approaches based upon the combination of their prior experience and personality (Pee et al., 2000; Van Woerkom et al., 2002). It is suggested in this research that at the beginning of the semester, students planned their learning performance based on their previous educational strategies in secondary education. The Poorly Prepared and Absent Mental Model indicated that students would be planning to use shallow levels of cognitive engagement in their attempt to get the work done just in time. This mental model also revealed that students could have low level skills in time management in the context of academic learning. They would not spend time thinking about the academic quality of their assignment but rather about the amount of hours they would spend on it. Students also indicated that they would memorise the content when it came to the examination. Students who constructed the Poorly Prepared and Absent Mental Model could be seen as novices having limited problem solving strategies (Staggers & Norcio, 1993; Zhang, 2008) in metacognitive and reflective thinking (Vermetten et al., 2002; Vermunt, 1998; Vermunt & Vermetten, 2004).

It is argued that students must construct mental models to facilitate knowledge construction, critical thinking, metacognitive skills, and learning strategies in order to solve problems (e.g., Benedicta, 2004; Bruner, 1996; Chesnevar, Maguitman, Gonzalez, & Cobo, 2004). Students learn best by engaging in learning. Constructivist theory (e.g., Benedicta, 2004; Bruner, 1996; Chesnevar et al., 2004) also argues that learning should be a proactive process in which students need to construct their thinking and knowledge for understanding any new concepts as well as solving problems based on their own previous and current knowledge. However, the Poorly Prepared and Absent Mental Model suggested that students were not strongly confident about their problem solving. These students would avoid much thinking. This conception implied that these students favoured a surface learning approach in which they would not use appropriate cognitive processing learning strategies. The Poorly Prepared and Absent Mental Model at pre-test could be seen as a naïve, inaccurate, or incomplete mental model. This mental model influenced their learning achievement.

Research in first-year university students indicated that early academic and social engagement is a key factor in encouraging academic application and success (Krause et al., 2005). New students who develop a sense of connectedness and engagement with university life can develop a desire for learning, critical reflection, the capacity to effectively collaborate with teachers and others, and in this subject, the confidence in the use of information and communication technologies. However, the Poor Prepared and Absent Mental Model of many students in this research did not include evidence of any of these above qualities which raises a concern.

The Poorly Prepared and Absent Mental Model at the beginning controlled students' learning performance which seriously affected their learning achievement at the end of the semester. A study on learning styles and academic achievement of first-year professional bachelor students in eight disciplines by Donche et al. (2013) revealed that analysing, processing, and external regulation were positively related to academic results. However, in this research, the Poorly Prepared and Absent Mental Model may have prevented students from attending the tutorial classrooms and computer workshops where they could have developed their cognitive processing strategies, regulation strategies, and orientation to learning. Looking back at the impact of the Poorly Prepared and Absent Mental Model on academic achievement, it is important to note that15 students (14.7%) who scored high (x = 15.86) on this mental model at pre-test failed this subject. Thirty two students (31.4%) who scored the highest mean on this mental model (x = 16.00) had the *Pass* grade. It is also important to note that students significantly scored higher on the Poorly Prepared and Absent Mental Model at post-test than pre-test. This research uncovered the control function and the memory function of mental models. First-year students stored the Poorly Prepared and Absent Mental Model that they constructed at the beginning of the subject in their long-term memory for future use. Students then retrieved this mental model at the end of the subject, even if students became conscious of how this mental model might be negatively controlling their learning behaviour. Some first-year students were being controlled by inaccurate mental models that did not facilitate an effective solution.

The espoused (pre) Poorly Prepared and Absent Mental Model was inaccurate and had negative implications on student learning. One of the purposes of mental models is their power to enable individual to predict how a system will work (Johnson-Laird, 1983; Norman, 1983). The negative impact of the espoused Poorly Prepared and Absent Mental Model on the learning achievements plus the increase of the scores of this mental model at post-test enables the teacher educators to predict that if no intervention occurs, this mental model could strongly influence the construction of students' mental models in the second semester of their first-year and the following years which may then negatively impact their learning achievement.

Mental Models and Learning Pedagogy

In addition to the finding that many students constructed the Poorly Prepared and Absent Mental Model which could prevent them from developing/changing their mental models which was discussed above, this section discusses reasons why mental models of some other students might not have improved in the constructivist and social constructivist leaning context. The reasons pertain to background knowledge and skills.

According to the mental model literature, the constructivist and social constructivist environment facilitate the development of students' mental models (e.g., Askell-Williams et al., 2005; Vosniadiou, 2007; Wilke, 2008). As mentioned in Chapter 4, the *ICTs in Education* subject in this study adopted the constructivist and social constructivist approach to teaching and learning. However, this study found that many students did not change or develop their mental models by the end of the subject.

The aim of the *ICTs in Education* subject was to produce students who have the Literacy skills, Information Literacy skills, and the ability to select and use appropriate ICT tools necessary for the rest of their education course and for their future teaching career. The findings from students' responses to the open-ended questions showed that many students had difficulties in comprehending the content and computer skills required of the subject. A likely reason for why many students found it difficult to adjust themselves to the constructivist learning environment was because they did not have the required literacy skills and computer skills to study the subject.

The cognitive tools (ICTs tools) can foster the development of mental models (e.g., Cronjea & Fouche, 2008; Hsu, 2006). However, in this subject, because many students had difficulties in ICT skills, they could not effectively use the cognitive tools. They could not actively engage and deeply think about how to work with their computer activities. According to Jones et al. (2011), if the cognition of the learners is limited, mental models of students do not change because any incoming information will be rejected. This appears to have occurred for many students in this study. As mentioned in Chapter Four, students enrolled in this compulsory subject without having an assessment of their literacy skills and computer skills. It is suggested that the Literacy skills and basic computer skills need to be tested before students enrol in this core *ICTs in Education* subject.

When this study was conducted, the *ICTs in Education* subject had been extensively redesigned (see Chapter 4). The redesign of this subject targeted high order thinking skills, strategies, and processes relevant to successful university study. In order to change their own mental models, according to Seel (1999), students need to have high order cognition and thinking skills to facilitate their understanding of the learning material. While high order thinking skills and effective strategies are considered critical factors in this subject and can foster the development of mental models, many first-year students in this subject, did not have these skills. According to Field et al. (2014), lecturers are likely to concentrate on teaching new knowledge, but rarely check if students have the skills which are essential to support their learning efficacy. In this study the lecturer of the subject likely focused on the redesign and teaching the subject, but did not help students recognise and acquire the skills that are required to study in this subject.

The mental model literature suggests that if mental models of students are incorrect or ineffective, then educators should design the learning environment or create materials that help students to construct accurate mental models (Gentner, 2002; Jonassen, 1994a). Because mental models of many students failed to develop in the teaching and learning environment of the *ICTs in Education* subject, it is suggested that the lecturer of this subject should reconsider the design of this subject.

Contribution to the Literature

Many studies have researched the mental models held by undergraduate students at university (Cin, 2013; García-Madruga et al., 2007; Huxster, Uribe-Zarain, & Kempton, 2015; Richardson, 2007; & Zhang, 2008) and also of pre-service teachers (Wilke, 2008). However, a search of the literature indicates that no study appears to have been conducted on the mental models of learning of pre-service teachers in their first-year education program. In short, there is a definite gap in the First-Year Experience literature concerning learning using the framework of mental models. This study focused its methodological lens on the mental models held by first-year university students at the beginning and at the end of their first semester through the *ICTs in Education* subject. It contributes to the existing literature in a variety of ways as listed below.

1. This study contributes to the literature by exploring what has been a gap in the mental model framework literature on the correlation between mental models and learning achievement; very few studies have directly addressed this relationship and no studies have been conducted with first-year pre-service teachers.

2. This study, using mental model framework to investigate mental models of learning of first-year students, adds the finding to the First-Year Experience literature that the Poorly Prepared and Absent Mental Model is a predictor of prospective first-year education students' poor learning achievement. The finding indicated that the espoused (pre) Poorly Prepared and Absent Mental Model was negatively related to students' learning achievements. As students scored higher (were less prepared and more absent), learning achievement went down, evidenced by grades. At the end of the semester, not only did students still maintain their existing scores on the Poorly Prepared and Absent Mental Model at post-test, but there was also an overall increase in the scores of Poorly Prepared and Absent Mental Model. This indicated students were even less prepared and more absent at the end of the semester. Male students were less prepared with poor attendance in the lectures, tutorial classrooms, and computer workshops than female students. Similar, school leaver students were more underprepared and more often skipped the lectures/tutorials/computer workshops than mature age students. These results call for institutional planning, interventions, and support mechanisms to assist many vulnerable groups to better manage university study.
3. This research expands on the work of other studies on the learning experience of first-year students which do **not** use a mental model framework. This study used a mental model framework which included all the factors of gender, school leaver and mature age students, academic engagement, and motivation that associated with learning achievements. In terms of gender, the findings in this thesis are consistent with the findings of various studies of first-year university students (Dobson et al., 1996; Lawrence et al., 2006; McKenzie & Schweitzer, 2001; Richardson & Woodley, 2003; Smith & Naylor, 2001; Tinklin, 2003) that indicate that females are better achievers than male students. In terms of school completion time, the results in this research support studies of first-year university students (Burke da Silva et al., 2008; Burton et al., 2009; Derrington, 2006) that found mature age students have a strong sense of purpose, motivation, and utilise effective learning strategies. Mature age students outperformed and obtained higher academic results than school leaver students. In terms of academic engagement and motivation, this research

showed that students who were not motivated and did not engage in learning did not gain higher results in their academic grades. This research agrees with other studies (James et al., 2009; Krause et al., 2005, McKenzie & Scheweitzer, 2001; Yu et al., 2007) that indicate academic engagement and motivation are related to student learning achievement. In terms of academic expectations, this study supports other studies (Crisp et al., 2009; Van der Meer et al., 2010) which found that many first-year education students were not clear about the university requirements at the beginning as well as by the end of the first semester.

4. While many studies in the literature (e.g., Bowles et al., 2011; Donnison & Penn-Edwards; James et al., 2009) have investigated the problems of first-year university students at one time point during their first-year, this study contributes new knowledge by having investigated and compared mental models of first-year university students at the beginning and at the end of the first semester.
5. This research supports the findings of various studies that use the mental model framework with participants other than first-year university students (e.g., Birnberg et al., 2007; Blythe & Camp; 2012; Gentner, 2002; Gentner & Stevens, 1983; Henderson & Tallman, 2006; Johnson-Laird, 1983; Muñoz et al., 2011; Norman, 1983; Vosniadou et al., 2004). The studies show the power of the control function of mental models. Mental models control students' learning behaviour. In this study, mental models of pre-service teachers controlled themselves therefore their mental models were resistant to change by the end of the subject. It is recommended that programs to help pre-service teachers become aware and modify their naïve pre-existing mental models be part of the first-year experience.
6. By using the mental model framework to investigate first-year pre-service teachers' mental models of learning, this thesis contributes to reducing the gap in the literature on research about pre-service teachers' conceptions that has been dominated by studies on beliefs and conceptions that Wilke (2008) stated.

Implications of the Research for Practice

This research has implications for how universities assist students in the transition to first-year academic studies and for the teaching of first-year students using constructivist pedagogy. There are six implications in this study: three implications for the interventions of universities' support learning programs and three implications for the lecturer of a subject.

1. The findings from this research call for on-going supportive activities to help students understand academic expectations of the university requirements and of the subjects, not only at the very early stages, but also during the semester. Although the first-year university students in this study had attended the Orientation week introducing them to student life and study at university, many students still did not have a clear understanding about how to best reach their learning goals. This was evident in the results reported in Chapter Five. After 11 weeks of their first semester, many first-year students still did not have clear expectations about the requirement of university study and specifically, the *ICTs in Education* subject. It is suggested that there should be a special transition program for first-year university students. Third year students or final year students from the same degree could be invited to be mentors (peer mentoring) in this program, together with academic advisors. The peer mentoring program is not new in the literature and many universities have implemented it to help first-year university students to be aware of university requirements (O'Brien, Llmas, & Stevens, 2012). O'Brien et al. (2012) conducted research on the mentoring program of first-year students for a six-week program at the start of first semester. They emphasised that it was unrealistic to expect that the six-week peer mentoring program would help students to achieve academic success. Therefore it is suggested that that the peer mentoring program should be a complimentary resource that spans the whole first-year experience.

   A national survey from Krause et al. (2005) emphasised the importance to engagement in learning, of not only the time spent in the classroom but also of the time spent with other students, lecturers, and support staff. A transition program that goes beyond Orientation week would enable first-year students to engage in discussions about the university culture and academic expectations with support staff and mentors when the need or occasion arises. Students would be given opportunities to discuss information on academic study for specific subjects, how much time to spend on each subject, and the workload of each subject. This could provide first-year university students important insights into academic skills that they normally lack upon arrival and for which they only develop an awareness with experience.

The peer mentoring programs would be a practical and useful method to better prepare students academically and socially for their academic learning. Positive learning experiences could be exchanged between mentors and mentees throughout the semester/year that will help first-year students make a smooth transition to university. This could contribute to a greater confidence at university among first-year students to engage with academic learning. The peer mentoring program could help first-year students comprehend the aims, objectives, workload, and expected learning outcomes from specific subjects as well as from the first-year learning experience.

Additionally, such a program could nurture the communication between the support staff and the first-year university students. This program should help first-year students expand their learning goals, motivation, strategies, and collaboration learning represented in their mental models. The educational staff could help first-year university students to think about higher level learning outcomes in their subjects. This, in turn, involves describing to first-year university students the cognitive process, especially in the areas of high-order thinking skills, needed to reach the desired learning goals and achieve successful academic results.

2. There is a need to support students in academic skills such as time management counselling. The mental models of students at the pre-and post-test in this research revealed that students had difficulties in time management. Many students struggled in coping with the workload of subjects in their first semester because of their lack of time management skills. Many studies of the first-year university experience (e.g., Coates & Radloff, 2010; Krause & Coates, 2008; Van der Meer et al., 2010; Yorke & Longden, 2007) using other research methodologies and frameworks have also identified the need to help students with time management skills. Krause (2005) found that students who sought help and advice from the support staff were more confident in time management.

Universities have general support programs to help students in time management skills. Students can always go to the learning centre to ask for help or access the online resources when needed. Nevertheless, the students in this study still had difficulties in these skills. It could be that many students who had commitments in addition to studying could not find time to see the counsellor.

With respect to the support given to developing time management skills, it is recommended that academic advisers pay attention to students with double workload, e.g., study and a family with children, or study, family, and work because they have to balance between the two or three situations constantly. Time management and good planning skills permit students to spread their workload throughout the semester. Planning skills such as how to design a study plan and timetable to balance work and study should be included. Students should be encouraged to visit the learning support centre to seek advice for time management skills in Orientation week and through the peer mentoring program. It is also suggested that there should be general workshop programs in the first three weeks of the semester to support students in academic skills, time management skills, and good planning skills.

3. The differences in the associations between the mental models and learning achievement of males and females and of mature students and younger students suggest that developing gender and age appropriate support structures for the different groups could improve learning.

   Fostering a culture that is supportive of the diverse needs of mature age students is a priority in order to retain these students in their first-year at university. Establishing learning communities for mature age students where they can share the experience of lectures, tutorials, and their understanding of course content would hasten university enculturation and their transition process. A support program may help mature age students to get used to learning with information technology skills, to figure out which learning skills that they need to have, and to learn how to build these skills. This program or these activities could help all students to expand their skillsets and networks and provide learning resources. For mature age female students who juggle between their study and family life, and work, the program could include guidance, encouragement, and emotional support in order to increase students' engagement at university.

This study reflected the disproportionate small number of males found in education programs generally (Cervini, 2015). For the small number of male students, there could be a mentoring program consisting of both face-to-face support and online support particular where male mentors have a recognised role. The diligence and application of male mentors mean they would function as positive role models for their first-year university male mentees. This learning support would provide an opportunity for valuable discussions on issues related to topics concerning learning strategies, time management, university life, and teaching careers where females dominate.

For school leaver students, in addition to the face to face learning support, it is suggested that there should be an additional support program via social media enabling mentors and students to network and communicate regarding academic issues virtually. This service would supplement the academic counselling available for students to access help. The connection and sharing information through social media would help students to exchange information among academic advisors, mentors, and students.

4. The results of this research indicated that most students did not modify or change most of their mental models by the end of the semester. This research suggests that student attention should be directed specifically to their mental models to ensure that they become aware of how to change their mental models of learning to be more adaptable to higher education. For many of the first-year university students, their newly acquired knowledge of learning goals and study strategies was tied to their learning experiences prior to their study at university. It is argued that, first-year students failed to modify or change their mental models because they might not have realised the weaknesses in their mental models (Henderson & Tallman, 2006).

   According to Gardner (2006) and Martin (2007), students' motivation to using a deep learning approach is an important factor in changing mental models.

However, in this study many students lacked motivation which is likely to have contributed to the failure of changing their mental models for the better. The importance of addressing any deficiencies in students' mental models of learning, particularly in motivation, becomes critical. The learning and teaching process (Alavi et al., 2002; Barker et al., 1998; Driscoll, 1994; Hinsz, 1995; Jonassen, 1994c; Silvan, 1999; Wilke, 2008) and the social learning environment including dialogue with learning peers, tutors, the lecturers, and the support staff (Gardner, 2006; Martin, 2007; Scott, 2008) are key factors to motivate students' learning and facilitate students understanding of their own mental models and develop them.

At the time this study was conducted, because of the university limited budget, students could only attend one tutorial per week. If students, especially mature age students who were busy with their family commitment, missed their own tutorial, they could not attend in any other tutorial classrooms. Students who were slow learners might also need to attend the extra tutorial classrooms to catch up with the content/problems that they did not fully understand. Should there be additional funding, it is suggested that the lecturer of any teacher education courses that integrate ICTs in the curriculum should provide an extra tutor and computer workshop in weeks one to four (if not six weeks) in which students are able to discuss academic study with the lecturer or tutors. The tutorial classes and informal discussions facilitated using constructivist and social constructivist paradigms would promote the development of mental models. Any interactive exchange of ideas or opinions, especially asking and answering questions in critical ways and academic feedback would help students realise any inadequacies and weaknesses in their own mental models. By providing extra learning aids from more knowledgeable people, first-year students' mental models could be modified and advanced.

5. Because the study concerned the change in mental models of learning in a particular subject, the implications for pedagogy are limited to those subjects involving communication information technologies. Consistent with other research into the first-year experience (Benettayeb, 2012; Parr & Woloshyn, 2013), lecturers need to check the assumptions they make about students'

literacy, cognitive skills, and ICT skills. Often students do not have the skills required to succeed. Many students in this research revealed that they had difficulties in information technology skills and comprehending the content of the subject. Educators must be aware of prior learning skills, ICT skills, and knowledge about being a university student that first-year students bring to the classrooms. It is suggested that the entrance assessment for the literacy skills and basic computer skills should be conducted before students enrol in any subjects related to ICT skills. When students demonstrate the required level of prerequisite literacy skills and the basic ICTs skills they would be more engaged with the subject. If students enter the subject with the required skills, they would not have difficulties in ICTs skills and in understanding the content of the subject which means they could fully benefit from any learning opportunities in the classroom.

6. It is recommended that educators develop better instructional design that facilitates students' thinking and helps them to construct their knowledge in the concepts of the subject and to apply them to practical learning.

   Although the *ICTs in Education* subject was taught using a constructivist pedagogy which promotes collaborative learning, the need for pedagogy that specially develops collaborative learning skills and the disposition to use them among first-year students was identified in this research. The results in this research found that the Collaboration Mental Model did not correlate with any other mental models at pre- and post-test. Various studies in mental models (Duffy, 2003; Henderson & Tallman, 2006; Jonassen, 1999) emphasised that the collaborative learning environment assists students to adjust, modify, and develop their existing mental models.. As suggested in implication four, the extra tutorials and computer workshop in weeks one to four (if not six weeks) at the beginning of the subject will help to enhance the collaborative learning.

   Collaborative learning should be emphasised in the tutorial classrooms and computer workshops in order to facilitate students' active learning engagement. Small size groups can be formed so students could distribute their mental models of learning across the members of a social group. Studying in a group promotes students to engage in a learning dialogue with other students. While studying in a group, students are forced to share and discuss their knowledge and mental models of learning with other students. In effect, this requires students to explore and understand mental models of other students, and compare these with their own mental models. As a result, students are able to recognise any weaknesses in their existing knowledge or mental models and will have an opportunity to develop them further.

Recommendations for Future Research

Quantitative and qualitative research is needed to investigate further the mental models of learning of first-year university students, not only in the first semester, but also in the second semester and possibly in the following years. At various time points, the changes in students' mental models of learning should be examined as well as the association between the mental models and learning achievement.

The results of this research revealed that mental models of first-year education students either did not change or got worse over the duration of the first semester. It is argued that, it was quite challenging for first-year university students to change entrenched mental models, first, during the first semester of first-year university study (11 weeks in this research) and second, without the intervention of educators or pedagogy. The findings in this research showed that once mental models were created, they became reinforced in the mind of students and became difficult to change.

The important follow-up studies on mental models and changes of mental models of first-year university students in the second semester and the following years will be able to track mental models and any incremental changes of students' mental models. The findings of these studies will have the potential to inform the instructional design of the bachelor programs to offer learning experiences that do positively affect changing mental models. If mental models of students at the second semester in their first-year are left unchallenged and still remain unchanged, there is a great need for providing support programs to help students to *unlearn* what they think they know in order to change their mental models.

As previously stated, research on mental models of first-year education students is still unexplored and this research contributes to closing this gap, therefore there is a need to have more research in this field. This research investigated espoused mental models and theories-in-use (or reflective) mental models of first-year university students. Espoused mental models related to what first-year education students said they would do while theories-in-use mental models were what students actually did. However, this research did not examine in-action mental models (in the middle of the semester) while first-year students were studying. This is another gap remaining in the research.

A future study could investigate espoused, in-action, and theories-in-use mental models of students in each semester of their first-year and the following years. The quantitative approach could be used to obtain espoused and theories-in use mental models of a larger group of students. The qualitative approach, employing data generation techniques, such as the stimulated recall method in the tutorial classrooms or computer workshops, pre-and post-interviews, or follow-up observations could be used to thoroughly document in-action mental models and any changes in students' mental models related to classroom management, assessment, group discussions and students' learning through reading comprehension. The combination of using quantitative and qualitative methods in different phases would give greater insights into how students construct their mental models and how mental models develop over time.

Analysis of qualitative and quantitative data to determine mental models would allow understandings into what would result and arguably what would be common and conflicting between the two approaches. It is essential to explore the degree to which themes such as motivation, collaboration, expectations, poor preparation, absence from study, or something else remain prominent in students' mental models. A combination of quantitative and qualitative approaches is well-suited to this more in-depth exploration of mental models of students.

Further studies of the mental models of students in other disciplines, especially in subjects where they use a range of IT tools as learning tools, will enable a comparison of results among student groups by discipline. Such studies will help produce a more detailed picture of the mental models of first-year university students.

Studies involving groups of students larger than the one used in this research are required to carry out exploratory and confirmatory factor analyses of the development of mental models. While this research used only exploratory factor analysis because there was no pilot study, a stronger research design using both exploratory and confirmatory factor analyses to find out the mental models is recommended. Much larger sample sizes are needed to accomplish this. Although the exploratory factor analysis in this research provided insight into students' mental models at pre-test, a larger sample size will allow for the exploratory factor analysis at pre-test and post-test.

Conclusion

Retaining first-year undergraduate students is a priority for universities. Understanding students' mental models and the connections between their mental models and their learning achievement in a subject adds to our understanding of the first-year experience. First-year students come to university with their pre-existing mental models of learning that they might have constructed in school or the workplace. These mental models of learning can be a mix of correct or incorrect and complete or incomplete mental models which can either promote or hinder students' learning achievement in their first-year at university.

First-year students who have constructed the incorrect mental models of learning may not recognise the weaknesses in their mental models. Because mental models are difficult to change, even those students who are aware of the inaccuracy in their own mental models, may unconsciously continue to use their existing mental models in their learning practices. Importantly, students may continue to use their incorrect mental models in the second semester of first-year and/or in the following years which can adversely affect their success in their academic study and the completion of their degree.

Understanding mental models of first-year university students is crucial because if any incorrect mental models are identified, educators can design the appropriate pedagogy to minimise the trigger to errors or weaknesses in students' mental models. Although students' mental models are resistant to change, it is possible for students to change or modify their mental models if they are aware of them. Programs that help first-year education students to be aware of any deficiencies in their mental models of learning are likely to improve academic achievement.

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Appendix A: Pre-Survey

Directions

This survey asks you to describe yourself and your learning strategies. This survey has three parts:

- Part A: In order to keep track of results please PRINT your student number and other details
- Part B: There are 50 sentences that require your response. There are no right or wrong answers. **The only correct response is those that are true for you.** Your option is greatly valued. For each sentence, please circle the number corresponding to how strongly you disagree or agree with the sentence.
- Part C: There are 2 short answer questions. Please print your answer.

Thank you for your cooperation

Part A: *Please answer the following questions (CIRCLE where appropriate):*

Student Number:____

Student Name:____

(Please **circle** relevant responses to the questions below)

I am: **Full-Time** **Part-time**

I am: **School leaver** **Matured aged**

Gender: **Male** **Female**

Age: **17–19** **20-23** **24-27** **27-30** **31-35** **35-40** **41-45** **45+**

OP score: (or equivalent)______________________________

Returning the *ICTs in Education* subject student: **Yes** **No**

Returning University students: **Yes** **No**

Previous highest education level:____

<u>Part B:</u> Please circle the number corresponding to how strongly you disagree or agree with the sentence. Please **answer all statements, thank you.**

SD= Strongly disagree; D: Disagree; U: Undecided; A: Agree; SA: Strongly agree

		SD	D	U	A	SA
1	I know what is required of a first-year university student	1	2	3	4	5
2	I really like being a university student	1	2	3	4	5
3	I really want to be a teacher	1	2	3	4	5
4	I have a clear idea of what is expected of me in this subject	1	2	3	4	5
5	I know what I am trying to accomplish with my learning	1	2	3	4	5
6	I enjoy the intellectual challenge of this subject	1	2	3	4	5
7	I get a lot of satisfaction from studying	1	2	3	4	5
8	If I do not enjoy the subject, I do not want to learn	1	2	3	4	5
9	When I try, I generally succeed	1	2	3	4	5
10	I find it is difficult to get myself motivated to study	1	2	3	4	5
11	I keep trying until I succeed	1	2	3	4	5
12	I give my opinions during tutorial discussion	1	2	3	4	5
13	I have a strong desire to do well in this subject	1	2	3	4	5
14	I prefer complex to simple questions	1	2	3	4	5
15	I keep thinking about information or an issue until I understand it	1	2	3	4	5
16	I would rather do something that requires little thought than something that is sure to challenge my thinking abilities	1	2	3	4	5
17	Learning new ways to learn doesn’t excite me very much	1	2	3	4	5
18	I really enjoy a task that involves coming up with new solutions to problem	1	2	3	4	5
19	I value opinions that differ from mine	1	2	3	4	5
20	I am willing to change my ideas when evidence show that my ideas are week	1	2	3	4	5
21	I prefer to agree with other people’s ideas rather than formulate my own opinion	1	2	3	4	5
22	I study with other students	1	2	3	4	5
23	I sit back when working with other students in activities during class	1	2	3	4	5
24	I work with classmates outside of class	1	2	3	4	5
25	Working together can help me gain a deeper understanding the *ICTs in Education* subject	1	2	3	4	5
26	I learn through discussion with other student	1	2	3	4	5
27	I ask other students for help when I encounter difficulties in solving the *ICTs in Education subject*	1	2	3	4	5

28	Other students work with me to achieve the *ICTs in Education subject*	1	2	3	4	5
29	I do not need to use a variety of strategies to be an effective learner	1	2	3	4	5
30	I regularly seek the assistance of the teaching staff	1	2	3	4	5
31	I prefer findings answers by myself rather than getting hep	1	2	3	4	5
32	When solving problems, I identify unexpected results as wells expected ones	1	2	3	4	5
33	I find out answers to questions by relying on the subject materials	1	2	3	4	5
34	I automatically recall relevant information when solving problems	1	2	3	4	5
35	If I forget the answer, I can usually think my way through	1	2	3	4	5
36	When reading, I try to connect things I am reading about with things I already know	1	2	3	4	5
37	I ask myself questions in order to make sure I am reading about with things I already know	1	2	3	4	5
38	When writing, I am more likely to paraphrase an author's words rather than use my own words	1	2	3	4	5
39	I try to remember solutions to similar computer problems in order to solve a computer problem	1	2	3	4	5
40	I find it really hard to keep up with the volume of work in the *ICTs in Education subject*	1	2	3	4	5
41	My other university workload is not as heavy	1	2	3	4	5
42	I find it difficult to comprehend a lot of the *ICTs in Education* material I am supposed to understand	1	2	3	4	5
43	I feel overwhelmed by all I have to do	1	2	3	4	5
44	I have difficulty adjusting to the styles of teaching at university	1	2	3	4	5
45	I can miss most of the Mas lecture in first-year because most notes and materials are on the web	1	2	3	4	5
46	I only read what I have to do in the *ICTs in Education* Web Lecture Topic in order to answer the question	1	2	3	4	5
47	If I do not have my tutorial reaction paper completed, I do not attend the tutorial for that topic	1	2	3	4	5
48	I usually do an assignment just before it is due	1	2	3	4	5
49	If I spend a lot of hours on my assignment, I will get a very good mark	1	2	3	4	5
50	When it comes to the exam, I usually try to memorise the content	1	2	3	4	5

<u>Part C:</u>

1. **List some adjectives (e.g., committed or scared) that describe you as a learner**

- ________________________________
- ________________________________
- ________________________________
- ________________________________

2. What problems do you think you may have in studying this subject?

Appendix B: Post-Survey

Directions

This survey asks you to describe yourself and your learning strategies. This survey has three parts:

- Part A: In order to keep track of results please PRINT your student number and other details
- Part B: There are 50 sentences that require your response. There are no right or wrong answers. **The only correct response is those that are true for you.** Your option is greatly valued. For each sentence, please circle the number corresponding to how strongly you disagree or agree with the sentence.
- Part C: There are 2 short answer questions. Please print your answer.

Thank you for your cooperation

Part A: *Please answer the following questions (CIRCLE where appropriate):*

Student Number:____

Student Name: :____

(Please **circle** relevant responses to the questions below)

I am: **Full-Time** **Part-time**

I am: **School leaver** **Matured aged**

Gender: **Male** **Female**

Age: **17–19** **20-23** **24-27** **27-30** **31-35** **35-40** **41-45** **45+**

OP score: (or equivalent)____________________________

Returning the *ICTs in Education* subject student: **Yes** **No**

Returning University students: Yes **No**

Previous education level: ____

Previous highest qualifications level:______________________________________

<u>Part B:</u> Please circle the number corresponding to how strongly you disagree or agree with the sentence. Please **answer all statements, thank you.**

SD= Strongly disagree; D: Disagree; U: Undecided; A: Agree; SA: Strongly agree

		SD	D	U	A	SA
1	I know what is required of a first-year university student	1	2	3	4	5
2	I really like being a university student	1	2	3	4	5
3	I really want to be a teacher	1	2	3	4	5
4	I have a clear idea of what is expected of me in this subject	1	2	3	4	5
5	I know what I am trying to accomplish with my learning	1	2	3	4	5
6	I enjoy the intellectual challenge of this subject	1	2	3	4	5
7	I get a lot of satisfaction from studying	1	2	3	4	5
8	If I do not enjoy the subject, I do not want to learn	1	2	3	4	5
9	When I try, I generally succeed	1	2	3	4	5
10	I find it is difficult to get myself motivated to study	1	2	3	4	5
11	I keep trying until I succeed	1	2	3	4	5
12	I give my opinions during tutorial discussion	1	2	3	4	5
13	I have a strong desire to do well in this subject	1	2	3	4	5
14	I prefer complex to simple questions	1	2	3	4	5
15	I keep thinking about information or an issue until I understand it	1	2	3	4	5
16	I would rather do something that requires little thought than something that is sure to challenge my thinking abilities	1	2	3	4	5
17	Learning new ways to learn doesn't excite me very much	1	2	3	4	5
18	I really enjoy a task that involves coming up with new solutions to problem	1	2	3	4	5
19	I value opinions that differ from mine	1	2	3	4	5
20	I am willing to change my ideas when evidence show that my ideas are week	1	2	3	4	5
21	I prefer to agree with other people's ideas rather than formulate my own opinion	1	2	3	4	5
22	I study with other students	1	2	3	4	5
23	I sit back when working with other students in activities during class	1	2	3	4	5
24	I work with classmates outside of class	1	2	3	4	5
25	Working together can help me gain a deeper understanding the *ICTs in Education* subject	1	2	3	4	5
26	I learn through discussion with other student	1	2	3	4	5
27	I ask other students for help when I encounter difficulties in solving the *ICTs in Education subject*	1	2	3	4	5

28	Other students work with me to achieve the *ICTs in Education subject*	1	2	3	4	5
29	I do not need to use a variety of strategies to be an effective learner	1	2	3	4	5
30	I regularly seek the assistance of the teaching staff	1	2	3	4	5
31	I prefer findings answers by myself rather than getting hep	1	2	3	4	5
32	When solving problems, I identify unexpected results as wells expected ones	1	2	3	4	5
33	I find out answers to questions by relying on the subject materials	1	2	3	4	5
34	I automatically recall relevant information when solving problems	1	2	3	4	5
35	If I forget the answer, I can usually think my way through	1	2	3	4	5
36	When reading, I try to connect things I am reading about with things I already know	1	2	3	4	5
37	I ask myself questions in order to make sure I am reading about with things I already know	1	2	3	4	5
38	When writing, I am more likely to paraphrase an author's words rather than use my own words	1	2	3	4	5
39	I try to remember solutions to similar computer problems in order to solve a computer problem	1	2	3	4	5
40	I find it really hard to keep up with the volume of work in the *ICTs in Education subject*	1	2	3	4	5
41	My other university workload is not as heavy	1	2	3	4	5
42	I find it difficult to comprehend a lot of the *ICTs in Education* material I am supposed to understand	1	2	3	4	5
43	I feel overwhelmed by all I have to do	1	2	3	4	5
44	I have difficulty adjusting to the styles of teaching at university	1	2	3	4	5
45	I can miss most of the Mas lecture in first-year because most notes and materials are on the web	1	2	3	4	5
46	I only read what I have to do in the *ICTs in Education* Web Lecture Topic in order to answer the question	1	2	3	4	5
47	If I do not have my tutorial reaction paper completed, I do not attend the tutorial for that topic	1	2	3	4	5
48	I usually do an assignment just before it is due	1	2	3	4	5
49	If I spend a lot of hours on my assignment, I will get a very good mark	1	2	3	4	5
50	When it comes to the exam, I usually try to memorise the content	1	2	3	4	5

Part C:

1. List some adjectives (e.g., committed or scared) that describe you as a learner

________________________________ ________________________________

________________________________ ________________________________

2. What problems did you have in studying this subject?

____

____

Appendix C: Seven Mental Model Subscales

Sense of Purpose and Expectations Mental Model (5 items)

Q1. I know what is required of a first-year university student

Q2. I really like being a university student

Q3. I really want to be a teacher

Q4. I have a clear idea of what is expected of me in this subject

Q5. I know of what I expected to accomplish with my learning

Motivation Mental Model (7 items)

Q6. I enjoy the intellectual challenge of this subject

Q7. I get a lot of satisfaction from studying

Q8. If I do not enjoy the subject, I do not want to learn

Q9. When I try, I generally succeed

Q11. I keep trying until I succeed

Q13. I have a strong desire to do well in this subject

Q18. I really enjoy a task that involves coming up with new solutions to problems

Learning Strategy Mental Model (10 items)

Q12. I give my opinions during tutorial discussions

Q14. I prefer complex to simple questions

Q19. I value opinions that differ from mine

Q20. I am willing to change my ideas when evidence shows that my ideas are weak

Q31. I prefer finding answers by myself rather than getting help

Q32. When solving problems, I identify unexpected results as well as expected ones

Q34. I automatically recall relevant information when solving problems

Q35. If I forgot the answer, I can usually think my way through

Q36. When reading, I try to connect things I am reading about with things I already know

Q37. I ask myself questions in order to make sure I understand the content I have been studying

Un-motivation and Ineffective Learning Strategy Mental Model (11items)

Q10. I find it is difficult to get myself motivated to study

Q17. Learning new ways to learn doesn’t excite me

Q15. I would rather do something that requires little thought

Q16. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities

Q21. I prefer to agree with other people's ideas than formulate my own opinions

Q23. I sit back when working with other students in activities during class

Q30. I regularly seek the assistance of the teaching staff

Q33. I find out answers to questions by relying on the subject materials

Q29. I do not need to use a variety of strategies to be an effective learner

Q38. When writing, I am more likely to paraphrase an author's words rather than use my own words

Q39. I try to remember solutions to similar problems in order to solve a computer problem

Collaboration Mental Model (6 items)

Q22. I study with other students

Q24. I work with classmates outside of class

Q25. Working together can help me gain a deeper understanding the *ICTs in Education* subject

Q26. I learn through discussion with other students

Q27. I ask other students for help when I encounter difficulties in solving the *ICTs in Education* subject

Q28. Other students work with me to achieve the learning goals of the *ICTs in Education* subject

Poor Comprehending and coping Mental Model (5 items)

Q40. I find it really hard to keep up with the volume of work in the *ICTs in Education* subject

Q41. My other university workload is not as heavy

Q42. I find it difficult to comprehend a lot of the *ICTs in Education* subject material I am supposed to understand

Q43. I feel overwhelmed by all I have to do

Q44. I have difficulty adjusting to the style of teaching at university

Poorly Prepared and Absent Mental Model (6 items)

Q45. I can miss most of the Mass lectures in first-year because most notes and materials are on the web

Q46. I only read what I have to do in the Web Lecture Topic of the *ICTs in Education* subject in order to answer the question

Q47. If I do not have my tutorial reaction paper completed, I do not attend the tutorial for that topic

Q48. I usually do an assignment just before it is due

Q49. When I spend a lot of hours on my assignment, I will get a very good mark

Q50. When it comes to the exam, I usually try to memorise the content

Appendix D: INFORMATION PAGE (STUDENTS)

INVESTIGATOR:	Trang Nguyen
PROJECT TITLE:	Mental Models of First-Year Education Students Studying Information Communication Technologies
SCHOOL	School of Education, James Cook University, Townsville Qld 4811
CONTACT DETAILS	Trang Nguyen Phone: (W) 4781 5667 Email: Trang.Nguyen@jcu.edu.au

Dear Student,

This letter is to inform you of the nature and purpose of the research I am completing as part of my PhD degree at James Cook University. The purpose of this study is to investigate first-year bachelor students' mental models studying the *Information Communication Technologies in Education* subject.

You are invited to participate in this study. The advantage of participating in the study helps provide you with insight into the processes of your thinking and learning strategies. You will be contributing to a much-needed body of knowledge in students' mental models and their relationship to students 'learning achievements.

The findings of the research on first-year, first semester university Bachelor of Education students' mental models and their learning achievements will enhance understanding of how the course is being processed and, hence, improve future subject redesign to further enhance student learning strategies. The lecturer and School of Education are committed to evaluating and improving (where needed) teaching and learning, particularly in first-year experience. The findings will also help James Cook and other universities refine their first-year mentoring strategies.

- If you have any concerns about this project, please contact me at the phone number: 4781 5657, or email: trang.nguyen@jcu.edu.au.
- If you have any questions regarding the ethical conduct of the research project, please contact the Human Ethics Sub-Committee at the phone number: 4781 4342.

INFORMATION:

A. Pre/Post-survey:

Each volunteer student will be invited to complete a pre/post questionnaire with attached open-ended questions: one at the beginning and one at the end of this semester (approximately 15 minutes each).

B. Confidentiality:

1. As by its nature the research needs to capture changes in students' mental models during their study, volunteer students will be asked to give the following on the pre/post questionnaires:
    a. Student number (for SPSS data tracking purposes), but NOT your name
    b. Age
    c. Gender
    d. School leaver or Matured aged entry status
    e. OP score or equivalent
    f. Returning the *ICTs in Education* subject student
    g. Returning University student
    h. Previous highest education level
2. No personal identifying information will be released into the public domain; only global categories such as gender, age, and entry status where applicable.
3. Participants' information will be kept confidential. NO names, NO students number or any identifying information of students will be used in the thesis or other published material.
4. Because the lecturer is my principal supervisor, she will only have access to your data (SPSS and printed transcripts) after the student number is deleted.
5. My co supervisor will only have access to students' data (SPSS and printed transcripts) after the student number is deleted.
6. The tutors and demonstrators will not see any of your comments or your data. They will only have access to the completed thesis and any publications.
7. Information from this study will be used only for my thesis, any articles, and conferences proceedings.
8. The outcomes of this study will be presented as part of my PhD's thesis in written form and a copy of this and of any published articles or conference proceedings will be made available to JCU and to the students.
9. James Cook University has approved this research and how it will be conducted. The Ethics No is:___________________

Thank you for your consideration of and involvement with this research project.

Trang Nguyen

Appendix E: INFORMED CONSENT FORM (STUDENTS)

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Appendix F: INFORMATION CONSENT FORM (PARENTS)

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Appendix G: Principal Component Extraction

Table F. Principal component extraction

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.557	15.114	15.114	7.557	15.114	15.114
2	3.887	7.774	22.888	3.887	7.774	22.888
3	3.287	6.575	29.462	3.287	6.575	29.462
4	2.921	5.843	35.305	2.921	5.843	35.305
5	2.367	4.734	40.040	2.367	4.734	40.040
6	2.003	4.006	44.046	2.003	4.006	44.046
7	1.894	3.788	47.834	1.894	3.788	47.834
8	1.711	3.421	51.256	1.711	3.421	51.256
9	1.501	3.002	54.258	1.501	3.002	54.258
10	1.442	2.883	57.141	1.442	2.883	57.141
11	1.351	2.703	59.843	1.351	2.703	59.843
12	1.269	2.538	62.382	1.269	2.538	62.382
13	1.217	2.434	64.816	1.217	2.434	64.816
14	1.102	2.204	67.020	1.102	2.204	67.020
15	1.065	2.130	69.150	1.065	2.130	69.150
16	1.018	2.036	71.187	1.018	2.036	71.187
17	.934	1.869	73.055			
18	.910	1.820	74.875			
19	.875	1.750	76.626			
20	.828	1.657	78.282			
21	.802	1.604	79.886			
22	.749	1.499	81.385			
23	.714	1.428	82.813			
24	.680	1.361	84.174			
25	.607	1.215	85.388			
26	.605	1.210	86.598			
27	.562	1.124	87.722			
28	.524	1.048	88.770			
29	.510	1.020	89.790			
30	.489	.978	90.768			
31	.440	.880	91.648			
32	.400	.801	92.449			
33	.386	.773	93.222			
34	.374	.749	93.970			
35	.353	.707	94.677			
36	.318	.636	95.313			
37	.296	.591	95.905			

38	.274	.547	96.452			
39	.241	.482	96.934			
40	.221	.442	97.376			
41	.207	.414	97.790			
42	.179	.359	98.148			
43	.171	.342	98.490			
44	.156	.312	98.802			
45	.138	.277	99.079			
46	.130	.259	99.338			
47	.110	.220	99.557			
48	.090	.180	99.738			
49	.069	.138	99.875			
50	.062	.125	100.000			

Appendix H: Varimax Rotation

Table H.1 Principal Component Factor Analysis - Varimax Rotation

	Component				
	1	2	3	4	5
Q1. I keep trying until I succeed	.667	.140	.066	.187	-.106
Q47. If I do not have my tutorial reaction paper completed, I do not attend the tutorial for that topic	-.628	-.049	-.060	.137	.098
Q15. I keep thinking about information or an issue until I understand	.626	-.003	-.077	.048	-.128
Q45. I can miss most of the Mass lectures in first-year because most notes and materials are on the web	-.617	.018	-.050	.187	.002
Q13.I have a strong desire to do well in this subject	.584	.098	.056	-.105	.082
Q3. I really want to be a teacher	.565	-.060	.142	.140	-.093
Q12. I give my opinions during tutorial discussions	.550	.041	-.015	.306	-.153
Q18. I really enjoy a task that involves coming up with new solutions to problems	.507	.337	.111	.023	.004
Q48. I usually do an assignment just before it is due	-.493	-.026	.059	.333	.232
Q21. I prefer to agree with other people's ideas than formulate my own opinions	-.477	.108	.248	-.063	.367
Q37. I ask myself questions in order to make sure I understand the content I have been studying	.465	.116	.287	.248	-.218
Q46. I only read what I have to do in the Web Lecture Topic of the *ICTs in Education* subject in order to answer the question	-.453	-.102	.284	.383	.044
Q5. I know what I am trying to accomplish with my learning	.449	.403	.018	.243	-.263
Q7. I get a lot of satisfaction from studying	.446	.313	.036	.022	-.382
Q6. I enjoy the intellectual challenges of this subject	.427	.275	.046	.120	-.014
Q38.When writing, I am more likely to paraphrase an author’s words rather than use my own words	-.390	.120	.220	.211	.068
Q39. I try to remember solutions to similar problems in order to solve a computer problem	.375	.052	.019	.017	-.135
Q19. I value opinions that differ from me	.328	.142	.273	-.164	-.176
Q36. When reading, I try to connect things I am reading about with things I already know	.298	.057	.249	.134	.154
Q30. I regularly seek the assistance of the teaching staff	.159	-.068	-.031	.016	.019
Q43. I feel overwhelmed by all I have I do	.097	-.708	.138	-.013	.205
Q42. I find it difficult to comprehend a lot of the *ICTs in Education* subject material	.096	-.672	-.136	.147	.166
Q4. I have a clear idea of what is expected of me in this subject	.078	.649	-.062	.076	.101
Q40. I find it really hard to keep up with the volume of work in the *ICTs in Education* subject	.036	-.598	-.264	.111	.098
Q44. I have difficulty adjusting to the style of teaching at university	-.049	-.554	.148	-.029	.297

Q1. I know what is required of a first-year university student	.124	.548	-.150	.287	-.113
Q2. I really like being a university student	.363	.470	.196	.054	-.038
Q41. My other workload is not as heavy	-.113	-.441	.024	.050	-.175
Q31. I prefer finding answers by myself rather than getting help	.305	.352	.030	.282	-.022
Q27. I ask other students for help when I encounter difficulties in solving *ICTs in Education* subject	-.022	-.111	.764	-.019	-.070
Q24. I work with classmates outside of class on assignments	-.031	.088	.706	-.228	.187
Q28. Other students work with me to achieve *ICTs in Education* subject learning goals	.162	.026	.648	-.005	.225
Q26. I learn through discussion with other students	.162	-.128	.605	.041	-.295
Q22. I study with other students	.039	.140	.600	-.129	.191
Q25. Working together can help me gain a deeper understanding the *ICTs in Education* subject	-.239	-.171	.558	.038	-.147
Q20. I am willing to change my ideas when evidences show that my ideas are weak	.369	.196	.382	-.189	.013
Q35. If I forgot the answer, I can usually think my way through	.272	.150	-.075	.589	.086
Q29. I do not need to use a variety of strategies to be an effective learner	-.287	.050	-.055	.541	.008
Q49. When I spend a lot of hours on my assignment, I will get a very good mark	-.115	.017	.013	.529	.124
Q9.When I try, I generally succeed	.438	.077	-.109	.526	-.025
Q34. I automatically recall relevant information when solving problems	.088	-.004	-.107	.495	-.069
Q17. Learning new ways to learn doesn't excite me	-.421	-.190	-.080	.459	-.317
Q50. When it comes to the exam, I usually try to memorise the content	.016	-.055	.239	.389	.022
Q14. I prefer complex to simple questions	.088	-.019	-.206	.383	-.233
Q32.When solving problems, I identify unexpected results as well as expected ones	-.049	.297	-.039	.377	.169
Q8. If I do not enjoy the subject, I do not want to learn	.029	-.076	-.126	.367	.339
Q10. I find it is difficult to get myself motivated to study	.009	-.167	.002	.094	.827
Q33. I find out answers to questions by relying on the subject materials	-.229	-.151	-.015	-.007	.791
Q16. I would rather do something that requires little thought	-.356	.021	.102	.017	.540
Q23. I sit back when working with other students in activities during class	-.357	-.109	.150	.064	.461

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Table H.2 Principal Component Factor Analysis – Component Transformation Matrix

Component Transformation Matrix

Component	1	2	3	4	5
1	.841	.404	.052	.062	-.350
2	.124	-.103	.807	-.529	.206
3	-.283	.659	.407	.517	.230
4	.377	-.554	.166	.605	.397
5	-.234	-.293	.390	.290	-.790

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Appendix I: Results of Independent t-Test – Mental Models by Gender

Table I.1 Group Statistics – Mental Models by Gender

		N	Mean	Std. Deviation	Std. Error Mean
Pre-Sense of Purpose and Expectation Mental Model	Female	78	19.46	2.597	.294
	Male	24	19.75	2.591	.529
Post- Sense of Purpose and Expectation Mental Model	Female	78	18.79	2.467	.279
	Male	24	18.98	2.225	.454
Pre-Motivation Mental Model	Female	78	26.24	3.006	.340
	Male	24	24.54	3.966	.809
Post-Motivation Mental Model	Female	78	25.18	2.652	.300
	Male	24	24.67	3.007	.612
Pre-Learning Strategy Mental Model	Female	78	35.83	3.787	.428
	Male	24	34.68	3.441	.702
Post-Learning Strategy Mental Model	Female	78	36.01	3.473	.393
	Male	24	35.47	3.515	.717
Pre-Collaboration Mental Model	Female	78	20.84	3.640	.412
	Male	24	20.00	3.889	.794
Post-Collaboration Mental Model	Female	78	20.67	4.040	.457
	Male	24	19.46	3.981	.812
Pre-Poor Coping and Comprehension Mental Model	Female	78	15.35	3.536	.400
	Male	24	15.28	3.065	.625
Post-Poor Coping and Comprehension Mental Model	Female	78	18.12	3.492	.395
	Male	24	15.73	4.664	.952
Pre-Un-motivation and Ineffective Learning Strategy Mental Model	Female	78	29.48	3.270	.370
	Male	24	31.37	3.114	.635
Post- Un-motivation and Ineffective Learning Strategy Mental Model	Female	78	30.83	3.650	.413
	Male	24	32.18	4.356	.889
Pre- Poorly Prepared and Absent Mental Model	Female	78	13.48	2.617	.296
	Male	24	15.78	2.257	.460
Post- Poorly Prepared and Absent Mental Model	Female	78	14.60	3.067	.347
	Male	24	16.33	2.219	.453

Table I.2 Results of Independent t-Test – Mental Models by Gender

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-Sense of Purpose and Expectation Mental Model	.463	.498	.-47	100	.635	-.28	.60	-1.49	.91
			-.47	38.31	.636	-.28	.60	-1.51	.93
Post- Sense of Purpose and Expectation Mental Model	.223	.638	-.34	100	.734	-.19	.56	-1.31	.92
			-.36	41.89	.720	-.19	.53	-1.26	.88
Pre-Motivation Mental Model	1.229	.270	2.23	100	.027	1.69	.75	.19	3.20
			1.93	31.55	.062	1.69	.87	-.09	3.48
Post-Motivation Mental Model	1.139	.288	.79	100	.427	.50	.63	-.75	1.77
			.74	34.78	.460	.50	.68	-.87	1.89
Pre-Learning Strategy Mental Model	.517	.474	1.33	100	.186	1.15	.86	-.56	2.87
			1.40	41.61	.168	1.15	.82	-.50	2.81
Post-Learning Strategy Mental Model	.324	.570	.66	100	.509	.53	.81	-1.07	2.15
			.65	37.87	.514	.53	.81	-1.11	2.19
Pre-Collaboration Mental Model	.268	.606	.98	100	.328	.84	.86	-.86	2.56
			.94	36.27	.349	.84	.89	-.96	2.66
Post-Collaboration Mental Model	.013	.910	1.29	100	.199	1.21	.93	-.64	3.08
			1.30	38.72	.200	1.21	.93	-.67	3.10
Pre-Poor Coping and Comprehension Mental Model	.726	.396	.08	100	.930	.07	.80	-1.51	1.66
			.095	43.51	.924	.07	.74	-1.42	1.56
	5.719	.019	2.69	100	.008	2.38	.88	.629	4.14

Post-Poor Coping and Comprehension Mental Model			2.31	31.34	.027	2.38	1.03	.28	4.48
Pre-Un-motivation and Ineffective Learning Strategy Mental Model	.008	.931	-2.49	100	.014	-1.88	.75	-3.38	-.38
			-2.56	39.87	.014	-1.88	.73	-3.37	-.39
Post- Un-motivation and Ineffective Learning Strategy Mental Model	1.34	.250	-1.51	100	.132	-1.35	.89	-3.12	.41
			-1.38	33.54	.176	-1.35	.98	-3.34	.63
Pre- Poorly Prepared and Absent Mental Model	22.87	.093	-3.87	100	.000	-2.29	.59	-3.47	-1.11
			-4.18	43.72	.000	-2.29	.54	-3.39	-1.19
Post- Poorly Prepared and Absent Mental Model	3.14	.079	-2.56	100	.012	-1.73	.67	-3.07	-.39
			-3.03	52.56	.004	-1.73	.57	-2.87	-.58

Appendix J: Results of Independent Sample t-Test –Mental Models by School Completion Time

Table J.1 Group Statistics – Mental Models by School Completion Time

	School Leaver/Mature Age	N	Mean	Std. Deviation	Std. Error Mean
Pre-Sense of Purpose and Expectation Mental Model	School Leaver	52	19.36	2.67	.37
	Mature Age	50	19.70	2.50	.35
Post- Sense of Purpose and Expectation Mental Model	School Leaver	52	18.82	2.24	.31
	Mature Age	50	18.86	2.57	.36
Pre-Motivation Mental Model	School Leaver	52	25.23	3.62	.50
	Mature Age	50	26.48	2.85	.40
Post-Motivation Mental Model	School Leaver	52	24.26	2.58	.35
	Mature Age	50	25.90	2.65	.37
Pre-Learning Strategy Mental Model	School Leaver	52	35.19	4.06	.56
	Mature Age	50	35.94	3.32	.47
Post-Learning Strategy Mental Model	School Leaver	52	35.11	3.38	.46
	Mature Age	50	36.68	3.41	.48
Pre-Collaboration Mental Model	School Leaver	52	20.94	3.19	.44
	Mature Age	50	20.34	4.16	.58
Post-Collaboration Mental Model	School Leaver	52	20.25	3.81	.52
	Mature Age	50	20.54	4.29	.60
Pre-Poor Coping and Comprehension Mental Model	School Leaver	52	15.26	3.44	.47
	Mature Age	50	15.41	3.41	.48
Post-Poor Coping and Comprehension Mental Model	School Leaver	52	17.56	3.80	.52
	Mature Age	50	17.55	4.05	.57
Pre-Un-motivation and Ineffective Learning Strategy Mental Model	School Leaver	52	30.73	3.40	.47
	Mature Age	50	29.09	3.03	.42
Post- Un-motivation and Ineffective Learning Strategy Mental Model	School Leaver	52	32.18	3.56	.49
	Mature Age	50	30.08	3.87	.54
Pre- Poorly Prepared and Absent Mental Model	School Leaver	52	14.08	2.72	.37
	Mature Age	50	13.96	2.72	.38
Post- Poorly Prepared and Absent Mental Model	School Leaver	52	15.84	2.70	.37
	Mature Age	50	14.14	3.01	.42

Table J.2 Results of Independent Sample t-Test – Mental Models by School Completion Time

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-Sense of Purpose and Expectation Mental Model	.278	.599	-.651	100	.516	-.334	.512	-1.35	.684
			-.652	99.91	.516	-.334	.512	-1.35	.683
Post-Sense of Purpose and Expectation Mental Model	.601	.440	-.081	100	.935	-.038	.478	-.98	.910
			-.081	96.97	.935	-.038	.479	-.99	.913
Pre-Motivation Mental Model	1.578	.212	-1.937	100	.056	-1.25	.648	-2.54	.030
			-1.946	96.33	.055	-1.25	.645	-2.53	.025
Post-Motivation Mental Model	.017	.896	-3.158	100	.002	-1.63	.518	-2.66	-.60
			-3.157	99.57	.002	-1.63	.518	-2.66	-.60
Pre-Learning Strategy Mental Model	2.129	.148	-1.019	100	.311	-.75	.737	-2.21	.71
			-1.023	97.53	.309	-.75	.734	-2.20	.70
Post-Learning Strategy Mental Model	.005	.943	-2.335	100	.022	-1.57	.673	-2.90	-.23
			-2.334	99.75	.022	-1.57	.673	-2.90	-.23
Pre-Collaboration Mental Model	1.696	.196	.826	100	.411	.60	.733	-.849	2.06
			.821	91.85	.414	.60	.737	-.858	2.07
Post-Collaboration Mental Model	.566	.453	-.364	100	.717	-.29	.803	-1.88	1.30
			-.363	97.63	.717	-.29	.805	-1.89	1.30
Pre-Poor Coping and Comprehension Mental Model	.248	.619	-.226	100	.822	-.15	.680	-1.50	1.19
			-.226	99.90	.822	-.15	.679	-1.50	1.19
Post- Poor Coping and Comprehension Mental Model	.193	.661	.018	100	.985	.014	.778	-1.52	1.55
			.018	98.95	.985	.014	.779	-1.53	1.56
	.592	.444	2.550	100	.012	1.63	.639	.362	2.90

Pre-Un-motivation and Ineffective Learning Strategy Mental Model			2.556	99.43	.012	1.63	.638	.365	2.89
Post- Un-motivation and Ineffective Learning Strategy Mental Model	.351	.555	2.846	100	.005	2.09	.736	.635	3.55
			2.842	98.52	.005	2.09	.738	.632	3.56
Pre- Poorly Prepared and Absent Mental Model	.351	.555	.216	100	.829	.11	.539	-.955	1.18
			.216	99.85	.829	.11	.539	-.952	1.18
Post - Poorly Prepared and Absent Mental Model	.433	.512	3.006	100	.003	1.70	.566	.579	2.82
			2.999	97.84	.003	1.70	.568	.576	2.83

Appendix K: One-way ANOVAs (Examination Results)

Table K.1 Descriptive Statistics- Examination Results

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Post-Sense of Purpose and Expectation Mental Model	12-20	21	18.66	2.24	.489	17.64	19.68	14.00	22.00
	21-25	39	18.35	2.49	.399	17.54	19.16	13.00	23.00
	26-35	36	19.15	2.44	.407	18.33	19.98	14.00	24.00
	Total	96	18.72	2.42	.247	18.23	19.21	13.00	24.00
Post-Motivation Mental Model	12-20	21	24.20	2.40	.523	23.10	25.29	21.00	29.00
	21-25	39	24.39	2.32	.373	23.64	25.15	20.00	29.00
	26-35	36	25.97	3.00	.501	24.95	26.99	20.00	32.00
	Total	96	24.94	2.71	.277	24.39	25.49	20.00	32.00
Post-Learning Strategy Mental Model	12-20	21	36.19	3.09	.674	34.78	37.59	31.00	42.00
	21-25	39	34.89	3.27	.524	33.83	35.95	30.00	40.00
	26-35	36	36.70	3.66	.611	35.46	37.94	30.00	44.00
	Total	96	35.85	3.45	.352	35.15	36.55	30.00	44.00
Post-Collaboration Mental Model	12-20	21	20.19	5.54	1.210	17.66	22.71	9.00	30.00
	21-25	39	20.69	3.41	.547	19.58	21.80	15.00	27.00
	26-35	36	20.25	3.70	.616	19.00	21.50	9.00	28.00
	Total	96	20.41	4.03	.411	19.60	21.23	9.00	30.00
Post-Poor Coping and Comprehension Mental Model	12-20	21	17.76	3.65	.798	16.09	19.42	10.00	24.00
	21-25	39	17.57	4.05	.648	16.26	18.89	6.00	25.00
	26-35	36	16.96	3.76	.627	15.68	18.23	9.00	24.00
	Total	96	17.38	3.83	.391	16.61	18.16	6.00	25.00
Post-Un-motivation and Ineffective Learning Strategy Mental Model	12-20	21	33.00	3.63	.792	31.34	34.65	25.00	39.00
	21-25	39	30.77	3.31	.530	29.70	31.84	24.00	38.00
	26-35	36	30.17	4.28	.713	28.72	31.62	22.00	40.00
	Total	96	31.03	3.88	.396	30.25	31.82	22.00	40.00
Post-Poorly Prepared and Absent Mental Model	12-20	21	15.47	3.34	.729	13.95	16.99	7.00	20.00
	21-25	39	15.58	2.65	.424	14.72	16.44	10.00	21.00
	26-35	36	14.16	3.06	.510	13.12	15.20	9.00	20.00
	Total	96	15.03	3.01	.307	14.41	15.64	7.00	21.00

Table K.2 Results of One-Way ANOVA- Examination Results

		Sum of Squares	Df	Mean Square	F	Sig.
Post-Sense of Purpose and Expectation Mental Model	Between Groups	12.05	2	6.03	1.025	.363
	Within Groups	546.68	93	5.88		
	Total	558.73	95			
Post-Motivation Mental Model	Between Groups	61.39	2	30.70	4.472	.014
	Within Groups	638.38	93	6.86		
	Total	699.78	95			
Post-Learning Strategy Mental Model	Between Groups	64.13	2	32.06	2.787	.067
	Within Groups	1069.82	93	11.50		
	Total	1133.95	95			
Post-Collaboration Mental Model	Between Groups	4.99	2	2.50	.151	.860
	Within Groups	1538.76	93	16.55		
	Total	1543.76	95			
Post-Poor Coping and Comprehension Mental Model	Between Groups	10.84	2	5.42	.364	.696
	Within Groups	1386.82	93	14.91		
	Total	1397.66	95			
Post- Un-motivation and Ineffective Learning Strategy Mental Model	Between Groups	110.26	2	55.13	3.878	.024
	Within Groups	1322.14	93	14.22		
	Total	1432.40	95			
Post-Poorly Prepared and Present Mental Model	Between Groups	43.11	2	21.55	2.445	.092
	Within Groups	819.80	93	8.82		
	Total	862.91	95			

Table K.3 Post Hoc Bonferroni- Examination Results

Dependent Variable	(I) EXAM	(J) EXAM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Post-Sense of Purpose and Expectation Mental Model	12-20	21-25	0.31	0.66	1.000	-1.29	1.91
		26-35	-0.49	0.67	1.000	-2.11	1.13
	21-25	12-20	-0.31	0.66	1.000	-1.91	1.29
		26-35	-0.80	0.56	.472	-2.17	0.57
	26-35	12-20	0.49	0.67	1.000	-1.13	2.11
		21-25	0.80	0.56	.472	-0.57	2.17
Post-Motivation Mental Model	12-20	21-25	-0.20	0.71	1.000	-1.92	1.53
		26-35	-1.77*	0.72	.047	-3.53	-0.02
	21-25	12-20	0.20	0.71	1.000	-1.53	1.92
		26-35	-1.57*	0.61	.032	-3.05	-0.10
	26-35	12-20	1.77*	0.72	.047	0.02	3.53
		21-25	1.57*	0.61	.032	0.10	3.05
Post-Learning Strategy Mental Model	12-20	21-25	1.29	0.92	.487	-0.95	3.53
		26-35	-0.51	0.93	1.000	-2.78	1.76
	21-25	12-20	-1.29	0.92	.487	-3.53	0.95
		26-35	-1.81	0.78	.070	-3.72	0.10
	26-35	12-20	0.51	0.93	1.000	-1.76	2.78
		21-25	1.81	0.78	.070	-0.10	3.72
Post-Collaboration Mental Model	12-20	21-25	-0.50	1.10	1.000	-3.19	2.18
		26-35	-0.06	1.12	1.000	-2.79	2.66
	21-25	12-20	0.50	1.10	1.000	-2.18	3.19
		26-35	0.44	0.94	1.000	-1.85	2.73
	26-35	12-20	0.06	1.12	1.000	-2.66	2.79
		21-25	-0.44	0.94	1.000	-2.73	1.85
Post-Poor Coping and Comprehension Mental Model	12-20	21-25	0.18	1.05	1.000	-2.36	2.73
		26-35	0.80	1.06	1.000	-1.79	3.38
	21-25	12-20	-0.18	1.05	1.000	-2.73	2.36
		26-35	0.61	0.89	1.000	-1.56	2.79
	26-35	12-20	-0.80	1.06	1.000	-3.38	1.79
		21-25	-0.61	0.89	1.000	-2.79	1.56

Post- Un-motivation and Ineffective Learning Strategy Mental Model	12-20	21-25	2.22	1.02	.095	-0.26	4.71
		26-35	2.83*	1.04	.023	0.30	5.35
	21-25	12-20	-2.22	1.02	.095	-4.71	0.26
		26-35	0.60	0.87	1.000	-1.53	2.72
	26-35	12-20	2.83*	1.04	.023	-5.35	-0.30
		21-25	-0.60	0.87	1.000	-2.72	1.53
Post-Poorly Prepared and Absent Mental Model	12-20	21-25	-0.11	0.80	1.000	-2.07	1.85
		26-35	1.31	0.82	.335	-0.68	3.30
	21-25	12-20	0.11	0.80	1.000	-1.85	2.07
		26-35	1.42	0.69	.124	-0.25	3.09
	26-35	12-20	-1.31	0.82	.335	-3.30	0.68
		21-25	-1.42	0.69	.124	-3.09	0.25

*. The mean difference is significant at the 0.05 level.

Appendix L: One-way ANOVAs (Academic Grades)

Table L.1 Descriptive Statistics- Academic Grades

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Post-Sense of Purpose and Expectation Mental Model	HD and D	29	18.68	2.65	0.49	17.67	19.69	13.00	24.00
	C	26	18.38	2.17	0.43	17.51	19.26	15.00	22.00
	P	32	18.75	2.49	0.44	17.85	19.65	13.00	23.00
	F	15	20.13	1.81	0.47	19.13	21.13	17.00	24.00
	Total	102	18.84	2.40	0.24	18.37	19.31	13.00	24.00
Post-Motivation Mental Model	HD and D	29	25.76	3.16	0.59	24.56	26.96	20.00	32.00
	C	26	24.71	2.58	0.51	23.67	25.75	20.00	30.00
	P	32	24.35	2.32	0.41	23.51	25.19	20.00	28.00
	F	15	25.87	2.64	0.68	24.40	27.33	21.00	29.00
	Total	102	25.07	2.73	0.27	24.53	25.60	20.00	32.00
Post-Learning Strategy Mental Model	HD and D	29	35.76	3.65	0.68	34.37	37.15	30.00	42.00
	C	26	35.77	3.69	0.72	34.28	37.26	30.00	44.00
	P	32	35.36	2.78	0.49	34.35	36.36	30.00	40.00
	F	15	37.47	3.94	1.02	35.28	39.65	31.00	44.00
	Total	102	35.89	3.47	0.34	35.20	36.57	30.00	44.00
Post-Collaboration Mental Model	HD and D	29	19.97	4.07	0.76	18.42	21.51	9.00	28.00
	C	26	20.73	3.60	0.71	19.28	22.18	14.00	30.00
	P	32	21.13	3.57	0.63	19.84	22.42	13.00	29.00
	F	15	19.07	5.44	1.41	16.05	22.08	9.00	25.00
	Total	102	20.39	4.04	0.40	19.60	21.19	9.00	30.00
Post-Poor Coping and Comprehension Mental Model	HD and D	29	17.90	3.59	0.67	16.53	19.26	9.00	25.00
	C	26	17.44	3.31	0.65	16.11	18.78	9.00	24.00
	P	32	16.77	4.56	0.81	15.13	18.41	6.00	25.00
	F	15	18.80	3.95	1.02	16.61	20.99	10.00	24.00

	Total	102	17.56	3.91	0.39	16.79	18.33	6.00	25.00
Post-Un-motivation and Ineffective Learning Strategy Mental Model	HD and D	29	30.03	3.93	0.73	28.53	31.52	22.00	39.00
	C	26	29.72	3.63	0.71	28.26	31.19	24.00	38.00
	P	32	32.44	3.55	0.63	31.16	33.72	26.00	40.00
	F	15	33.07	3.24	0.84	31.27	34.86	28.00	38.00
	Total	102	31.15	3.85	0.38	30.40	31.91	22.00	40.00
Post-Poorly Prepared and Absent Mental Model	HD and D	29	13.76	2.92	0.54	12.65	14.87	9.00	19.00
	C	26	14.69	2.74	0.54	13.58	15.79	7.00	19.00
	P	32	16.00	2.86	0.51	14.97	17.03	10.00	21.00
	F	15	15.87	2.95	0.76	14.23	17.50	10.00	20.00
	Total	102	15.01	2.97	0.29	14.42	15.59	7.00	21.00

Table L.2 Results of One-Way ANOVA- Academic Grades

		Sum of Squares	Df	Mean Square	F	Sig.
Post-Sense of Purpose and Expectation Mental Model	Between Groups	31.49	3	10.50	1.864	.141
	Within Groups	551.84	98	5.63		
	Total	583.33	101			
Post-Motivation Mental Model	Between Groups	43.23	3	14.41	1.988	.121
	Within Groups	710.41	98	7.25		
	Total	753.64	101			
Post-Learning Strategy Mental Model	Between Groups	47.31	3	15.77	1.319	.272
	Within Groups	1171.25	98	11.95		
	Total	1218.56	101			
Post-Collaboration Mental Model	Between Groups	51.99	3	17.33	1.064	.368
	Within Groups	1596.76	98	16.29		
	Total	1648.74	101			
Post-Poor Coping and Comprehension Mental Model	Between Groups	46.65	3	15.55	1.018	.388
	Within Groups	1497.36	98	15.28		
	Total	1544.01	101			
Post-Un-motivation and Ineffective Learning Strategy Mental Model	Between Groups	197.40	3	65.80	4.965	.003
	Within Groups	1298.76	98	13.25		
	Total	1496.16	101			
	Within Groups	802.51	98	8.19		
	Total	892.989	101			

Bonferroni

Table K.3 Post Hoc Bonferroni- Academic Grades

Bonferroni							
Dependent Variable	(I) Academic Grades	(J) Academic Grades	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Post-Sense of Purpose/Expectation Mental Models	HD and D	C	0.29	0.64	1.000	-1.4314	2.0203
		P	-0.07	0.61	1.000	-1.71	1.57
		F	-1.45	0.75	.341	-3.49	0.58
	C	HD and D	-0.29	0.64	1.000	-2.02	1.43
		P	-0.37	0.63	1.000	-2.05	1.32
		F	-1.75	0.77	.151	-3.82	0.32
	P	HD and D	0.07	0.61	1.000	-1.57	1.71
		C	0.37	0.63	1.000	-1.32	2.05
		F	-1.38	0.74	.393	-3.38	0.62
	F	HD and D	1.45	0.75	.341	-0.58	3.49
		C	1.75	0.77	.151	-0.32	3.82
		P	1.38	0.74	.393	-0.62	3.38
Post-Motivation Mental Model	HD and D	C	1.05	0.73	.913	-0.91	3.01
		P	1.41	0.69	.264	-0.45	3.27
		F	-0.11	0.86	1.000	-2.41	2.20
	C	HD and D	-1.05	0.73	.913	-3.01	0.91
		P	0.36	0.71	1.000	-1.56	2.27
		F	-1.16	0.87	1.000	-3.51	1.19
	P	HD and D	-1.41	0.69	.264	-3.27	0.45
		C	-0.36	0.71	1.000	-2.27	1.56
		F	-1.52	0.84	.450	-3.79	0.75
	F	HD and D	0.11	0.86	1.000	-2.20	2.41
		C	1.16	0.87	1.000	-1.19	3.51
		P	1.52	0.84	.450	-0.75	3.79
Post-Learning Strategy Mental Model	HD and C	C	-0.01	0.93	1.000	-2.52	2.50
		P	0.40	0.89	1.000	-1.98	2.79
		F	-1.71	1.10	.741	-4.67	1.25
	C	HD and D	0.01	0.93	1.000	-2.50	2.52

		P	0.41	0.91	1.000	-2.04	2.87
		F	-1.70	1.12	.799	-4.72	1.32
	P	HD and D	-0.40	0.89	1.000	-2.79	1.98
		C	-0.41	0.91	1.000	-2.87	2.04
		F	-2.11	1.08	.323	-5.02	0.80
	F	HD and D	1.71	1.10	.741	-1.25	4.67
		C	1.70	1.12	.799	-1.32	4.72
		P	2.11	1.08	.323	-0.80	5.02
Post-Collaboration Mental Model	HD and D	C	-0.77	1.09	1.000	-3.70	2.17
		P	-1.16	1.03	1.000	-3.95	1.62
		F	0.90	1.28	1.000	-2.56	4.36
	C	HD and D	0.77	1.09	1.000	-2.17	3.70
		P	-0.40	1.07	1.000	-3.27	2.47
		F	1.66	1.31	1.000	-1.86	5.19
	P	HD and D	1.16	1.03	1.000	-1.62	3.95
		C	0.40	1.07	1.000	-2.47	3.27
		F	2.06	1.26	.634	-1.34	5.46
	F	HD and D	-0.90	1.28	1.000	-4.36	2.56
		C	-1.66	1.31	1.000	-5.19	1.86
		P	-2.06	1.26	.634	-5.46	1.34
Post-Poor Coping and Comprehension Mental Model	HD and D	C	0.45	1.06	1.000	-2.39	3.30
		P	1.13	1.00	1.000	-1.57	3.82
		F	-0.90	1.24	1.000	-4.25	2.44
	C	HD and D	-0.45	1.06	1.000	-3.30	2.39
		P	0.67	1.03	1.000	-2.11	3.45
		F	-1.36	1.27	1.000	-4.77	2.06
	P	HD and D	-1.13	1.00	1.000	-3.82	1.57
		C	-0.67	1.03	1.000	-3.45	2.11
		F	-2.03	1.22	.602	-5.32	1.26
	F	HD and D	0.90	1.24	1.000	-2.44	4.25
		C	1.36	1.27	1.000	-2.06	4.77
		P	2.03	1.22	.602	-1.26	5.32
Post-Un-motivation and Ineffective Learning Strategy	HD and D	C	0.30	0.98	1.000	-2.34	2.95
		P	-2.41	0.93	.068	-4.92	0.11
		F	-3.04	1.16	.060	-6.16	0.08

Mental Model	C	HD and D	-0.30	0.98	1.000	-2.95	2.34
		P	-2.71*	0.96	.035	-5.30	-0.12
		F	-3.34*	1.18	.034	-6.52	-0.16
	P	HD and D	2.41	0.93	.068	-0.11	4.92
		C	2.71*	0.96	.035	0.12	5.30
		F	-0.63	1.14	1.000	-3.70	2.44
	F	HD and D	3.04	1.16	.060	-0.08	6.16
		C	3.34*	1.18	.034	0.16	6.52
		P	0.63	1.14	1.000	-2.44	3.70
Post-Poorly Prepared and Absent Mental Model	HD and D	C	-0.93	0.77	1.000	-3.01	1.15
		P	-2.24*	0.73	.017	-4.22	-0.27
		F	-2.11	0.91	.136	-4.56	0.34
	C	HD and D	0.93	0.77	1.000	-1.15	3.01
		P	-1.31	0.76	.514	-3.35	0.72
		F	-1.18	0.93	1.000	-3.68	1.32
	P	HD and D	2.24*	0.73	.017	0.27	4.22
		C	1.31	0.76	.514	-0.72	3.35
		F	0.13	0.90	1.000	-2.28	2.54
	F	HD and D	2.11	0.91	.136	-0.34	4.56
		C	1.18	0.93	1.000	-1.32	3.68
		P	-0.13	0.90	1.000	-2.54	2.28

*. The mean difference is significant at the 0.05 level.