SELF-REGULATED LEARNING STRATEGIES, CONCEPT UNDERSTANDING AND PERFORMANCE IN STATICS

HABIBAH @ NOREHAN HJ. HARON

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Engineering Education)

School of Graduate Studies
Universiti Teknologi Malaysia

SEPTEMBER 2012

Al-Fatihah to my late MOM Hjh. Kamariah Saadon and DAD Hj. Haron Kassim

To my FAMILY:

Nurul Hidayah, Muhammad Iman, Nurul Hasanah, Nurul Solehah, Norhizam

ACKNOWLEDGEMENTS

In the name of Allah the Most Beneficient and Benevolent. Alhamdulillah, thank you for giving me good health, energy, endurance and will to complete this study. I would like to express my gratitude to the Universiti Teknologi Malaysia for granting me a fully paid study leave and for providing all the valuable support.

Thank you to my supervisors Professor Dr. Awaluddin Mohamed Shaharoun and Associate Prof. Dr. Marlia Puteh for their mentoring, advice, understanding, continuous encouragement and beliefs in me. Thank you to all the professors who had conducted classes for the pioneer students in Engineering Education and had given their continuous support, to colleagues and friends who gave their full support and cooperation. Special thanks to Prof. Dr. Salleh, Mr. Abd. Rahman, Dr. Amir, Puan Safariah and Puan Latifah who had helped me in specific areas during my data collection. Thank you to the pioneer group of Engineering Education PhD candidates who shared ideas, experience, motivation, sweat, tears and laughter throughout this journey. The experience of going through this academic journey together was indeed very memorable.

Thank you to the administrative staff of the Graduate School, KST, Razak School and the Universiti Teknologi Malaysia in general who have helped make this journey a smoother one. Last but not least, my deepest appreciation and gratitude to my dear family members who have been understanding and had given their full support and encouragement throughout this wonderful journey. Thank you to my siblings, nieces, nephews, in-laws, bibik, and special friends, especially for the doa.

ABSTRACT

Many students find Statics a difficult to understand fundamental engineering course, affecting their performance in the course and in other follow on courses, which consequently disheartened them from pursuing engineering as a career. This has prompted the researcher to carry out a preliminary study, which has revealed the challenges in the teaching and learning of Statics in three categories: student, teaching and learning, and nature of the course. Meanwhile, the educational psychology researchers claim that self-regulated learning (SRL) is important in students' academic achievement. Therefore, focussing on student learning, this study was carried out quantitatively to investigate the relationships between the concept understanding, performance in Statics and SRL. The data collected were from sample undergraduate students of four universities in Malaysia responding to the SRL questionnaire, and the Statics Concept Inventory test. Students' end of the semester Statics marks form one part of the data. Findings from the correlation analysis confirm the literature on the relationships between students' understanding of the fundamental engineering concepts and their academic performance. Results from the multiple regression analysis reveal that students' learning beliefs and self-efficacy, and their use of meta-cognitive regulation strategies are significant predictors of their concept understanding and performance in Statics. The findings are an addition to the current academic achievement literature, bridging the two research fields of educational psychology and engineering education. The study provides the engineering educators with a better appreciation and understanding of the complexity of engineering education as a whole. Specifically, the study provides a useful insight into students' learning of Statics, leading to an improved curriculum that could enhance understanding and performance of the engineering students and retain them in the engineering programme.

ABSTRAK

Ramai di kalangan pelajar kejuruteraan menghadapi kesulitan di dalam pembelajaran Statik yang merupakan mata pelajaran asas di dalam bidang kejuruteraan. Kesulitan yang dihadapi sering menyebabkan pelajar gagal di dalam mata pelajaran ini dan mata pelajaran berikutnya sehingga menyebabkan mereka tidak bersemangat untuk meneruskan pilihan kerjaya di dalam bidang kejuruteraan. Penyelidik telah melaksanakan kajian awal dan mengenalpasti tiga kategori cabaran di dalam pengajaran dan pembelajaran Statik: pelajar, pengajaran dan pembelajaran, dan sifat kursus. Penyelidik saikologi pendidikan menyatakan bahawa 'self-regulated learning' (SRL) penting untuk pencapaian akademik pelajar. Oleh itu, memfokus kepada pembelajaran pelajar, kajian ini telah dijalankan secara kuantitatif untuk melihat hubungan antara kefahaman konsep, pencapaian dalam Statik dan SRL. Data dikutip di kalangan sampel pelajar dari empat buah universiti di Malaysia yang menjawab soalan-soalan kajiselidik SRL dan ujian 'Statics Concept Inventory'. Markah Statik akhir semester turut dikumpul sebagai data untuk dianalisa. Analisis korelasi mengesahkan dapatan dari kajian literatur berkaitan hubungan di antara kefahaman pelajar tentang konsep-konsep dan pencapaian akademik mereka di dalam Statik. Dapatan dari analisis regresi berganda pula menunjukkan 'learning beliefs and self-efficacy' dan 'meta-cognitive regulation' adalah prediktor signifikan kepada kefahaman konsep dan pencapaian akademik dalam Statik. Dapatan kajian ini merupakan tambahan kepada literatur pencapaian akademik yang sedia ada, dan sebagai penghubung antara dua bidang kajian, iaitu saikologi pendidikan dan pendidikan kejuruteraan. Umumnya, kajian ini dapat membantu pendidik kejuruteraan untuk lebih menghargai dan memahami bidang kejuruteraan pendidikan yg kompleks. Secara khusus pula, ia memberikan kefahaman yang berguna tentang pembelajaran Statik, dan dapat membantu perekabentuk kurikulum menghasilkan kurikulum yang lebih mantap, meningkatkan kefahaman dan pencapaian pelajar-pelajar kejuruteraan, dan mengekalkan mereka di dalam bidang kejuruteraan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CPA	-	Cumulative Points Average
EFA	-	Exploratory Factor Analysis
IP	-	Information Processing
LASSI	-	Learning and Study Strategies Inventory
MSLQ	-	Motivated Strategies for Learning Questionnaire
PCA	-	Principal Component Analysis
SAL	-	Students' Approaches to Learning
SCI	-	Statics Concept Inventory
SPM	-	*Sijil Pelajaran Malaysia*
SPSS	-	Statistical Packages for the Social Sciences
SRL	-	Self-Regulated Learning
T&L	-	Teaching and Learning

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Statics is a fundamental engineering course which many students find to be difficult (Chen, Kadlowec, & Whittinghill, 2004; Dollár & Steif, 2007; Haik, 1999). The difficulty has often resulted in poor students' performance in Statics and other follow-on courses (Dollar & Steif, 2004; Sidhu & Ramesh, 2006), which consequently has often discouraged students from pursuing engineering (Milano & Golub, 2001, Sidhu & Ramesh, 2006). Additionally, studies on engineering students' academic achievement revealed that students who are academically successful do not necessarily have a deep understanding of fundamental concepts (Haron, 2008; Montfort, Brown, & Pollock, 2009; Streveler, Geist, Ammerman, Sulzbach, & Miller, 2006). There are claims that the difficulties in learning Statics are mainly due to universal impediment such as the difficult concepts, local culture and work habit of students (Chen et al., 2004; Steif, 2008). Meanwhile, researchers in self-regulated learning believe that students' perceptions of themselves as learners and their use of various processes to regulate their learning are critical in the academic achievement (Zimmerman, 1989). Therefore, this study seeks to understand the students' self-regulated learning (SRL) strategies that predict their understanding of the fundamental concepts and performance in Statics. The relationship between students' understanding of the fundamental concepts and performance in Statics is also examined.

1.2 Background of Problem

Friedman (2006), in his book ‘The World Is Flat’ emphasized the importance of having strong fundamentals in science and engineering for a society to be competing in the current world. Despite the changes in the global scenario which affected engineering training and education, the need for a strong base of engineering fundamentals has remained constant (Engineering, 2007). This notion is supported by Steif and Dollar (2003), who believed that for *engineers to be increasingly flexible in their careers and to adjust to an ever-widening range of technologies, they must have a firm command of basic engineering subjects*, such as Statics.

As a pre-requisite for other core engineering courses, students are expected to comprehend the key concepts in Statics at sufficient depth and to transfer this understanding to other courses and contexts, but many find it difficult (Chen et al., 2004; Dollár, Steif, & Strader, 2007). The concepts in Statics are challenging and continually build upon one another in increasing complexity (Chen et al., 2004). However, the learning strategies that students usually used are more inclined towards treating the problem solving in Statics as an exercise in mathematics, and ignoring the importance of understanding the conceptual details (Milano & Golub, 2001).

The literature on Statics highlighted various challenges that students encountered in learning the course. These include the teaching method and assessment that reward rote learning and procedural knowledge (Arnott, 2000; Haron, 2008); such as the series of assignment sets that require self-discipline to complete. These learning strategies do not contribute much to the students’ understanding of *the challenging concepts that continually build upon one another in increasing complexity* (Chen et al., 2004). Additionally, the textbook presentations, which are normally a combination of non-animated schematic diagrams and text descriptions, of the variables explaining the concepts are difficult to visualize. The textbook problems are usually complex (Steif & Dollar, 2004) but are often used for class exercises, disseminating the procedural knowledge. It is also worth highlighting that the transition from high school to college learning environment offers an additional cause for them to struggle in relation to the learning strategies (Haron, 2008).

Additionally, the literature on Statics are mostly focused on the researches related to the shortcomings and mistakes that students make in their learning tasks, and consequently on Statics instructions emphasizing the web-based, project-based and game-based learning (Dollar & Steif, 2006; Dollár & Steif, 2007; Haik, 1999; Holzer & Andruet, 2000; Hubing et al., 2002; Mehta & Kou, 2005; Oglesby, Carney, Prissovsky & Crites, 1998; Philpot, Hall, Hubing & Flori, 2005; Scheja & Pettersson, 2010). Figure 1.1 summarized into three categories the teaching and learning (T & L) approaches that the researcher had identified from the literature on Statics. The three categories are technology-based, design-based and in-class face to face strategies. The design-based, integrated and in-class face to face T & L activities, such as the active learning and problem-based learning, using artifacts and models to explain the concepts, were designed to increase the students' participation in learning (Dollar & Steif, 2006; Steif & Hansen, 2006; Milano & Golub, 2001; Holzer & Andruet, 2000). The initiatives on improving T & L are mostly emphasizing on the concept understanding and have been reported to improve the students' motivation in learning the course.

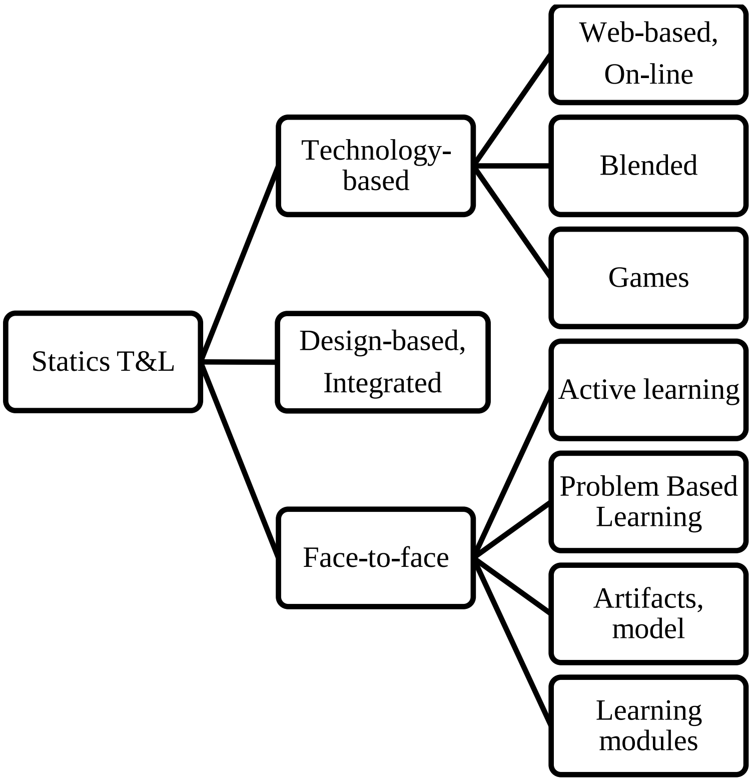


Figure 1.1 Current trends in teaching and learning of Statics

Conversely, Montfort, Brown & Pollock (2009) suggested that persistently low conceptual understanding cannot be attributed to how concepts are being taught, or not being taught. It is the complex cognitive phenomenon of students' beliefs that interfere with the learning of certain subjects. This phenomenon explains that people learn by constructing their own context for understanding. Consistent with the shift from behaviourism to cognitivism theory in educational psychology, students are perceived to have more responsibility for their own learning. Chen (2002), Winnie & Nesbit (2009) and Schunk & Zimmerman (1994) viewed academic achievement as the result of students taking responsibility for their learning. When students take ownership of the learning activities, monitor the outcomes and regulate their efforts accordingly, they are said to self-regulate learning (Schunk, 2009; Zimmerman, 1989; Abdullah, 2010).

A preliminary study at a public university was carried out by the researcher to confirm the magnitude of the problems in Statics in the Malaysian context. The study exposed that the percentage of students not graduating on time and failing to graduate for the mechanical engineering program to be consistently above 20% for four consecutive semesters. This high rate was affected by the students' poor performance in their first year, compounded by their inferior results in Statics that was offered as the first fundamental engineering course (Haron, 2009).

It was also identified that Statics has the highest failure rate for almost all semesters during the period of the study when compared to other science and engineering courses taken by the mechanical engineering students (Haron, 2009). The highest percentage of students failing Statics was recorded at 45%, whilst the lowest at 13% for the semesters shown in Figure 1.2. The 45% failing rate was perhaps contributed by the change in lecturer and the number of repeating students taking Statics in that semester. Some 19% of these students had to repeat the course three times before obtaining a pass and able to move on to the follow-on courses. Meanwhile, 15% of the students who had failed Statics and have poor CPAs were either terminated or withdrew from the program.

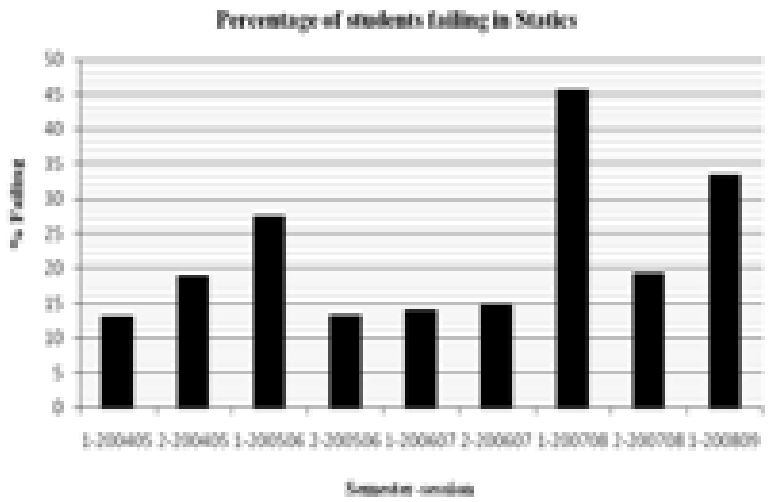


Figure 1.2 Percentages of students failing Statics per semester

The preliminary study also included an investigation of the students' concept understanding. A sample of the Mechanical engineering students was given a Statics

Concept Inventory test (Steif & Dantzler, 2005) to evaluate their understanding of the concepts. The result obtained was similar with the U.S data in terms of the concepts students find difficult and the overall score of individual students (Steif, 2004). The result also revealed that some students who performed well and scored ‘A’ in Statics obtained a low score in the concept test, similar to the low scores obtained by students who had failed Statics. This illustrates that students’ inability to grasp the concepts is not necessarily reflected in their course grades, consistent with claims made by other researchers in Engineering Education that *engineering students who are academically successful often lack deep understanding of fundamental concepts* (Montfort et al., 2009; Streveler et al., 2006).

The preliminary study supports the literature regarding the generic challenges in learning the course; including the students’ motivation and learning strategies. Observations by the researcher on the students’ attitude and the lecturers’ interviews on their perceptions of students’ behaviour in class during the preliminary study seem to indicate that motivation is a challenge to them. Findings on the teaching and learning strategies show a focus on the mathematical problem solving approach, which relates to the drill and practice but not appropriate for concept understanding. Coherent with the literature on learning and academic performance, several students and Statics lecturers from the preliminary study perceived students’ learning beliefs, goals and learning strategies use are the contributing factors of their achievement (Haron, 2009; Bandura, 1977). Therefore, it can be concluded that there are universal issues in the students’ understanding of Statics concepts and their performance in Statics, and the probable relationships with students’ self-regulated learning.

1.3 Statement of the Problem

Based on the preliminary study carried out at the local university in Malaysia, it was found that the problems of poor performance in Statics and concept understanding are caused by similar challenges that students face in other countries (Haron, 2008; Steif, 2008; Milano & Gulob, 2001; Sidhu & Ramesh, 2006; Dollar, Steif, & Strader, 2007). It was identified that the students' performance in Statics is generally poor, and the grades of those who had performed well do not reflect their understanding of the fundamental concepts. Although there are a few literature in other engineering courses highlighting a weak relationship between the two variables (Streveler et. al., 2006; Montfort, Brown, & Pollock, 2009), papers by Steif and Hansen (2006) and Anderson et. al. (2009) reported a strong correlation. Consequently, there is a need to investigate the relationship between understanding of the fundamental concepts in Statics and Statics academic performance.

Then again, the literature on Statics are largely on students' understanding of Statics concepts, and its T & L approaches to encourage concept understanding (Beston, 1999; Dollar & Steif, 2007; Dollár, Steif, & Strader, 2007; Holzer & Andruet, 2000). There are, to a lesser degree, researches on Statics academic performance and its relationship with T & L (Dollar & Steif, 2004). These researches appear to focus on how Statics is delivered to the students, with more recent studies centred on the internet-based technology approaches (Hubing et al., 2002; Oglesby, Carney, Prissovsky, & Crites, 1998, Dollár & Steif, 2007).

These researchers claimed that the internet-based T & L can help to improve the students' understanding, motivation and engagement in learning. However, there are a lot of issues to overcome for the internet-based T & L to be implemented in the universities (Haron, 2009). The lack of facilities, support from the department, incentives and the technological know-how have forced many institutions to maintain the traditional classroom instruction, which is teacher-centred, emphasizing on the procedural knowledge and rewards rote learning (Haron & Shaharoun, 2009; Nygaard & Holtham, 2008). In addition to the implementation issue, the preliminary study revealed that although there are numerous Statics learning resources available online, the students do not take advantage of it (Haron, 2009). It does not seem to be necessary as the course requirement could easily be fulfilled with a lot of drill and practice in solving the calculation problems (Haron, 2009).

Some efforts in developing the face-to-face active learning approaches to accentuate student's responsibility in the learning process were also reported in the literature. The outcome of the T & L implementation was mostly measured through the students' assessment grades, and observations of their motivation through participation in the class activities and feedback notes (Dollar & Steif, 2004; Steif & Hansen, 2006; Milano & Golub, 2001; Holzer & Andruet, 2000; Ates & Cataloglu, 2007). Therefore, the researcher believes it necessary to investigate how the students deal with the challenges in learning Statics from the self-regulated learning (SRL) perspective. Self-regulated learners are responsible for their own learning process, affected by their learning beliefs that influence the learning strategies they choose to use (Nygaard & Holtham, 2008). Hence, this study investigates how the students' performance and understanding of the concepts in Statics, and their self-regulated learning are related to each other.

1.4 Purpose of the Study

The present thesis examines three variables: students' performance, concept understanding and self-regulated learning (SRL) strategies in Statics. The relationships between the variables were investigated and the SRL factors that influence the students' understanding of Statics concepts and performance in Statics were identified. The research objectives (RO) and research questions (RQ) for this study are as the following:

RO 1. To investigate the relationship between the students' performance and their understanding of the concepts in Statics.

RQ 1 What is the relationship between the students' performance in Statics and their understanding of the fundamental concepts in Statics?

RO 2. To investigate the self-regulated learning strategy use in predicting the students' academic performance and their understanding of the concepts in

Statics.

RQ 2 How does self-regulated learning predict performance?

RQ 3 How does self-regulated learning predict understanding?

Hypotheses:

i. Performance in Statics is influenced by concept understanding, self-regulated learning strategies.

ii. Concept understanding is influenced by self-regulated learning strategies.

1.5 Significance of the Study

Statics is normally the first core-engineering course that students undertake in their undergraduate degree program. Understanding the concepts in Statics is of great importance as it serves as the fundamental knowledge for other core-engineering courses like Dynamics, Strength of Materials, Design, Machine and Structural Mechanics. The challenges students face in learning Statics, if not overcome, will be detrimental to them as they progress through their degree program and later in their career.

From the education perspective, students hold the ultimate responsibility for their own learning (Chen, 2002). They are responsible for the outcome of their learning, particularly in making sure that they achieve deep understanding of the concepts and good performance in their assessment. Therefore, students need to be active participants in their learning process. They need to be self-regulated learners, who are able to design, monitor, and control their own learning.

This study investigates the influences of the self-regulated learning strategies on students' concept test scores and Statics assessment scores. The results provide a useful insight into students' learning of this fundamental engineering course, which are beneficial to both the lecturers and the students. The lecturers will be able to be more equipped to address the challenges students face in the learning and understanding of Statics. They will be able to choose appropriate, individualized interventions or more general changes in their teaching practices (Givvin, Stipek, Salmon, & MacGyvers, 2001). The findings will be able to facilitate the lecturers in addressing these challenges in Statics and other similar core engineering courses.

Additionally, a curriculum that could enhance the understanding and performance of engineering students and retain them in the programme could be designed. Curriculum developers may also use the outcomes of this study to design a more holistic curriculum. A syllabus that includes self-regulated learning skills will definitely benefit the students. They need to be exposed to the positive influences of self-regulated learning, and be able to use the appropriate strategies in learning, especially in this challenging core engineering course.

Furthermore, the self-regulated learning variables that are identified in this study could help the students become aware of their current motivated learning strategies use in Statics. They can then choose appropriate strategies to regulate their current learning (regarding strategies, activities) for an improved outcome.

Finally, the findings of this study will further advance the current understanding of the self-regulated learning strategy use of engineering students in general. It will also introduce a fresh perspective to the literature on engineering students learning of Statics.

1.6 Scope of the Study

This study is focused on engineering undergraduate students from four higher education institutions in Malaysia. The student respondents must have taken Statics to be eligible as the participants for this research. These four institutions offer Statics with almost similar syllabus, teaching approach and assessment method.

With an aim to identify how students' self-regulated learning affects students' achievement in Statics, the study was conducted to investigate the relationships between the following variables: students' performance, understanding and SRL in Statics. The data were gathered quantitatively using the Statics Concept Inventory, which measures the standard concepts found in most Statics textbooks and syllabus; an adapted Motivated Strategies for Learning Questionnaire (MSLQ) for measuring SRL; and students' end of the semester Statics scores.

1.7 Conceptual Framework

Considerable research in education and educational psychology has revealed that motivational variables are highly related to students' learning (Kizilgunes, Tekkaya, and Sungur, 2009). Pintrich (2004) suggested that students' motivation is related to the use of learning strategies that influence their academic achievement. Meanwhile, Schunk (2009) advocated that motivation results in meaningful learning and promotes self-regulated learning (SRL). It directs learners' thoughts, feelings and motivated behaviour toward the attainment of their goals in learning (Schunk, 2009; Reid & Petocz, 2008; Bembo & Seli, 2008). Greene and Azevedo (2007), Zimmerman and Schunk (2001), and Pintrich (2004) described SRL as a constructive process where students set their goals based on past experiences and current environments. Self-regulated learners are meta-cognitively, motivationally, behaviourally, and socially active participants in the learning process (Zimmerman, 1989). Such process involves acquiring and modifying knowledge, skills, strategies, beliefs, attitudes and behaviours, and is influenced by the learners' identity (Nygaard & Holtham, 2008).

There are many different SRL perspectives in the research carried out on college and university students' motivation and learning (Pintrich, 2004; Pintrich, 1999; Zimmerman, 1989). Two generic perspectives are student approaches to learning (SAL) and information processing (IP). SAL is characterized by bottom-up approach (in-depth qualitative interviews with students), while IP is characterized by top-down approach (using quantitative methods to measure psychological constructs and theories in cognitive and educational psychology) (Pintrich, 2004). However, with developments in the research area the IP perspective is being replaced by SRL perspective, which is more reflective of current theory and research.

Pintrich (2004) elaborated that SRL perspective includes cognitive, motivational, affective and social contextual factors, which assumes that students will be able to:

1. Become active learning participants in the learning process and construct their own meanings, goals, and strategies.
2. Monitor, control, and regulate certain aspects of their cognition, motivation, behaviour and environment.
3. Set goals, criterion or standards to assess their learning process.
4. Self-regulate their cognition, motivation and behaviour to mediate the relations between person, context and performance.

SRL conceptual framework based on the four assumptions outlined above classifies four phases and four areas for regulation. According to Pintrich (2004), the four phases are planning and goal setting; monitoring; controlling and regulating; and reacting and reflecting. The four areas for regulation are cognition, motivation/affection, behaviour and social context. SRL models emphasize the importance of integrating both motivational and cognitive components of learning (Pintrich, 1999).

Data collected from the author’s preliminary study indicated that students’ learning beliefs and choices of learning strategies were perceived to be the main contributing factors for the poor students’ performance and understanding of Statics concepts (Haron, 2009). These findings are found to be coherent with the literature on learning and academic performance, which support Bandura’s claim in suggesting that students' motivation and learning strategies influence their academic achievement. This is consistent with the shift from behaviourism to cognitivism in educational psychology, where students are perceived to have more responsibility for their own learning. As students hold the ultimate responsibility for their own learning (Chen, 2002), and learning Statics demands students to achieve both deep understanding and good performance, this study discusses the influences of the self-regulated learning (SRL) variables on students' concept test scores and Statics summative scores. As such, the framework in Figure 1.3 shows the three main variables that are modeled in this study: Self-regulated learning (motivation and learning strategies), concept understanding and academic performance.

Motivation variable is measured by questionnaire items on learning beliefs and self-efficacy, study goals & values, and anxiety. Meanwhile, learning strategies are measured by items on critical thinking and elaboration, organization and memorization, persistence and regulation, study effort, meta-cognitive regulation and help-seeking. Concept understanding and Statics performance are measures of Statics concept scores and scores from summative assessment respectively. Data was analyzed by statistical tools to obtain the nature of relationships between the variables and to model the SRL in Statics.

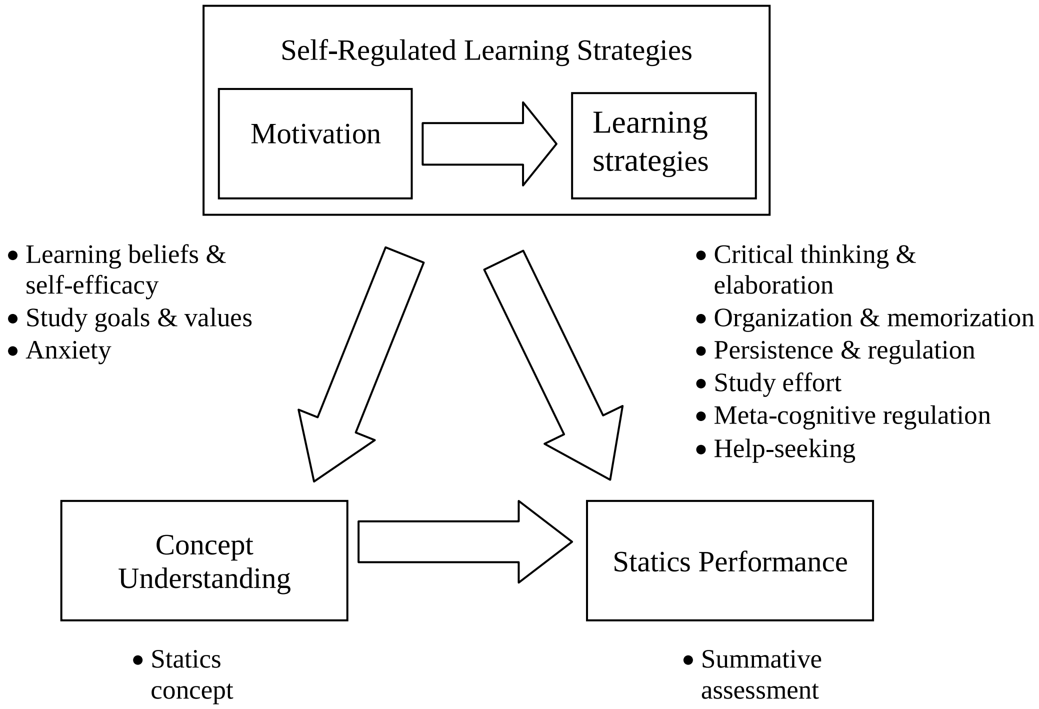


Figure 1.3 Conceptual Framework

Assumptions made in this study include the following:

i. Students who are motivated will adopt appropriate learning strategies that will enable them to have deep understanding of the concepts and to perform well in Statics assessment.

ii. Students who have deep understanding of the concepts will perform well in Statics assesment.

1.8 Definition of Terms

This section explains the terms used in this thesis.

1.8.1. Mechanics

Mechanics is a physical applied science, a foundation to most engineering sciences and is an indispensable pre-requisite (Beer & E. Russell Johnston, 1990). Mechanics has three distinct areas namely: mechanics of rigid bodies (subdivided into Statics and Dynamics), mechanics of deformable bodies, and mechanics of fluids (Hibbeler, 2006). Its purpose is to explain and predict physical phenomena and thus, to lay the foundations for engineering applications. Its application is to gain insight into, and to design the engineering systems.

1.8.2. Statics

Statics is the first part of Mechanics. It deals with bodies at rest or in equilibrium (Bedford & Fowler, 2003). Statics is a fundamental course in engineering and a pre-requisite to other core engineering courses like Dynamics, Fluid Mechanics, Solid Mechanics, Mechanics of materials, Machine Mechanics and Design.

1.8.3. Self-Regulated Learning

Self-regulated learning (SRL) refers to the process whereby "*learners systematically direct their thoughts, feelings, and actions toward the attainment of their goals"* (Schunk, 2009, p. 19). Self-regulation is defined here as learning that is guided by meta-cognitive strategic action and motivation to learn. Self-regulated learners display personal initiative, perseverance, and adaptive skills in pursuing learning (Zimmerman & Schunk, 2001). In this study, SRL is measured by motivation and learning strategies variables.

1.8.4. Motivation and Learning Strategies

Motivation is an internal state that initiates and maintains goal-directed behavior to facilitate self-regulated learning (Reid & Petocz, 2008; Schunk, 2009). Motivation is measured in terms of goal orientation, self-efficacy, task value, learning beliefs and anxiety. On the other hand, learning strategies are defined as *"any thoughts, behaviors, beliefs or emotions that facilitate the acquisition, understanding or later transfer of new knowledge and skills"* (Weinstein, Husman, & Dierking, 2000, p. 727). Learning strategies are differentiated between strategies that operate directly on information (rehearsal, elaboration, and organization) and strategies that provide affective and meta-cognitive support for learning (affective control strategies, and comprehension monitoring strategies) (Weinstein and Mayer, 1986).

1.8.5. Achievement in Statics

In this study, achievement in Statics is defined as the students' 'performance in Statics' assessment and 'concept understanding'.

1.8.6. Statics performance

Statics performance refers to the Statics summative assessment results at the end of semester.

1.8.7. Concept understanding

Concepts understanding is defined as the ability to use the fundamental concepts in solving statics problems. Deep understanding refers to the ability to deduce relationships between variables which represent features of the physical system (Steif & Dollar, 2005).

1.8.8. Statics Concepts

Statics concepts are ‘defined’ concepts, which involve relations (as opposed to ‘concrete’ concepts), and include the concepts of equilibrium, friction and forces on static bodies. The concepts in Statics are the foundation for most engineering principles.

1.9 Organization of the Thesis

This thesis is organized into six chapters. Chapter 1 provides the introduction, background of the research, objectives of the research, significance of the study and the scope of the research. It also includes the conceptual framework and definition of terms used in this research. Chapter 2 reviews the literature related to the researches on Statics and educational psychology, particularly regarding the self-regulated learning. Chapter 3 presents the research methodology. The research design, operational framework, data collection methods, data analysis and issues related to the reliability and validity of the instruments are described. Meanwhile, Chapter 4 provides the preliminary study results. The results and analysis of the research are provided in Chapter 5. Chapter 6 discusses the findings, presents the contributions and implications of the study, and ended it with the discussions, conclusions and recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature on Statics, education and other related issues as illustrated in the literature map in Figure 2.1. Literature on Statics mainly describes the challenges and issues in Statics, covering the aspects of concept understanding, performance, teaching and learning. Meanwhile, the literature on education describes issues related to academic learning and performance, and Self-regulated learning. Finally, the literature on the instruments for data collection is included.

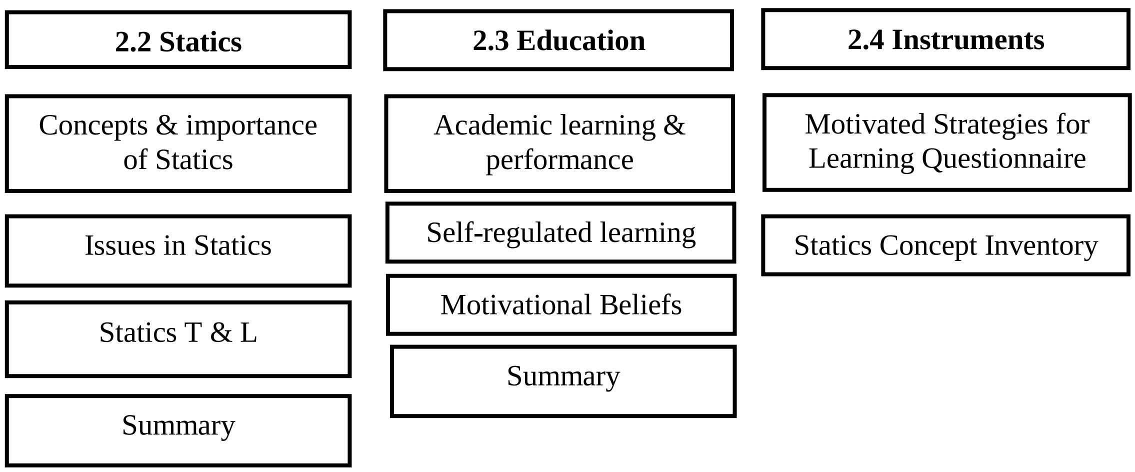


Figure 2.1 Literature map

2.2 Statics

Figure 2.2 summarizes the literature on Statics, which highlights the importance of Statics in engineering curriculum, the teaching and learning (T & L) strategies, and issues related to the difficulties in learning Statics. Section 2.2.1 details the importance of Statics in Engineering Education, whilst Section 2.2.2 elaborates on the issues, and Section 2.2.3 describes the T & L strategies. Section 2.2.4 is the summary of literature on Statics.

2.2.1. Statics concepts, importance in Engineering Education

Statics is a fundamental engineering course in many engineering disciplines, forming an important prerequisite for many subsequent courses. Statics is one part of mechanics of rigid bodies. Mechanics is a physical science as it deals with the study of physical phenomena. Although some associate it with mathematics many consider it as an engineering subject. Irrespective of the views, mechanics is the foundation of most engineering sciences and is an indispensable prerequisite to their study (Beer & Russell Johnston, 1990). Mechanics is not an abstract or pure science, but it is an applied science with the purpose to explain and predict physical phenomena and thus to lay the foundations for engineering applications. Its application is to gain insight into, and to design, engineering systems. Thus, Statics in particular deals with the design and physical phenomena of bodies at rest.

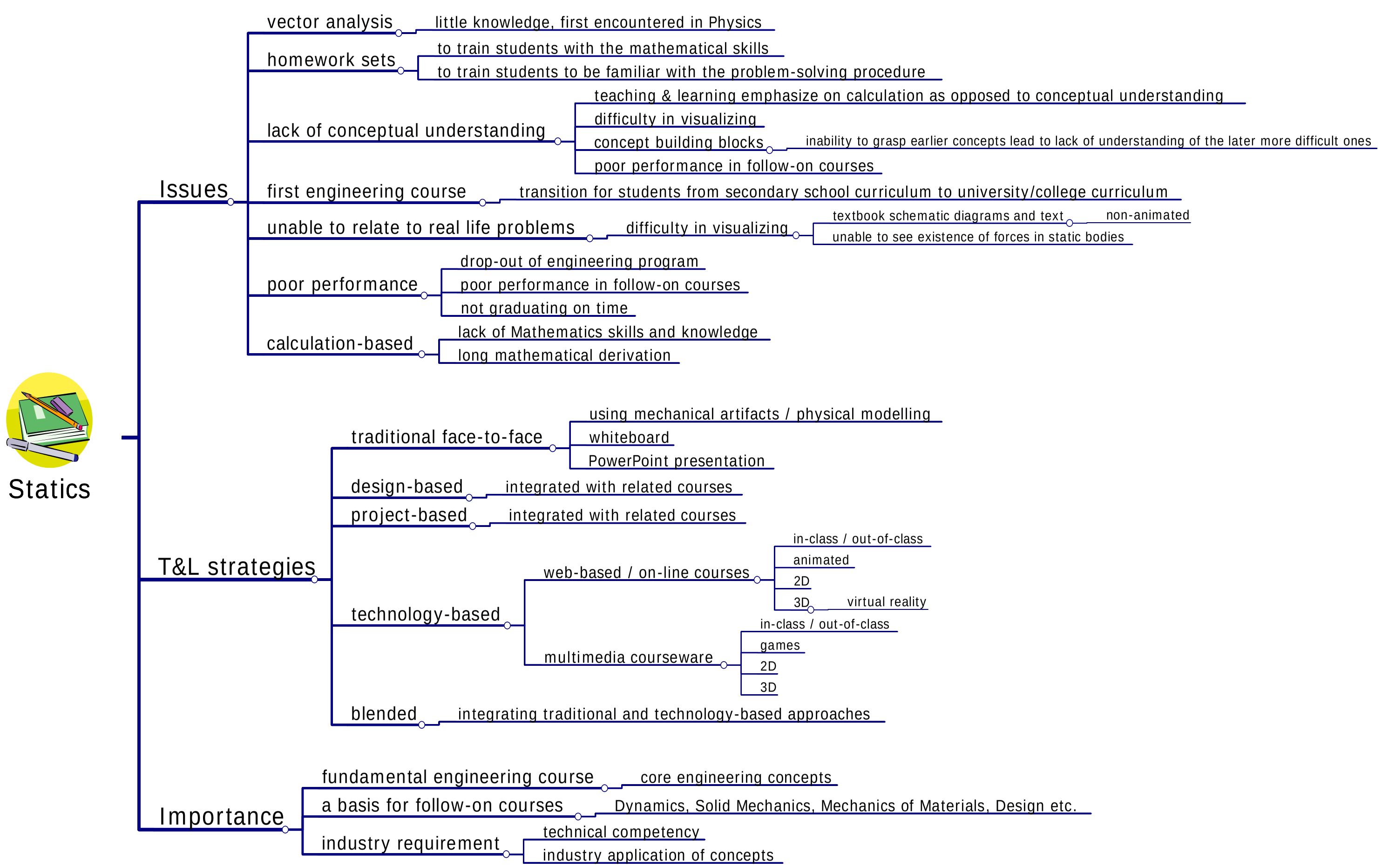


Figure 2.2 Statics in the Literature

As such students are expected to grasp and apply the concepts in Statics not only in the follow-on courses but also importantly in the real engineering world. However, many lecturers have often expressed their disappointment with the extent to which their students are able to use concepts in Statics in the analysis and design of real systems and structures (Haik, 1999; Steif & Dollár, 2003). Students at many universities found Statics not a popular course, and perceived it as a difficult subject (Haik, 1999; Milano & Golub, 2001). Nevertheless, as an academic requirement, students must obtain a passing grade to move on to the next level of their engineering curriculum. This is even more important as Statics is a central to both the Civil and Mechanical Engineering curriculum as it serves as the basis and pre-requisite for other core courses (Milano & Golub, 2001).

A good foundation in Statics and other fundamental engineering courses has always been and has become increasingly important, especially in meeting the ‘new’ expectations of an engineer affected by today’s global changes. Global changes in the economics, politics, social, cultural and environmental scenarios have affected the engineering profession and demanded engineering graduates to be equipped with a variety of new skills and attributes. Some of those include leadership, communication and team working skills, and the ability to be adaptable to and holistic in their profession. Various professional bodies and professional interest groups have made statements about the generic and transferable skills desirable in graduates, and the curriculum content reforms necessary to meet the perceived needs of the engineering profession (Arnott, 2000). The change in global scenario has provided the drive for change in engineering training and education. However, despite these changes, the need for a strong base of engineering fundamentals that include sound basis of science, engineering principles, and analytical capabilities, have remained constant, as claimed below:

> *Industry's top priorities for engineering graduate skills are practical application, theoretical understanding, creativity and innovation. Whilst broader technological understanding is also important it should not be at the expense of understanding the*

> *fundamentals. It is important that courses are not overloaded with technical content: the emphasis should be on the ability to understand and apply theory to real problems.*
>
> *(Engineering, 2007, pp.18)*

Friedman (2006), supported by Steif and Dollar (2003), emphasized the importance of having strong fundamentals in science and engineering for a society to be competing in the current world. It becomes increasingly important for Engineers to have a firm command of basic engineering concepts to meet the demanding career expectations like flexibility and adaptability to the ever-widening range of technologies.

2.2.2. Issues in learning Statics

Reviews of the literature have pointed to Statics being a course that many students have difficulty in. It remains a challenging course for many students in many countries worldwide (Chen, Kadlowec, & Whittinghill, 2004; Dollár & Steif, 2007; Haik, 1999). The difficulty is attributed to a variety of reasons. Chen, Kadlowec, & Whittinghill, 2004; Dollár & Steif, 2007; and Haik, 1999 quoted deep conceptual understanding in Statics as a major concern, with challenging concepts continually building upon one another in increasing complexity.

Statics requires comprehension of the concepts at sufficient depth as opposed to rote memorization of procedure (Chen, Kadlowec et al., 2004) for it to be durable and transferable to future courses and in other contexts. However, rote memorizations in learning are common in the education system (Owens, 2007; Anderson and Gunderson, 1998). Although it is not necessarily a bad technique for some types of courses, it is not suitable for learning Statics because the method only involves learning facts without deep understanding.

Mechanics is essentially a deductive science based on a few fundamental principles, with derivations presented in their logical sequence. However, the learning process is largely inductive, with simple applications being considered first (Beer & Russell Johnston, 1990). Course content and problems are presented in the textbooks as a combination of non-animated schematic diagrams and text descriptions. However, the problems in Statics are often complex, and the variables are normally difficult to visualize. Students find it difficult to solve the problems that they cannot visualize, thus, become de-motivated to learn when they are unable to relate to real life situations.

> *Students prefer to use formulas that they can plug-and-chug. They are resistant to analyzing. Vector cross products have them seeing cross-eyed and dot products has them dumbfounded. As a result, there was a high drop rate in the course. Students attempted to take the course without doing the time-consuming homework required to master the material. This resulted in high failure rate of those that remained in the course.*
>
> *(Milano & Golub, 2001)*

Most textbooks approach Statics by putting more emphasis on problem-solving procedure, with which requires drill and practice. Hibbeler (2006) stated that the most effective way of learning the principles of engineering mechanics is to solve problems. Statics is fundamentally about problem solving through the application of scientific principles, requiring students to know how to apply learned knowledge to form an internal model of the problem, and not just plugging in numbers into the mathematical equations.

Chen, Kadlowec et al. (2004) are in the opinion that for core engineering courses concept understanding is as important as the calculation-based understanding. Sidhu and Ramesh (2006) supported the opinion and emphasized that for Statics students' grasp of the concepts involved is more valuable than their performance on calculation-based problems. However, in most institutions, Statics is taught with an emphasis on the mathematical operations. This is useful but not sufficient to model interactions between real mechanical artifacts (Dollár & Steif, 2007; Haron, 2008).

Most problems in Statics involve lengthy mathematical derivation of equation. Lengthy mathematical derivations often cause students to be de-motivated to solve the problems in Statics. It involves many cognitive steps leading from problem to solution. As a result, students face difficulties such as the lack of ability to translate mathematical equations into the form necessary for effective computation.

> *….lengthy mathematical derivations that lead to the principle of design for machine elements cause students to be de-motivated because they are unable to neither connect to real life nor express their creativity.*
>
> *….students become more motivated and even willing to deal with long mathematical derivations and difficult problems only when they realize the importance of machine design course in the real life of a mechanical engineer, and the limitations of their knowledge.*
>
> *(Khoshaba & Shrivastas, 2004)*

Mathematics has been identified as an area of concern for engineering (Bowen, Prior, Lloyd, Thomas, & Newman-Ford, 2007). According to Bowen et. *al.* (2007), the Quality Assurance Agency course report for Mechanical, Aeronautical and Manufacturing Engineering (QAA 1998) highlighted that failure is common due to difficulties in mathematical skills and that mathematical problems exist in all engineering courses. It was also reported that there are evidence of a decline in the mathematical capabilities of entrants onto engineering programs and there are diversity in mathematical knowledge among the student population. However, Mathematics and Physics are the pre-requisites for entry into Statics to ensure success in the course (Anderson, E., Taraban, R., Hudson, D., 2009). Therefore, this may affect the success in Statics and be a cause for students to leave the course.

The rapid pace of the materials presented, the challenging concepts, and the sets of homework and self-discipline required to complete them are some other issues that have often affected students’ performance in the course (Chen, Kadlowec, & Whittinghill, 2004; Dollár & Steif, 2007; Haik, 1999; Sidhu & Ramesh, 2006). Consequently, students performance in the follow-on courses are also affected, causing them to not graduate on time, and some failed to graduate from the engineering program (Haron, 2008). As a result they are disheartened from pursuing engineering as a career (Dollar & Steif, 2004; Sidhu & Ramesh, 2006).

Chen, Kadlowec, & Whittinghill (2004) discussed several issues that inhibit better student learning in higher education. The perceptions of both teachers and learners are one example. From the perspective of students, the lack of individual feedback on learning, lack of opportunities for dialogue to improve learning, and a feeling that the course learned is impersonal are some of the valid concerns raised. On the other hand, issues highlighted by the lecturers include the difficulties in knowing what students are learning, in providing individualized feedbacks, addressing students’ specific misconceptions, attending to diverse learning styles, and engaging students in learning. Steif (2008) added that other universal issues like the local culture and students’ work habit are contributions to Statics continual problem.

2.2.3. Statics Teaching and Learning

Engineering lecturers have often reported difficulties with students learning of concepts and skills associated with the solution of typical basic mechanics problems, such as the uses of force and moment equilibrium concepts on free-bodies.

A significant number of students find it a difficult area even in later years of their studies (Haik, 1999; Steif & Dollar, 2003). It does not help the situation further when teaching and learning are heavily relying on textbook exercises and mathematical manipulations without much help in visualization. Steif & Dollar (2004) are quoted elaborating on this:

> *The typical textbook experience, relying strongly on mathematical manipulations, is not adequate to preparing students to model mechanical systems. Experienced users of mechanics rely on an intuitive, even visceral, sense for the forces which are present in mechanical systems, and how they combine to maintain the system in equilibrium (or produce its motion). With the observation that students do not readily perceive forces between inanimate objects, we have reorganized Statics instruction to focus initially on situations in which they can experience forces directly: forces exerted by hand or that are evident from motion or deformation.*
>
> *(Steif & Dollár, 2004)*

Many efforts have been put into improving the existing and developing new teaching approaches to enhance students learning. Teaching practices has transformed from teacher-centered to student-centered, where students themselves are responsible to gather knowledge and make sense of it. Many engineering schools have adopted innovative approaches to teaching and learning of Statics to accommodate a variety of learning styles, and to adopt different learning strategies and theories. Several teaching approaches of Statics as described in the literature are summarized in Figure 1.1. Three types of T & L approaches were identified; technology-based, design-based and in-class face to face. Several examples of the strategies for each of the approaches are further elaborated in Appendix A.

Most recent researchers in Statics have focused their efforts in developing the technology-based approach. This include the development of web-based and online courses, and multimedia courseware, utilizing the computers and Internet in and out of class (Beston, 1999; Dollár & Steif, 2007; Dollar, Steif, & Strader, 2007; Holzer & Andruet, 2000; Hubing et al., 2002; Oglesby, Carney, Prissovsky, & Crites, 1998; Sidhu & Ramesh, 2006; Steif & Dollar, 2005). Blended learning is one type of technology-based T & L. Technology is used together with traditional means in engineering classes. One most recent approach is using games to present the concepts and problems (Chan & Black, 2006; Philpot, Hall, Hubing, & Flori, 2005).

There were attempts to integrate the syllabus for Statics and Dynamics and offered as Mechanics, to integrate Statics with Mechanics of Materials, or to include Statics as part of design-based courses (Haik, 1999; Holzer & Andruet, 2000). Students are required to design and build a product that requires the engineering mechanics concepts. Usually T & L activities adopt the collaborative group learning approach, which is a part of the development in the T & L for class face to face environment. Other efforts for in-class T & L include the use of mechanical artifacts or physical model, PowerPoint presentation, learning modules, problem-based learning and active-cooperative learning (Holzer & Andruet, 2000; Mehta & Danielson, 1999; Steif & Dollar, 2003)

The researchers in Statics T & L made claims that the outcomes of their research have enriched the learning process in many ways. Students are more motivated to learn, engaged in learning, and have better understanding of the course (Babur, 2011; Dollar & Steif, 2004; Holzer & Andruet, 2000). It was claimed that visualization and modeling had helped students to grasp the concepts better, overcoming the difficulty from non-animated textbook presentations. However, Barbur (2011) believed that the technology-based learning materials should not substitute the classical materials. It should be a complementary, although they can significantly improve the T & L. He also highlighted the requirement for high skill and time to develop the computer enhanced T & L approach. Facilities, support from the management, incentives, knowledge in learning theories and principles are some other factors that dampens the transformations of T & L (Haron, 2009).

2.2.4. Summary

The literature on Statics can be summarized as the following:

i. Statics is an important fundamental engineering course.
ii. Concept understanding is a problem for students learning Statics.
iii. T & L approaches emphasize on the mathematical problem solving, drill and practice, procedural knowledge.
iv. The challenges in Statics are generic and categorized into three: T & L, nature of Statics and students.
v. Researches in Statics are mostly on T & L approaches, which are focused on delivering Statics using the technology.
vi. Researches in the T & L approaches claim that the problem-based learning, active learning, and internet-based T & L seems to promote students' motivation and self-regulated learning.

2.3 Education

As Statics demands students to achieve deep understanding and good performance, improvement in T & L requires commitment from the lecturers and department. This research aims to assess how the 'self' factor can influence students' concept test scores and Statics summative scores. The assumption is whatever that motivates students to learn Statics and the learning strategies they subsequently adopt would influence their learning outcome. Therefore, in trying to understand the predictors for students learning in Statics, differentiating between those for concept understanding and Statics performance, the reviews focus on self-regulated learning.

Section 2.3.1 discusses the issues related to academic learning and performance, 2.3.2 is about the self-regulated learning theories, model and strategies, and Section 2.3.3 describes the motivational beliefs in SRL. Finally, the summary of the literature on education is presented in Section 2.3.4.

2.3.1. Academic learning and performance

Montfort, Brown & Pollock (2009) suggested that persistently low conceptual understanding cannot be attributed to how concepts are being taught. Students' beliefs are the *complex cognitive phenomenon* that interferes with learning certain subjects. Beliefs and self-efficacy are part of the motivation variables that relate to the use of learning strategies that influence students' academic achievement (Bandura, 1977). This phenomenon is supported by learning theories explaining that people learn by constructing their own context for understanding, and learning is affected by previous knowledge.

According to Schunk (2009, p.16), *behavioural theories view learning as a change in the rate, frequency of occurrence, or form of behaviour or response, which occurs primarily as a function of environmental factors.* Learning involves the formation and associations between stimuli and responses. Behavioural theories stress the role of environment, emphasizing the teachers' role in stimulating and reinforcing learners and learning. Contrasting to cognitive theories, *learning is the acquisition of knowledge and skills, the formation of mental structures, and the processing of information and beliefs* (Schunk, 2009, p.16). Learning is an internal mental phenomenon inferred from what people say and do. Schunk (2009) added, cognitive theories acknowledge the role of environment but argue that the quality of instruction alone fully account for students' learning. Cognitive theories emphasize the role of learners' thoughts, beliefs, attitudes, and values in a successful learning.

Chen (2002) suggested that the psychological framework for understanding learning has shifted from behaviourism to cognitivism. Learners are perceived to have more responsibility for their own learning, no longer viewed as passive learners, but actively reorganizing and reconstructing existing knowledge with new knowledge (Chen, 2002).

Learning is a relatively permanent change in knowledge or behavior as a result of experience (O'Donnell, Reeve, & Smith, 2009, p.5). Learning process is defined as acquiring and modifying knowledge, skills, strategies, beliefs, attitudes and behaviours, and influenced by the learners' identity (Nygaard & Holtham, 2008). For learning to take place, it would depend on a variety of factors like students' motivation, quality of instruction, students' engagement in learning and the educational environments (O'Donnell, Reeve & Smith, 2009). Greene and Azevedo (2007) suggested that learning process involves memory storage and retrieval, strategy use, motivation, self-efficacy and goal orientation, and that learning is contextual. Pintrich (2000, 2004) identified cognitive, motivational, behavioural, and the contextual as the factors affecting the learning process.

The relationship of learning and academic performance is through assessment. However, learning should not be equated to performance (Schunk, 2009). Schunk (2009) emphasized that students who fail to perform well in the assessment do not necessarily indicate that learning has not taken place. Apart from learning, there are many other factors such as low motivation, poor health and distraction that prevent them from getting a good grade in assessment. However, a well-planned and constructed assessment should reflect students learning (assessment of learning), and the process of learning (assessment for learning) (O'Donnell, Reeve & Smith, 2009). Outcome of the assessment is useful for the students in motivating and strategizing their future undertakings, and for the lecturers to improve their teaching.

Chen (2002), Winnie & Nesbit (2009) and Schunk & Zimmerman (1994) viewed academic achievement as the result of students taking responsibility for their learning. When students take ownership of the learning activities, monitor the outcomes and regulate their efforts accordingly, they are said to self-regulate learning (Schunk, 2009; Zimmerman, 1989; Abdullah, 2010). For self-regulation to occur learners must have the element of choice; among others in their goals of learning, learning methods, time spent and the setting where learning occurs (Zimmerman, 2000).

2.3.2. Self-regulated learning

In his book, Schunk (2000) highlighted that the research on self-regulation began as an investigation into self-control and the development of self-regulation in children. He added that early research in self-regulation was conducted in therapeutic contexts, teaching participants to alter dysfunctional behaviours. The area of research has now expanded to address academic learning, across different age groups of students, level of studies (from primary school to university), and different courses (English language, Social Science, Mathematics, Introductory Psychology and Calculus). Students' motivation and self-regulated learning are assumed to be context specific, thus, a focus on course level are the most appropriate level of context for investigations (Pintrich, 1999).

Literature in SRL by Wolters & Pintrich (1998) covers investigations on student motivation and learning strategies in Mathematics, English language and social studies. The research looked at the contextual differences of SRL on seventh and eighth grade students, using a self-report questionnaire. A study by Chen (2002) on SRL strategies and achievement in Information System course, investigated the effect of SRL on two different learning environment; lecture-based and hands-on. Participants were university students doing business information systems course, were required to respond to MSLQ. Another was a PhD thesis on motivation and learning strategies of Korean migrants in America on English language (Stoffa, 2009). One example of SRL researches is closer to home, measuring the effects of SRL on students in Malaysian Smart schools. The study investigated IT integration in class learning (Abdullah, 2010). Kosnin (2007) did a research on SRL and academic achievement regarding the Malaysian engineering undergraduates. The participants in her research were from the Electrical Engineering faculty. These are some samples of the various researches carried out on SRL. Other important work on SRL includes studies predicting academic performance, and investigating its relationships with motivation by Kizilgunes, Tekkaya, and Sungur, 2009; Pintrich, 1999, 2004; Zimmerman & Schunk, 2001; Chen, 2002.

The sections that follow elaborate on the definitions of SRL, SRL theories and framework and the SRL strategies. Figure 2.3 shows the literature map for the SRL topic.

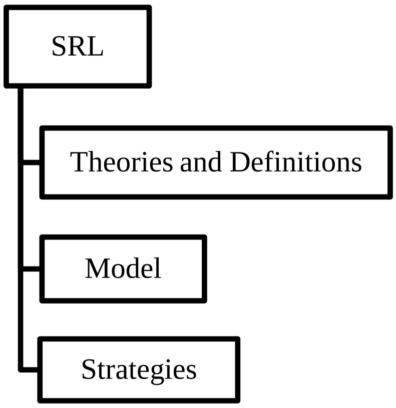


Figure 2.3 Self-regulated learning

2.3.2.1 Theories and definitions

It is important to highlight that SRL is a complex construct, positioned at the junction of many different research fields. Researchers from the various fields conceptualized SRL in their own perspectives, using different terms and labels for similar aspects of the construct (Boekaerts, 1999). However, the main feature of SRL can be contrasted between two general perspectives: student approaches to learning (SAL) and information processing (IP). Pintrich (2004) elaborated that SAL perspective is often used in Europe and Australia, whilst IP perspective is more often used by researches in the North America. IP perspective has been replaced by self-regulated learning (SRL) to reflect the current development in the research area.

Pintrich (2004) explained that SAL perspective is characterized by the bottom-up model, derived from qualitative interviews on students about their motivation and learning in real university context. Quantitative methods like questionnaires are also used in SAL perspective to assess students' learning. On the contrary, SRL perspective is characterized by the top-down model. Top-down model is derived from psychological constructs, cognitive theories and theories in educational psychology. It includes the perspective of cognitive, motivational, affective and contextual factors in modelling student learning. SRL perspective has its applications in investigating college students learning, using quantitative methods (Pintrich, 2004).

Self-regulated learning is a powerful construct to describe the various components of successful learning, to explain the interactions between and among the different components, and to relate learning and achievement directly to learner’s *goal structure, motivation, volition, and emotion* (Boekaerts, 1999, p.447). Within the framework of self-regulated learning, cognitive strategies and self-regulated learning are predictors for academic achievement (Pintrich, 2000). However, there are numerous definitions of self-regulated learning in relation to the different psychological perspectives. Table 2.1 summarized the different theories on self-regulated learning.

Table 2.1 : Theories on self-regulated learning (Source: Abdullah, 2010, pp. 17-18).

Theory	Underlying beliefs	Important concepts
Social cognitive	Humans are cognitive beings whose active processing of information from the environment plays a major role in learning. Self-regulated learning is influenced by both personal and environmental factors. Self-efficacy is the key personal variable affecting self-regulated learning.	Self-efficacy Social learning
Operant	Self-regulated learning responses must be linked to external reinforcing. Learners’ immediate environment is vital for self-regulated learning.	Reinforcing stimuli. Self-monitoring. Self-reinforcement.
Phenomenological	Self-regulated learning develops naturally with	Self-concept.

	the development of self-concept. Positive self-concept and realistic academic expectation can produce high self-regulated learning.	Self-evaluation. Self-reward. Self-awareness.
Volitional	Individuals vary in needs to self-regulate. Self-regulated learning is mainly influence by cognitive factors, such as intellectual ability.	Will power. Control beliefs.
Vygotskian	Self-regulated learning is learnt through social interactions with more competent learners or with teachers. Self-regulated learning is a product of multiple social interactions. Student-teacher interactions must be considered when promoting self-regulated learning.	Multiple social interactions. Scaffolding. Inner speech.
Cognitive constructive	Students are hypothesized to function as ‘scientist’ who actively construct own theories to self-regulate. Students must have knowledge in self-regulated learning strategies.	Active learning. Instrumental strategies.

Irrespective of which learning theories, SRL involves *having a goal, employing goal-directed actions, monitoring strategies and actions, and adjusting them to ensure success* (Schunk, 2009, p. 20). Boekaerts (1999, p.446) described self-regulation to mean *being able to develop knowledge, skills, and attitudes which can be transferred from one learning context to another and from learning situations in which this information has been acquired to a leisure and work context.*

Zimmerman and Schunk (1989) conceptualized SRL as how learners meta-cognitively, motivationally, and behaviourally improve their learning and performances. Pintrich (2000) suggested SRL as a constructive process, learners set goals based on their past experiences and current environments. SRL directs learners’ thoughts, feelings and motivated behaviour toward the attainment of their goals in learning (Zimmerman & Schunk, 2001; Schunk, 2009; Reid & Petocz, 2008; Bembo & Seli, 2008). Self-regulated learners can control their own learning by applying cognitive strategies in their own learning process (Zimmerman, 1994). Greene and Azevedo (2007) suggested that self-regulated learners are characterized as active, and manage their own learning through monitoring and strategy use. Self-regulated learners are proactive (Abdullah, 2010; Pintrich, 2004) and independent, taking ownership of own learning and require the will power and learning skills (Abdullah, 2010).

Consequently, students who have both the “will” (motivation to use strategies) and the “skill” (learning strategies) can be successful in their academic performance (Dembo & Seli, 2008). Therefore, SRL learners can be defined as metacognitively, motivationally and behaviourally active participants in their learning; having the ability to adopt self-regulatory learning strategies to plan, control, evaluate and reflect their learning processes. Hence, it can be concluded that he definition of SRL is the systematic use of behavioural, motivational, cognitive and meta-cognitive strategies, portraying how and why students choose to use a particular learning strategy (Stoffa, 2009).

2.3.2.2 SRL model

Although there are numerous theories and models trying to explain SRL processes, Pintrich’s (2000) model is one of the most relevant (Stoffa, 2009). Pintrich (2004) described four general assumptions that most SRL models are based on:

1. Active, constructive.

   Based on the cognitive perspective, learners are viewed as active participants in the learning process; assumed to construct their own meanings, goals and strategies.

2. Potential for control.

Learners are assumed to be able to monitor, control, and regulate certain aspects of their own cognition, motivation, behaviour and environment.

3. Goal, criterion, or standard.
   SRL assumed a standard for comparison to assess the learning process, if the process should be changed or should continue. There can exist multiple goals and combinations of different learning goals and strategies.

4. Mediators between personal and contextual characteristics and actual performance.
   Learners' self-regulated cognition, motivation and behaviour mediate the relations between the learner, context and performance.

Based on the four assumptions, Pintrich (2000) modelled SRL using a taxonomy focusing on four phases and four areas of self-regulation. Phase 1 involves planning and goal setting (planning), Phase 2 monitoring the learning processes (monitoring), Phase 3 controlling and regulating the self, learning tasks and context (controlling), and Phase 4 reacting and reflecting on them (regulating). Phases 2 and 3 do not find much separation, and accordingly, some instruments may not be able to distinguish even among the four variables. Depending on the research questions or conceptual model sometimes there need not be a separation between the phases (Pintrich, 2004).

The four areas in which self-regulation can occur include cognition, motivation, behaviour and context, shown in Table 2.2. The first three columns are the areas of cognition, motivation and behaviour. These reflect the different areas of psychological functions. Meanwhile, the context column reflects the social context and its importance. The items in each column under the areas for regulation are the activities and strategies related to the planning, monitoring and regulating. Generally, in most SRL models, *monitoring, control and reaction can occur simultaneously and dynamically as the individual progresses through the tasks, with the goals and plans being changed or updated on the basis of feedback from the monitoring, control and reaction processes* (Pintrich, 2004, p.389).

Table 2.2 : SRL model showing the phases and processes under each area for self-regulation (Source - adapted: Pintrich, 2004)

Phases	**Areas for regulation**			
	Cognition	Motivation	Behaviour	Context
1. Planning	Goal setting Prior knowledge activation Meta-cognitive knowledge activation	Goal orientation adoption Efficacy judgements Perceptions of task difficulty Task value activation Interest activation	Time and effort planning Planning for self-observations of behaviour	Perceptions of task Perceptions of context
2. Monitoring	Meta-cognitive awareness and monitoring of cognition	Awareness and monitoring of motivation and affect	Awareness and monitoring of effort, time use, need for help Self-observation of behaviour	Monitoring changing task and context conditions
3. Controlling	Selection and adaptation of cognitive strategies for learning, thinking	Selection and adaptation of strategies for managing, motivation and affect	Increase/decrease effort Persist, give up Help seeking behaviour	Change or renegotiate task Change or leave context
4. Regulating	Cognitive judgements Attributions	Affective reactions Attributions	Choose behaviour	Evaluation of task Evaluation of context

2.3.2.3 SRL strategies

Pintrich (1999) specified three categories of strategies for students to regulate their own learning. They are cognitive, meta-cognitive and resource management. Figure 2.4 depicts the strategies for each of those three categories.

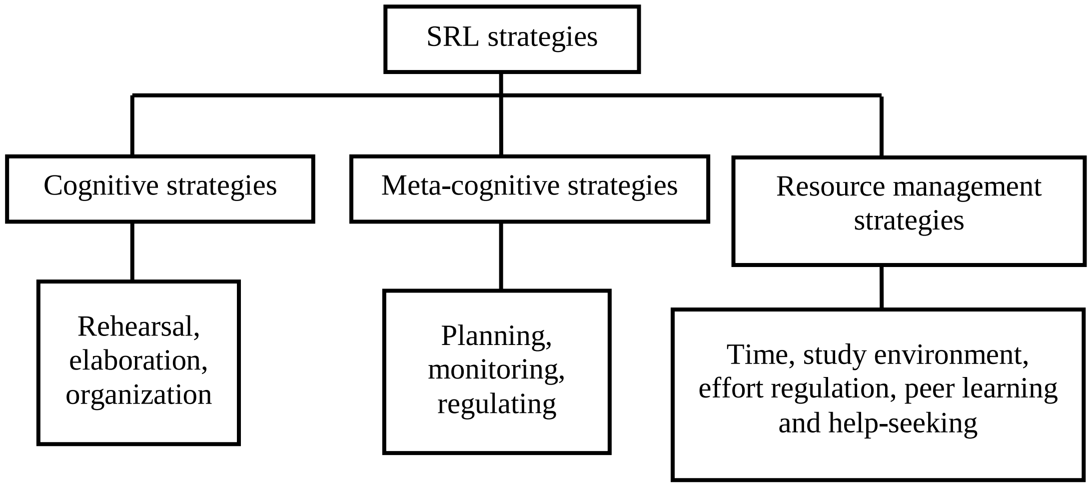


Figure 2.4 SRL strategies

Referring to Pintrich (1999), Abdullah (2010), Chen (2002), Zimmermann (1989), those categories are defined as follows:

1. Cognitive learning strategies are rehearsal, elaboration and organizational strategies.

Rehearsal strategies include activities such as recitation of items and highlighting text to help students select important information from texts or lists and keep them in working memory. Elaboration strategies include paraphrasing or summarizing what was learnt, creating analogies and generating notes, reorganizing and connecting ideas in their notes, explaining to others and seeking help for better understanding. Organizational strategies include outlining important points from the text and using techniques like sketching mind maps, which lead to a deeper processing of information learned.

2. Meta-cognitive or self-regulation strategies reflect the student's intention to plan, monitor and regulate their cognitive strategies.

Planning activities include goal setting, skimming and asking questions before reading a text. Monitoring involves checking what was learnt to a set of standards or set goals, tracking of attention while learning in the classroom and monitoring comprehension of the lessons. Regulation strategies are the reactions of the outcomes from monitoring activities. Regulation involves bringing back the behaviour closer to the goals.

3. Resource management strategies refer to activities that manage and control the students' environment, which includes their time, effort, study environment and other people, such as their lecturers and peers. The strategies involve, for example, students studying outside class time at a location where they find it conducive, for example at the library, alone or with a group of friends.

It is important to note that not only do students need to know how, when, and what learning strategies to apply, but they also need to be motivated to use these strategies.

2.3.3. Motivational beliefs in SRL

Motivational factors are highly related to students' learning (Kizilgunes, Tekkaya, and Sungur, 2009; Schunk, 2009). Considerable researches in education and educational psychology for decades have looked into motivation from various perspectives in trying to understand how people think and behave. It is claimed that motivational beliefs enable students to control their thoughts, feelings, motivations and actions, thus, enabling them to influence their own cognitive processes and actions to change the environments (Abdullah, 2010). Motivated students perceive themselves as competent, autonomous and constantly striving hard to achieve their academic goals through the use of learning strategies that influence their academic achievement (Kizilgunes, Tekkaya, and Sungur, 2009; Pintrich, 1999). Thus, motivation theories are most often used to explain students' choices of activity, such as engagement, persistence and help-seeking, and their academic performance (Meece, Anderman, Anderman, 2006).

Early theories, which include drive theory, conditioning theory, cognitive consistency theory and humanistic theory (Schunk, 2009), explained motivated behaviour in terms of drives, motives and other internal traits; and behavioural associations involving rewards as external reinforcements (Meece, Anderman, Anderman, 2006; Abdullah, 2010). However, in line with the developments in cognitive theories, the current perspective of motivation focuses on the internal processes such as self-beliefs, self-determination, achievement goal, expectancy value theories, cognitive and social processes (Abdullah, 2010; Fulmer, Frijters, 2009). This focus is in line with Bandura's (1986) social cognitive theory of motivation, where motivation emerges from the interaction between individuals within their social context of the school (Urdan, Schoenfelder, 2006).

There are many models of motivation relevant to student learning. Models of motivated learning assume that motivation occurs before, during and after learning (Schunk, 2009). Pintrich (1999) defined motivation in terms of self-efficacy, task value and goal orientations. Dembo and Seli (2008) added attribution, while Wolters & Pintrich (1998) added others, including anxiety. Three general components seem to be important in these different models: beliefs about one's ability or skill to perform the task (expectancy components), beliefs about the importance and value of the task (value components), and feelings about the self, or emotional reactions to the task (affective components) (Pintrich and Zusho, 2007). Figure 2.5 shows a model of motivational beliefs as described in Abdullah (2010).

Pintrich (1999) defines self-efficacy as beliefs of the individuals about their performance capabilities in a particular domain. Bandura (1977) claimed self-efficacy to be an accurate predictor of performance. Dembo and Seli (2008) suggested that students with high self-efficacy are more likely to use more challenging strategies and experience less anxiety regarding their academic tasks.

Self-efficacy helps students to monitor their own learning strategies and accuracy in their own learning. They added that setting goals and learning how to use different learning strategies are two ways of enhancing self-efficacy.

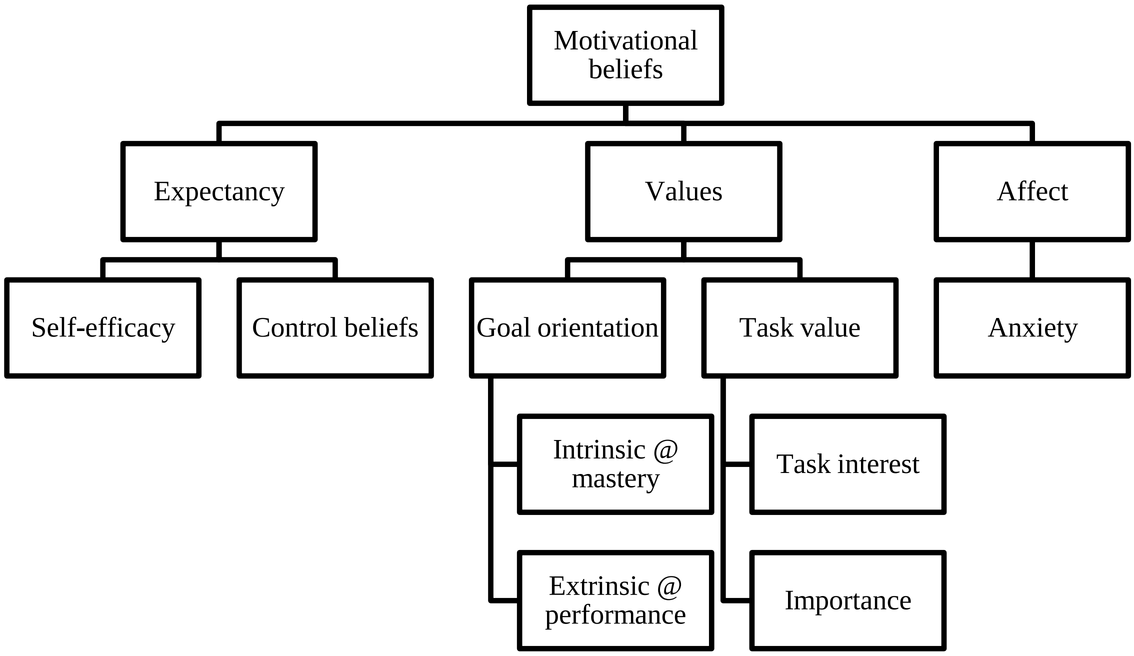


Figure 2.5 Model of motivational beliefs

Task value, important for academic achievement, is individual student's perception of the importance of their task, their personal interest in the task, and their perception of the task for future goals (Pintrich, 1999). Task value affects students' choice of activities and the level of effort and persistence to put in. If students value a task and believe they can master it, they are more likely to use different learning strategies with persistence to complete the task (Dembo, Seli, 2008). Even when there is little interest in the task, the task value will motivate students to complete it.

O'Donnell, Reeve & Smith (2009) described two types of learning goals, mastery and performance. Mastery goal means students have the objectives to improve competency, make progress, overcome difficulties and gain understanding. On the contrary they described students with performance goal as having the learning aims to prove competence, display high ability, and avoid difficult tasks in learning.

The differences between mastery goals (aiming to learn and improve) and performance goals (aiming to compare ability with others) are associated with the way students think and behave. Mastery goal orientation is often related to intrinsic values, meanwhile performance goal orientation with extrinsic values (Abdullah, 2010). These positive outcomes associated with the adoption of mastery goals are shown in Table 2.3.

Comparing to the performance goals, O'Donnell, Reeve & Smith (2009) summarized that students with mastery goals show greater engagement, more positive functioning, higher quality learning, and more adaptive help-seeking. Meece, Anderman, Anderman (2006) suggested that when mastery, understanding, and improving skills and knowledge are emphasized, students show the most positive motivation and learning patterns. However, when focus is on competing for grades and academic performance, students become less motivated.

Table 2.3 : Positive outcomes associated with mastery goals (Source: Adapted from O'Donnell, Reeve & Smith, 2009)

Greater engagement	**More positive functioning**	**Higher quality learning**	**More adaptive help-seeking**
Greater effort in the face of failure. Greater persistence during learning activities.	Higher interest, intrinsic motivation. More resistant to learned helplessness. Higher self-efficacy. Greater preference for challenge.	Use conceptually based learning strategies such as elaborating more. Use superficial learning strategies such as memorizing less.	More likely to ask others for helpful hints and clues, not answers. Less likely to ask others for answers without explanations.

Students may attribute their success or failure to a specific cause, termed as attribution (Dembo & Seli, 2008). Attributions are related to different emotional responses. Dembo & Seli (2008) claimed that attribution is the most important factor determining how students will approach a particular task and how long they will persist at it. Ability and effort are two most common attributions to academic performance.

When students attribute their past successful performance to ability, they are more ready to face similar challenging task in the future and anticipate success. But if they are less optimistic, they are likely to attribute prior success to luck. Meanwhile, students who attribute their failures to lack of effort are likely to try harder in future situations, and persist on difficult tasks.

Controllable (for example, effort) and uncontrollable (for example, luck) attributions affect students' choices of learning strategies (Dembo & Seli, 2008). Students who believe in controllable causes are more likely to choose strategies like seeking help from their lecturers. On the contrary, those who believe in uncontrollable causes are less likely to seek help that they need. Therefore, when students perceive controllable factors as causes for their performance, they will more likely feel motivated to perform better.

As for anxiety, it is defined in two dimensions: worry and emotionality (Dembo & Seli, 2008). Worry is a disruption of mental activity, whereas emotionality is more related to physiological distress. Worry reflects the cognitive aspects of the anxiety, such as the negative beliefs, troubling thoughts and poor decisions. Emotionality refers to the unpleasant affective reactions, such as tension and nervousness.

Worry dimension, compared to emotionality, has a stronger negative relation to academic performance. Some students who are anxious, have good study skills but cannot handle the pressure of examinations. Dembo & Seli (2008) suggested the higher the anxiety, the more likely students will experience lower achievement. Procrastination, quitting a task before completion and inability to concentrate in their learning strategy are some other effects of anxiety. Self-talk is a strategy for coping with anxiety. However, students with high anxiety are more prone to use avoidance to cope, and use poorer learning strategy in their learning process.

2.3.4. Summary

The literature on Education can be summarized as the following:

i. Learning and academic achievement are students' responsibility, affected by their motivation.
ii. Self-regulated learning consists of the motivational and learning strategies variables.
iii. Most SRL researches are focused on the academic achievement, measured in terms of their GPAs; but lacks on the effect of SRL on engineering courses and concept understanding.
iv. During the period of this study there was no research that compares the SRL of students' achievement between their academic performance and concept understanding in Statics.
v. Little is known on the SRL research carried out on engineering students at the undergraduate level in Malaysia.
vi. Motivational beliefs in SRL consist of the expectancy, values and affect components; and affect the learning strategies that students choose.
vii. Researches on motivation are mostly focused on the effect of individual components such as students' goal orientation and self-efficacy on their academic achievement.

2.4 Instruments

This section elaborates about the instruments that measure self-regulated learning and concept understanding.

2.4.1. Measuring Self-regulated learning

Two popular self-report instruments in the literature are the Learning and Study Strategies Inventory (LASSI) and the Motivated Strategies for Learning Questionnaire (MSLQ). LASSI focuses more on students' approaches to learning (SAL) than on self-regulated learning (SRL) (Pintrich, 2004). Thus, LASSI will not be discussed further.

The MSLQ is a self-report instrument developed by Pintrich and his collegues to measure students' motivation and use of learning strategies (Pintrich, et. al., 1991). The development of MSLQ started in the early 1980s and finalized in 1991 (Pintrich, 2004). Details of the development process, validity and reliability of the instrument can be found in the MSLQ manual (Pintrich, et. al., 1991). This instrument has been used extensively in various disciplines, but little is known on the use of SRL and achievement in a fundamental engineering course like Statics.

This instrument was designed to measure the different aspects of the self-regulated model in Table 2.3. The MSLQ variables that assess those different aspects of the model are shown in Table 2.4. Pintrich (2000, 2004), Pintrich, Smith, Garcia, and McKeachie (1991), and Stoffa (2009) are referred to in elaborating the measurement scale of MSLQ. There are five variables as indicators for the cognitive regulation of the students. The variables measure the monitoring and controlling activities of the cognition that students might use in the classroom. Rehearsal, elaboration and organization reflect the use of basic cognitive and learning strategies to understand the materials learnt. Meta-cognition reflects students activities regarding their planning (like setting goals), monitoring (e.g. monitoring understanding) and regulating (re-read text when fail to understand) of their learning. The critical thinking variable measures the extent to which students apply their prior knowledge to new situations and applications, analyze and evaluate information in a thoughtful manner.

Table 2.4 : The MSLQ variables that assess the SRL model (Source: Adapted from Pintrich, 2004)

	Areas for regulation			
	Cognition	**Motivation**	**Behaviour**	**Context**
MSLQ Variables	Rehearsal Elaboration Organization Critical thinking Meta-cognition	Intrinsic goals Extrinsic goals Task value Control beliefs Self-efficacy Test anxiety	Effort regulation Help-seeking Time, study environment	Peer learning Time, study environment

The variables in motivation regulation assess students' motivational beliefs for the course or task, and not their strategies to monitor, control or regulate their motivation or emotion. The goal variables identify students' learning goals, reflecting whether students are intrinsically or extrinsically motivated. Their goal setting may be affected by the perceptions of the value of the tasks that they are undertaking. Control beliefs reflect students' belief in their ability to control their affect and emotions using various coping strategies. The self-efficacy reflects students' perceptions of their own competence in doing the tasks they are involved in. Meanwhile the anxiety variable represents students' worry and concerns about doing well in examinations.

The variables measuring behavior reflect how students regulate their effort when faced with difficulty, boring or uninteresting tasks. Their efforts may include persistent behavior, seeking help from peers or teachers, and managing their time and study environment. The latter two variables are conceptually in the contextual regulation but from factor analysis the developers found them to be loaded together, thus, it became one variable. Finally, peer learning in the contextual regulation represents the effectiveness of an individual student in using peers as a resource for learning. It may be more difficult to control the tasks related to the context because they are not always under the direct control or influence of individual student.

The MSLQ consists of two main sections: questions that examine motivation and learning strategies. The motivation category includes 31 items that access students' goals and value beliefs for a course, their beliefs about their skills to succeed, and their anxiety about the tests. The learning strategy category includes 50 items: 31 items concerning the use of meta-cognitive and cognitive strategies; and 19 items concerning the resource management strategies. There are a total of 81 items on the MSLQ, using a 7-point Likert scale score, from 1 (not at all true of me) to 7 (very true of me).

Taylor (2012) quoted many researches that had used MSLQ in and outside the US. His study was focused on the reliability and validity of the instrument based on those researches. It was concluded that researchers should always examine the reliabilities of the scores of their own data. Although, the instrument can be used across a variety of different samples with reasonable confidence for obtaining generally reliable scores, *reliability is not an immutable property of the scale, it differs across samples*. It was also highlighted that some items may not be appropriate for some cultures and that some researchers were reported to carry out factor analysis.

It is worth noting that MSLQ are operational at course level, assuming students use different strategies for different courses and have dissimilar motivation for different courses, instead of using it at a more global level, such as for college in general. Therefore, MSLQ is an appropriate instrument to measure college students' SRL, assessing how they control their behaviours and regulate their learning strategies in trying to improve their academic performance.

2.4.2. Measuring Statics concept understanding

An established instrument to measure Statics concept understanding is Statics Concept Inventory (SCI) developed by Steif and his associates (Steif, Dollar, Dantzler, 2005). The development was transpired from an earlier effort to assess conceptual knowledge using the Force Concept Inventory, which is widely used by Physics education community (Steif, Dollar, & Dantzler, 2005; Steif & Dantzler, 2005).

The theoretical construct of this instrument is Statics conceptual knowledge (Steif & Dantzler, 2005). Steif & Dantzler (2005) described that the conceptual framework for developing SCI is based on the following four clusters of concepts:

C1. Forces are always in equal and opposite pairs acting between bodies, which are usually in contact.

C2. Distinctions must be drawn between a force, a moment due to a force about a point, and a couple. Two combinations of forces and couples are statistically equivalent to one another if they have the same net force and moment.

C3. The possibilities of forces between bodies that are connected to, or in contact with, one another can be reduced by virtue of the bodies themselves, the geometry of the connection and/or assumptions of friction.

C4. Equilibrium conditions always pertain to the external factors acting directly on a chosen body, and a body is in equilibrium if the summation of forces on it is zero and the summation of moments on it is zero.

SCI is a multiple choice test that measures the ability of a student to use fundamental concepts (Steif, Dollar, Dantzler, 2005). It consists of 27 questions that are mainly testing students' conceptual reasoning, with no significant mathematical calculation. The inventory tests students on nine core Statics concepts, each in isolation. The nine concepts, each is represented by three questions, are listed below (Steif, 2008):

1. Free Body Diagrams
2. Newton's 3rd Law
3. Static equivalence of combinations of forces and couples
4. Direction of forces at roller
5. Direction of forces at pin-in-slot joint
6. Possible directions of forces between frictionless contacting bodies (e.g. pin joint)
7. Representing a range of forces using variables and vectors
8. Limit on the friction force and its trade-off with equilibrium conditions
9. Equilibrium conditions

Details of the development and psychometric analysis of SCI can be found in Steif & Dantzler (2005). The developers believe that understanding of concepts should be at least partially predictive of the overall achievement in Statics course. They recommended SCI to be used to improve the teaching and learning of Statics. Feedback from the test would allow lecturers to identify the difficult concepts for them to prepare remedial actions, to test students starting knowledge for the follow-on courses, and to improve their teaching approaches. For the purpose of this study SCI is used to assess students' understanding of Statics concepts.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The thesis examines how self-regulated learning strategies influence the students' understanding of Statics concepts and their performance in Statics assessment, and how the latter two variables relate to each other. Henceforth, Chapter 3 discusses the methodology, instrumentation and data analysis. It begins with the research design, starting with a brief description of the preliminary study.

3.2 Research Design

A preliminary study at a university in Malaysia was conducted earlier to confirm that Statics is a generic problem for engineering students, and to investigate the challenges that are related to Statics learning. Qualitative methods were used: document analysis, concept test, observations, and interviews.

The outcome of the preliminary study confirms three variables of interest: the concept understanding, performance and self-regulated learning. The relationships between the three variables were investigated using the statistical analysis. An adopted concept test, the end of semester Statics score and an adapted questionnaire were used in this quantitative data collection method. The expected outcome is the self-regulated learning (SRL) variables that predict students' understanding of the concepts and their performance in Statics. The cross-sectional survey method was used so that the findings can be generalized to represent the Malaysian engineering student population.

3.3 Operational Framework

Figure 3.1 depicts the operational framework for this study. The diagram shows three variables identified from the preliminary study: concept understanding, students' performance and their self-regulated learning strategies. These variables are measured using Statics Concept Inventory (SCI) test, end of semester results from Statics assessment and the modified Motivated Strategies for Learning Questionnaire (MSLQ) respectively.

The adapted MSLQ was validated and pilot tested prior to distribution to the participants. The adopted SCI test and SRL questionnaire were distributed to the participants at the end of the semester and before the final exams to ensure that the syllabus had been covered, thus, enabling them to answer the concept test questions. The respondents were engineering students from four institutions of higher learning in Malaysia. Meanwhile, the students' end-of-semester Statics results were gathered from the respective universities after the official results were released.

Data collected from the questionnaire, concept test and Statics results were then keyed-in into the statistical data analysis software, Statistical Package for Social Sciences (SPSS) version 18.0. Data cleaning and relevant tests to assess statistical assumptions, descriptive analysis and factor analysis were carried out on the data from the questionnaire, prior to the analyses of correlation and multiple regressions. The analyses were to reveal the predictive nature of the variables in this study.

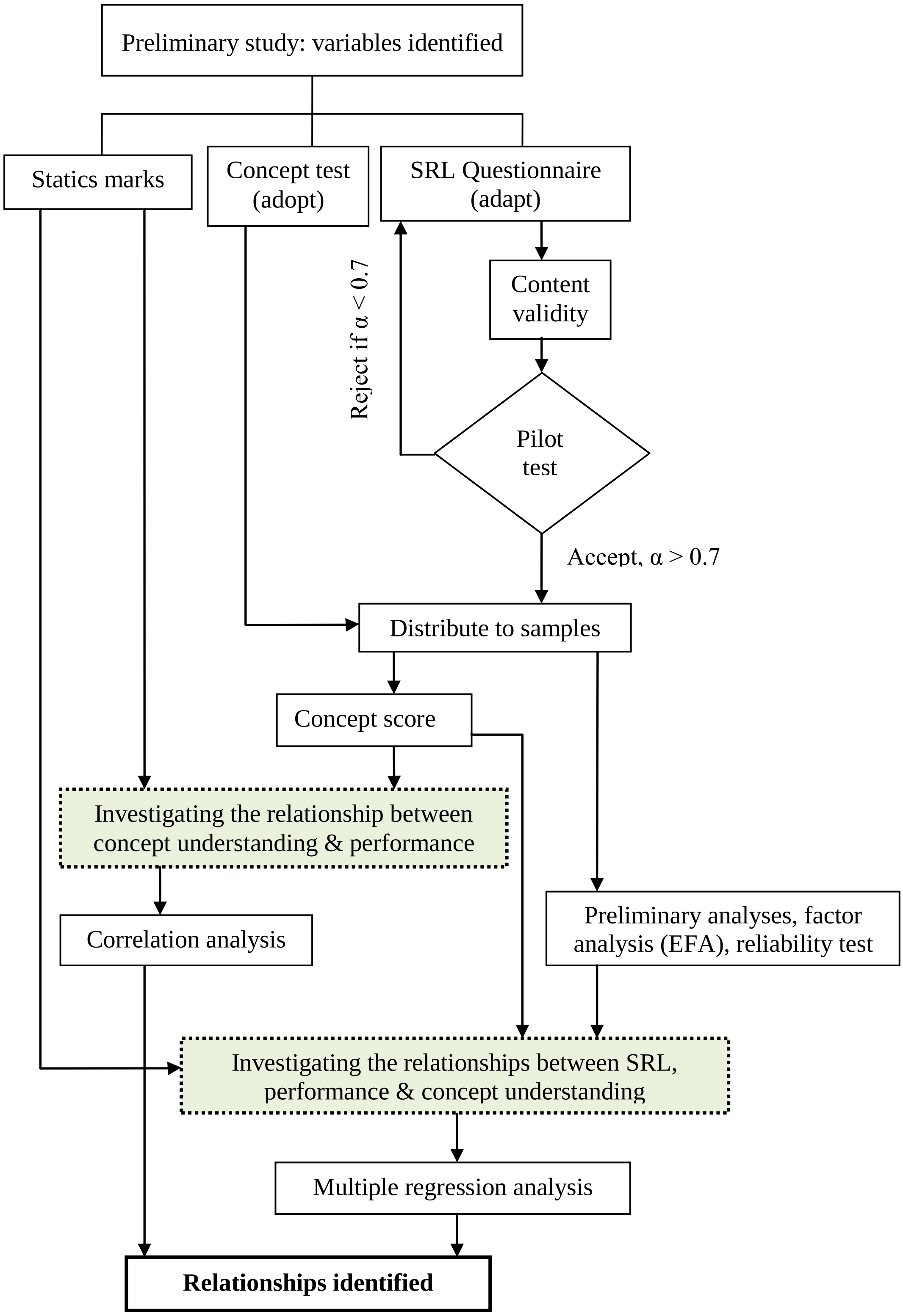


Figure 3.1 Operational framework

3.4 Data sources

The population of this study was the undergraduate engineering students in the public universities, taking Statics course. The institutions were selected by cluster sampling, i.e. randomly selected groups, in ensuring similar characteristics. The criteria for selection of the institutions include: common syllabus, textbook, assessment format, teaching methods, and accessibility to students Statics end of the semester results. Four institutions in Malaysia were selected; one was from the north, one was from the south and two were from the central regions.

The sample of students was selected at random to represent the Malaysian Mechanical Engineering student population taking Statics at the public universities. Students from four institutions were given the consent form once agreed to participate in the survey and the concept test. There are 20 public universities in Malaysia (at this point in time), with an estimated total of 8000 mechanical engineering student population. The sample size was determined by referring to the statistical Table 3.1. For the population of (N) 8000, the sample size (S) suggested is 367. However, the number of respondents who had given their consent to participate in this research was 636 students.

Table 3.1 : Table for determining sample size from a given population
(Source: Krejeie & Morgan, 1970)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]

3.5 Instrumentation

Statics performance is measured by the end-of-semester Statics score, which consist of marks from the final examination, tests, and take-home assignments. The marks are summed up as the total percentage. Other instruments used in this study are the Statics Concept Inventory (SCI) questions and a modified version of the Motivated Strategies for Learning Questionnaire (MSLQ).

The students' understanding of Statics concepts is measured using SCI, developed by Paul Steif of Carnegie Mellon University and his collaborators. The SCI was adopted with permission via e-mail (Steif, 2008). It consists of twenty-seven multiple-choice questions that represent nine concepts in Statics, as listed in Chapter 2. The inventory had been used to test over 6000 students at more than 20 universities in the United States (Steif & Dantzler, 2005). The test is available online but for the purpose of this study it was administered using paper and pencil method. From the experience gained during the preliminary study, the students were found to be more responsive using this method instead of the online method.

As for students' self-regulated learning strategy, the self-report survey used was adapted from the Motivated Strategies for Learning Questionnaire (MSLQ). MSLQ was developed by Paul Pintrich and his associates of the University of Michigan (Pintrich, 1991) to measure college students' motivational factors and their use of different learning strategies in college courses. Although the MSLQ is a well established instrument, some items in the questionnaire may not be appropriate for some cultures. Taylor (2012) reported that some researchers who had used the instrument were reported to modify and carry out factor analysis on the modified versions. For the purpose of this study, some items in the questionnaire had been changed to accommodate the Statics course. The general terms representing motivation and learning strategies items were modified to suit to Statics learning.

The modified instrument consists of three parts: Parts A, B and C. Part A is students' basic information such as gender and academic history. It also includes questions related to student learning experience in Statics. It requires the respondents to choose from a list of relevant statements that describe their belief on the factors affecting their performance in Statics and on their general feelings about themselves during class. A list of objectives in learning Statics was included to identify whether the students learn to gain knowledge, just to pass examinations or a combination of both. These lists were gathered from the literature and refined through the preliminary study that the researcher had carried out.

Part B includes questions on motivation; whilst Part C is related to the learning strategies. The total number of items in the questionnaire for parts B and C was reduced from 81 in the original questionnaire to 58. Responses for these parts were scored using a 4-point Likert scale, from 1 (not at all true of me) to 4 (very true of me). A sample questionnaire and the cover letter are included in Appendix B.

3.6 Pilot testing

Pilot studies are a crucial element of a good study design (Creswell, 2003). They become a 'mini study' of the actual and a validation tool for the instruments used. Modifications have to be made based on the findings from the pilot study if the instrument does not function properly and questions are not well understood by the respondents. The instruments in this pilot study were tested for validity and reliability, described in the following sections.

3.6.1. Validity

In quantitative research, there are two main types of validity. There is content validity, measuring if items actually measure the content it is supposed to measure, and construct validity, if items actually measure the hypothetical constructs (Creswell, 2003). Content validity is established through expert reviews. Meanwhile, construct validity, which includes convergent validity (related) and discriminant validity (unrelated), is explored by investigating its relationship with other constructs (Pallant, 2007). In qualitative research, validity and reliability have different emphasis. Validity is used to determine the accuracy of findings from the perspective of the researcher, participant, or those interested in the research.

For measuring the concepts understanding, SCI was adopted from Steif and Dantzler (2005). This instrument had already been extensively validated by its developers. However, for the purpose of application in the local context, SCI was sent to experts in the field of Mechanics from a public university and engineers in the research and development industry for content validity. The experts were requested to answer the concept questions, feedback on their relevance and comment on any difficulty. The response was positive; the instrument is commended suitable for use in the local context.

This instrument was also distributed to the senior mechanical engineering students to evaluate their understanding of the questions and Statics concepts. The time taken to complete the test was noted to be on average an hour. The students' feedback was mainly regarding a slight difficulty in the English terms used. However, the terms had already been compared to those used in the textbooks and class materials, and found to be the standard terms. Hence, it should not be a problem to maintain the SCI in its original form.

Similarly, validation for the modified MSLQ was carried out on both the content and the language. The instrument was distributed to experts in SRL, educational psychology, measurement and Mechanics for content validity. Items in the instrument were listed according to their specific subscales with spaces for comments for each item. An instrument validation form was also distributed to the experts for feedback on a scale of 1 (strongly disagree) to 5 (strongly agree) on the relevance of the instrument for measuring SRL strategy. Additionally, they were also expected to feedback on the clarity of the objective, meaning of each item and instructions, and the appropriateness of the format, font size and measurement scale.

Copies of the instrument for validation purpose and the instrument validation form are attached in Appendix C.

Meanwhile, construct validity for the instrument was estimated using Exploratory Factor Analysis (EFA). This statistical method summarized the patterns of correlations between items in the instrument. It gives a new set of factors for the modified version of MSLQ that represents the SRL variables investigated in this study. The EFA results are presented in Chapter 5.

3.6.2. Reliability

In quantitative research, reliability is assessed by measuring the internal consistency of the instrument. Internal consistency measures the extent to which items in the instrument measure the underlying construct, using the most common statistic Cronbach's alpha coefficient (α) (Creswell, 2003). A reliability value (α) can take on any value less than or equal to 1, including the negative values, although higher values of alpha are more desirable. The value above 0.7 is ideal, however, for scales with less than ten items, α of 0.5 is common (Pallant, 2007). It becomes appropriate then to report the mean inter-item correlation values, with the suggested optimal values of between 0.2 and 0.4 (Pallant, 2007).

In this research, reliability is checked for the quantitative modified version of MSLQ only. Pilot test on the modified MSLQ was carried out on 43 students at the university where the preliminary study was done. The time taken to complete the questionnaire was recorded, and the respondents were asked to give their feedback for ambiguities and any difficulty in understanding the questions. Questions were checked if all of them were answered, revised and re-worded when answers were not as expected. The edited version is used for the real data collection.

3.7 Data Analysis

Table 3.2 provides a summary of the data analysis methods. SPSS version 18 is used to analyze the data from the modified MSLQ, SCI and Statics assessments. Two types of relationships between the variables in this study were analyzed: correlation and multiple regressions.

Table 3.2 : Data analysis

Research question		Data collection method	Data analysis
RQ 1.	What is the relationship between the students' performance in Statics and their understanding of the fundamental concepts in Statics?	Concept test and Statics score	Correlation
RQ 2.	How does self-regulated learning predict performance?	Questionnaire and Statics score	Multiple regression
RQ 3.	How does self-regulated learning predict understanding?	Questionnaire and Concept test	Multiple regression

Correlation analysis was carried out to investigate the strength and direction of the relationship between concept score and Statics score, representing concept understanding and Statics performance respectively. The Pearson product-moment coefficient was used for the continuous data in this study. Meanwhile, the multiple regression analysis was carried out to see the effect of SRL variables on Statics performance and on the concept understanding separately. The analysis gives the factors that best predict students' performance and understanding of Statics concepts, and how well the variables are able to predict performance and understanding. It provides the relative contribution of each of the variables that make up the models (SRL-concept understanding, and SRL-Statics performance models). The standard multiple regression is adequate for the purpose of this study.

Prior to carrying out those analyses, data screening and exploring using the descriptive analysis had to be carried out. The frequencies, percentages and mean values of some items that indicated minor errors in data entry were identified and corrected. Normally distributed data is an important assumption for parametric analysis; this was also checked. Skewness and kurtosis values of 0 would indicate a perfect normal distribution; however, it is an uncommon occurrence in social science researches. In this study some variables are skewed but with large samples it is as expected that skewness is not the best method to test normality. Other statistical techniques such as the Kolmogorov-Smirnov significant value of more than 0.05, the 5% trimmed mean and mean with small difference, histogram and other plots like the normal Q-Q plots and boxplot can also be used (Pallant, 2007). The data in this study are found to be normally distributed, enabling correlation and multiple regressions to be carried out.

EFA was carried out next prior to the multiple regression analysis. EFA is data driven, with the purpose to identify groups of items from the questionnaire that best represent the motivation and learning strategies sub-constructs. This is done first to explore the interrelationships among the variables of the modified instrument. Several techniques for EFA are available, namely the principal component analysis (PCA) and principle axis factoring (PAF) (James, 2005; Pallant, 2007). PCA analyzes all the variance in the items, and is generally considered the best method for data reduction, done by summarizing the variance associated. Meanwhile, PAF analyzes only the variance in the items that is shared with other items, and is generally considered best for exploring the underlying factors for theoretical purposes (James, 2005). Both techniques gave similar results. However, only the results using PCA is described in Chapter 5. PCA is psychometrically sound, is the commonly used approach in the analysis of psychological data, and therefore, is more suitable for the purpose of this research. The use of PCA is justified for the purpose of reducing the number of related variables without the need to confirm specific theories; as the instrument used was established in its original form and is based on the social cognitive theory.

3.8 Assumptions

This study assumed that the respondents were accurate and sincere in responding to the questionnaires.

3.9 Limitations

The student sample for this study was limited to the mechanical engineering student population. This was to ensure that the syllabus for Statics was common among the sample universities. However, only one university offered Statics to all first year engineering students irrespective of the engineering program they would be majoring later on. This was not a problem because all other criteria related to the sample selection were fulfilled.

Another limitation relates to the Statics performance variable. Statics scores, measuring the performance, for each student were required for the analysis. However, there was a confidentiality issue to overcome, where only the grades were released at one of the institutions. As a result, the samples without Statics score had to be eliminated from the analysis of RQ 2 and RQ 3. In addition to the confidentiality issue, copies of the examination papers and assessment questions were available but the researcher was allowed a limited access to the final examination answer scripts and the students' assignment. Nevertheless, this is not a concern to the scope of the study.

On the other hand, there was no limitation in obtaining the concept scores because the test was administered and personally marked by the researcher. The limitation was in the period to run the concept test. The test had to be carried out at the end of the semester to ensure that the syllabus was completely covered. However, end of semesters are usually the hectic period for lecturers to give final tests, complete final chapters, and return marked assignments. Consequently, it was rather difficult to obtain agreements from the lecturers to allow their students to participate in the study and their class period to be used. Therefore, samples had to be chosen from classes and universities that could give such cooperation. It was also fortunate that two of the universities provided a specific time slot and space for the purpose of the concept test.

Finally, for statistical data analyses, the software package SPSS had to be purchased, as they were not readily available for postgraduate use. The lengthy purchasing procedure had caused a delay in starting the data analysis.

CHAPTER 4

PRELIMINARY STUDY

4.1 Introduction

Based on the literature, Statics is generically a problematic course for many engineering students. Therefore, the preliminary study was to confirm the magnitude of the problem at the local scenario and the challenges that students face in learning Statics. This chapter discusses the research methodology for the preliminary study and briefly presents the findings.

The data collection method, period of data collection, sample size and data analysis are shown in Table 4.1. Documents on the engineering students' results were analyzed in order to observe the pattern of their performance, in Statics and in other related courses over several semesters. A concept test administered was to gauge the students' understanding of Statics concepts. Class observations and the lecturers' interviews were to collect data on the students' behaviour in the classroom and the teaching approach. Students' interviews were conducted to gain insights into their experiences in learning Statics. The following main questions were asked to the students:

i. What are your experiences during Statics class and what do you think of the course?
ii. Do you think that the lecturers and their teaching and learning approaches affect your performance in Statics?
iii. Do you think that your beliefs and behaviour affect your performance in Statics?

Table 4.1 : From data collection to analysis

Data collection method	Data collection period	Sample size	Data analysis
Document analysis	2004 – 2008	124 students	Using Excel for percentages and graphs.
Observations	Semester 2 2007-2008 Semester 1 2008-2009	109 students 18 students (only class offered)	Outstanding behaviour and behaviour patterns of both students and lecturers were identified from observation notes.
Interviews	Semester 2 2007-2008	2 lecturers and 4 students	Keywords from transcript representing the interviewees' perspectives.
Concept test	Semester 2 2007-2008	168 respondents	Using Excel for percentages and graphs

4.2 Validation

The various data collection methods act as the validation process, in this context as a triangulation method, comparing data collected using one method with the data collected using the other methods. In addition, interviews were validated by getting the interviewee to check the accuracy of what they said from the transcript prepared. These two strategies, triangulation and member-checking, are most frequently used and easy to implement for validating the accuracy of findings from the qualitative methods of data collection (Creswell, 2003).

4.3 Sample and background data

The sample for the preliminary study was the Mechanical Engineering students from a public university in Malaysia. Documents analyzed were students' results in Statics and other related courses offered during their period of study from the first year until graduation. Out of 124 students, 113 of them entered into the program with high school certificate, while the other 11 were with polytechnic certificate. 19% had to repeat the course three times before obtaining a pass and thereby being able to move on to the follow-on courses. Meanwhile, 15% who had failed Statics and have poor cumulative points average (CPA) were either terminated or withdrew from the program.

The interviews on lecturers teaching Statics were carried out on two lecturers: a male lecturer with 15 years experience and a female lecturer with 10 years experience in teaching Statics. Meanwhile, the students interviewed were from the group where the observations were made. There were three Statics classes; two classes with a total of 109 students, while another was with 18 students, most of whom were repeating Statics. Based on the observations, two from the first group agreed to be interviewed on certain aspects of their observed attitude, and two from the second group volunteered to share their experiences.

Regarding the concept test the respondents are 88% males and 12% females; Malays were the majority with 85%, Chinese and Indian were 6% respectively. 35% of the respondents came into the program from the technical schools, while the other 65% came from either the science or national schools. It was anticipated that students from the technical schools to have some advantages in learning Statics due to their technical exposure.

It was also identified that there were 88% respondents who had taken Statics once, 10% had taken twice and 2% had taken more than twice. Table 4.2 showed the distribution of students’ grades in Statics; about 83% scored grades C and better. As for their cumulative grade point average (CGPA), 63% respondents had good pointers of 3 and above.

Table 4.2 : Distribution of students' grades in Statics

	Frequency	Percent
A- to A+	35	26.7
B to B+	37	28.2
C to B-	37	28.2
D+ to C-	13	9.9
E to D	8	6.1
Missing	1	.8
Total	131	100.0

4.4 Results from the preliminary study

Only some results are discussed here; the others are included in Appendix D and elaborated in the journal and conference articles (Haron, 2008, 2009; Haron, Shaharoun and Harun, 2009).

4.4.1. Magnitude of the problems in Statics

Faculty records on academic performance show the rate of the Mechanical engineering students not graduating on time for the academic sessions 2004/2005 to 2007/2008 is consistently above 20%. This percentage is higher for mechanical engineering when compared to civil and electrical engineering programs (Table 4.3).

Table 4.3 : Percentage of engineering students not graduating on time

Academic Session	Engineering Program	Percentage not graduating on time (%)
2004/2005	Civil	11
	Electrical	26
	Mechanical	45
2005/2006	Civil	15
	Electrical	30
	Mechanical	43
2006/2007	Civil	10
	Electrical	23
	Mechanical	33
2007/2008	Civil	15
	Electrical	28
	Mechanical	23

A further investigation indicated poor student performance in the first year as a contributing factor. Poor results in Statics that was offered in the first year contributed to the poor performance. It was revealed that Statics has the highest failure rate in almost all semesters when compared to other science and engineering courses taken by the mechanical engineering students. Figure 4.1 shows the pattern for 2004/2005 session. Data for sessions 2005/2006 to 2007/2008 are attached in Appendix D.

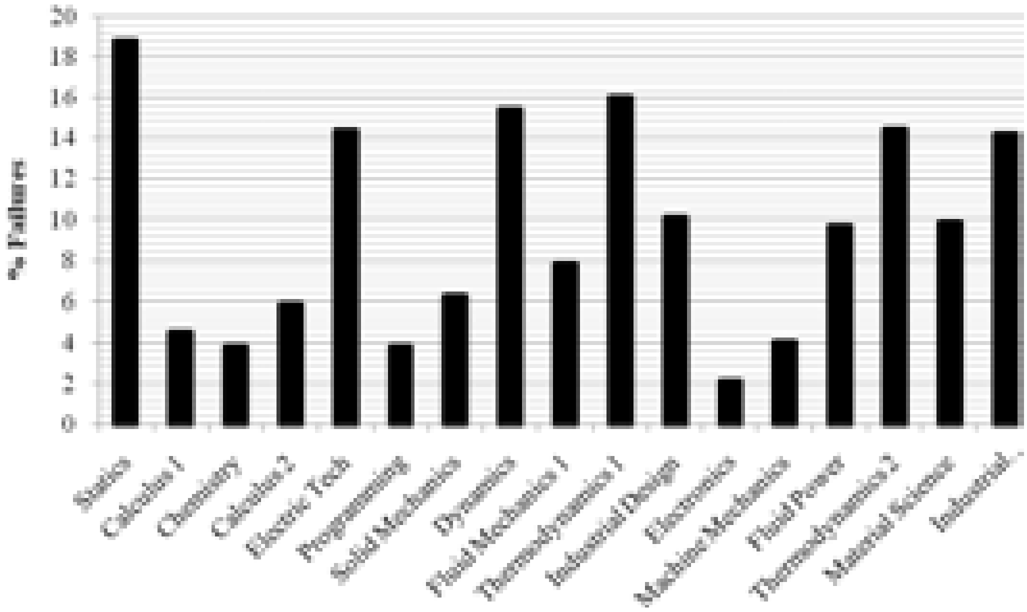


Figure 4.1 Failure rates for engineering and science courses for 2-2004/2005.

Following that, concept tests were distributed to 168 respondents consisting of senior mechanical engineering students, several mechanical engineering lecturers teaching Statics, Dynamics and Machine Mechanics, and eleven mechanical engineers in the industry involved in mechanical design work. The lecturers and engineers were included in the preliminary study to represent the people who are actually applying Statics concepts in the real engineering applications. The concept test was to confirm the literature that claims understanding Statics concepts is the problem in learning the course. Therefore, results from the concept test could give an indication of students' understanding while they are still in the university, the lecturers and engineers' understanding as the users in the field.

The concept test questions were adopted from the Statics Concept Inventory. The results in Figure 4.2 show the percentage of correct answers for each question in the concept test. The results for questions 10 and 20 show the same trend with the results from several universities in the United States (Steif, 2004, 2008). Concept question number 10 was found to be the easiest and question number 20 was the most difficult. It was interesting also to discover that a student who had scored an A in Statics end-of-semester assessment achieved the same low score for the concept test with a D and an E student.

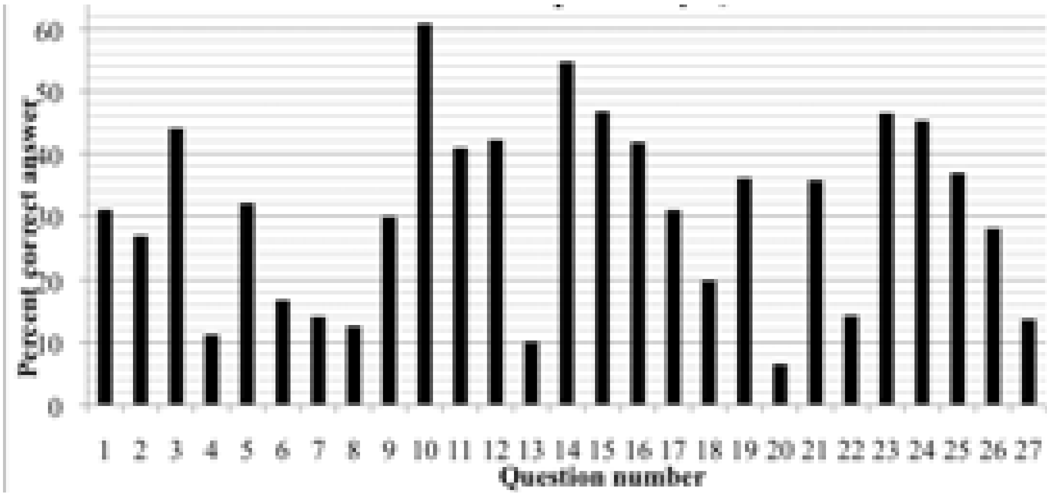


Figure 4.2 Percentage of correct answers for each question

4.4.2. Challenges in Statics

Results from the analyses of the observations, interviews, documents and concept test were compared to each other. The findings from the documents do support the lecturers' observation that students' knowledge in pre-requisite courses is necessary in doing well in Statics. Their prior knowledge and skills in Mathematics and Physics, is an influential factor that provides the skills necessary in solving Statics problems. Findings from the interviews indicated that the transition from the school learning environment to the university learning environment showed to have an effect on the students learning culture. Both students and lecturers agreed that attitude and personal efforts are the success factors of students' achievements in Statics. Students admitted that understanding what is learnt has helped them to be motivated to learn, and that personalized attention from the lecturers could contribute to better understanding of the material being learnt. Students were observed to be passive and appeared to be uninterested in Statics.

It can be summarized that the challenges in learning Statics uncovered in the preliminary study are found to be universal to Statics. Figure 4.3 summarizes the findings; meanwhile Figure 4.4 presents diagrammatically three categories of those challenges. The three categories are related to students, teaching and learning approaches, and nature of the course. These categories provide a reference for further studies or future researches with the areas of research in Statics that they can focus on. These categories can also be extended as a reference point for other researches on fundamental engineering courses such as Thermodynamics, Mechanics, and Electric Circuits.

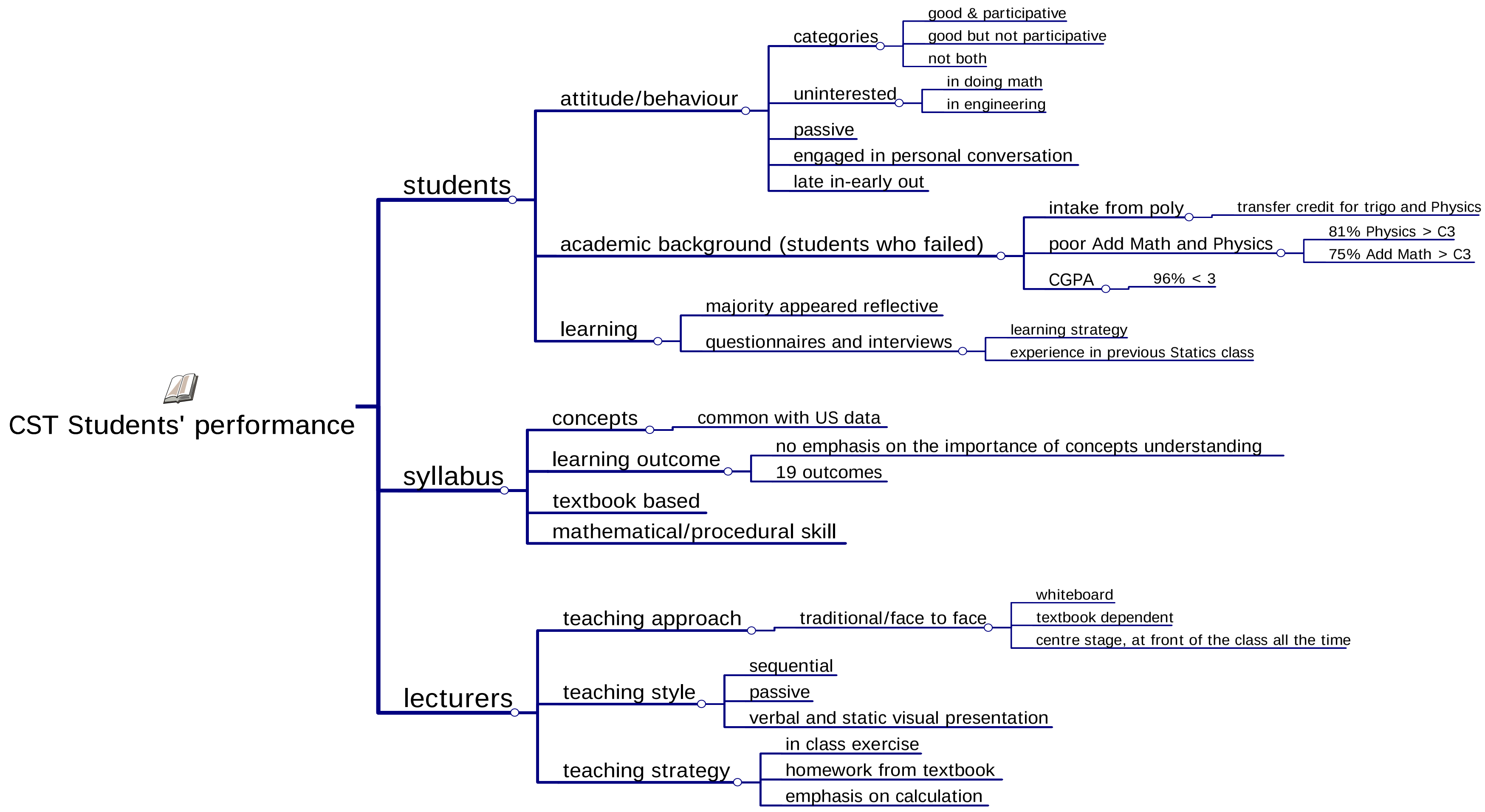


Figure 4.3 Factors affecting students' performance.

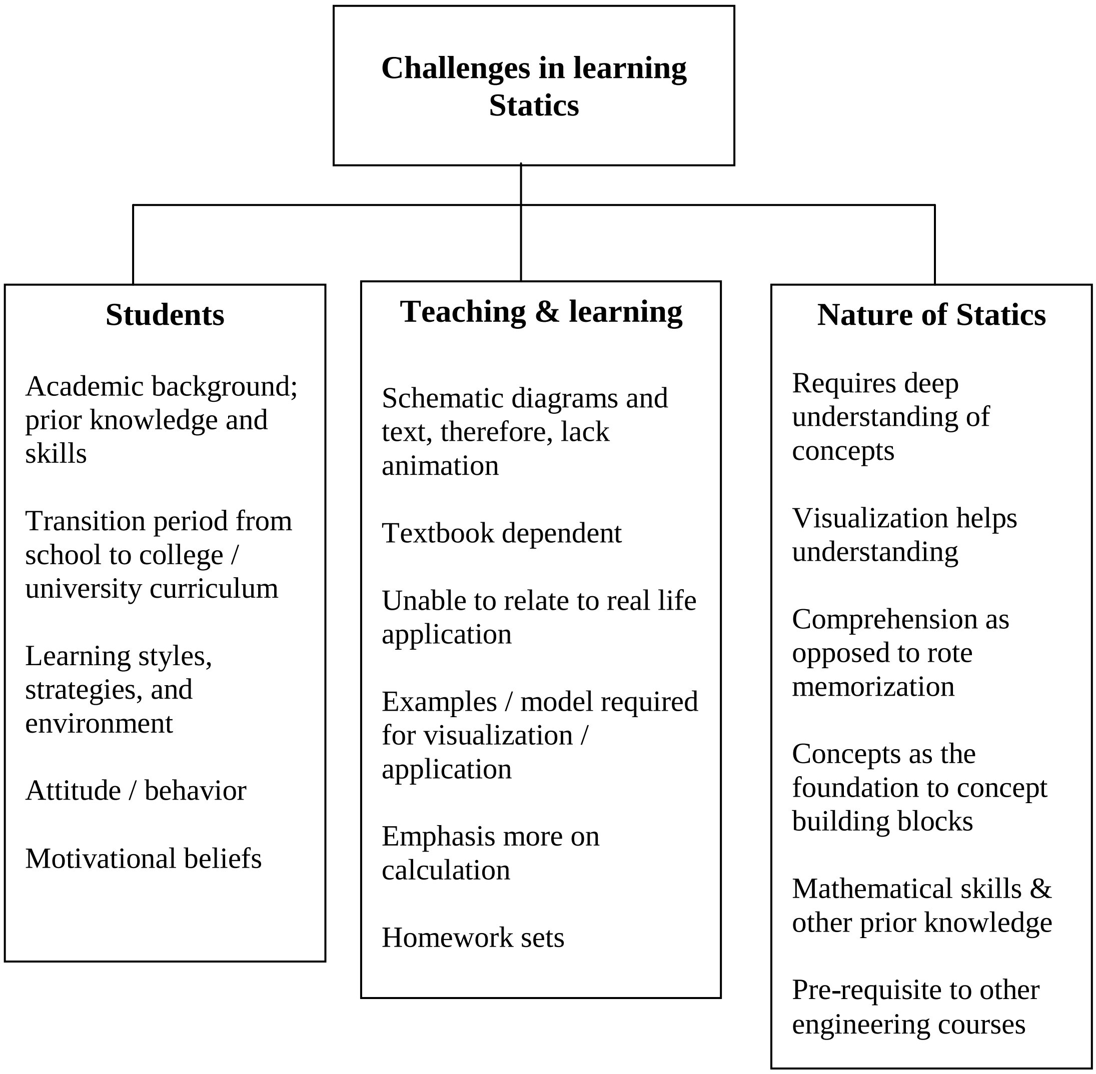


Figure 4.4 Categories of challenges in Statics

4.5 Discussions

Results from the preliminary study confirmed the literature by Chen, Kadlowec, & Whittinghill (2004), Dollár & Steif (2007), Haik (1999) and others in the field that learning Statics has its challenges. Results had shown that students who did not graduate on time and failed to graduate had problems with Statics, which they took in the first year. Statics has the highest failure rate when compared to other engineering and science courses for almost all semesters that it was offered.

Analysis of the documents and lecturers' interview revealed that pre-requisite courses influence students' performance in Statics. Although, from the interview students expressed that Mathematics is not a problem for them in solving Statics textbook exercises, faculty records showed students who did not do well in Statics entered the program with lower grades in Physics and Mathematics. Students who performed well in Statics were from the group with good pre-requisite course marks. As derived from the statistical analysis, Calculus has a highly significant strong positive relationship with Statics (r = .706, n = 131, p <.01). Students' ability in Calculus explains about 49% of the variance of students' performance in Statics. These results are consistent with the lecturer's assumption from the interview that students' ability in pre-requisite courses affects their performance in Statics. These findings support those by Anderson, Taraban, Hudson (2009) who found significant strong relationships between Statics, Calculus and Physics.

It is worthwhile to highlight that especially students coming into the engineering program with certificates from polytechnics or other foundation courses must have a strong basis in pre-requisite courses like Mathematics. Additionally, transfer credits should only be allowed if the content of their previous Mathematics syllabus meets the standard content of the first year university Mathematics. These are being emphasized because during the data collection period, the said university had allowed students from polytechnics to skip taking first year Mathematics. This had been identified as the cause for some of them to repeat Statics more than twice, and consequently failed to graduate on time. The findings implied that students may face greater challenges in Statics if they have poor skills and knowledge in the pre-requisite courses. Students' ability in pre-requisite courses plays an important role in students' performance in Statics, which concurs with the findings by Bowen, Prior, Lloyd, Thomas, & Newman-Ford (2007). Therefore, policy makers have the responsibility to ensure relevant standards are set, whilst the authority is responsible to ensure entry students meet the standard requirement.

In comparing the results for students from six different classes taught by different lecturers, faculty records showed a similar pattern. The pattern implies that irrespective of the lecturers, students' performance in terms of Statics grades is similar. However, students feel that a more personalized teaching approach would give a positive impact on their understanding and appreciation of the course. This is supported by class observation, where students were seen to be more focussed in the class activities. From the interviews students expressed that understanding what is learnt elevates their motivation in learning Statics. They perceived that teaching approach does not affect their performance in Statics as much as it does to their understanding of the concepts. Therefore, it is safe to suggest that the more important factor that influences learning and performance is the teaching approach instead of who the lecturer is.

Class observations showed that classes were conducted using traditional method, teacher-centred, with textbook exercises as worked examples in class. This approach may help students in familiarising with the method to solve Statics calculation problems, which is useful for the current examination format. Nevertheless, the approach is not effective for students to have a deep understanding of Statics concepts. Students were found to have poorer scores in Statics concept tests when compared to their examination scores. This corroborates the literature that claimed problem solving in Statics as an exercise in mathematics, ignoring the importance of understanding the conceptual details (Milano & Golub, 2001; Dollar & Steif, 2004; Steif & Dollar, 2003).

Deep understanding is required in Statics but rote memorization is common to most students, with drill and practice widely adopted. Consequently, students are able to prepare for the typical examination format, but would require more guided help in understanding the concepts. Therefore, an appropriate design teaching and learning approach is important to help with students' understanding. Steif & Dollar (2003, 2004, and 2005), Mehta & Kou (2005), Haik (1999) and others in the field had reported successful implementation of improved teaching and learning in Statics. Practical applications are needed to grasp concepts but there is a lack of implementation or usage of models, artefacts and animation which could help students to visualize and make connections between the concepts and real world application. Although many efforts have gone towards developing technology-based teaching and learning of Statics, traditional face to face and whiteboard approach is maintained in many institutions. This is due to the lack of support from the engineering department in terms of funding, facility, technological know-how and incentives.

Some students and lecturers perceived that learning environment affect students' performance in Statics. Some students attributed the challenges they face to the different teaching and learning approaches in school and at college. The lecturers too felt that students taking Statics, which is offered in the first year, are not yet adjusted to the university learning environment. The transition from school learning to university learning environment has been globally recognized as a problem for first year students (Tinto, 1975; Barefoot, 2000; Baker et. al. 2002; Darlaston-Jones et. al., 2003; Meyers et. al., 2010). Therefore, this transition to a more self-regulated university learning environment would require students to have the relevant skills.

In contrast to attributing learning challenges to the external factors like the learning environment, both students and lecturers believed good performance in Statics examinations can be achieved if students put effort in solving the textbook calculation exercises. The lecturers believed that, especially for the non-performing students, seeking help from other students or lecturers can help them to perform better in Statics assessment. However, from their observations these students are hesitant to seek their assistance when encountered with problems. The lecturers also shared that students who were repeating Statics are usually faced with clash class schedule, which they believed to be the cause for these students to become passive and to lose interest in learning the course. It should be noted that students who attribute the causes for their difficulties to 'uncontrollable' factors, such as the teaching method and learning environment, are less likely to seek help or put additional effort to improve their situation. It is also possible that the students do not seek help because they do not want to appear incompetent (Dembo and Seli, 2008). Therefore, if this is the case, some external intervention is necessary to guide this group of students to be self-regulated learners.

In one of the observations in a two-hour class period, the researcher noted class distractions. There were students who came in late, took their time to settle down, and some left earlier than scheduled. This kind of learning environment can be distracting to other students in the classroom. The distractions that occurred during class may affect negatively students' actual motivation, which also depends on the time of the day it is held, or the period in the semester (Dembo & Seli, 2008). It was also noted that students were seen to pay attention to the lecturer when emphasis was made on the examination topics, thus, indicating an influence of the performance goal. Another possible reason for the discrepancy is perhaps related to students' inability to remain persistent in their tasks. Therefore, it is important to improve this situation because motivation is an essential success factor in SRL (Schunk, 2009; Pintrich, 2004; Zimmerman, 1989).

Zimmerman (1989), Nygaard & Holtham (2008), Schunk (2009), Dembo & Seli (2008), Reid & Petocz (2008) and other researchers in their field stress the importance of motivation for learning to be meaningful, and for students to be self-regulated learners. Students' perceptions of themselves as learners and their use of various processes to regulate learning are critical for their academic performance. Hence, how self-regulated learning influence Statics performance and understanding were investigated in the actual study. The results are discussed in the following chapter.

CHAPTER 5

RESULTS AND ANALYSIS

5.1 Introduction

This chapter presents the results and analyses of the study in three sections:

i. Modified instrument measuring students' SRL.
ii. Part A of the questionnaire.
iii. Relationships between the variables.

5.2 Modified instrument measuring SRL

This section presents the results and analysis of the instrument reliability and validity in three parts: Reliability analysis for the existing factors, Factor analysis, and the Reliability analysis for the new factors.

5.2.1. Reliability analysis for the existing factors

The reliability, indicated by Cronbach's alpha coefficient (α) value, measures the internal consistency of the modified instrument. The reliability for each motivation and learning strategies factors for the pilot study data and actual data are shown in Table 5.1, along with the values for the original instrument. Although, the values for the original version are not for comparison with those for the modified instrument, the much lower reading in almost all of the pilot study modified factors indicated the need to make some amendments in the instrument. The amendments were mostly rephrasing the statements in the questionnaire.

Table 5.1 : Instrument reliability

Motivation and learning strategies sub-construct	**Alpha Cronbach, α**			
	Modified			**Original**
	Inter-item correlation	**Pilot study data**	**Actual data**	
Intrinsic goals	0.245	0.565	0.562	0.740
Extrinsic goals	0.391	0.659	0.567	0.620
Task value	0.452	0.718	0.633	0.900
Learning beliefs	-0.123	-0.749	0.498	0.680
Self-efficacy	0.367	0.621	0.699	0.930
Test anxiety	0.212	0.444	0.580	0.800
Rehearsal	0.223	0.464	0.606	0.690
Elaboration	0.323	0.647	0.658	0.760
Organization	0.357	0.600	0.591	0.640
Critical thinking	0.153	0.361	0.542	0.800
Meta-cognitive	0.138	0.618	0.638	0.79
Time and study environment	0.038	0.184	0.344	0.760
Effort regulation	0.164	0.408	0.118	0.690
Peer learning	0.140	0.330	0.530	0.760
Help-seeking	-0.007	-0.066	0.199	0.520

The data collected from the amended questionnaire shows a slight increase in the reliability values for most of the factors. A reliability value (α) can take on any value less than or equal to 1, including negative values. Although higher values of alpha are more desirable the value above 0.7 is ideal. However, for scales with less than ten items, α of 0.5 is common (Pallant, 2007). It becomes appropriate then to report the mean inter-item correlation values, with the suggested optimal values of between 0.2 and 0.4 (Pallant, 2007).

5.2.2. Factor analysis

Exploratory factor analysis (EFA) was carried out on the modified MSLQ, which had been revised based on the output from the pilot study. The principal components analysis (PCA) was used to produce more reliable factors out of the items in the questionnaire.

The number of samples in this study is suitable for EFA. It is well above 150 set as minimum in the literature (Pallant, 2007). The general recommendation is, the larger it is the more reliable is the output. Table 5.2 and Table 5.3 show the mean, standard deviation, and the sample size of each item in the motivation and learning strategies variables respectively.

Table 5.2 : Descriptive Statistics for Motivation items

	Mean	Std. Deviation	Analysis N	Missing N
i1	2.90	.772	612	0
i2	3.36	.691	612	0
i3	2.78	.914	612	0
i4	2.94	.790	612	0
i5	2.70	.824	611	1
i6	3.12	.820	612	0
i7	2.99	.798	612	0
i8	2.84	.767	612	0
i9	3.24	.778	612	0
i10	2.64	.963	612	0
i11	2.61	.908	612	0
i12	2.76	.947	612	0
i13	2.79	.753	609	3
i14	3.15	.713	609	3
i15	2.79	.801	609	3
i16	3.22	.755	609	3
i17	3.48	.700	609	3
i18	3.12	.780	609	3
i19	3.48	.669	609	3
i20	3.36	.759	609	3

Table 5.3 : Descriptive Statistics for Learning strategies items

	Mean	Std. Deviation	Analysis N	Missing N
i21	2.71	.792	609	2
i22	2.47	.851	609	2
i23	2.67	.794	609	2
i24	3.17	.794	609	2
i25	2.78	.870	609	2
i26	2.41	.924	609	2
i27	2.78	.754	609	2
i28	2.52	.900	609	2
i29	2.60	.826	609	2
i30	3.00	.767	609	2
i31	2.85	.799	609	2
i32	2.36	.915	609	2
i33	2.51	.849	609	2
i34	2.78	.782	609	2
i35	2.57	.834	609	2
i36	2.84	.791	608	3
i37	2.88	.733	608	3
i38	2.48	.841	608	3
i39	2.60	.867	608	3
i40	2.82	.797	608	3
i41	2.31	.929	608	3
i42	2.87	.718	608	3
i43	2.87	.783	608	3
i44	2.92	.745	608	3
i45	3.02	.749	608	3
i46	2.80	.841	608	3
i47	3.13	.774	608	3
i48	2.88	.812	608	3
i49	2.91	.695	608	3
i50	2.79	.750	608	3
i51	2.79	.802	608	3
i52	3.28	.781	608	3
i53	2.84	.767	608	3
i54	2.99	.706	608	3
i55	2.47	.909	608	3
i56	2.88	.734	608	3
i57	2.27	.902	608	3
i58	2.85	.727	608	3

The suitability of the data for factor analysis was assessed prior to performing PCA. The strength of the inter-correlations among the items was inspected and they revealed all values greater than 0.3. This value indicates that EFA to be appropriate for the data. Two other statistical measures to assess the factorability were generated by SPSS and are shown in Table 5.4. The Bartlett's Test of Sphericity shows that the statistical significance ($p < 0.05$) was reached. The table also shows the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) indexes to be 0.856 for the motivation variables and 0.910 for the learning strategies. The minimum value for a good factor is 0.6 (Pallant, 2007), hence, the KMOs for these data are considered great. Therefore, these measures support the factorability of the correlation matrix.

Table 5.4 : KMO and Bartlett's Test for Motivation and Learning strategies

		Motivation	Learning strategies
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.856	.910
Bartlett's Test of Sphericity	Approx. Chi-Square	2736.609	6148.243
	df	190	703
	Sig.	.000	.000

To determine the number of factors to extract from the data, the Kaiser's criterion (or eigenvalue) was used. Shown in Table 5.5, PCA for the motivation variable revealed four factors (referred to as 'components') with eigenvalues of more than 1. Table 5.6 shows eight factors for the learning strategies variables. The Total Varianced Explained tables for both motivation and learning strategies variables provide the individual variances for each of the factors as shown in the Initial % of variance column.

The screeplots and Component Matrix tables (in Appendix E) were also referred to in determining the number of factors to extract. It was decided that three factors for the motivation variable and six factors for the learning strategies were appropriate, thus, retained. With three factor loadings, the total variance for the motivation variable is 42.2%. Meanwhile, the total variance for the six learning strategies variable is 44.4%. These are shown in the Total Varianced Explained Tables, which also show the contributions for each individual factor. The total variance of about 50% is common for the social science research.

Table 5.5 : Total Variance Explained for Motivation

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.727	23.636	23.636	4.727	23.636	23.636	3.225	16.125	16.125
2	2.291	11.455	35.092	2.291	11.455	35.092	3.075	15.375	31.499
3	1.426	7.131	42.223	1.426	7.131	42.223	2.145	10.723	42.223
4	1.248	6.241	48.464						
5	.967	4.835	53.299						
6	.885	4.426	57.725						
7	.807	4.035	61.760						
8	.775	3.874	65.634						
9	.732	3.659	69.294						
10	.696	3.479	72.773						
11	.676	3.380	76.153						
12	.654	3.268	79.421						
13	.615	3.075	82.496						
14	.596	2.979	85.475						
15	.561	2.804	88.279						
16	.553	2.766	91.045						
17	.489	2.443	93.488						
18	.459	2.294	95.782						
19	.447	2.236	98.017						
20	.397	1.983	100.000						

Extraction Method: Principal Component Analysis.

Table 5.6 : Total Variance Explained for Learning strategies

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.521	22.423	22.423	8.521	22.423	22.423	4.072	10.715	10.715
2	2.699	7.103	29.525	2.699	7.103	29.525	3.222	8.480	19.195
3	1.704	4.484	34.010	1.704	4.484	34.010	2.855	7.512	26.707
4	1.569	4.129	38.139	1.569	4.129	38.139	2.583	6.797	33.505
5	1.235	3.249	41.388	1.235	3.249	41.388	2.489	6.549	40.054
6	1.159	3.050	44.438	1.159	3.050	44.438	1.666	4.384	44.438
7	1.153	3.035	47.473						
8	1.039	2.735	50.208						
9	.966	2.542	52.751						
10	.922	2.426	55.177						
11	.908	2.391	57.568						
12	.904	2.379	59.946						
13	.849	2.235	62.181						
14	.797	2.097	64.278						
15	.770	2.026	66.304						
16	.765	2.014	68.318						
17	.742	1.952	70.269						
18	.738	1.943	72.212						
19	.698	1.838	74.050						
20	.693	1.823	75.873						

Table 5.6 (continued)

21	.671	1.764	77.637						
22	.648	1.705	79.343						
23	.632	1.663	81.006						
24	.615	1.618	82.624						
25	.602	1.584	84.208						
26	.571	1.502	85.710						
27	.559	1.471	87.181						
28	.533	1.402	88.582						
29	.523	1.377	89.960						
30	.508	1.338	91.298						
31	.471	1.240	92.537						
32	.457	1.203	93.740						
33	.455	1.197	94.937						
34	.416	1.094	96.031						
35	.408	1.074	97.105						
36	.381	1.002	98.107						
37	.370	.974	99.082						
38	.349	.918	100.000						

Extraction Method: Principal Component Analysis.

Once the number of factors was decided on, factor rotation was carried out using the orthogonal approach to interpret the factors. Varimax, the most common method for orthogonal rotation (Pallant, 2007), was used. The rotations revealed strong loading items that fall into each factor (referring to the 'component' in Tables 5.7 and 5.8). The detailed items representing each factor are listed in Appendix F. All items, except one or two, load substantially on only one factor. The items that have loadings on more than one factor represent the factors with the higher loadings.

Table 5.7 : Rotated Component Matrix[a] (Motivation)

	Component		
	1	**2**	**3**
i19	.757		
i9	.631		
i17	.621		
i2	.598		
i20	.587		
i18	.578		
i16	.515	.427	
i7			
i6			
i13		.695	
i8		.672	
i5		.651	
i1		.642	
i15		.577	
i4		.496	
i14		.487	
i10			.708
i3			.690
i11			.687
i12			.588

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 5.8 : Rotated Component Matrix[a] (Learning strategies)

	Component					
	1	2	3	4	5	6
i48	.715					
i44	.711					
i46	.633					
i50	.622					
i36	.530					
i42	.530					
i58	.459					
i49						
i32		.634				
i21		.609				
i43		.569				
i51		.562				
i33		.491			.477	
i40		.481				
i56		.445				
i35	.402	.414				
i34						
i53			.613			
i52			.581			
i45			.522			
i24			.511			
i54			.483			
i31			.466			
i37						
i27						
i41				-.702		
i55				.688		
i22				.642		
i38				.629		
i26				.516		
i57				.507		
i23					.665	
i39					.564	
i29					.405	
i25					.404	
i28						.659
i47						.651
i30						.508

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

Therefore, the resulted new factors for motivation and learning strategies are three and six factors respectively. Referring to Table 5.7 for motivation and Table 5.8 for learning strategies, the item-clusters under each component column made up the new factors, which are named as the following:

1. Motivation:
   Study goals and values (component 1);
   Learning beliefs and self-efficacy (component 2);
   Anxiety (component 3)

2. Learning strategies:
   Critical thinking and elaboration (component 1);
   Organization and memorization (component 2);
   Persistence and regulation (component 3);
   (Lack of) Study effort (component 4);
   Meta-cognitive regulation (component 5);
   Help seeking (component 6).

5.2.3. Reliability analysis for the new factors

Descriptive analysis, normality and reliability tests were carried out on the new factors. Table 5.9 presents only the results for meta-cognitive regulation, anxiety and learning beliefs and self-efficacy. Other results for the descriptive analysis are presented in Appendix G. The 5% trimmed mean, skewness and kurtosis values were specifically looked at. The 5% trimmed mean for all the factors show the values that do not vary much from the mean values, indicating that the outliers are not a problem. The skewness and kurtosis ratios to their standard errors were mostly found to fall between -2 and 2. This indicates a normal distribution, although skewness and kurtosis values are usually not reliable indicators for a large sample (Pallant, 2007).

Table 5.9 : Descriptives

			Statistic	Std. Error
Meta-cognitive regulation N = 606	Mean		10.64	.094
	95% Confidence Interval for Mean	Lower Bound	10.45	
		Upper Bound	10.82	
	5% Trimmed Mean		10.67	
	Median		11.00	
	Variance		5.312	
	Std. Deviation		2.305	
	Minimum		4	
	Maximum		16	
	Range		12	
	Interquartile Range		3	
	Skewness		-.187	.099
	Kurtosis		-.104	.198
Anxiety N = 612	Mean		10.80	.105
	95% Confidence Interval for Mean	Lower Bound	10.60	
		Upper Bound	11.01	
	5% Trimmed Mean		10.85	
	Median		11.00	
	Variance		6.697	
	Std. Deviation		2.588	
	Minimum		4	
	Maximum		16	
	Range		12	
	Interquartile Range		4	
	Skewness		-.175	.099
	Kurtosis		-.339	.197
Learning beliefs and self-efficacy N = 609	Mean		20.10	.139
	95% Confidence Interval for Mean	Lower Bound	19.83	
		Upper Bound	20.37	
	5% Trimmed Mean		20.13	
	Median		20.00	
	Variance		11.747	
	Std. Deviation		3.427	
	Minimum		7	
	Maximum		28	
	Range		21	
	Interquartile Range		4	
	Skewness		-.143	.099
	Kurtosis		.127	.198

Other methods to assess normality include the Kolmogorov-Smirnov statistic. A non-significant result (sig. > 0.05) indicates a normal distribution but the results in Table 5.10 show significant values. It is however, usual for large samples to obtain such significant results. Therefore, Histograms, Normal Q-Q Plot and boxplots were used, and they show normal distributions of the data. The related tables and graphs are attached in Appendix G; only three histograms are included in Figure 5.1.

Table 5.10 : Tests of Normality

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Study goals and Value	.100	609	.000	.947	609	.000
Anxiety	.092	612	.000	.979	612	.000
Learning beliefs and self-efficacy	.072	609	.000	.989	609	.000
Critical thinking & elaboration	.081	608	.000	.985	608	.000
Organization and memorization	.068	606	.000	.991	606	.001
Persistence and regulation	.090	606	.000	.980	606	.000
(Lack of) study effort	.096	606	.000	.982	606	.000
Meta-cognitive regulation	.112	606	.000	.980	606	.000
Help-seeking	.127	606	.000	.958	606	.000

a. Lilliefors Significance Correction

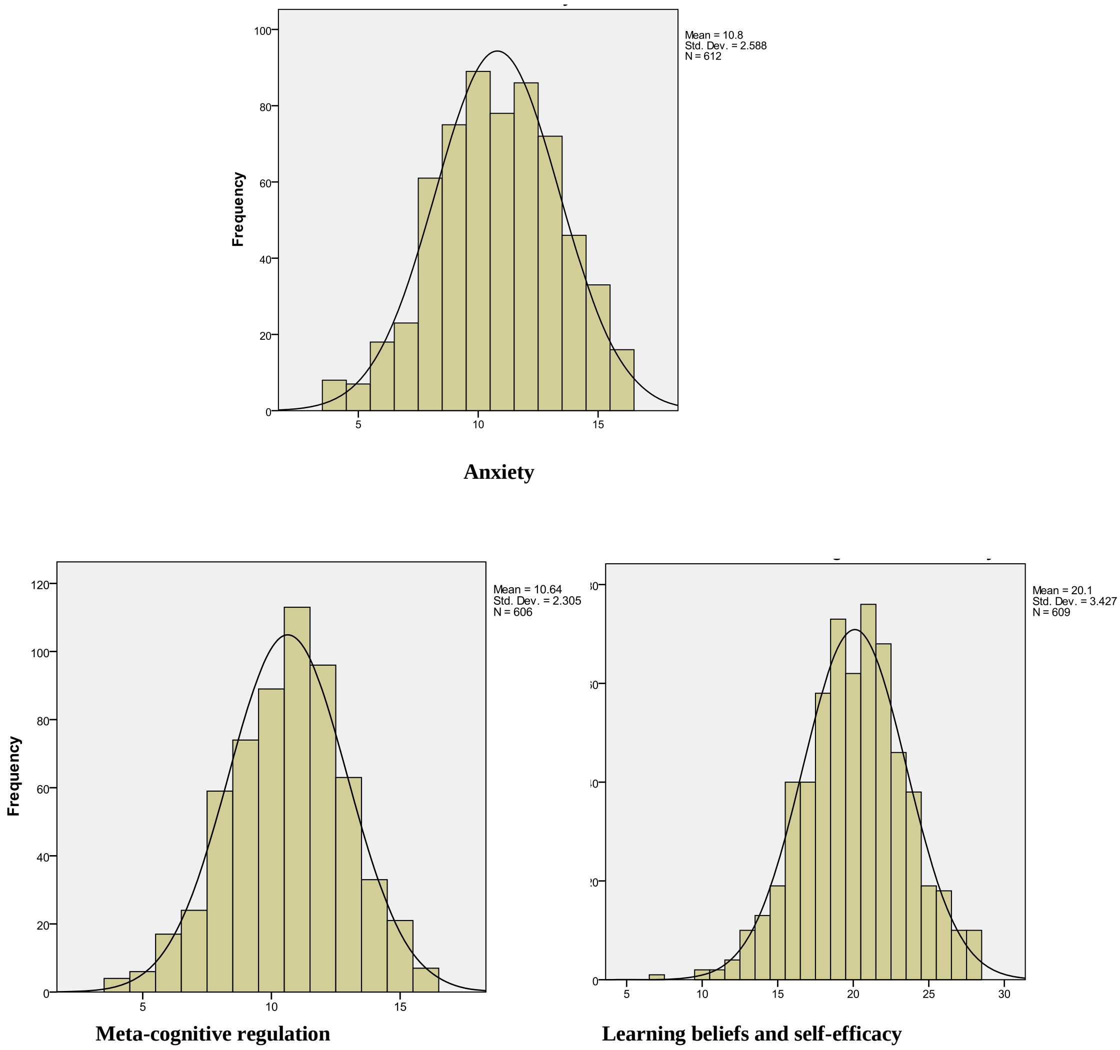


Figure 5.1 Histograms for Anxiety, Meta-cognitive regulation, Learning beliefs & self-efficacy showing normal distribution of data

Several relevant tables generated by SPSS in investigating factor reliabilities are included in Appendix H. The Inter-Item Correlation Matrix tables were checked for negative values but all items in each of the factors showed positive values. This means that the items are correctly measuring the respective same underlying factor characteristics. In the Item-Total Statistics tables, the ‘corrected item-total correlation’ values were checked to see how each item correlates with the total score. A low value of less than 0.3 indicates that the item do not measure a particular factor as well as the other items. Therefore, items with such values were considered for removal. An item was deleted for each of the Study effort, and Study goals and value factors. The items were deleted when the value for 'Cronbach's Alpha if item deleted' of the total score improves (shown in the Item-Total Statistics Table).

An item in the Help-seeking was also found to require some attention but there was only three items in the factor, hence too little to delete. Instead, the inter-item correlation mean value in the Summary Item Statistics table was considered. The mean showed an acceptable value that falls between 0.2 and 0.4 (indicating an optimal range for factors with less than 10 items). Hence, it was decided to maintain the said item in Help-seeking.

Finally, the reliability tests to assess the internal consistency of the new factors revealed improved Cronbach's Alpha values. Table 5.11 illustrates the Cronbach's Alpha values for the motivation and learning strategies variables after factor analysis. The results show that the values for all the new factors to fall within 0.6 to 0.8, except for one factor, the help-seeking. The value of 0.7 is considered ideal, whilst 0.5 is common for a factor with less than 10 items (Pallant, 2007). Therefore, these values indicate that the new factors have good reliabilities.

This section concludes that the data distributions for the new factors are normal, and the new factors representing the motivation and learning strategies variables are reliable. And these variables are the measures for SRL used in the study.

Table 5.11 : Reliability values for motivation and learning strategies subscales

Motivation & learning strategies (after factor analysis)	**Cronbach's Alpha**
Study goals and values	.766
Anxiety	.640
Learning beliefs and self-efficacy	.750
Organization and memorization	.765
Critical thinking and elaboration	.810
Persistence and regulation	.692
(Lack of) Study effort	.621
Meta-cognitive regulation	.623
Help-seeking	.467

5.3 Analysis of Part A of the questionnaire

This section presents the analysis of Part A of the questionnaire. The sample for this research was from four institutions in Malaysia. There were a total of 636 questionnaire respondents. The respondents were randomly selected and their participation was voluntary. After data cleaning only 521 respondents' raw scores for Statics were available for the analysis. According to gender, 81% were males and 19% were females. 73% of these respondents were between 17 to 20 years of age, whilst the remaining 27% were above 21 years old. The respondents were mainly local students and mostly Malays, although there were a number of foreign students at two of the universities. The frequency of the students taking Statics more than twice is 3%, twice 14% and once 83%.

Table 5.12 shows the number of respondents (N), mean values and standard deviations for each variable in this study. The mean score for Statics is higher than the concept score mean. The minimum value for both Statics and concept scores were 0%, whilst the maximum values were 100% and 81% respectively. The table also illustrates the three highest mean values: Study goals and value, followed by Organization and memorization, and Learning beliefs and self-efficacy.

Two main statistics from the analysis of Part A on students' learning goals and perceptions on the factors influencing their Statics learning are highlighted in the following two sub-sections.

Table 5.12 : Descriptive statistics

	Variables	**N**	**Mean**	**Standard deviation**
1.	Statics score	521	69.43	16.09
2.	Concept score	625	30.68	14.38
3.	Study goals and value	609	23.27	3.31
4.	Anxiety	612	10.80	2.59
5.	Learning beliefs and Self-efficacy	609	20.10	3.43
6.	Critical Thinking And Elaboration	608	19.97	3.69
7.	Organization and Memorization	606	21.52	4.01
8.	Persistence and Regulation	606	18.16	2.88
9.	(Lack of) study effort	606	12.10	2.80
10.	Meta-Cognitive Regulation	606	10.64	2.31
11.	Help Seeking	606	8.65	1.70

5.3.1. Students' learning goals in Statics

Results from the questionnaire that were distributed to the four institutions were analyzed to investigate the students' learning goals. Students were given choices of whether their goals in learning Statics were to pass (G1), to score (G2), to gain understanding (G3), or a combination of any or all of those. Their choices are as indicated below (as a percentage of respondents):

1. 62.1% focused on gaining understanding (G3),
2. 43.8% aimed to score Statics (G2),
3. 19.7% targeted to pass (G1),
4. 18.6% targeted on both gaining understanding and scoring high marks (G2 and G3).
5. 10.3% aimed to pass and gain understanding (G1 and G3), and
6. 8.5% aimed to pass and score (G1 and G2),

Analysis was also carried out to see the pattern of students learning goals based on the number of times they took Statics. Shown in Table 5.13, most students put priority in gaining understanding when they learn Statics; even for the students who had taken Statics more than once. Students who had taken the course more than twice were also more interested to score the course instead of just getting a pass. The same finding was shown for students who had gone through the course the first time. However, the analysis showed those who had repeated Statics for the second time were hoping to pass more than to score, although, only slightly.

Table 5.13 : Number of Times Taking Statics vs. Goals of Learning (choices were a combination of to pass, score and/or to gain understanding)

No. of times taking Statics	**Percent (%) of total respondents**	**To pass, G1 (%)**	**To gain understanding, G3 (%)**	**To score, G2 (%)**
Once	83.0	19.2	48.8	39.1
Twice	14.0	4.7	8.4	4.5
More than twice	3.0	0.3	1.8	1.6

5.3.2. Perceptions on the factors influencing students' performance in Statics

Students were asked to choose from a given list the possible factors that could affect their performance in Statics. The factors shown in Table 5.14 can be grouped into intrinsic and extrinsic factors. Interest, effort, ability, understanding of Statics concepts are intrinsic factors. Meanwhile, extrinsic factors include the influences from coursework marks, teaching methods, lecturer's attitude, and friends. The statistical analysis shows that students perceived the intrinsic factors to be more influential on their performance in Statics than on the intrinsic factors; and ranking effort as the most influential factor.

From the total respondents, 10% of them selected all four intrinsic factors; meanwhile, 4% selected all four extrinsic factors. This emphasizes the fact that students put themselves responsible for their own success, more than blaming others or other external factors for their weak performance. This finding may seem to contradict with the preliminary findings on the lecturers' perceptions of students' poor attitude, lack of interest and effort in learning Statics.

A question on their general feelings in Statics class revealed the data in Table 5.15. It is shown that 70% of the students were mostly motivated to learn Statics, even though there were 5% of them who felt not confident of themselves. It is interesting to note that more than half of the 30% of students, who were not motivated, were actually confident in doing well in Statics.

Another specific question was to gauge the students' appreciation in knowing where to apply Statics concepts. The result show 94% of the respondents agreed that it could help them in understanding Statics better.

Table 5.14 : Factors Influencing Students' Performance

No.	Influencing factors	Percentage (%)
1.	Effort	20
2.	Understanding	17
3.	Interest	14
4.	Ability	12
5.	Teaching method	12
6.	Lecturer's attitude	9
7.	Friends	8
8.	Coursework	7
9.	Other factors	1

Table 5.15 : General feelings in Statics class

	General feelings in Statics class
Motivated (70%)	Motivated and confident – 65% Motivated but not confident – 5%
Not confident (30%)	Not confident but motivated – 16%* Not confident and other thoughts – 14%

5.4 Relationships between the variables

The following sub-sections present the results for the correlation and multiple regression analyses separately. Table 5.16 provides the summary of those results according to the research questions and analysis method.

Table 5.16 : Summary of the results and analysis for RQ 1 – RQ 3

<table>
<tr><th>Research Question (RQ)</th><th>Data analysis</th><th>Results</th></tr>
<tr><td>RQ 1
What is the relationship between the students' performance in Statics and their understanding of the fundamental concepts in Statics?</td><td>Correlation</td><td>(r = .371, n =516, p < .001)</td></tr>
<tr><td>RQ 2
How does self-regulated learning predict performance?</td><td>Multiple regression</td><td rowspan="2">Learning beliefs and self-efficacy makes the largest unique contribution.</td></tr>
<tr><td>RQ 3
How does self-regulated learning predict understanding?</td><td>Multiple regression</td></tr>
</table>

5.4.1. Correlation analysis

Using SPSS 18.0 Pearson product-moment correlation coefficient, the relationships between Statics performance, concept understanding, and all the SRL variables were analyzed. The resulted correlation values are shown in Table 5.17.

In answering RQ 1, the correlation analysis between Statics scores and Concept scores shows the relationship is highly significant, positive and moderately correlated (r = .371, n =516, $p < .001$). Based on Cohen's interpretation (1988, pp.79-81): r = 0.10 to 0.29 is a weak relationship, r = 0.30 to 0.49 moderate, and r = 0.50 to 1.0 is strong. Therefore, r = 0.371 implies a moderate relationship, and that the concept score, measuring understanding, helps to explain 16% of the variance in respondents' performance, measured by Statics score.

The correlation table also shows the relationships that are highly significant but moderate between Statics score and the following:

i. Learning beliefs and self-efficacy (r = .325, n = 495, p < .001)
ii. Meta-cognitive regulation (r = .307, n = 493, p < .001).

There are also weak relationships, although they are highly significant, between the concept score and:

i. Learning beliefs and self-efficacy (r = .231, n = 598, p < .001)
ii. Meta-cognitive regulation (r = .224, n = 595, p < .001).

There are strong positive significant relationships between the learning beliefs and self-efficacy with the following:

i. Critical thinking and elaboration (r = .591, n = 606, p < .001).
ii. Meta-cognitive regulation (r = .552, n = 606, p < .001).
iii. Persistence and regulation (r = .533, n = 606, p < .001).

There are also strong positive significant relationships between the meta-cognitive regulation and:

i. Critical thinking and elaboration (r = .572, n = 606, p < .001).
ii. Organization and memorization (r = .565, n = 606, p < .001).
iii. Persistence and regulation (r = .510, n = 606, p < .001).

Other strong positive significant relationships include the relationships between critical thinking and elaboration and:

i. Organization & memorization (r = .581, n = 606, p < .001).
ii. Persistence and regulation (r = .537, n = 606, p < .001).

Table 5.17 : Pearson Correlations of SRL, concept and Statics scores

Variables		1	2	3	4	5	6	7	8	9	10	11
1.	Statics score	-										
2.	Concept score	.371**	-									
3.	Study goals and values	.061	.069	-								
4.	Anxiety	-.224**	-.106**	.217**	-							
5.	Learning beliefs and Self-efficacy	.325**	.231**	.477**	.022	-						
6.	Critical Thinking And Elaboration	.214**	.192**	.301**	.142**	.591**	-					
7.	Organization and Memorization	.157**	.086	.199**	.141**	.496**	.581**	-				
8.	Persistence and Regulation	.269**	.199**	.489**	.093	.533**	.537**	.496**	-			
9.	(Lack of) study effort	.166**	.130	-.084	-.472**	-.028	-.168**	-.162**	.030	-		
10.	Meta-Cognitive Regulation	.307**	.224**	.200**	.044	.552**	.572**	.565**	.510**	-.051	-	
11.	Help Seeking	.112**	.090	.269**	-.024	.161**	.135**	.133**	.312**	.095	.158**	-

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

5.4.2. Multiple regression analysis

In answering RQ 2 and RQ 3 the multiple regression analysis was used to analyze the SRL factors that contribute to the performance and understanding of the concepts in Statics. This section describes the associations between SRL variables and Statics score, followed by the results for the associations between SRL variables and the concept score. The variables from the learning strategies and motivation variables (measuring SRL) were analyzed together using the SPSS method Enter (Standard), first with the Statics score (measuring performance), then with the Concept score (measuring concept understanding).

Table 5.18 shows a moderate correlation of all SRL variables with the Statics score ($R = 0.46$). This value implies that the SRL variables could explain about 21% of the variance in the Statics score. Table 5.19 shows the regression is highly significant F (9,483) = 14.084, $p < 0.001$. It implies that this model is a significant fit of the overall data.

Table 5.20 shows that the study goals and value, and anxiety are negatively and significantly associated to the concept score. Meanwhile, learning beliefs and self-efficacy, persistence and regulation, and meta-cognitive regulation made positive statistically significant contributions. The Beta values indicate that learning beliefs and self-efficacy factor makes the largest unique contribution (beta = 0.241, $p < 0.001$).

Table 5.18 : Multiple Correlation Variables: Statics Score

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.456 [a]	.208	.193	14.449

a. Predictors: (Constant), Help-seeking, Anxiety, Learning beliefs and self-efficacy, (Lack of) study effort, Organization and memorization, Study goals and value, Meta-cognitive regulation, Persistence and regulation, Critical thinking and elaboration.

b. Dependent Variable: % Statics score.

Table 5.19 : Independent Variables Significance: Statics Score

ANOVA[b]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	26464.810	9	2940.534	14.084	.000[a]
Residual	100841.520	483	208.782		
Total	127306.329	492			

a. Predictors: (Constant), Help-seeking, Anxiety, Learning beliefs and self-efficacy, (Lack of) study effort, Organization and memorization, Study goals and value, Meta-cognitive regulation, Persistence and regulation, Critical thinking and elaboration.

b. Dependent Variable: % Statics score.

Table 5.20 : Correlation Coefficient and Independent Variables Significance: Statics Score

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	43.189	7.676		5.627	.000	28.107	58.271					
Study goals and Values	-.530	.253	-.109	-2.093	.037	-1.028	-.032	.061	-.095	-.085	.603	1.660
Anxiety	-1.151	.295	-.185	-3.899	.000	-1.731	-.571	-.224	-.175	-.158	.728	1.374
Learning beliefs and Self-efficacy	1.132	.280	.241	4.049	.000	.583	1.682	.325	.181	.164	.462	2.165
Critical Thinking and Elaboration	.036	.256	.008	.141	.888	-.467	.539	.214	.006	.006	.477	2.096
Organization and Memorization	-.327	.222	-.081	-1.470	.142	-.763	.110	.157	-.067	-.060	.536	1.865
Persistence and Regulation	.839	.325	.150	2.580	.010	.200	1.478	.269	.117	.104	.483	2.072
(Lack of) Study Effort	.378	.273	.066	1.386	.167	-.158	.913	.166	.063	.056	.730	1.369
Meta-Cognitive Regulation	1.165	.391	.167	2.976	.003	.396	1.934	.307	.134	.121	.521	1.918
Help Seeking	.272	.411	.029	.662	.508	-.535	1.080	.112	.030	.027	.869	1.151

a. Dependent Variable: % Statics score.

Tables 5.21 and 5.22 show the multiple correlations of all SRL factors with the concept score as moderate (R = 0.33). It also shows that the SRL variable could explain about 11% of the variance in the concept score, with the highly significant regression F (9,585) = 7.683, $p < 0.001$. This implies that the model is a significant fit of the overall data. Table 5.23 shows that learning beliefs and self-efficacy, meta-cognitive regulation, and the (lack of) study effort are positively and significantly associated to the concept score. Meanwhile, organization and memorization has negative significant association. The Beta values indicate that learning beliefs and self-efficacy makes the largest unique contribution (beta = 0.145, p < 0.05).

Table 5.21 : Multiple Correlation Variables: Concept Score

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.325[a]	.106	.092	13.701

a. Predictors: (Constant), Help-seeking, Anxiety, Learning beliefs and self-efficacy, (Lack of) study effort, Organization and memorization, Study goals and value, Meta-cognitive regulation, Persistence and regulation, Critical thinking and elaboration.

b. Dependent Variable: %Tot concept score.

Table 5.22 : Independent Variables Significance: Concept Score

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12978.634	9	1442.070187.708	7.683	.000[a]
	Residual	109809.069	585			
	Total	122787.704	594			

a. Predictors: (Constant), Help-seeking, Anxiety, Learning beliefs and self-efficacy, (Lack of) study effort, Organization and memorization, Study goals and value, Meta-cognitive regulation, Persistence and regulation, Critical thinking and elaboration.

b. Dependent Variable: %Tot concept score.

Table 5.23 : Correlation Coefficient and Independent Variables Significance: Concept Score

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	5.551	6.624		.838	.402	-7.58	18.560					
Study goals and values	-.264	.219	-.061	-1.210	.227	-.694	.165	.069	-.050	-.047	.603	1.660
Anxiety	-.330	.255	-.059	-1.297	.195	-.830	.170	-.106	-.054	-.051	.728	1.374
Learning beliefs and Self-efficacy	.610	.241	.145	2.529	.012	.136	1.084	.231	.104	.099	.462	2.165
Critical Thinking and Elaboration	.378	.221	.097	1.712	.087	-.056	.812	.192	.071	.067	.477	2.096
Organization and Memorization	-.459	.192	-.128	-2.396	.017	-.836	-.083	.086	-.099	-.094	.536	1.865
Persistence and Regulation	.447	.281	.090	1.594	.112	-.104	.998	.199	.066	.062	.483	2.072
(Lack of) Study Effort	.503	.235	.098	2.139	.033	.041	.965	.130	.088	.084	.730	1.369
Meta-Cognitive Regulation	.814	.338	.131	2.410	.016	.151	1.477	.224	.099	.094	.521	1.918
Help Seeking	.238	.355	.028	.670	.503	-.459	.934	.090	.028	.026	.869	1.151

a. Dependent Variable: %Tot concept score

5.5 Summary

Findings from this study related to the students' self-regulation, performance and concept understanding are summarized below:

1. Motivation plays an important role in students' learning of Statics.
2. Students are motivated to learn although Statics is a challenging course.
3. Learning beliefs and self-efficacy are the main motivation predictors in students understanding and performance in Statics.
4. Meta-cognitive regulation is the main learning strategies predictor in students understanding and performance in Statics.
5. Anxiety negatively affects performance but no significant association with concept understanding.
6. The majority of students, including those who had been repeating the course due to previous poor results, have mastery learning goal.
7. Students perceived that understanding helps increase self-efficacy, which consequently helps to motivate them to perform well in the assessment.
8. Students believe in being responsible for their own learning, and have the characteristics of a successful learner.
9. Students attribute their success and failure to controllable factors, such as effort, understanding, interest and ability. Thus, indicating that these students are more inclined to choose strategies like help seeking and more likely to feel motivated.
10. Understanding moderately affects performance and vice-versa.

CHAPTER 6

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This last chapter discusses pertinent findings that had emerged from the research. The findings are the relationships between SRL variables, performance and understanding, and are discussed separately based on the type of analysis. Section 6.2 discusses the results from Part A of the questionnaire, Section 6.3 the correlation analysis, while Section 6.4 describes the results from the multiple regression analysis.

The rest of this chapter includes the sections on the contributions to knowledge, implications of the findings, the conclusions and recommendations for future work.

6.2 Discussions on the findings from Part A

The frequency of students' learning goals in Statics from Part A of the questionnaire show that students' foremost goal was to gain understanding, instead of just wanting to pass. And as opposed to the general perception, repeating students too put priority in understanding the course material when they learned Statics.

Following understanding, students' goal was to score good grades, and the least favourable was just to pass the course. This result implied that students put mastery learning goal as priority, and this supports the finding in the preliminary study.

The results from interviews in the preliminary study are consistent with the students' feedback from the survey. The feedback shows that students believed their effort, understanding, and interest are the most influencing factors on their performance in Statics. Ability and teaching method came fourth in the list, implying that students believed intrinsic factors to be more influential than the extrinsic factors. Based on the attribution theory (Dembo & Seli, 2008), how students perceive the cause for their success or failure determines how they will approach that particular task, and how long they will persist at it. Therefore, since these students attributed the causes of their learning outcome to their own effort, they can be expected to choose the correct learning strategies, such as seeking help from lecturers, to overcome their problems. They would be more likely to try harder in future situations and would persist on difficult tasks. Referring to Dembo and Seli (2008), these students appear to have the characteristics of a self-directed learner. However, it is worth noting that attribution does not always reflect reality.

Regarding motivation, there is a difference between perceived motivation and actual motivation. The majority of students who responded to the survey felt motivated and confident in learning and doing well in Statics. Even from among those who were not confident, most of them were motivated. However, these findings seem to contradict with those from the preliminary study, which were gathered from observations on students' attitude in the classroom and the lecturers' perceptions of the students' behavior. This difference may perhaps be a factor of the teaching and learning approaches, or the study environment.

6.3 Discussions on the findings from the correlation analysis

There are three categories of relationships described in this section: Concept understanding and performance; SRL variables with concept understanding and performance; and the SRL variables between each other.

6.3.1. Concept understanding and performance

It was interesting to notice from the preliminary study that the concept test results for an A student in Statics to be equally low as the students who had obtained a D and an E in Statics. The finding seems to agree with the studies by Montfort et al. (2009) and Streveler et al. (2006). They realized that engineering students who had scored good grades in a fundamental engineering course final mark may not have a good understanding of the concepts. These had prompted the researcher to analyze the relationship between Statics concept understanding and performance. The assumption made regarding the positive effect of students' understanding on examination results provides a stronger justification for the investigation.

The result of the correlation analysis shows that the relationship between concept understanding and performance is highly significant, positive and moderately correlated. Better student understanding of the concepts helps improve their performance but only moderately. This is also true for the effect of performance on understanding. Concept score, measuring understanding, helps to explain about 16% of the variance in the respondents' performance, which was measured by Statics score.

Although this result is similar to the findings by Steif & Hansen (2006), Steif, Dollar & Dantzler (2005) and Anderson et. al. (2009) regarding its significance, the strength of the relationship differs. They reported strong correlations between concept test scores and the examination scores, unlike the result from this study, which revealed a moderate correlation between the two variables. This finding may be used to support the claims made by Montfort et. al. (2009) and Streveler et. al. (2006) that students who perform well in engineering may not necessarily have a deep understanding of the fundamental concepts.

One possible explanation as to why there is only a moderate relationship between concept understanding and performance is related to the examination question format. Assessments are mainly focused on testing students on their calculation skill and procedural knowledge rather than their concept understanding. Therefore, students do not require much concept understanding to score in their examinations. Using drill and practice strategies students are able to familiarize themselves with the question format. They are able to do better in the assessment with more effort in solving the textbook problems and past years' examination questions.

6.3.2. Relationships of the SRL variables with concept understanding and performance

It is worth highlighting that the relationships between all SRL variables (except study goals and value) and performance are highly significant, although each vary in strength. However, this is not the case for the relationships between SRL variables and understanding. Results indicated that organization and memorization, study effort and help-seeking variables do not have significant relationships with concept understanding.

Comparing the effects of SRL variables on performance and understanding, the correlation strengths are greater for students aiming to perform well in the examinations. Learning beliefs and self-efficacy, and meta-cognitive regulation are the two most used strategies related to concept understanding and performance. They have moderate effect on students' performance, but have weak links with concept understanding.

The differing effect of SRL variables on concept understanding and performance could perhaps be explained by the different types of tasks involved. In trying to achieve better understanding, students may require external intervention to help them understand the concepts in Statics. Conversely, students have better control in preparing themselves for the examinations. It can be interpreted that when students believe and are confident they have control over their tasks, they would use meta-cognitive regulation strategies to plan, monitor and regulate their performance.

How learning goals affect students' performance and understanding in Statics concepts were also investigated using the modified MSLQ. The statistical results showed no significant correlation between them, although the mean value showed study goals as highest when compared to the variables organization and memorization, and learning beliefs and self-efficacy. Why is this so?

Learning goals are associated with the way students think and behave, and play a very important role in motivating students and predicting the academic performance. Boekaerts (1999) suggested that if students use internal regulation they would specify their own learning goals and choose own learning strategy. In contrast, if they depend on external regulation they would wait for others to direct their learning. In this study it appears as though, students have mastery goals but they do not use appropriate strategies to help them learn Statics. It is possible that these students have mixed regulation, having both internal and external regulations; they were able to choose their learning goals but expected to be directed in learning. Further investigation is recommended.

6.3.3. Significant relationships between SRL variables

Other findings worth discussing from the correlation analysis include the highly significant strong relationships between individual SRL variables. There exist very strong relationships between learning beliefs and self-efficacy, and the following learning strategies:

i. Critical thinking and elaboration (*r* = .591).
ii. Meta-cognitive regulation (*r* = .552).
iii. Persistence and regulation (*r* = .533).

These results imply that students with learning beliefs and self-efficacy would use learning strategies like critical thinking and elaboration, meta-cognitive regulation, persistence and regulation strategies. In elaborating the relationships further, sample items from the questionnaire for each factor above are used. A student who has positive learning beliefs and self-efficacy is "confident of doing an excellent job on Statics assignments and tests", therefore, would "choose to ask questions to herself to make sure she understands what she has learnt" (critical thinking and elaboration). She would "always try to solve any confusion with what was learnt in Statics after class" (meta-cognitive regulation), and "even if the course materials are dull and uninteresting, she would managed to keep working until it is done" (persistence and regulation).

Another important SRL variable, the meta-cognitive regulation, shows highly significant strong relationships with factors similar to the above, but with an additional strong relationship with organization and memorization strategies. One example of a meta-cognitive learner that "often tries to explain the material learnt to a classmate" would often "set aside time to discuss the course material with a group of friends" (organization and memorization). The following lists the correlation strength between meta-cognitive regulation and those factors:

i. Critical thinking and elaboration (*r* = .572).
ii. Organization and memorization (*r* = .565).
iii. Learning beliefs and self-efficacy (*r* = .552).
iv. Persistence and regulation (*r* = .510).

Other very strong relationships show that students who use critical thinking and elaboration strategies would also choose to use Organization and memorization (*r* = .581), Meta-cognitive regulation (*r* = .572) and Persistence and regulation (*r* = .537) strategies.

6.4 Discussions on the findings from the multiple regressions

This section discusses the associations between: SRL variables and Statics score, and SRL variables and Concept score. Results from the multiple regression analysis show that SRL variables predict performance better (21% of the variance) than concept understanding (11% of the variance). The greater effects of SRL variables on understanding than on performance can be explained by the students' ability to control performance better than understanding.

Learning beliefs and self-efficacy is the most significant predictor on understanding of Statics concepts and performance in Statics. This finding is consistent with the results by researchers in this field, including Wolters and Pintrich (1998) and Kosnin (2007), who found self-efficacy to predict performance. Learning beliefs and self-efficacy reflect students' beliefs of their competence and confidence in their academic ability, which could be translated to control of learning and regulate effort in learning. Students who have learning beliefs and self-efficacy ("I always believe I will get an excellent grade in Statics class") would choose appropriate strategies in controlling their own learning and effort to materialize their beliefs. Results from the correlation analysis showed that students with learning beliefs and self-efficacy would choose learning strategies like the critical thinking and elaboration, meta-cognitive regulation, persistence and regulation.

However, the influence of learning beliefs and self-efficacy is greater on students' performance compared to their understanding. Students have a higher level of learning beliefs and self-efficacy in Statics performance perhaps because they are more familiar with the examination format and have a better control in their learning strategies. Assessment questions are mostly calculation based, thus, can be mastered using drill and practice strategies. On the other hand, perhaps because concept understanding is more dependent on the teaching methods, students have less control in the learning strategies. This finding is supported by the discussions in Chapter 4.

The other significant predictor for both students' Statics and concept test scores is the meta-cognitive regulation. This finding is consistent with the results by researchers in this field, including Pintrich (2004) and Schunk (2009). Meta-cognitive regulation indicates students' use of strategies to control, monitor and regulate learning. Students using meta-cognitive regulation strategies ("always try to solve any confusion with what was learnt in Statics after class") may also "choose to ask questions to herself to make sure she understands what she has learnt" (critical thinking and elaboration) or "continue with a task until completion even if is dull and uninteresting" (persistence and regulation) or "outline the material studied to organize thoughts" (organization and memorization). However, again the contribution of the strategies is slightly greater for Statics performance when compared to the understanding of Statics concepts.

Anxiety is another motivation predictor, which was found to significantly affect Statics performance. Anxiety usually causes students to adopt performance avoidance strategies or to procrastinate, thus, causing them to have poor results in assessments. This finding is consistent with other works in the social cognitive framework reported by Wolters and Pintrich (1998). However, anxiety was not found to affect concept understanding probably because the students knew that the concept marks do not contribute to their final grade, but are purely for use in this study. Therefore, they were able to take the concept test in a more relaxed manner.

Some anxiety can give positive effect, pushing students to do better in examinations. But generally anxiety that occurs before and during a test can interfere with students' concentration and performance. Negative association between anxiety and Statics performance reflects that students could have probably used more negative motivational strategies, like the self-handicapping strategies ("When I take tests I think of the consequences of failing"). Self-handicapping strategies usually resulted in decreasing effort in studying, and procrastination in learning or completing assignments (Pintrich, 2004). However, there are motivation strategies that students can use to control the negative effects of anxiety. Pintrich (2004) quoted anxiety researchers regarding two strategies, self-talk ("don't worry about grades now") and defensive pessimism. Meanwhile, Wolters (1998) suggested that by invoking negative affects (such as shame or guilt) students may be able to motivate themselves to persist at a task.

Another significant predictor is persistence and regulation; however, it is only highly significant for Statics performance and not for concept understanding. Persistence and regulation ("I practice solving calculation problems over and over") imply that students put effort in learning, and are persistent in doing so until they achieve the goal they set. Perhaps because persistence and regulation strategy is more suitable for drill and practice in preparing for the examination, students were able to be better prepared, thus, perform well in Statics examinations.

It can be concluded that SRL affects engineering students' concept understanding and performance through its two main components, motivation and learning strategies (see Figure 6.1). In both performance and understanding, the students are found to have positive learning beliefs and self-efficacy, and the use of positive meta-cognitive regulation strategies to control, monitor and regulate their learning. However, performance has an additional predictor, the negative-effect of anxiety. Both learning beliefs and self-efficacy, and meta-cognitive regulation strategies predicted performance better than concept understanding.

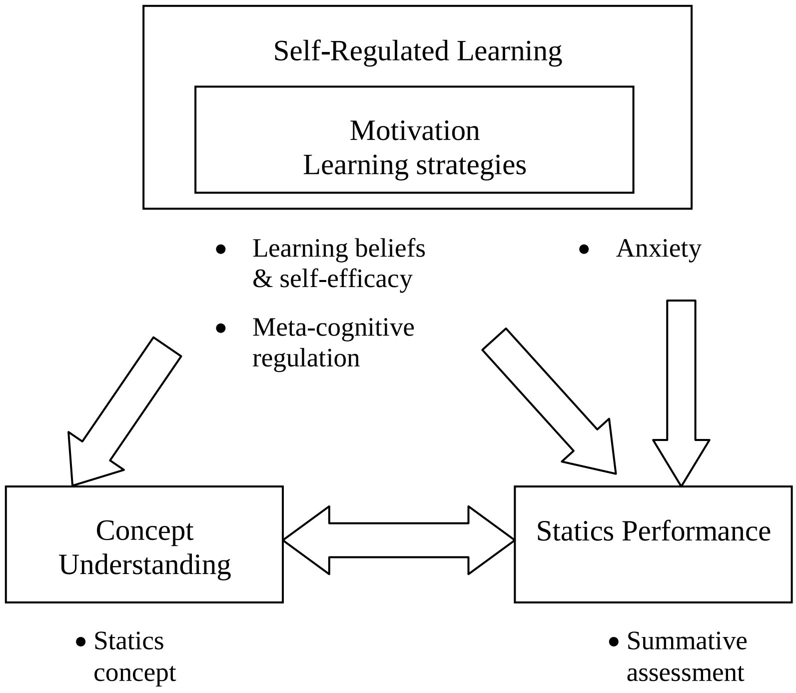


Figure 6.1 SRL, concept understanding, performance

6.5 Contributions to knowledge

This study explains the complex relationships between motivation, learning strategies, performance and understanding of a challenging fundamental engineering course; bridging the two research fields of educational psychology and engineering education. The field of educational psychology has made its claim that motivation is the most important predictor for students' academic performance. Meanwhile, the researches in engineering education, particularly in Statics, had shown efforts to improve students' understanding in the fundamental concepts through teaching and learning. This study provides the link between the two fields, revealing a broad understanding of their relationships for a fundamental engineering course. Therefore, this research provides engineering educators, especially the lecturers teaching Statics, with a better appreciation and understanding of the problems and complexity in the field of engineering education.

This study had revealed that motivation is not the perceived problem for engineering students learning Statics. This is true even when Statics is generically recognized as a very challenging course, and by the students having difficulty with the course. The specific motivation factor, self-efficacy, was found to be the main predictor of students' performance, thus, supporting the claims in the literature on educational psychology. Additionally, most students (including those who did not perform well in Statics) chose mastery learning goals, and attributed their success and failures to intrinsic factors; thus, indicating their positive motivational beliefs.

However, this study also revealed that in contrast, the lecturers have negative perceptions on students' motivation and attitude regarding their efforts in seeking help. Students' positive motivation and attitude towards learning were also not reflected during class observations. Therefore, these contradicting findings from the lecturers' interviews and researcher's class observations highlighted an important finding. The study identified a conflict between perceived and actual motivation, thus, indicating the contribution of a mixed method data collection. This finding and the knowledge about the influences of meta-cognition and anxiety on Statics achievement have also helped to contribute a better understanding of students' SRL in Statics.

In addition to that, the contradicting findings may reflect that students were actually much affected by how the teaching and learning is designed. The teaching and learning must be able to maintain students' motivation and positive attitudes throughout the course. Emphasis should also be made on concept understanding and a better designed assessment format to reflect students' competency in using the concepts. This recommendation is also based on the findings related to the different strengths of associations between the SRL predictors and the two achievement variables (performance and understanding). Therefore, an improvement in Statics curriculum is inevitable. This justifies other researches that emphasize on teaching and learning, and justifies the necessary support that should be provided by engineering departments to ensure the implementation of positive outcomes.

In relation to curriculum improvement, the categories of challenges in learning Statics as revealed in the preliminary study (Chapter 4) are a contribution on its own. The categories provide researchers in Statics and other fundamental engineering courses the reference areas for further research or for designing and implementing improvement in their courses.

Besides justifying the need to improve the curriculum for Statics, this study revealed new factors from the modified MSLQ instrument for measuring SRL. The new grouped factors are the outcome of the exploratory factor analysis. Since the modification made was to suit to Statics, the modified instrument is a contribution in itself. It can be used by others who wish to carry out similar investigations on Statics, or with a minor modification, extending its use to investigate other fundamental and challenging engineering courses like Thermodynamics and Mechanics.

Other contributions include the publication of articles in a journal and five conference proceedings. The titles of the articles and selected comments from the reviewers of the articles are presented in Table 6.1. A positive comment supporting the researcher's finding during a poster presentation at the 2010 ASEE Global Colloquium on Engineering Education is also included.

Finally, this study differs from other studies in the following aspects:

1. The study compares the influences of the SRL predictors on two related dependent variables, performance and concept understanding, which are both crucial achievement measures of Statics.
2. The instrument was adapted to suit the course nature, and using Malaysian data revealed new factor groupings.
3. The methodology for data collection used provides a comprehensive data.
4. This study provides the bridge between two fields of research: engineering education and educational psychology. While, most other studies on Statics focus on the teaching and learning approaches.

Table 6.1 : Titles of articles and positive comments

Title	Comments
Basiron.S., Ali.R., Salim K.R., Hussain N.H., & Haron, H. (2008). *History, Philosophy and Trends in Engineering Education (EE): The Malaysian Context.* International Conference on Engineering Education: New Challenges in Engineering Education and Research in the 21st Century, Pécs-Budapest, Hungary.	Not available.
Haron, H. (2008). *Challenges in Teaching and Learning of Engineering Statics*. 4th International Conference on University Learning and Teaching, Shah Alam, Malaysia, pp.141-149.	Not available.
Haron, H. (2009) *The Pedagogical Issues in Engineering Statics*. International Conference on Engineering and Education in the 21st Century (ICEE 2009), Kuching, Malaysia.	Not available.
Haron, H. N., Shaharoun A.M., Harun H. (2009), The Learning Issues In Engineering Statics. *The International Journal of Science in Society*, Vol. 1(2), pp. 121-136, http://www.Science-Society-Journal.com, ISSN 1836-6236	Not available.
Haron, H., Shaharoun A.M., Puteh M. (2010), *An Introspective Study on Students' Motivation, Understanding and Performance in Engineering Statics*, 9th ASEE Global Colloquium on Engineering Education, Marina Bay Sands, Singapore.	Prof. Emeritus Richard Felder, an expert in the field of engineering education: *…the findings of your research support current efforts in improving the teaching method.*
Haron, H., Shaharoun A.M. (2011), *Self-regulated Learning, Students' Understanding and Performance in Engineering Statics*, IEEE EDUCON – Engineering Education 2011, Amman, Jordan.	Reviewer 1 *Contribution of the submission:* Description of the challenge of teaching Statics; Empirical study on factors that influence understanding and scoring Importance of motivation and learning strategies Thoughtful questioning on the effectiveness of lecturing and drill exercises *Comments for the authors:* The paper gives a good example of an empirical study on various factors of learning. Though focusing on teaching/learning Statics, it raises several important questions as to what really

	matters in learning & understanding complex, technical issues. It has inspired me to extend my research to some of the issues the authors investigate. [Personal note: I like the idea to research SRL in a constructivist course and believe this learning paradigm would improve understanding of concepts.]
	<u>Reviewer 2</u> *Contribution of the submission:* This study investigates through statistical data analysis how Self-Regulated Learning (SRL) affects students' understanding of Statics concepts and performance in the course. SRL is described as a constructive process, where students are active participants in the learning process. *Comments for the authors:* A well written paper with a very good analysis.

6.6 Implications of this study

Implications of this study to the field of engineering education include a strong recommendation for a revised Statics curriculum. An improvement on teaching and learning is crucial to capture, materialize and maintain students' positive motivation, correct learning goals and self-regulatory. The syllabus must emphasize on concept understanding because the current procedural learning, using drill and practice strategies are insufficient for the follow-on courses and in engineering practice later on in their carrier. Consequently, the lecturers will need to be committed to adopt appropriate strategies in delivering the course content. With the current development in internet-based teaching and learning, various online materials are already made available and can be used to complement in-class activities. Consequently, a variation in the teaching and learning approaches can be implemented with fewer resources. In-class active learning strategies, emphasizing learners' autonomy, are also possible tools to improve learning and help students' self-regulation. Conducive learning environment both in the physical and social contexts will encourage students' learning beliefs and self-efficacy and their use of meta-cognitive regulation strategies.

Accordingly, appropriate assessment of learning and for learning are needed, and should reflect the outcomes of the new teaching and learning approaches. Firstly, assessment must include tasks that portray students' understanding of Statics concepts. The use of questions similar to those in SCI could help to emphasize on students' knowledge on how to use Statics concepts. Assessment could also be in the form of group projects and laboratory experiment, instead of only the usual assessment format. This is to balance the current practice that focuses on the assessment of procedural knowledge, which is more inclined to test students' mathematical skills.

Secondly, it is important to design assessment in such a way that students are able to control the nature of their anxiety and its level, especially since anxiety has been found to negatively influence academic performance. From the researcher's personal experience in conducting tests, many mediocre students commented that group assessment has helped them to reduce anxiety and increase self-efficacy. Therefore, laboratory reports, project-based and group assignments are possible additional tools to assess students' academic achievement.

Another important implication of the study is to teach students to become self-regulated learners. This is important also in view of the global challenges that first year college students normally encounter. The transition phase from high school to first year, especially in the learning strategies use, is their most common problem. A content related to SRL can be included in the curriculum as a stand-alone course, offered at the department level. The content can also be built into specific courses being taught in the first year, integrating it with the teaching and learning of the course.

It is therefore crucial to have the necessary support from the engineering department in making the curriculum change a success. The necessary support should include funding, improved facilities, and incentives or a motivating reward system for the implementers. The lack of basic knowledge in relevant educational theories and practices among the engineering lecturers is something that needs to be addressed. In-house training should be provided to include new developments in teaching and learning.

6.7 Conclusions

The research objectives of this study have been achieved and questions have been answered. RQ 1 investigates how performance correlates with understanding. The relationship is found to be highly significant but moderately correlated. This finding is consistent with the engineering education literature, however, seems atypical from the education perspective.

It was revealed from RQ 2 and RQ 3 that the self-regulated learning variables predict performance better than predicting understanding of Statics concepts. Learning beliefs and self-efficacy, and meta-cognitive regulation strategies are the main predictors for both dependent variables (concept understanding and academic performance). Meanwhile, anxiety has a negative but highly significant association with performance only. These results appear to support other studies related to the academic performance in educational psychology.

Additional findings are related to students' motivational belief and positive attitude associated with their learning. Students appeared to have positive beliefs and attitude, chooses the mastery learning goal, task value (understanding and interest) and intrinsic attribution (effort and ability). These findings are as identified in the literature as important academic success factors. However, the statistical results in this study do not seem to show that goals and study value to be a significant predictor to both performance and concept understanding.

Another conclusion includes the three categories of challenges in Statics, which are related to students, teaching and learning approaches, and the nature of Statics (see Figure 4.4). The challenges are found to be consistent with the findings from other researches in Statics, except that in this study the categorization is established.

6.8 Recommendations for future work

Following are several recommendations for future work as presented at a conference by the researcher (Haron, Shaharoun, 2011):

1. Further analysis should also include the investigations on relationships between SRL variables and scores for the different students' achievement groups. This could indicate which independent variables are strong predictors to the variance in understanding and performance for the different student groups.

2. In relation to the results from multiple regression analysis, a further research is recommended to look at why the study goals and value subscale is not significant, and negatively associated with the concept and Statics scores.

3. Experimental study measuring the same SRL variables can be carried out to see the effects of any teaching intervention program.

4. Further study is recommended in a constructivist classroom environment for comparisons on the predictive nature of SRL to be made.

5. Similar research could also be carried out on other fundamental engineering courses to compare findings with this study.

REFERENCES

Abdullah, M.N.L.Y. (2010). Self-regulated learning: Theory and Application. Penerbit Universiti Sains Malaysia.

Albright, Jeremy J., & Hun Myoung Park. (2009). Confirmatory Factor Analysis Using Amos, LISREL, Mplus, and SAS/STAT CALIS. Working Paper. The University Information Technology Services (UITS) Center for Statistical and Mathematical Computing, Indiana University. http://www.indiana.edu/~statmath/stat/all/cfa/index.html

Anderson, E., Taraban, R., Hudson, D., (2009). A study of the impact of visuospatial ability, conceptual understanding, and prior knowledge upon student performance in engineering statics courses. American Society for Engineering Education.

Arnott, S. (2000). Learning in engineering: Teacher as researcher in a tertiary context [Subject Collection Humanities, Social Sciences and Law]. *Research in Science Education, 30*(3), 317-337.

Ates, S., & Cataloglu, E. (2007). The effects of students' reasoning abilities on conceptual understandings and problem-solving skills in introductory mechanics. *European Journal of Physics.* 28 (2007) pp. 1161-1171.

Babur, D. (2011). Computer Technology for Enhancing Teaching and Learning Modules of Engineering Mechanics. Computer applications in engineering education. Vol. 19 (3), pp. 421-432.

Baker, K., Barrington, F., Gleeson, D., Livett M. and McFadyen D. (2002). Development of a Science Transition Program 2000 – 2002. The Sixth Pacific Rim - First Year in Higher Education Conference: Changing Agendas "Te Ao Hurihuri". The University of Canterbury in conjunction with Queensland University of Technology. Christchurch, New Zealand.

Bandura, A. (1977). Self-efficacy: Toward a Unifying Theory of Behavioural Change. Psychological Review 1977, Vol. 84. No. 2, 191-215.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, New Jersey: Lawrence Erlbaum.

Barefoot, Betsy O (2000). The First-Year Experience: Are We Making It Any Better? About Campus, January–February.

Bedford, A., & Fowler, W. (2003). *Statics & Dynamics Principles.* New Jersey: Prentice Hall.

Beer, F. P., & E. Russell Johnston, J. (1990). *Vector Mechanics for Engineers* (2nd S.I Metric ed.): McGraw-Hill Book Co.

Beston, W. C. (1999). Teaching Engineering Statics and Dynamics Completely on the Web. *29th ASEE/IEEE Frontiers in Education Conference.* San Juan, Puerto Rico.

Boekaert,.M (1999). Self-regulated learning: where we are today. Int. J. Educ. Res. 31, pp. 445-457.

Bowen, E., Prior, J., Lloyd, S., Thomas, S., & Newman-Ford, L. (2007). Engineering more engineers - bridging the mathematics and careers advice gap. *Engineering Education: Journal of the Higher Education Academy Engineering Subject Centre, 2*(1).

Chen, C. S., Self-regulated learning strategies and achievement in an introduction to Information Systems course. *Information Technology, Learning, and Performance Journal*, 2002, 20(1): pp. 11-25.

Chen, J. C., Kadlowec, J., & Whittinghill, D. (2004, October 20 - 23, 2004). *Work In Progress: Combining Concept Inventories with Rapid Feedback to Enhance Learning.* Paper presented at the 34th ASEE/IEEE Frontiers in Education Conference, Savannah, GA.

Clark, D. (2008, Nov 15). *Learning Strategies*. Retrieved February 1, 2009, from http://www.skagitwatershed.org/~donclark/hrd/strategy.html

Cohen, J.W. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Hillside, NJ: Lawrence Erlbaum Associates.

Creswell, J. W. (2003). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (2nd ed.): Sage Publications, Inc.

Darlaston-Jones, D., Cohen, L., Haunold, S., Pike, L., Young A. & Drew N., (2003). The Retention and Persistence Support (Raps) Project: A Transition Initiative. Issues In Educational Research, Vol. 13.

Dembo, M. H., & Seli, H. (2008). *Motivation and Learning Strategies for College Success: A Self-Management Approach (3rd ed.).* New York: Taylor & Francis Group, LLC.

Dollar, A., & S.Steif, P. (2006). Learning Modules for Statics. *International Journal of Engineering Education, 22*(2), 381-392.

Dollar, A., & Steif, P. S. (2004). *Reinventing The Teaching of Statics.* Paper presented at the Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition.

Dollár, A., & Steif, P. S. (2007). *An Interactive Online Course on Engineering*

Statics. Paper presented at the International Conference on Engineering Education – ICEE 2007, Combria, Portugal

Dollár, A., Steif, P. S., & Strader, R. (2007). *Enhancing Traditional Classroom Instruction with Web-based Statics Course.* Paper presented at the 37th ASEE/IEEE Frontiers in Education Conference, Milwaukee, WI

Emmons, M., Frances Wilkinson, C. (2001). *Designing the electronic classroom: applying learning theory and ergonomic principles.* Library Hi Tech. Bradford, 19 (1), pp.77-87.

Engineering, T. R. (2007). Educating Engineers for the 21st Century. London, United Kingdom.

Felder, R. M., & Soloman, B. A. (n.d.). *Felder & Soloman: Learning Styles and Strategies.* Retrieved February 26, 2009, from Index of Learning Styles: http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/styles.htm

Felder, R. M., Felder, G., & Dietz. (2002). The Effects of Personality Type on Engineering Student Performance And Attitudes. *Journal of Engineering Education* , 3–17.

Felder,R. M., *A Whole New Mind For A Flat World*, Chem. Engr. Education, 40(2), 96-97 (2006)

Felder,R.M., *The Future of Engineering Education*, Chem. Engr. Education, 34(1), 16-25 (2000)

Fulmer, S. M., Frijters, J. C. (2009). A review of self-report and alternative approaches in the measurement of student motivation. Educ. Psychol Rev. 21:219-246.

Givvin, K. B., Stipek, D. J., Salmon, J. M., & MacGyvers, V. L. (2001). In the eyes of the beholder: students' and teachers' judgments of students' motivation. *Teaching and Teacher Education,* 17(3), 321-331.

Greene, J. A. and Azevedo, R. (2007). A theoretical review of Winne and Hardwin's model of self-regulated learning: new perspectives and directions, Review of Educational Research, 77(3): pp. 334-372.

Haik, Y. S. (1999). *Design-Based Engineering Mechanics.* Paper presented at the Proceedings of the 1999 American Society for Engineering Education Annual Conference & Exposition, Charlotte, NC.

Haron, H. N. (2008). *Challenges in Teaching and Learning of Engineering Statics.* Paper presented at the 4th International Conference On University Learning And Teaching, Shah Alam, Malaysia.

Haron H.N., (2009) *The Pedagogical Issues in Engineering Statics*. International Conference on Engineering and Education in the 21st Century (ICEE 2009), Kuching, Malaysia.

Haron, H., Shaharoun, A. M. and Harun, H. (2009). “The learning issues in Engineering Statics”. The International Journal of Science in Society. 1(2): pp. 121-136.

Haron, H. N., Shaharoun, A.M. and Puteh, M. (2010). “An introspective study on students' motivation, understanding and performance in Engineering Statics”, The 9th ASEE Global Colloquium in Engineering Education, Marina Bay Sands, Singapore.

Haron H. N., Shaharoun A.M. (2011), *Self-regulated Learning, Students’ Understanding and Performance in Engineering Statics,* IEEE EDUCON – Engineering Education 2011, Amman, Jordan.

Hibbeler, R. C. (2006). *Principles of Statics*. New Jersey: Prentice Hall.

Holzer, S. M., & Andruet, R. H. (2000). Experiential Learning in Mechanics with Multimedia. *International Journal of Engineering Education.* 16(5), 372±384.

Hooper, D., Coughlan, J. and Mullen, M. R. (2008). Structural Equation Modelling: Guidelines for Determining Model Fit. *The Electronic Journal of Business Research Methods,* 6 (1), pp. 53 - 60, available online at www.ejbrm.com

Hu & Bentler (1999). Cutoff criteria for fit indexes in covariance structure analysis: Coventional criteria versus new alternatives, *Structural Equation Modeling,* 6(1), 1-55.

Hubing, N., Oglesby, D. B., Philpot, T. A., Yellamraju, V., Hall, R. H., & Flori, R. E. (2002). *Interactive Learning Tools: Animating Statics.* Paper presented at the Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition.

Kizilgunes, B., Tekkaya, C. and Sungur, S. (2009). Modeling the relations among students' epistemological beliefs, motivation, learning approach, and achievement, *The Journal of Educational Research*, 102(4).

Kosnin, A. (2007). Self-regulated learning and academic achievement in Malaysian graduates. International Education Journal, 8(1), 221-228.

Maclellan, E., Soden, R. (2006). Facilitating Self-Regulation in Higher Education

Meece, J. L., Anderman, E. M. Anderman, L. H. (2006). Classroom goal structure, student motivation, and academic achievement. Annu. Rev. Psychol. 57:487-503.

Mehta, S., & Kou, Z. (2005). *Research in Statics Education - Do Active, Collaborative, and Project-Based Learning Methods Enhance Student Engagement, Understanding, and Passing Rate?* Paper presented at the Proceedings of the 2005 American Society for Engineering Education Conference & Exposition.

Meyers, K. L., Silliman, S. E., Gedde, N. L. & Ohland, M. W. (2010). A

Comparison of Engineering Students' Reflections on Their First-Year Experiences. *Journal of Engineering Education*, April.

Milano, G. B., & Golub, E. (2001). *A Remedy for the "Statics" Condition.* Paper presented at the 2001 American Society for Engineering Education Annual Conference & Exposition.

Montfort, D., Brown, S., & Pollock, D. (2009). An Investigation of Students' Conceptual Understanding in Related Sophomore to Graduate -Level Engineering and Mechanics Courses. *Journal of Engineering Education*, 98(2), 111-129.

Morelli, N., 'Social Innovation and New Industrial Contexts: Can Designers "Industrialize" Socially Responsible Solutions?' http://www.mitpressjournals.org/doi/pdfplus/10.1162/desi.2007.23.4.3

James, N. (2005). Factor Analysis Resources: Understanding & Using Factor Analysis in Psychology & the Social Sciences. http://wilderdom.com/research/factoranalysis.html

Nygaard, C., & Holtham, C. (2008). The Need for Learning-Centred Higher Education. In C. Nygaard & C. Holtham (Eds.), *Understanding Learning-Centred Higher Education* (pp. 9-30): Copenhagen Business School Press.

O'Donnell, A. M., Reeve, J., & Smith, J. K. (2009). *Educational Psychology Reflection for Action 2nd Edition.* NJ: John Wiley & Sons.

Oglesby, D. B., Carney, E. R., Prissovsky, M., & Crites, D. (1998, June). *Statics On-Line: A Project Review.* ASEE Annual Conference Seattle, WA.

Omar, I., Director Academic Quality Unit, UTM, 'MQA Road show 2007 presentation'

Owens, K. (2007). Classroom Critiques: Transforming Conformity into Creativity. Industry and Higher Education, v21 n5 p345-351.

Pallant, J. (2007). SPSS Survival Manual. A Step by Step Guide to Data Analysis using SPSS for Windows. 3rd. Ed., McGraw Hill.

Philpot, T. A., Hall, R. H., Hubing, N., & Flori, R. E. (2005). Using Games to Teach Statics Calculation Procedures: Application and Assessment (Publication. Retrieved 5 April 2008, from Wiley InterScience: www.interscience.wiley.com/cgi-bin/fulltext/112093244/PDFSTART

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning, International Journal of Educational Research, 31: pp. 459-470.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, R. Pintrich, & M. Zeidner (Eds.), Handbook of self regulation (pp. 452-502). New York: Academic Press.

Pintrich, P. R. (2004). A Conceptual Framework for Assessing Motivation and Self-Regulated Learning in College Students. *Educational Psychology Review,* Vol. 16 (4), pp. 385-407.

Pintrich, P.R., Smith, D., Garcia, T., and McKeachie, W. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ),* The University of Michigan, Ann Arbor, MI.

Pintrich, P. R. and Zusho, A. (2007). *Student Motivation and Self-Regulated Learning in the Classroom*. In R.P. Perry and J.C. Smart (eds.), The Scholarship of Teaching and Learning in Higher Education: An Evidence-Based Perspective, pp.731–810.Springer.

Reid, A., & Petocz, P. (2008). A Tertiary Curriculum for Future Professionals. In *Understanding Learning-Centred Higher Education* (pp. 31-50): Copenhagen Business School Press.

Reid, A., Petocz, P. (2008). “A tertiary curriculum for future professionals, in understanding learning-centred higher education”, Copenhagen Business School Press, pp. 31-50.

Roberts, G. R. (2005). Technology and Learning Expectations of the Net Generation. In D. G. Oblinger & J. L. Oblinger (Eds.), Educating the Net Generation Available from http://www.educause.edu/Resources/EducatingtheNetGeneration/TechnologyandLearningExpectati/6056

Scheja, M., & Pettersson, K. (2010). Transformation and contextualisation: conceptualising students' conceptual understandings of threshold concepts in calculus. *Higher Education, 59*, 221-241.

Schreiber, J. B., Stage, F. K., King, J., Nora, A., Barlow, A. E. “Reporting Structural Equation Modeling and Confirmatory Factor Analysis Results: A Review.” The Journal of Educational Research. Vol. 99 (No. 6). pp. 323-337.

Schunk, D. H. (2009). *Learning Theories - An Educational Perspective* (5th ed.). Upper Saddle River, New Jersey 07458: Pearson Education, Inc.

Schunk, D.H., & Zimmerman, B.J. (Eds.). (1994). Self-regulation of learning and performance: Issues and educational applications. Hillsdale, NJ:Lawrence Erlbaum Associates.

Sidhu, S. M., & Ramesh, S. (2006). Multimedia Learning Packages: Design Issues and Implementation Problems. *Malaysian Online Journal of Instructional Technology (MOJIT), 3*(1), 43-56.

Steif, P. S. & Hansen, M., (2006). Comparisons between performances in a Statics Concepts Inventory and course examinations. Int. J. Eng. Educ., 5.

Steif, P. S. (2004). Initial data from a Statics Concept Inventory. American Society for Engineering Education Annual Conference & Exposition.

Steif, P. S. (2008). Progress Updates. In H. Haron (Ed.) (pp. E-mail communication). Kuala Lumpur.

Steif, P. S., & Dantzler, J. A. (2005). A Statics Concept Inventory: Development And Psychometric Analysis. *Journal of Engineering Education*.

Steif, P. S., & Dollar, A. (2003). *A New Approach to Teaching and Learning Statics.* Paper presented at the 2003 American Society for Engineering Education Annual Conference & Exposition.

Steif, P. S., & Dollar, A. (2004). *Reinventing engineering statics to address the conceptual difficulties of students.* ASME 2004 International Mechanical Engineering Congress and Exposition (IMECE2004) Anaheim, California, USA.

Steif, P. S., & Dollar, A. (2005). Reinventing the teaching of Statics. *International Journal of Engineering Education, 21*(4), 723-729.

Steif, P. S., Dollar, A. & Dantzler, J. A. (2005). *Results from a Statics Concept Inventory and their Relationship to other Measures of Performance in Statics.* ASEE/IEEE Frontiers in Education Conference, Indianapolis, IN.

Stoffa, R.C. (2009). An examination of the factors underlying the motivation and learning strategies of generation 1.5 Korean American students. PhD. Thesis. Unpublished.

Strength of relationships. Retrieved 2010, from http://www.experiment-resources.com/statistical-correlation.html, http://mathbits.com/mathbits/tisection/statistics2/correlation.htm

Streveler, R., Geist, M., Ammerman, R., Sulzbach, C., & Miller, R., Olds, B. (2006). *Identifying and Investigating Difficult Concepts in Engineering Mechanics and Electric Circuits.* American Society for Engineering Education.

Tabachnick, B.G., & Fidell, L.S, (2007). Using multivariate statistics (5th ed). Boston: Pearson Education.

Through Self-Report. Learning Environments Research (2006) 9: 95–110.

Vincent Tinto (1975). Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational Research*. Vol. 45, No. 1, pp. 89-125

Weinstein, C. E., Woodruff, A., & Awalt, C. (2001). *Why Understanding Motivation is Important* . Retrieved January 2009, from Becoming A Strategic Learner: http://www.hhpublishing.com/_onlinecourses/study_strategies/BSL/motivation/B2.html

Winne, P. H, Nesbit, J.C. (2009). The Psychology of Academic Achievement. The Annual Review of Psychology. www.annualreviews.org. Retrieved 09.11.09.

Wolters, C. (1998). Self-regulated learning and college students' regulation of motivation. *J. Educ. Psychol*. 90: 224-235.

Wolters, C.A. & Pintrich P.R. (1998). Contextual differences in student motivation and self-regulated learning in Mathematics, English, and Social studies classrooms. Instructional Science 26: 27-47. Kluwer Academic Publishers.

Young Sam Ryu, Tonya L. Smith-Jackson (2006). Reliability and Validity of the Mobile Phone Usability Questionnaire (MPUQ), Vol. 2, Issue 1, November 2006, pp. 39-53

Zimmerman, B. J. (1989). Models of Self-regulated Learning and Academic Achievement. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-Regulated Learning and Academic Achievement: Theory, Research and Practice* (pp. 1-26). New York: Springer-Verlag.

Zimmerman, B.J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), Handbook of self-regulation (pp. 13-39). San Diego: Academic Press.

Zimmerman, B. J., & Schunk, D. H. (Eds.). (2001). *Self-Regulated Learning and Academic Achievement: Theoretical Perspectives* (2nd ed.). Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

APPENDIX A: STATICS TEACHING AND LEARNING

1. Web-based

Interactive online course called Open Learning Initiative (OLI) Statics (Dollár & Steif, 2007):

Weave together interactive elements such as user-controlled simulations, voice-graphic linked explanations, and problem-solving tutors with hints, feedback and evolving scaffolding to assist the user in achieving learning objectives consistent with a conceptual understanding of, and a practical facility with, Statics.

OLI development made use of knowledge on how people learn and advances in technological tools in education.

Expected applications:

- Blended learning, OLI as a supplemental material to be used in class or out of class; with or without supervision.
- Totally online course with credit from an institution.
- Independent study, OLI as an electronic textbook and an on-line tutor.

Benefits:

- Provides students with instantaneous feedback and repetitive use of online material as 'required learning'.
- Provides lecturer/instructor with students' performance, and more time to focus on in-class instruction for concepts least understood and other activities.
- Provides visualization by making forces and their effects visible.

- Promotes peer interaction on the physical phenomena in a simulation as compared to superficial discussion on answers obtained for a particular homework.

Challenges include:

- Issue on the requirement to solve problems on paper with drawings, symbols, and mathematics, as is traditionally done.

- The need for a good interface design for students to be fruitfully engaged without the need for external intervention.

2. Learning Modules (Dollar & Steif, 2004):

Is an instructional approach that *(i) teach concepts first entirely in the context of situations in which the forces are real to students, where they can experience by the senses of touch and sight; and (ii) decouple concepts from each other and treat them sequentially, with new concepts building on those which have already been covered.*

The instructional design is based on the identification of what constitute difficulties in learning Statics, and the knowledge on students' learning styles and strategies.

The teaching approach:

All major concepts are introduced separately in sequence, using simple objects on which students can exert forces and couples or considering the balance of the human body. Focus on forces, also in multiple bodies that must be separated and how the bodies interact in different ways through connections.

The learning modules include a combination of activities in the classroom that include classroom desktop experiments, PowerPoint presentations, and frequent concept questions where students vote for different answers. Students are encouraged to discuss with peers; depending on responses, and to manipulate demonstration objects.

The approach allows active engagement, and sequential concept building. The reorganization of the conceptual content able to overcome the misconception that rigid, unmoving, inanimate objects do not exert forces.

3. Active-cooperative learning (ACL), classroom assessment techniques (CATs) and web technology (Mehta & Danielson, 1999) to address the issues on students' learning.

Two factors affect students learning that are highly rated by both students and teachers as quoted from a survey (Mehta & Danielson, 1999) are:

- Study problems (homework) on new material.
- Prompt feedback on student work.

The approach is based on the paradigm shift in education where knowledge should be jointly constructed by students and academic staff, and students act as the active constructors, discoverers, and transformers of knowledge. The teaching approach is as follows:

Two to three mini lectures followed by multiple-choice questions. Students to discuss answers in an informal group of neighbours and using the flashcard to indicate answers. At the end of class session attention quiz (AQ) is given. Questions cover critical ideas and concepts discussed in class. Other strategies include the Daily Homework and Quiz Manager (DHQM) to monitor learning on a daily basis and to point out correction needed; Personalized Assessment System for Success (PASS) to record grades from homework, AQs and regular quizzes; and four group projects in a semester.

Benefits are based on students' perceptions. Student ratings grouped by cumulative GPA indicate different strategies as helpful by different groups of students. Combinations of strategies seem to help all groups.

4. Design-based (Haik, 1999):

The design-based instruction uses systematic design process as a tool to enhance the learning objectives. Students are required to design and build a product that requires the engineering mechanics concepts, adopting the collaborative group learning approach. Assessment is based on competition between design groups.

Students and instructors showed preference in the method. The benefits include:

- Increase in team working and systematic problem solving skills.
- Increase enthusiasm in learning because students can relate concepts to application.

5. Web-based (Beston, 1999):

Delivery of the course is in Asynchronous Learning (ASL). Seventeen modules were developed using SUNY Learning Network (SLN):

Module 1: An Introduction to the history of Mechanics and a review of software tools needed by the student to navigate the course. Tasks included downloading an executable file, opening a Word, Excel, and PowerPoint file, and viewing GIF files.

Modules 2-16: Each module represented a week in a traditional class. Each module was developed with PowerPoint lectures (usually three a week, including examples of homework solutions), a journal the student used to record time spent during the week on course related activities, a quiz or exam, group project activities with assessment tools, and a discussion area.

Module 17: Final assessment tool for course and an optional Final Exam.

All solutions to homework problems are posted thus, homework are not collected. The problems are used as the tool for generating discussion and questions. Students are encouraged to review the past exams to establish a level of performance that would be expected on quizzes and exams.

There are two group projects assigned, each requires a paper with references and a PowerPoint presentation including a detailed analysis of the appropriate object, ride, etc. Team members assess the team performance and their performance on the team. They also assess the other teams PowerPoint presentations.

6. Multimedia (Holzer & Andruet, 2000):

   Learning modules for Statics are integrated with mechanics of materials, physical models, interactive multimedia, traditional pencil-paper activities, and cooperative learning in the framework of experiential learning. The experiential learning Kolb's four-stage model was adopted to guide the design of learning activities. These activities focus on grasping and transforming experience; and the design of the multimedia program. The program is divided into two parts: inductive part (concepts and procedures are developed); and deductive part (concepts and procedures are summarized, illustrated, and applied in the solution problem).

   Students are actively engaged in learning, but occasionally they do not like computer as a learning tool.

7. Multimedia and Online (Hubing et al., 2002; Oglesby, Carney, Prissovsky, & Crites, 1998):

   The modules were created using an animation package (Flash) so that concepts such as sectioning of trusses and the generation of shear and moment diagrams can be presented in an intuitive and interactive manner. The modules are able to represent dynamic and abstract aspects of these concepts in a way that is not possible with traditional instructional tools.

   The multimedia courseware developed includes a comprehensive assessment program, based on model that emphasized some of the fundamental themes as follows:

- assessment process is iterative, with assessment ongoing during development;
- multiple experimental methodologies are utilized;
- conclusions and recommendations are based on the triangulation of multiple qualitative and quantitative outcomes.

Statics On-Line project is to better address the needs of both teacher and learner. It is a combination of "BEST" (Basic Engineering Software for Teaching) Statics and On Call Instruction (OCI) for Statics. BEST is a multimedia project aimed at developing tools to aid the instructor in the classroom. OCI was directed more toward the students from the outset. Its aim was to provide audio mini-lectures and other supplementary material directly to the student over the Internet on a "just in time" basis.

8. Games (Philpot et al., 2003):

The computer as a teaching medium affords new opportunities for creative instructional activities that are not possible in the traditional lecture and textbook format. One such type of activity is the use of interactive games. Several games have been developed and implemented. The games focus on fundamental topics that seek to develop the student's proficiency and confidence in narrowly defined but essential topic areas using repetition and carefully constructed levels of difficulty. The game format provides students with a learning structure and an incentive to develop their skills at their own pace in a non-judgmental but competitive and often fun environment.

Benefits include:

- The response to the games has been positive. Students rated games as significantly more effective than textbooks as a learning aid.

- Individual instructors have reported that the games appear to improve student performance in the targeted topic areas.
- Student learning is higher.

APPENDIX B: SAMPLE QUESTIONNAIRE

HABIBAH @ NOREHAN HJ. HARON
Mechanical Engineering Department
College of Science & Technology
Universiti Teknologi Malaysia International Campus
54100 Kuala Lumpur

October 2009

Dear student,

Data Collection for a PhD Study in Engineering Education on Learning Strategies

The above and attached questionnaire is referred to.

I (name and address as above) would be grateful if you could respond to this questionnaire. The purpose of the questionnaire is to gather some information about your study habits, learning skills, and motivation in learning Statics. Please respond to each question as accurately as possible, reflecting your own attitude and behaviour in Statics.

There is no right or wrong answers to the questionnaire, and this is NOT a test. The information collected is for the purpose of my PhD research. Your responses will be analyzed and the results will be made available upon request by the end of year 2010, God willing.

Please be informed that the confidentiality of your responses is assured.

Thank you for your time and cooperation.

Sincerely

Habibah Haron
habibah@ic.utm.my
Phone: 03-26154687

Part A: Profile

Tick (/) the option that best describes you and fill in the answers where appropriate.

1. Age
   - 17 to 20 years old
   - 21 and above
   - Other (specify):

2. Gender
   - Male
   - Female

3. Ethnic
   - Malay
   - Chinese
   - Indian
   - Bumiputera Sabah/Sarawak
   - Other (specify): ______________________

4. Name of last school attended: ____

5. Hometown (example: Johor Bahru, Johor) ____

6. Entrance qualification to this institution/university
   - SPM
   - STPM
   - Matriculation
   - Diploma
   - Other (specify): __________________________

7. Current semester 1 2 3 4 5 6 7 or more

8. Program (example: Mechanical Engineering) ____

9. CGPA
   - Below 2.0
   - 2.0 - 2.99
   - 3.0 - 3.49
   - 3.5 - 4.0

10. Grades for the following subjects (circle one):

Physics (SPM)	1/ 2/ 3/ 4/ 5/ 6/ 7/ 8/ Other (specify): ____
Add Math (SPM)	1/ 2/ 3/ 4/ 5/ 6/ 7/ 8/ Other (specify): ____
Trigonometry and Geometry	A+/A/A-/B+/B/B-/C+/C/C-/ Other (specify): ____
Calculus	A+/A/A-/B+/B/B-/C+/C/C-/ Other (specify): ____
Physics	A+/A/A-/B+/B/B-/C+/C/C-/ Other (specify): ____
Statics	A+/A/A-/B+/B/B-/C+/C/C-/ Other (specify): ____

11. Monthly income (parents / guardian)
   - RM 1,000 and below
   - RM 1,001 – RM 3,000
   - RM 3,001 – RM 5,000
   - RM 5,001 and above

Part B: Past experience in Statics class.

Tick (/) the option that best describes you. Fill in the blanks where necessary.

1. I pass Statics after taking it the first time.
   - Yes.
   - No.
     The number of times I have taken Statics is ____

2. My final grade in Statics is influenced by...
   (you may tick more than one options)
   - My interest in Statics.
   - My effort in studying.
   - My ability to solve problems in Statics.
   - My understanding of the concepts in Statics.
   - Course work marks.
   - The teaching method.
   - The lecturer's attitude.
   - Friends
   - Other (specify):_____________________

3. In Statics class I feel...
   (you may tick more than one options)
   - Motivated to learn.
   - Not confident of myself.
   - Bored.
   - Other (specify):_____________

4. Knowing the application helps in understanding the Statics concepts
   - Yes.
   - No.

Other experiences in Statics class that you would like to share, please write below:

____

____

____

____

____

Part B: Motivation

The statements below describe your motivation for and attitudes about the STATICS class you attended.
Tick (/) the option that best describes you.

1	2	3	4
not at all true of me	**sometimes true of me**	**often true of me**	**very true of me**

No.	Item	1	2	3	4
1.	I prefer course materials that really challenge me so I can learn new things.				
2.	I will be able to learn the material in this course if I study well.				
3.	When I take a test I think about how poorly I am doing compared to other students.				
4.	I think I will be able to use what I learn in Statics in other courses.				
5.	I always believe I will get an excellent grade in Statics class.				
6.	It is my own fault if I do not learn the material in this course.				
7.	My main concern in Statics class is getting a good grade.				
8.	I am confident I understand the basic concepts taught in Statics class.				
9.	I want to get better grades in Statics than most of the other students.				
10.	When I take tests I think of the consequences of failing.				
11.	I do not understand the course material because I didn't try hard enough.				
12.	I feel my heart beating fast when I take an exam.				
13.	I am confident I can do an excellent job on Statics assignments and tests.				
14.	The most satisfying thing for me in learning Statics is trying to understand the content.				
15.	I normally choose assignments that can increase my knowledge although they do not guarantee a good grade.				
16.	I believe Statics is useful for me.				
17.	Understanding the concepts in Statics is important.				
18.	I want to do well in Statics because it is important to show my ability.				
19.	I will get good grades in Statics if I study hard enough.				
20.	I study because it is my responsibility.				

Part C: Learning Strategies

The statements below describe your learning strategies and study skills for STATICS class. Tick (/) the option that best describes you.

1	2	3	4
not at all true of me	**sometimes true of me**	**often true of me**	**very true of me**

No.	Item	1	2	3	4
21.	I would outline the material I study to organize my thoughts.				
22.	I often miss important points during class because I am thinking of other things.				
23.	I often try to explain the material I learn to a classmate or a friend.				
24.	I usually study in a place where I can concentrate better.				
25.	When I study Statics, I ask questions to help focus my learning.				
26.	I stop studying Statics if I feel bored with it.				
27.	I often find myself questioning things I hear or read in this course.				
28.	Even if I have problems, I try to do Statics work on my own and without help from anyone.				
29.	I always try to solve the confusion I had with Statics after class.				
30.	I try to work with other students to complete the course assignments.				
31.	I practice solving calculation problems over and over.				
32.	I make simple charts, diagrams or tables to help me organize course material.				
33.	I often set aside time to discuss the course material with a group of friends.				
34.	When I study Statics, I combine information from different sources, such as lectures, readings, and discussions.				
35.	Before I study new course material, I often skim it to see how it is organized.				
36.	I ask myself questions to make sure I understand what I learn.				
37.	I try to change the way I study in order to fit the course requirements.				
38.	I often find that I do not know about what I have been studying.				
39.	I ask the lecturer to clarify concepts I do not understand well.				
40.	I memorize keywords to remind me of important concepts in Statics class.				
41.	I only study the easy parts in Statics.				
42.	I try to think through a topic and decide what I am supposed to learn from it.				
43.	I outline important concepts when studying Statics.				

44.	I try to relate the material in Statics to what I already know.				
45.	I work hard to do well in Statics even when the concepts are difficult to understand.				
46.	I try to play around with my own ideas related to what I am learning in Statics.				
47.	When I do not understand the materials in Statics, I ask other students for help.				
48.	I try to understand the concepts learnt in Statics by relating them to real life applications.				
49.	I make sure I keep up with the assignments for this course.				
50.	Whenever I read or hear a statement or conclusion in Statics, I think about possible alternatives.				
51.	I make and memorize the lists of important terms for Statics.				
52.	I attend class regularly.				
53.	Even when course materials are dull and uninteresting, I manage to keep working until I finish.				
54.	I always try to determine which concepts I do not understand well.				
55.	I do not spend much time studying Statics outside class period.				
56.	I set goals for myself in order to direct my activities in each study period.				
57.	I seldom find time to revise before exams.				
58.	I try to apply ideas from what I read to other class activities such as lecture and discussion.				

APPENDIX C: QUESTIONNAIRE FOR VALIDATION

Habibah @ Norehan Hj. Haron
Department of Mechanical Engineering
Universiti Teknologi Malaysia International Campus
Jln Semarak, 59100 Kuala Lumpur

16 September 2009

Dear Professor/Associate Professor/Dr/Sir/Madam,

Questionnaire for Validation

The above is referred to.

I am a postgraduate student in Engineering Education. I would appreciate very much if you could help validate my survey instrument entitled "Self-Regulated Learning Strategy Questionnaire". The purpose of this survey is to gather information on the motivation and learning strategies of engineering students' in learning Statics. This information will be used to predict the components that influence students' performance and understanding of the concepts in Statics, and to propose a self-regulated learning strategy framework that serves as a guideline for lecturers, students and program developers.

This questionnaire consists of three parts:

Part A	15 questions on students' profile.
Part B	20 questions on motivation, adapted from the Motivated Strategies for Learning Questionnaire, MSLQ (Pintrich, Smith, Gracia, & McKeachie, 1991).
Part C	37 items on the use of learning strategies adapted from the Motivated Strategies for Learning Questionnaire, MSLQ (Pintrich, Smith, Gracia, & McKeachie, 1991).

Your evaluation will only be used for academic research and reference. Please acknowledge me by e-mail or phone once you have completed the evaluation.

Your kind cooperation is much appreciated.

Regards,

HABIBAH HARON
012-2240465
habibah@ic.utm.my

Survey Instrument Validation Form
Validation by Experts

Title of Survey Instrument: **Self-Regulated Learning Strategy**

I hereby acknowledge that the above mentioned survey instrument adapted by Habibah @ Norehan Haron, a postgraduate student in Engineering Education from the Universiti Teknologi Malaysia, has been evaluated. The outcome is as follows: (Please tick your answer).

		Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
1.	The objective of the instrument is stated clearly.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
2.	The instrument format is appropriate.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
3.	The font size is appropriate.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
4.	The meaning of every item is clear.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
5.	The instructions are clear.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
6.	The measurement scale is appropriate.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
7.	The item is representative of the self-regulated learning strategies.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Comments:

____

____

____

______

Signature: ______________________________
Full Name: ______________________________
Designation / Expertise: ______________________________
Name and Address of Organization: ______________________________
____

Stamp of Employer: ______________ Date: 16 September 2009

Name of expert: Prof/Assoc Prof/Dr ________________________________ Date: ______________

Position & Department: ________________________________ Signature: ______________

Organization/Institution: ________________________________

The following 58 items are to identify the Mechanical Engineering students' motivation and learning strategies in learning Statics. These items belong to six motivation and nine learning strategy scales, adapted from the Motivated Strategies for Learning Questionnaire (MSLQ).

Please mark **(X)** and write your comment/suggestions in the relevant column if an item is **inappropriate**.

Motivation

Ques no.	1. Value Component: Intrinsic Goal Orientation	Is item inappropriate?	Comment / suggestion
1.	I prefer course materials that really challenge me so I can learn new things.		
14.	The most satisfying thing for me in learning Statics is trying to understand the content.		
15.	I normally choose assignments that can increase my knowledge although they do not guarantee a good grade.		
20.	I study because it is my responsibility.		
Ques no.	2. Value Component: Extrinsic Goal Orientation	Is item inappropriate?	Comment / suggestion
7.	My main concern in Statics class is getting a good grade.		
9.	I want to get better grades in Statics than most of the other students.		

18.	I want to do well in Statics because it is important to show my ability.		
Ques no.	3. Value Component: Task Value	Is item inappropriate?	Comment / suggestion
4.	I think I will be able to use what I learn in Statics in other courses.		
16.	I believe Statics is useful for me.		
17.	Understanding the concepts in Statics is important.		
Ques no.	4. Expectancy Component: Control Of Learning Beliefs	Is item inappropriate?	Comment / suggestion
2.	I will be able to learn the material in this course if I study well.		
6.	It is my own fault if I do not learn the material in this course.		
11.	I do not understand the course material because I didn’t try hard enough.		
19.	I will get good grades in Statics if I study hard enough.		
Ques no.	5. Expectancy Component: Self-Efficacy For Learning And Performance	Is item inappropriate?	Comment / suggestion
5.	I always believe I will get an excellent grade in Statics class.		

8.	I am confident I understand the basic concepts taught in Statics class.		
13.	I am confident I can do an excellent job on Statics assignments and tests.		
Ques no.	6. Affective Component: Test Anxiety	Is item inappropriate?	Comment / suggestion
3.	When I take a test I think about how poorly I am doing compared to other students.		
10.	When I take tests I think of the consequences of failing.		
12.	I feel my heart beating fast when I take an exam.		

Cognitive and Metacognitive Strategies

Ques no.	1. Rehearsal	Is item inappropriate?	Comment / suggestion
31.	I practice solving calculation problems over and over.		
40.	I memorize keywords to remind me of important concepts in Statics class.		
51.	I make and memorize the lists of important terms for Statics.		
Ques no.	2. Elaboration	Is item inappropriate?	Comment / suggestion
34.	When I study Statics, I combine information from different sources, such as lectures, readings, and discussions.		
44.	I try to relate the materials in Statics to what I already know.		

48.	I try to understand the concepts learnt in Statics by relating them to real life applications.		
58.	I try to apply ideas from what I read to other class activities such as lecture and discussion.		
Ques no.	3. Organization	Is item inappropriate?	Comment / suggestion
21.	I would outline the material I study to organize my thoughts.		
32.	I make simple charts, diagrams or tables to help me organize the course material.		
43.	I outline important concepts when studying Statics.		
Ques no.	4. Critical Thinking	Is item inappropriate?	Comment / suggestion
27.	I often find myself questioning things I hear or read in this course.		
46.	I try to play around with my own ideas related to what I am learning in Statics.		
50.	Whenever I read or hear a statement or conclusion in Statics, I think about possible alternatives.		
Ques no.	5. Metacognitive Self-Regulation	Is item inappropriate?	Comment / suggestion
22.	I often miss important points during class because I am thinking of other things.		
25.	When I study Statics, I ask questions to help focus my learning.		
29.	I always try to solve the confusion I had with Statics after class.		

35.	Before I study new course material, I often skim it to see how it is organized.		
36.	I ask myself questions to make sure I understand what I learn.		
37.	I try to change the way I study in order to fit the course requirements.		
38.	I often find that I do not know about what I have been studying.		
42.	When studying a topic in Statics I decide what I am supposed to learn from it.		
54.	I always try to determine which concepts I do not understand well.		
56.	I set goals for myself in order to direct my activities in each study period.		

Resource Management Strategies

Ques no.	1. Time And Study Environment	Is item inappropriate?	Comment / suggestion
24.	I usually study in a place where I can concentrate better.		
49.	I make sure I keep up with the assignments for this course.		
52.	I attend class regularly.		
55.	I do not spend much time studying Statics outside class period.		
57.	I seldom find time to revise before exams.		
Ques no.	2. Effort Regulation	Is item inappropriate?	Comment / suggestion
26.	I stop studying Statics if I feel bored with it.		

41.	I only study the easy parts in Statics.		
53.	Even when course materials are dull and uninteresting, I manage to keep working until I finish.		
45.	I work hard to do well in Statics even when the concepts are difficult to understand.		
Ques no.	3. Peer-Learning	Is item inappropriate?	Comment / suggestion
23.	I often try to explain the materials I learn to a classmate or a friend.		
30.	I try to work with other students to complete the course assignments.		
33.	I often set aside time to discuss the course materials with a group of friends.		
Ques no.	4. Help Seeking	Is item inappropriate?	Comment / suggestion
28.	Even if I have problems, I try to do Statics work on my own and without help from anyone.		
39.	I ask the lecturer to clarify the concepts I do not understand well.		
47.	When I do not understand the materials in Statics, I ask other students for help.		

APPENDIX D: RESULTS FROM PRELIMINARY STUDY

1. Magnitude of the problems in Statics

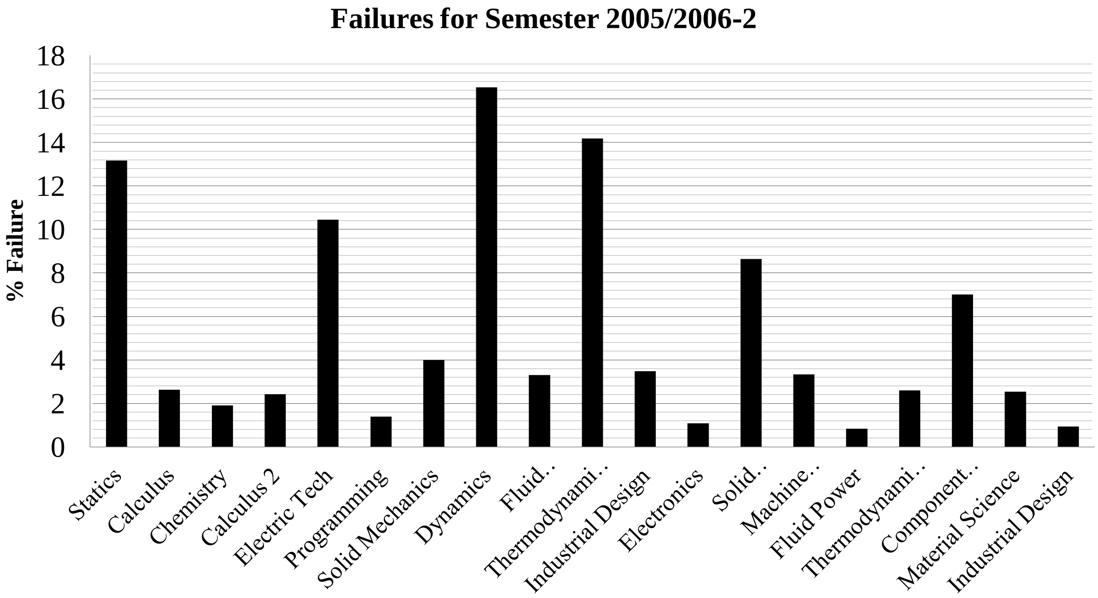


Figure 4 (a) : Failure rates for engineering and science courses for 2-2005/2006.

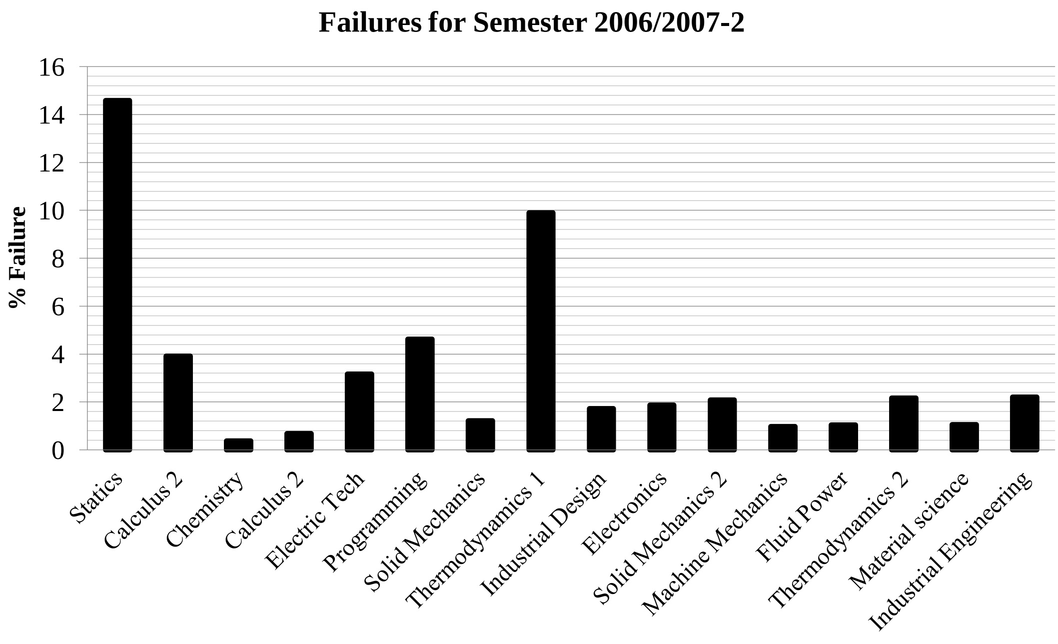


Figure 4 (b) : Failure rates for engineering and science courses for 2-2006/2007.

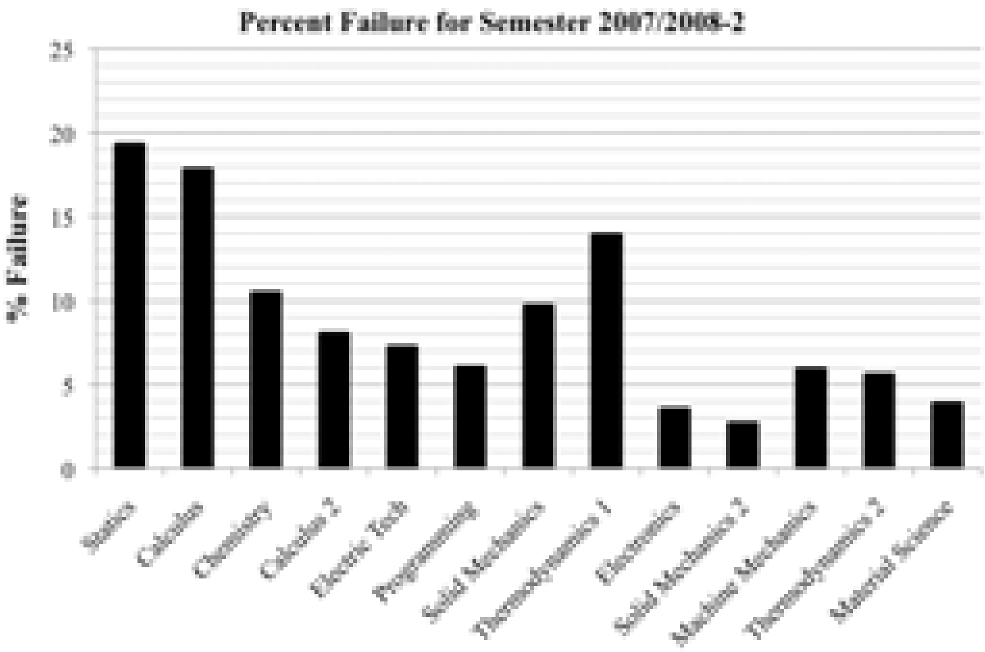


Figure 4 (c) : Failure rates for engineering and science courses for 2-2007/2008.

2. The challenges in learning Statics

Document analysis, class observations, interviews and questionnaires were the protocol used to gather the required data. The following sub-sections describe each protocol.

a. Document Analysis

Documents from the academic office related to 124 students who had failed Statics were first analyzed. The documents analyzed include students' results in related courses offered during their period of study from the first year until graduation. The focus of the analyses was to verify the claims made in the literature on the effects of entry qualification, performance in pre-requisite courses, and teaching factors on students' performance in Statics. Some of the following questions were investigated:

i. Do entry qualification and pre-requisite course grades affect students' performance?
ii. Do lecturers and the teaching approaches affect students' performance in Statics?
iii. Are there differences in the assessment method and format?

Analysis of the documents showed that students entering the program varied in terms of their academic background. Whilst the majority of students came into the program with a high school national exam certificate, *Sijil Pelajaran Malaysia* (SPM) that is equivalent to O-Level, there were some 8.9% who entered with polytechnic certificates. The students from polytechnics were given transfer credits for quite a number of pre-requisite courses, such as Physics and Trigonometry, thus these courses were not taken during their first year. From the faculty record it was identified that some of the students given the transfer credits had to repeat Statics, with several cases repeating it twice or more. This finding shows that pre-requisite courses do affect student results in Statics.

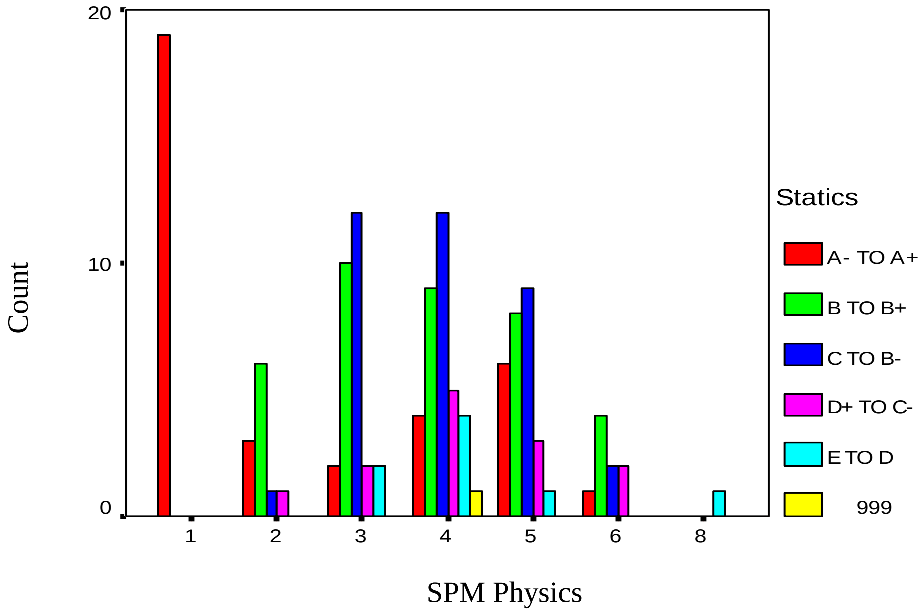
Further analysis on student results for the pre-requisite and entrance-requirement courses, summarized in Table 4(a), revealed that the percentage of student numbers who came in with inferior grades of 4 and greater in SPM Physics is about 81% and for Additional Mathematics is 75%. First year Mathematics (Geometry and Trigonometry) and Physics that should provide the basic skills and knowledge required in Statics showed that 91% obtained the inferior grades for Trigonometry, and 80% for first year Physics. It is also noted that only 4% of these students have CPA 3 and better (4 is best).

These results revealed that the majority of students who had failed Statics had previously performed poorly in the pre-requisite and entrance-requirement courses, thus implying the possible connection between knowledge in those courses and students performance in Statics.

Table 4 (a) : Distribution in percentage (%) of students who failed Statics according to their performance in Physics and Mathematics

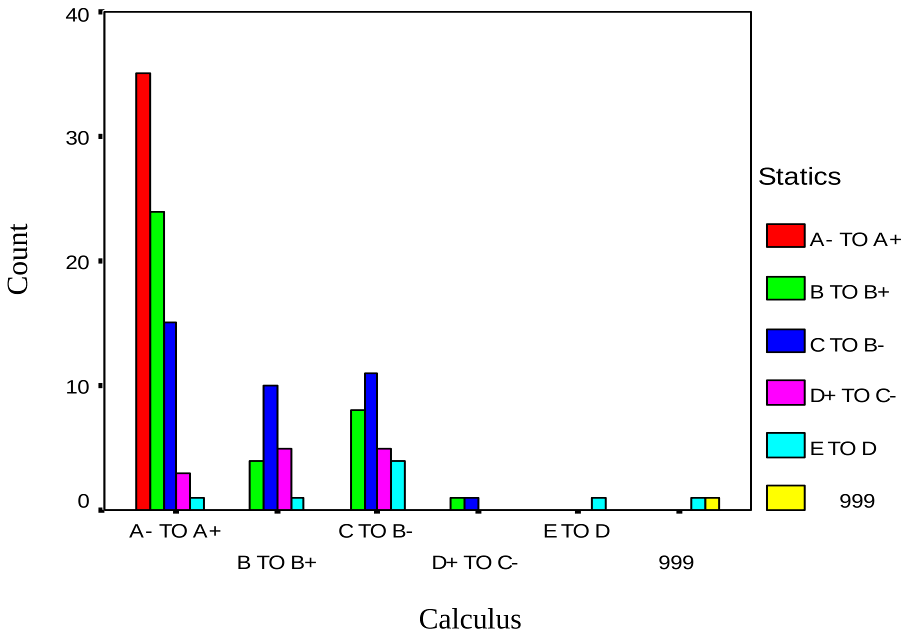
Grade	Physics (first year)	Mathematics (first year)	Add Math (SPM)	Physics (SPM)
1 to 3; A+ to B (Performing grades)	20.4	8.8	24.8	18.6
4 to 7; B- to E (Inferior)	79.6	91.2	75.2	81.4

The patterns of the pre-requisite course grades, CPA and Statics grades, and the relationships between them were investigated. Their perceptions of what could have affected their performance in Statics, and their general feelings whilst in Statics class were also analyzed. The majority of students with good grades in SPM Physics and first year Calculus did well in Statics. For both Physics and Calculus, students who scored grades 1 and A respectively, were the majority who scored A in Statics. These are shown in Figures 4 (d) and 4 (e). The same trend is also seen for Additional Mathematics and other pre-requisite courses like first year Mathematics and Physics. It is worth noting that the graph showing the pattern for Calculus and Statics grades depicted that none of those who scored less than an A in Calculus obtained an A in Statics. Calculus was shown to have a strong positive highly significant relationship with Statics (r = .706, n = 131, p <.01). This implies that students' ability in Calculus plays an important role in students' performance in Statics.



Note: '999' is missing data.

Figure 4 (d) SPM Physics results versus Statics



Note: '999' is missing data.

Figure 4 (e) Calculus results versus Statics

Students' results from six classes, taught by six different lecturers were analyzed. A stacked line graph in Figure 4 (f) based on the students' grades revealed a similar pattern for the different lecturers teaching the course. The lecturers were of similar background, with work experiences between 10 to 15 years. This finding implies that the lecturer is not a major contributor to students' performance in Statics.

Other documents such as the assessment format, examination question papers, textbook used, syllabus and learning outcomes were examined and compared with those from other local universities, and some universities abroad. The analysis indicated that the syllabus is generally similar with the syllabus from other universities, except for some specific learning outcomes. The textbook and references used are the popular ones, commonly used worldwide. Additionally, the assessment format is typical with those universities that taught Statics in the traditional method. The commonality of the syllabus and assessment method eliminates the possible bias in the students' results.

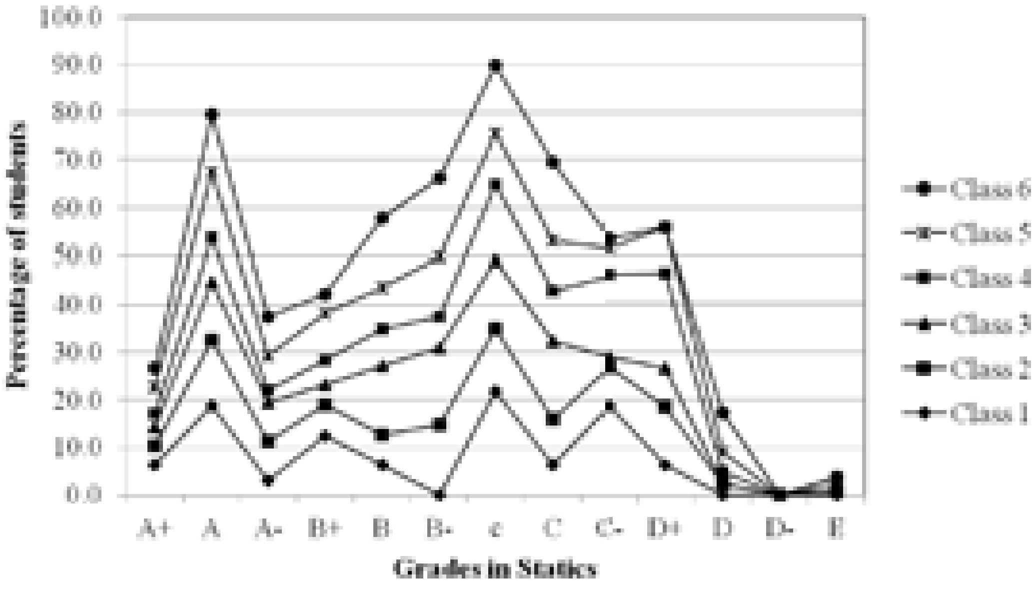


Figure 4 (f) Stacked line graph showing the distribution of students according to Statics grades per class, each with different lecturer

b. Interviews

Interviews were carried out with two Statics lecturers in the semester 2-2007-2008 on how they conduct their classes and perceive their students' learning Statics. Students were also interviewed to gain understanding on their experience and perceptions on learning Statics.

Lecturers

From the lecturers' interview sessions, students' attitude and behaviour are perceived as the main factor for their poor performance in Statics. The lecturers were in the opinion that students who did not perform well in Statics were not yet adjusted to the first year transition period, not interested in the course, and for some of them not interested in doing engineering altogether. The lecturers believed this is because most of the students are lacking in the mathematical ability, thus unable to solve the mathematical problems in Statics. This perception was arrived at from the lecturer's knowledge on student's pre-requisite course grades.

The students were also perceived as passive, uninterested in Statics because they were not willing to seek help when encountered with problems in Statics exercises, and did not participate in class activities. It was glaring to the lecturers that those few students who regularly seek their help performed better in Statics.

It was noticeable to the lecturers that repeating students have a disadvantage with regards to the timetable. Their class schedule often clashes with other courses that they have to take in the same semester. This had often caused them to miss some Statics classes, came in late or left earlier, especially when Statics classes were run in two periods consecutively.

As to how they conduct their lectures, the lecturers informed that lessons are conducted face to face, using whiteboard as the teaching aid, and occasionally using the PowerPoint slides. Related lab experiments in Statics are offered to students as a separate course. The lecturers described using the textbook exercises for in-class worked examples.

It can be summarized that the lecturers highlighted issues related to the transition period from high school to university learning environment, pre-requisite course requirements, motivation, learning strategies and class schedule. They also described about their teaching approaches.

Students

Students interviewed expressed that the transition period from school to the university curriculum was a factor for their poor performance in Statics. Apart from Statics being the first engineering course they encountered in the program, the learning and teaching approaches were very different from what they had experienced before.

The learning strategy now is different in many ways, which include the need for less rote memorization and more independence in their effort to study. They feel the need to be more independent, proactive in seeking more information on the courses taught and in communicating their ideas, thoughts and questions.

One student who had gone through the course several times indicated that she had put a mental block to learning Statics, ‘I just sit in class, trying to focus but it seems I can’t take in anything anymore’. Learning to pass the examination had become her main agenda.

This student and another repeating student shared their experiences taking Statics with different lecturers. Comparing the teaching approaches, they felt that learning is more effective with a more personalized approach to problem solving, and a more elaborated explanation of what Statics is all about. The researcher noted that this more personalized approach was made possible due to the smaller class size in the semester it was offered, as it was mainly for the repeating students.

Students who had previously failed admitted that they gained more confidence and understanding in Statics when taking it the second time. All of the students interviewed expressed that the motivation to learn would come with understanding of what was learnt. The students elaborated that they believe they can perform well in examinations if they practice a lot in solving Statics problems. The students, including those who had failed, believed that the calculation part was not a problem; but understanding the concepts in Statics is a struggle.

To summarize the outcomes from students' interviews, issues that were highlighted include those related to the transition period, teaching approaches, learning strategies, learning goals and motivation.

c. Class observations

Three in-class observations were undertaken during the period of two semesters, 2-2007-2008 and 1-2008-2009. The objectives were to observe how the course was taught and how students behave during class. Observations are described accordingly.

Teaching approach

In the two semesters when observations were made, classes were taught by two different lecturers but in the same traditional, face-to-face approach. The only teaching aid used was the white board, and a textbook.

In semester 2-2007/2008, two classes that were observed were taught by the same lecturer. It was observed that the lecturer started his classes by giving verbal explanations on the topic that was to be covered during the class period; however, almost all students were unaware that the lecturer had started to speak until after almost five minutes. The students took time to settle down as most of them had a class prior to Statics. Some students came in late and this added to class distraction.

The class continued with the lecturer explaining about the theories for 10 minutes, showing the applications of concepts in about 7 minutes, and then moved on showing the procedure to solve a related textbook problem on the whiteboard. He continued writing until the board was full, and then rubbed off the earlier section to continue writing the rest of the solution, while the students copied down each line. It appeared that the students had insufficient time to ask questions or to reflect their understanding on the concepts presented.

Immediately after the whiteboard demonstration of problem solving, the students were asked to solve several textbook problems. In one of the classes, students were asked to volunteer to solve the problems on the whiteboard, but when no one volunteered, the lecturer had to call a name at random from the attendance list. In the other class, the lecturer gave some time for the students to attempt the problems on their own before working through it on the whiteboard.

In semester 1-2008/2009, the lecturer was observed to interact more with the students. Students were guided on how to approach Statics problems from the textbook. They were given time to solve the problems on their own before being asked to share their answers. The lecturer was observed to check on students' work while they were still solving the problems. The students were given personal attention, made possible with the small number of students in the class.

It was noted that in all three classes observed, there was lack of emphasis on conceptual understanding and practical application of the concepts. The teaching approach was mainly focused on the mathematical derivations of the textbook problems and emphasized on the problem-solving procedures. However, this activity was able to engage the students. Generally, the lecturers did not adopt any learning principles in conducting their classes, for instance in identifying students' preconception and in engaging students' learning at the beginning and throughout the class periods.

Students' behaviour

In semester 2-2007/2008, it was observed that only about 10% of the students were involved in the class activities. Those students were observed attempting to solve the problems given on the whiteboard, discussing the questions with friends and asking questions to the lecturer. The other 90% were seen passive, did not make any attempt to solve the problems given but appeared to be waiting for the lecturer to provide the solutions, or waiting for the next activity. About 10% out of these 90% of students appeared to be uninterested, not even copying solutions, but seems to be in their own world throughout the class session. Towards the end of the class period students were already noisy with own conversation, and only paid attention to the lecturer when tips on the coming test were given.

There were about 27% of the students enrolled that semester who are repeaters, with some of them taking the course for the third time. It is possible to assume that those who were passive are those who were repeating the course. And those students who appeared to just sit and stare unresponsively may be assumed to be uninterested in the course as they hurriedly left the class at the end of class period.

Generally classes were quiet throughout, and students were not paying attention to the question and answer session. However, jokes and some story sharing by the lecturer caught their interest. There also seem to be no opportunity for the students to reflect and digest information given during the class period, as the students were mostly busy copying solutions from the whiteboard. It was also noticeable that a student who was called out but unable to solve the calculation problem on the whiteboard, appeared to be at ease about it.

In semester 1-2008/2009, it was observed that although some students were unable to solve Statics problems, most of them were engaged and appeared to be motivated to try. However, a student in particular was observed to be de-motivated and passive. This student was invited for the interview.

APPENDIX E: EFA

Communalities (Motivation)

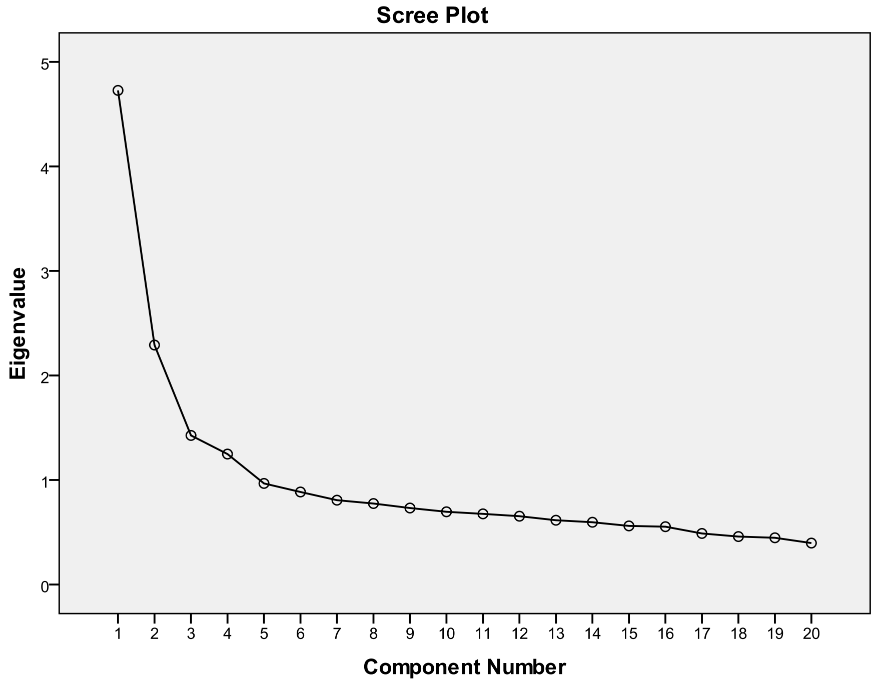
	Initial	Extraction
i1	1.000	.465
i2	1.000	.408
i3	1.000	.518
i4	1.000	.317
i5	1.000	.619
i6	1.000	.275
i7	1.000	.606
i8	1.000	.496
i9	1.000	.485
i10	1.000	.526
i11	1.000	.491
i12	1.000	.389
i13	1.000	.574
i14	1.000	.468
i15	1.000	.566
i16	1.000	.576
i17	1.000	.563
i18	1.000	.381
i19	1.000	.579
i20	1.000	.392

Extraction Method: Principal Component Analysis.

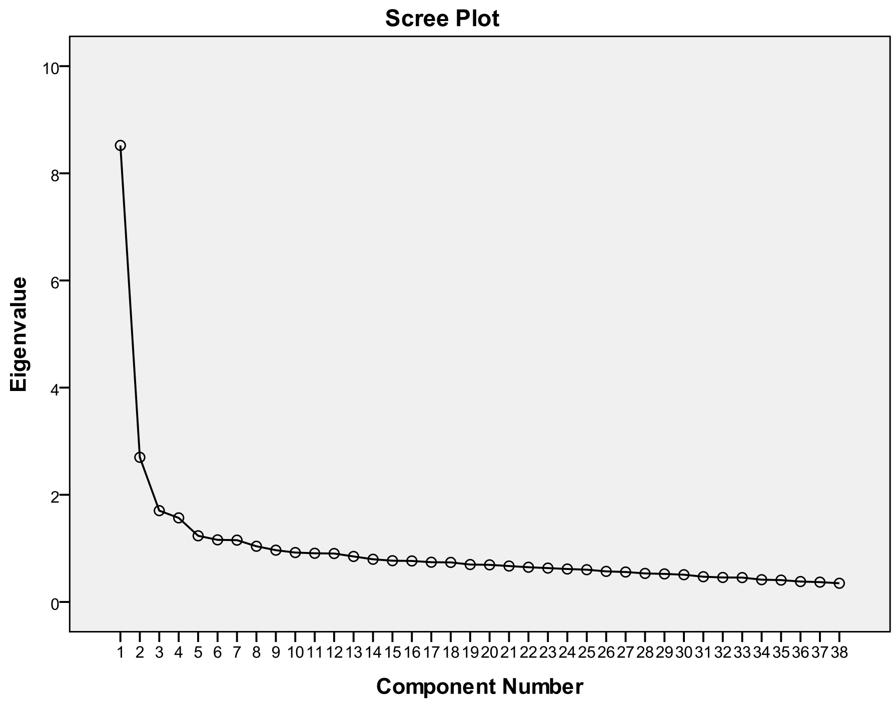
Communalities (Learning Strategies)

	Initial	Extraction
i21	1.000	.436
i22	1.000	.448
i23	1.000	.507
i24	1.000	.333
i25	1.000	.365
i26	1.000	.271
i27	1.000	.267
i28	1.000	.601
i29	1.000	.459
i30	1.000	.500
i31	1.000	.489
i32	1.000	.526
i33	1.000	.491
i34	1.000	.350
i35	1.000	.419
i36	1.000	.430
i37	1.000	.372
i38	1.000	.417
i39	1.000	.420
i40	1.000	.418
i41	1.000	.526
i42	1.000	.414
i43	1.000	.507
i44	1.000	.571
i45	1.000	.423
i46	1.000	.526
i47	1.000	.577
i48	1.000	.575
i49	1.000	.402
i50	1.000	.519
i51	1.000	.423
i52	1.000	.434
i53	1.000	.434
i54	1.000	.428
i55	1.000	.527
i56	1.000	.358
i57	1.000	.371
i58	1.000	.352

Extraction Method: Principal
Component Analysis.



Scree Plot (Motivation)



Scree Plot (Learning strategies)

Component Matrix[a] (Motivation)

	Component			
	1	2	3	4
i16	.647			
i14	.630			
i2	.585			
i9	.578			
i17	.577			
i18	.569			
i1	.546			
i13	.544	-.438		
i19	.523		-.492	
i4	.490			
i8	.485			
i20	.467			
i6	.462			
i3		.650		
i11		.633		
i10		.520	.426	
i5	.484	-.492		
i12		.472		
i15	.419		.433	-.429
i7	.463			.618

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Component Matrix[a] (Learning strategies)

	Component							
	1	2	3	4	5	6	7	8
i36	.624							
i50	.614							
i48	.608							
i44	.600							
i54	.576							
i46	.575							
i31	.574							
i49	.571							
i58	.565							
i35	.559							
i34	.556							
i45	.552							
i43	.541							
i51	.540							
i42	.533							
i29	.527							
i40	.519							
i25	.514							
i33	.514							
i39	.504							
i23	.496				-.433			
i37	.495							
i53	.486							
i21	.486							
i56	.483							
i30	.456							
i41		-.684						
i55		.612						
i38		.600						
i22		.582						
i57		.477						
i26		.458						
i32	.436		.496					
i47	.404		-.446					
i52			-.420					
i28		.404		.443				
i27							.562	
i24							.406	

Extraction Method: Principal Component Analysis.

Component Matrix[a] (Learning strategies)

	Component							
	1	2	3	4	5	6	7	8
i36	.624							
i50	.614							
i48	.608							
i44	.600							
i54	.576							
i46	.575							
i31	.574							
i49	.571							
i58	.565							
i35	.559							
i34	.556							
i45	.552							
i43	.541							
i51	.540							
i42	.533							
i29	.527							
i40	.519							
i25	.514							
i33	.514							
i39	.504							
i23	.496				-.433			
i37	.495							
i53	.486							
i21	.486							
i56	.483							
i30	.456							
i41		-.684						
i55		.612						
i38		.600						
i22		.582						
i57		.477						
i26		.458						
i32	.436		.496					
i47	.404		-.446					
i52			-.420					
i28		.404		.443				
i27							.562	
i24							.406	

Extraction Method: Principal Component Analysis.

a. 8 components extracted.

APPENDIX F: NEW FACTORS AND ITEMS

MOTIVATION

STUDY GOALS AND VALUE
I want to get better grades in Statics than most of the other students.
I will be able to learn the material in this course if I study well.
Understanding the concepts in Statics is important.
I will get good grades in Statics if I study hard enough.
I study because it is my responsibility.
I want to do well in Statics because it is important to show my ability.
I believe Statics is useful for me.

ANXIETY
When I take a test I think about how poorly I am doing compared to other students.
When I take tests I think of the consequences of failing.
I do not understand the course material because I didn't try hard enough.
I feel my heart beating fast when I take an exam.

LEARNING BELIEFS AND SELF-EFFICACY
I prefer course materials that really challenge me so I can learn new things.
I think I will be able to use what I learn in Statics in other courses.
I always believe I will get an excellent grade in Statics class.
I am confident I understand the basic concepts taught in Statics class.
I am confident I can do an excellent job on Statics assignments and tests.
The most satisfying thing for me in learning Statics is trying to understand the content.
I normally choose assignments that can increase my knowledge although they do not guarantee a good grade.

LEARNING STRATEGIES

CRITICAL THINKING AND ELABORATION
I try to relate the material in Statics to what I already know.
I try to play around with my own ideas related to what I am learning in Statics.
I try to understand the concepts learnt in Statics by relating them to real life applications.
Whenever I read or hear a statement or conclusion in Statics, I think about possible alternatives.
I ask myself questions to make sure I understand what I learn.
I try to think through a topic and decide what I am supposed to learn from it.

I try to apply ideas from what I read to other class activities such as lecture and discussion.

ORGANIZATION AND MEMORIZATION

I make simple charts, diagrams or tables to help me organize course material.
I would outline the material I study to organize my thoughts.
I outline important concepts when studying Statics.
I make and memorize the lists of important terms for Statics.
I often set aside time to discuss the course material with a group of friends.
I memorize keywords to remind me of important concepts in Statics class.
I set goals for myself in order to direct my activities in each study period.
Before I study new course material, I often skim it to see how it is organized.

PERSISTENCE & REGULATION

I attend class regularly.
Even when course materials are dull and uninteresting, I manage to keep working until I finish.
I work hard to do well in Statics even when the concepts are difficult to understand.
I usually study in a place where I can concentrate better.
I always try to determine which concepts I do not understand well.
I practice solving calculation problems over and over.

(LACK OF) STUDY EFFORT

I only study the easy parts in Statics.
I do not spend much time studying Statics outside class period.
I often miss important points during class because I am thinking of other things.
I often find that I do not know about what I have been studying.
I stop studying Statics if I feel bored with it.
I seldom find time to revise before exams.

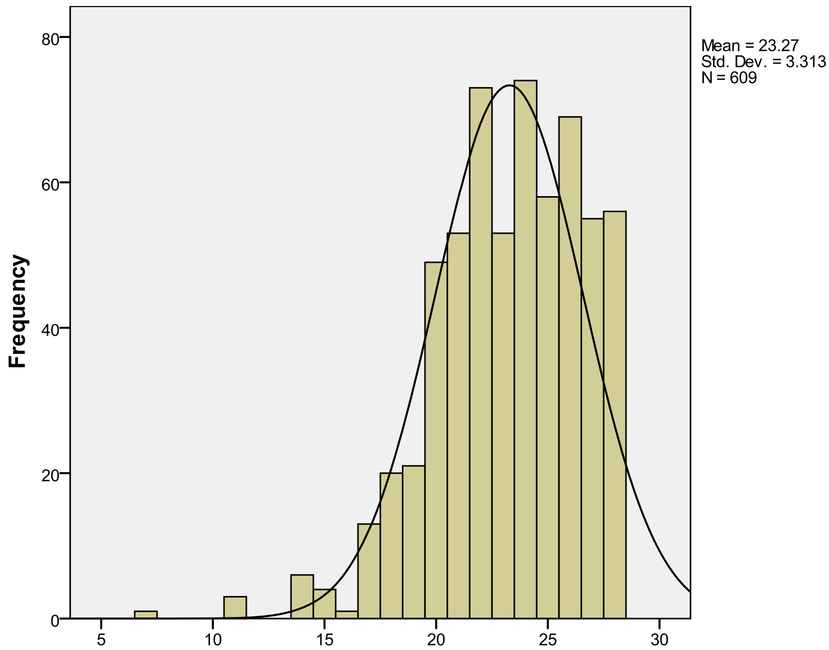
META-COGNITIVE REGULATION

I often try to explain the material I learn to a classmate or a friend.
I always try to solve the confusion I had with Statics after class.
When I study Statics, I ask questions to help focus my learning.
I ask the lecturer to clarify concepts I do not understand well.

HELP-SEEKING

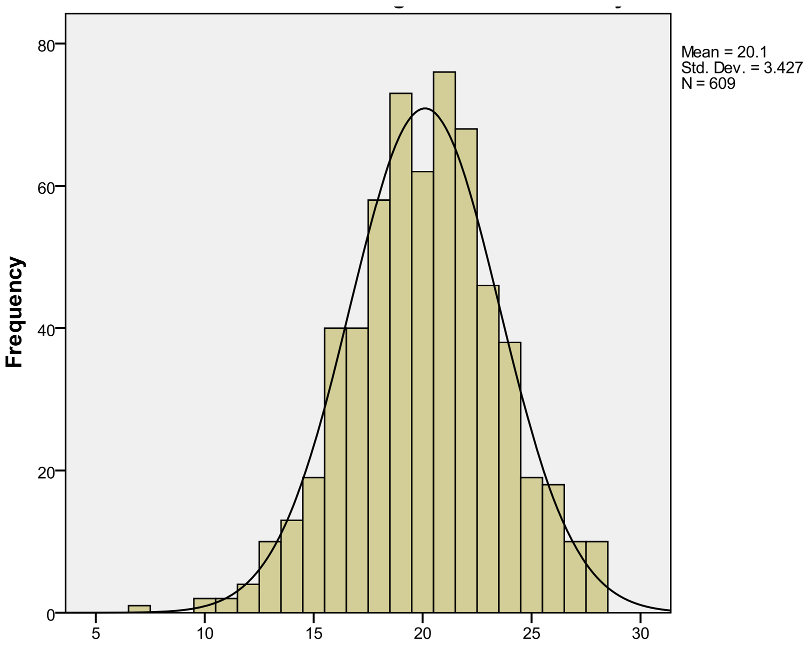
When I do not understand the materials in Statics, I ask other students for help.
I try to work with other students to complete the course assignments.
Even if I have problems, I try to do Statics work on my own and without help from anyone.

APPENDIX G: NORMALITY

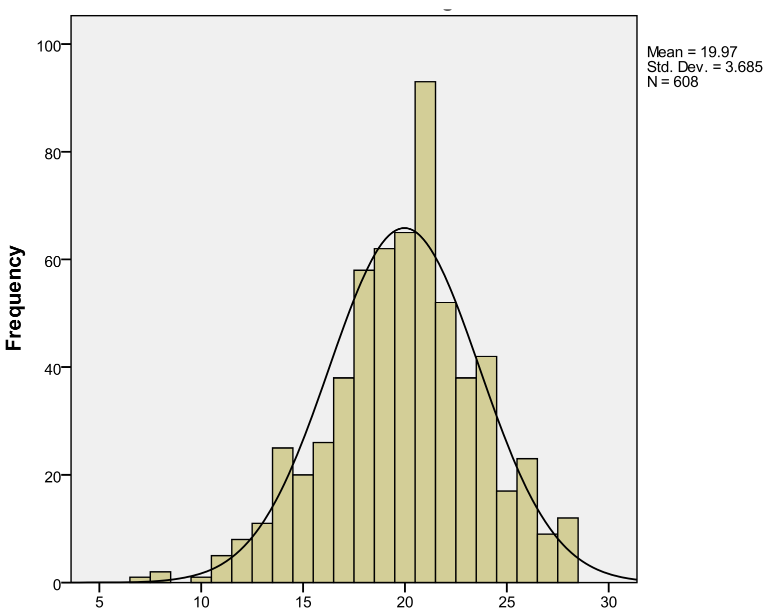


Study goals and value

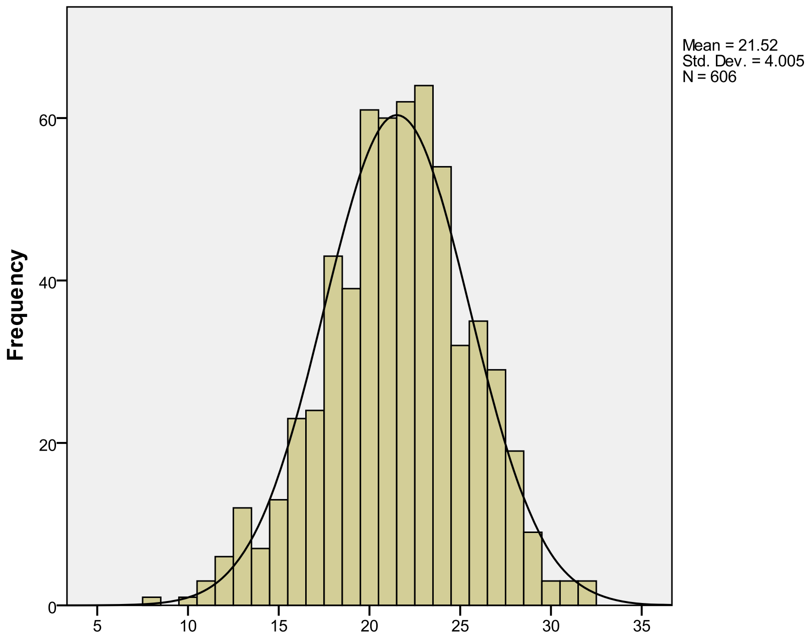
Anxiety



Learning beliefs and self-efficacy

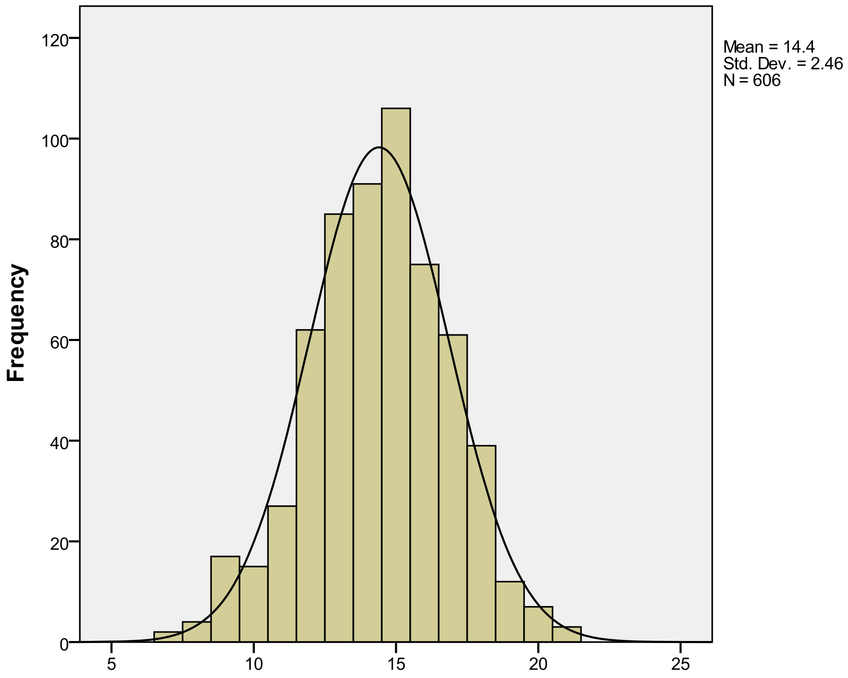


Critical thinking and elaboration



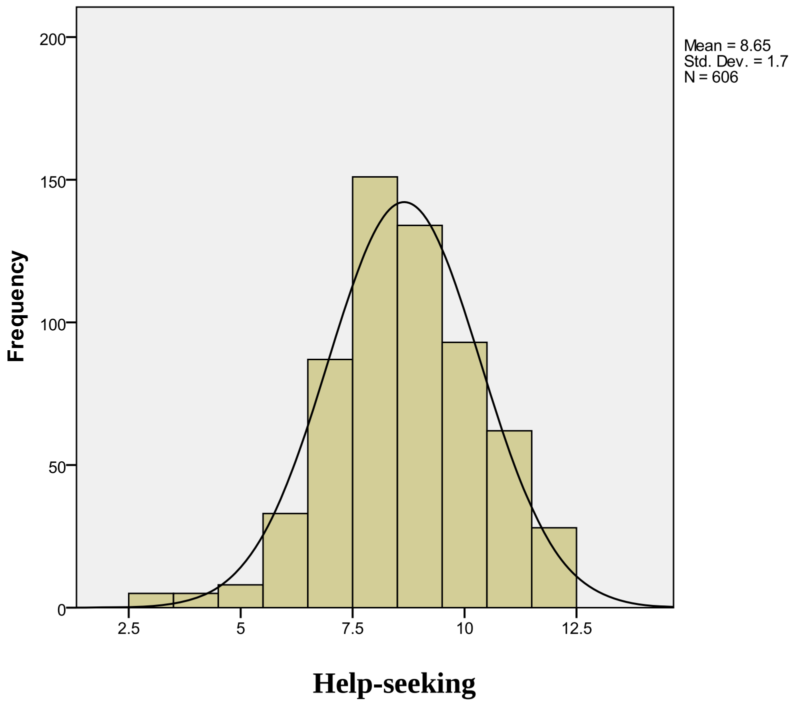
Organization and memorization

Persistence and regulation



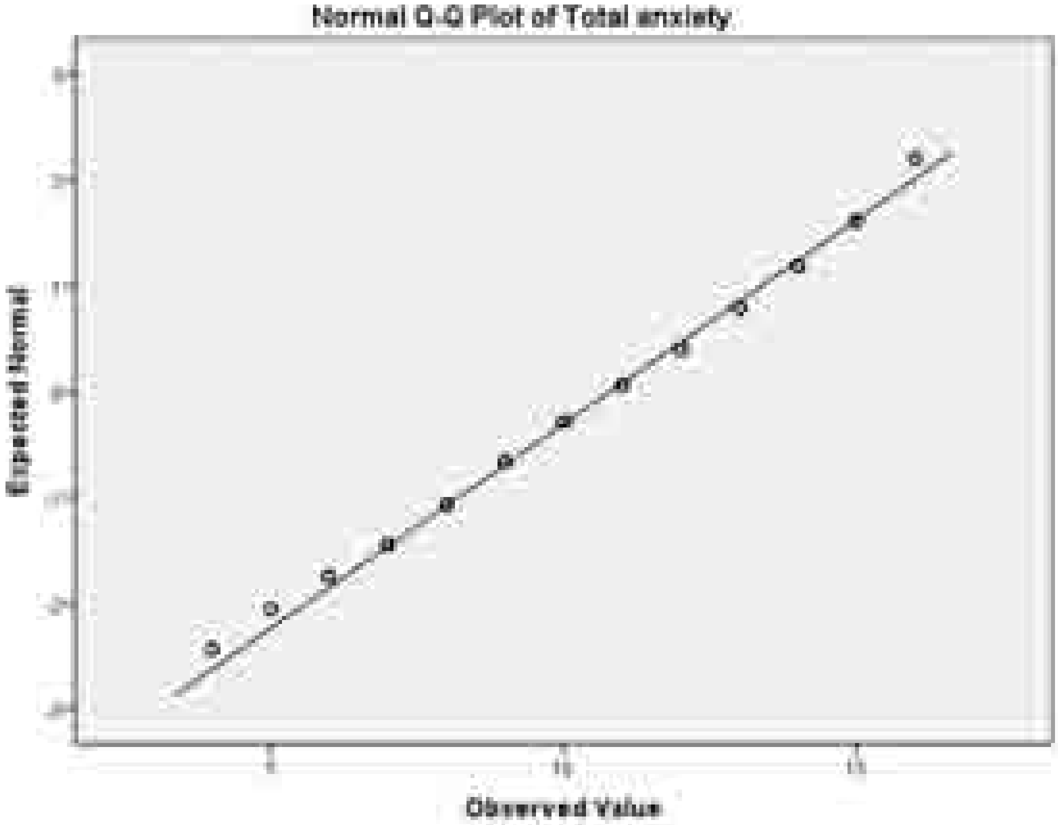
(Lack of) study effort

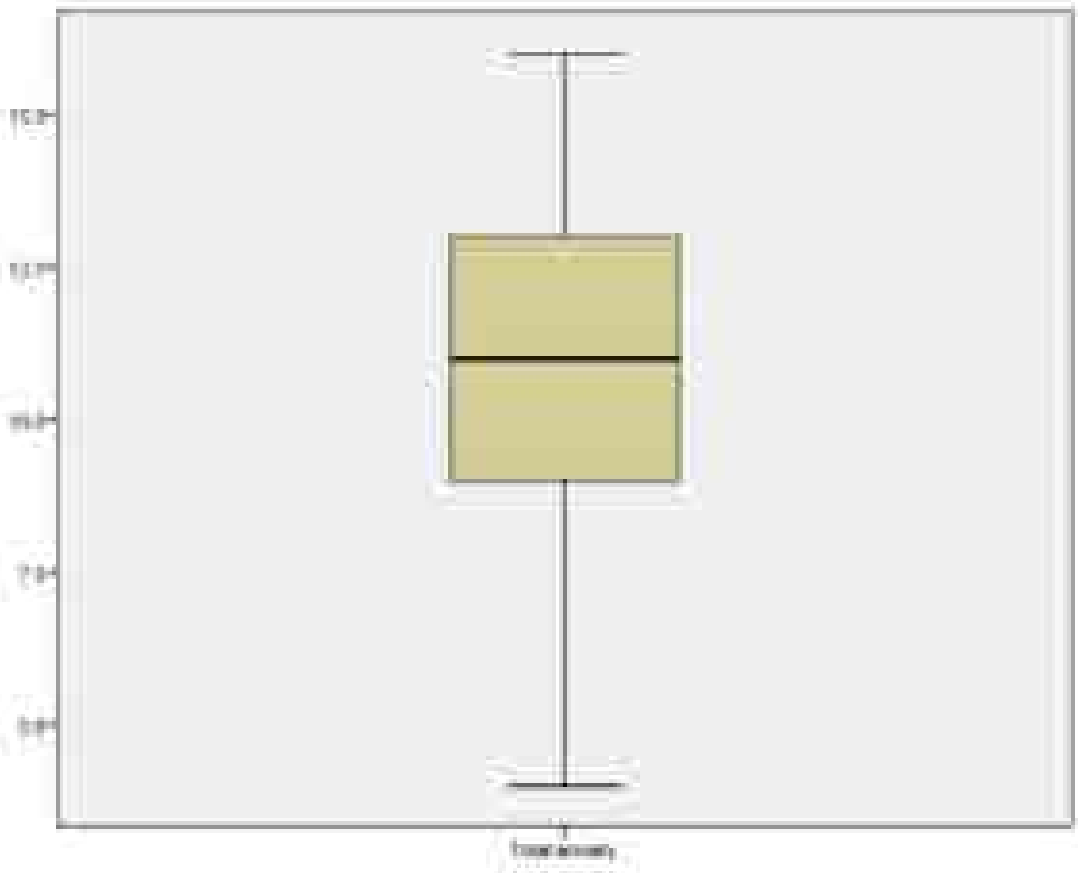
Meta-cognitive regulation

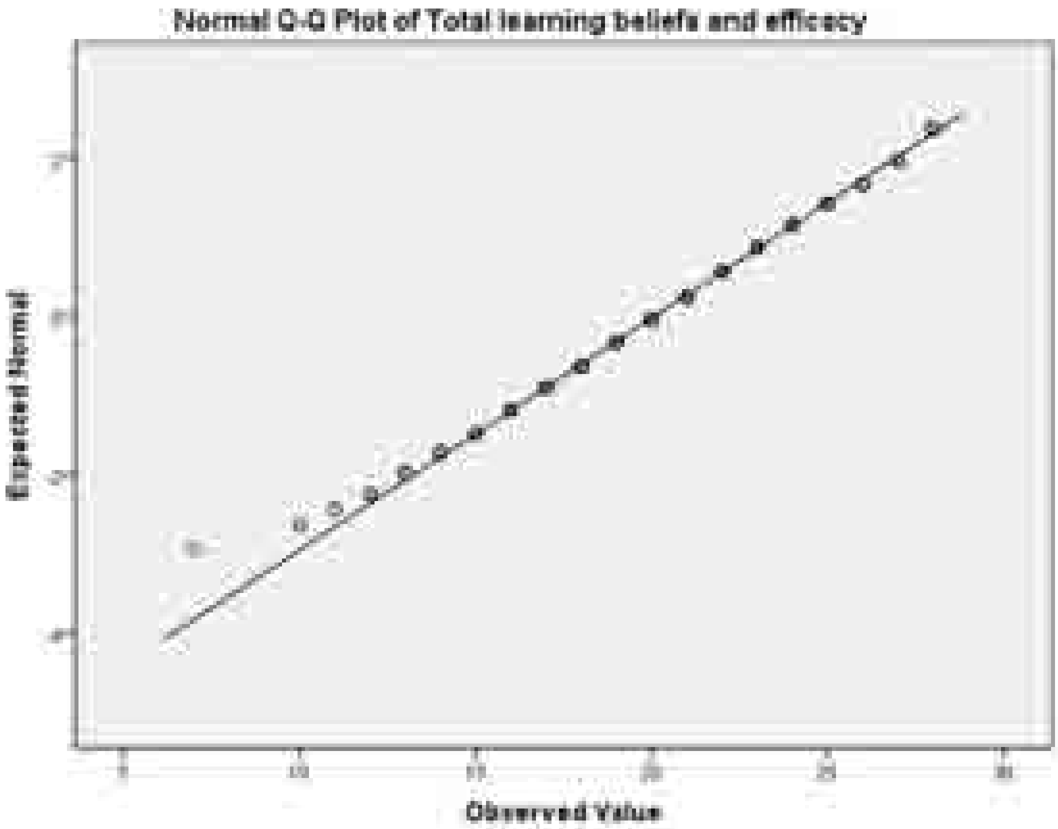


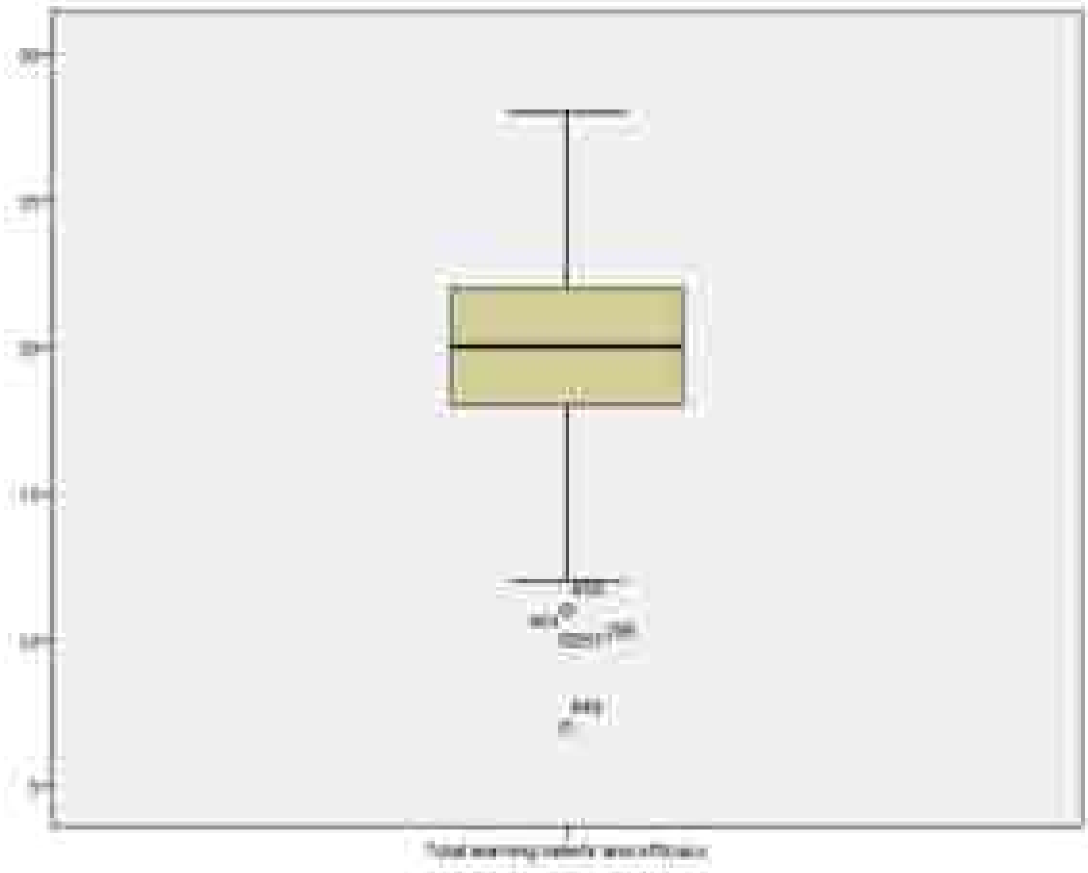
Total metacognitive self -regulation Stem-and-Leaf Plot

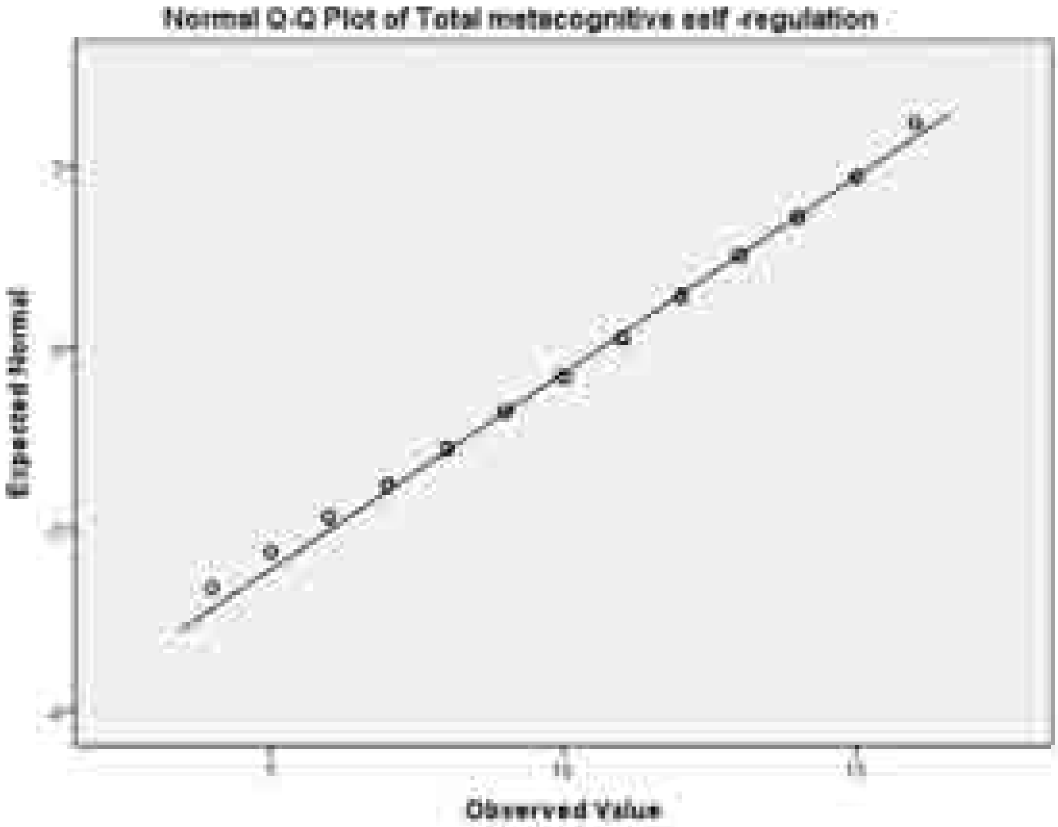
```
 Frequency    Stem &  Leaf

     4.00 Extremes    (=<4.0)
     6.00        5 .  000
    17.00        6 .  00000000
    24.00        7 .  000000000000
    59.00        8 .  00000000000000000000000000000
    74.00        9 .  0000000000000000000000000000000000000
    89.00       10 .  00000000000000000000000000000000000000000000
   113.00       11 .  00000000000000000000000000000000000000000000000000000000
    96.00       12 .  000000000000000000000000000000000000000000000000
    63.00       13 .  0000000000000000000000000000000
    33.00       14 .  0000000000000000
    21.00       15 .  0000000000
     7.00       16 .  000

 Stem width:        1
 Each leaf:       2 case(s)
```

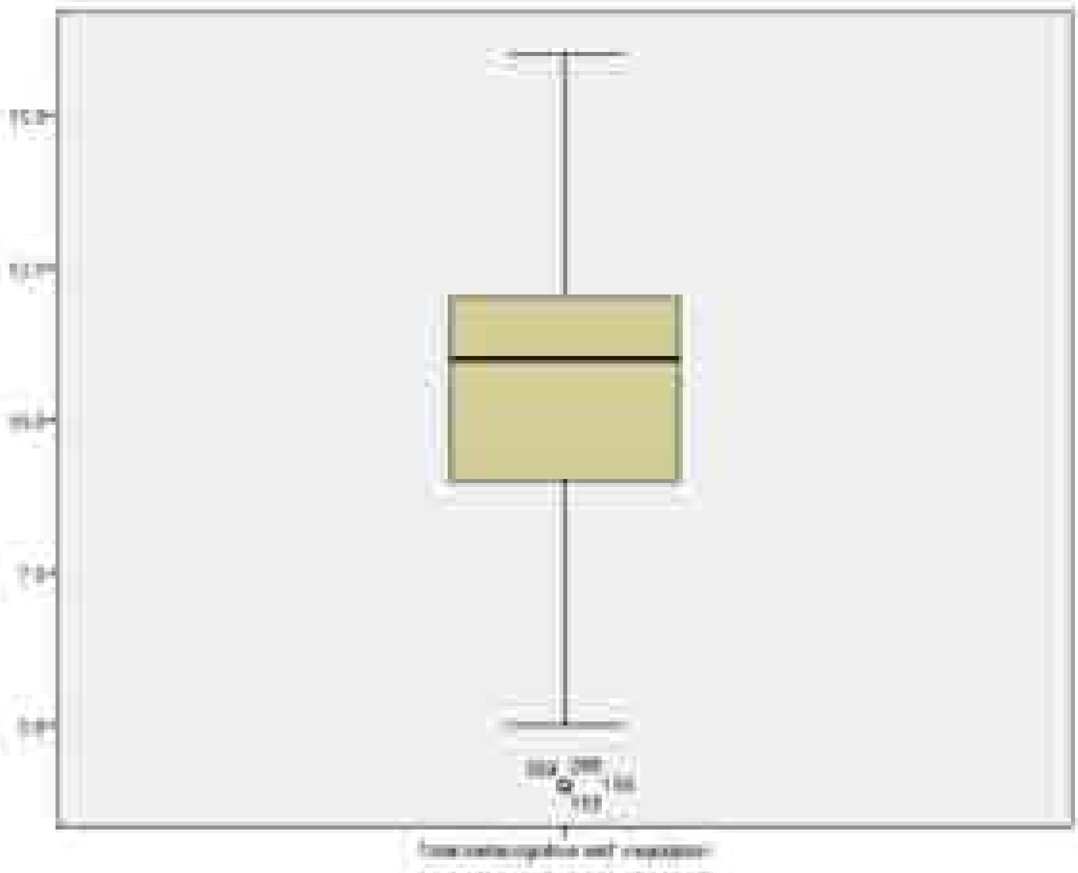

Normal Q-Q Plot of Total anxiety
Expected Normal
Observed Value


Total anxiety


Normal Q-Q Plot of Total learning beliefs and efficacy
Expected Normal
Observed Value




Normal Q-Q Plot of Total metacognitive self -regulation
Expected Normal
Observed Value



Descriptive Analysis

Descriptives				
			Statistic	Std. Error
Total goals and Value	Mean		23.27	.134
	95% Confidence Interval for Mean	Lower Bound	23.01	
		Upper Bound	23.53	
	5% Trimmed Mean		23.45	
	Median		24.00	
	Variance		10.973	
	Std. Deviation		3.313	
	Minimum		7	
	Maximum		28	
	Range		21	
	Interquartile Range		5	
	Skewness		-.772	.099
	Kurtosis		1.076	.198
Total anxiety	Mean		10.80	.105
	95% Confidence Interval for Mean	Lower Bound	10.60	
		Upper Bound	11.01	
	5% Trimmed Mean		10.85	
	Median		11.00	
	Variance		6.697	
	Std. Deviation		2.588	
	Minimum		4	
	Maximum		16	
	Range		12	
	Interquartile Range		4	
	Skewness		-.175	.099
	Kurtosis		-.339	.197
Total learning beliefs and efficacy	Mean		20.10	.139
	95% Confidence Interval for Mean	Lower Bound	19.83	
		Upper Bound	20.37	
	5% Trimmed Mean		20.13	
	Median		20.00	
	Variance		11.747	
	Std. Deviation		3.427	
	Minimum		7	
	Maximum		28	
	Range		21	
	Interquartile Range		4	
	Skewness		-.143	.099
	Kurtosis		.127	.198
Total critical thinking & elaboration	Mean		19.97	.149
	95% Confidence Interval for Mean	Lower Bound	19.68	
		Upper Bound	20.26	
	5% Trimmed Mean		20.03	
	Median		20.00	
	Variance		13.577	

	Std. Deviation		3.685	
	Minimum		7	
	Maximum		28	
	Range		21	
	Interquartile Range		4	
	Skewness		-.264	.099
	Kurtosis		.168	.198
Total organization and rehearsal	Mean		21.52	.163
	95% Confidence Interval for Mean	Lower Bound	21.20	
		Upper Bound	21.84	
	5% Trimmed Mean		21.59	
	Median		22.00	
	Variance		16.039	
	Std. Deviation		4.005	
	Minimum		8	
	Maximum		32	
	Range		24	
	Interquartile Range		5	
	Skewness		-.215	.099
	Kurtosis		.041	.198
Total effort regulation	Mean		18.16	.117
	95% Confidence Interval for Mean	Lower Bound	17.93	
		Upper Bound	18.39	
	5% Trimmed Mean		18.22	
	Median		18.00	
	Variance		8.320	
	Std. Deviation		2.884	
	Minimum		8	
	Maximum		24	
	Range		16	
	Interquartile Range		4	
	Skewness		-.316	.099
	Kurtosis		.220	.198
Total time & study environment	Mean		14.40	.100
	95% Confidence Interval for Mean	Lower Bound	14.21	
		Upper Bound	14.60	
	5% Trimmed Mean		14.44	
	Median		14.50	
	Variance		6.053	
	Std. Deviation		2.460	
	Minimum		7	
	Maximum		21	
	Range		14	
	Interquartile Range		3	
	Skewness		-.171	.099
	Kurtosis		.020	.198
Total metacognitive self -	Mean		10.64	.094
	95% Confidence Interval for Mean	Lower Bound	10.45	
		Upper Bound	10.82	

regulation	5% Trimmed Mean		10.67	
	Median		11.00	
	Variance		5.312	
	Std. Deviation		2.305	
	Minimum		4	
	Maximum		16	
	Range		12	
	Interquartile Range		3	
	Skewness		-.187	.099
	Kurtosis		-.104	.198
Total peer & help-seeking	Mean		8.65	.069
	95% Confidence Interval for Mean	Lower Bound	8.52	
		Upper Bound	8.79	
	5% Trimmed Mean		8.68	
	Median		9.00	
	Variance		2.891	
	Std. Deviation		1.700	
	Minimum		3	
	Maximum		12	
	Range		9	
	Interquartile Range		2	
	Skewness		-.258	.099
	Kurtosis		.358	.198

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Study goals and Value	.100	609	.000	.947	609	.000
Anxiety	.092	612	.000	.979	612	.000
Learning beliefs and self-efficacy	.072	609	.000	.989	609	.000
Critical thinking & elaboration	.081	608	.000	.985	608	.000
Organization and memorization	.068	606	.000	.991	606	.001
Persistence and regulation	.090	606	.000	.980	606	.000
(Lack of) study effort	.096	606	.000	.982	606	.000
Meta-cognitive regulation	.112	606	.000	.980	606	.000
Help-seeking	.127	606	.000	.958	606	.000

a. Lilliefors Significance Correction

Statistics

		Study goals and Value	Anxiety	Learning beliefs and self-efficacy	Critical thinking & elaboration	Organization and memorization	Persistence and regulation	(Lack of) study effort Total time &	Meta-cognitive regulation	Help-seeking
N	Valid	609	612	609	608	606	606	606	606	606
	Missing	27	24	27	28	30	30	30	30	30
Mode		24	10	21	21	23	18	15	11	8

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Study goals and Value	609	7	28	23.27	3.313	-.772	.099	1.076	.198
Anxiety	612	4	16	10.80	2.588	-.175	.099	-.339	.197
Learning beliefs and self-efficacy	609	7	28	20.10	3.427	-.143	.099	.127	.198
Critical thinking & elaboration	608	7	28	19.97	3.685	-.264	.099	.168	.198
Organization and memorization	606	8	32	21.52	4.005	-.215	.099	.041	.198
Persistence and regulation	606	8	24	18.16	2.884	-.316	.099	.220	.198
(Lack of) study effort	606	7	21	14.40	2.460	-.171	.099	.020	.198
Meta-cognitive regulation	606	4	16	10.64	2.305	-.187	.099	-.104	.198
Help-seeking	606	3	12	8.65	1.700	-.258	.099	.358	.198
Valid N (listwise)	606								

APPENDIX H: RELIABILITY

Scale: metacog-self regulation

Case Processing Summary

		N	%
Cases	Valid	606	95.3
	Excluded[a]	30	4.7
	Total	636	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.623	.624	4

Item Statistics

	Mean	Std. Deviation	N
i23	2.67	.795	606
i39	2.60	.868	606
i29	2.60	.827	606
i25	2.78	.872	606

Inter-Item Correlation Matrix

	i23	i39	i29	i25
i23	1.000	.353	.275	.300
i39	.353	1.000	.304	.322
i29	.275	.304	1.000	.205
i25	.300	.322	.205	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Inter-Item Correlations	.293	.205	.353	.148	1.725	.002	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
i23	7.97	3.416	.430	.187	.535
i39	8.04	3.149	.458	.210	.511
i29	8.04	3.535	.351	.130	.589
i25	7.86	3.355	.375	.149	.574

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
10.64	5.312	2.305	4

Scale: peer & help-seeking

Case Processing Summary

		N	%
Cases	Valid	606	95.3
	Excluded[a]	30	4.7
	Total	636	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.467	.482	3

Item Statistics

	Mean	Std. Deviation	N
i28	2.52	.899	606
i47	3.13	.771	606
i30	3.00	.767	606

Inter-Item Correlation Matrix

	i28	i47	i30
i28	1.000	.183	.117
i47	.183	1.000	.410
i30	.117	.410	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N ccbbof Items
Inter-Item Correlations	.237	.117	.410	.293	3.497	.019	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
i28	6.14	1.668	.179	.035	.582
i47	5.52	1.559	.383	.187	.208
i30	5.65	1.656	.328	.170	.306

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
8.65	2.891	1.700	3