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An Investigation Into Developing The Mathematical Achievement for

Foundation Students in Kuwait

By

Sali Hammad

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Sali Hammad

An Investigation Into Developing The Mathematical Achievement for Foundation Students in Kuwait

Abstract

Kuwait’s educational leaders have been putting efforts into improving their educational systems for the past 30 years. However, Kuwaiti students have performed in lower percentiles, in comparison with other countries, in international testing projects such as the Trends in International Mathematics and Science Study (TIMSS). This study investigated the development of a new framework that could improve students’ mathematical achievement for freshmen students at an American university foundation program in Kuwait. The framework is based on exploring approaches that can improve students’ mathematical self-efficacy, motivation and understanding.

The study explored students’ mathematical backgrounds, self-efficacy, motivation, and mathematical understanding during the course. The study was divided into four stages (0 to 3). Students were asked to answer the background, self-efficacy, and motivation questionnaires at stage 0 of the study. They also answered a level quiz that examined their previous mathematics knowledge. They were also asked to draw concept maps for analysing and explored their conceptual understanding of their previous mathematical knowledge. For the stages (1 to 3), the students completed the self-efficacy and motivation questionnaires, drew concept maps, and took three major tests (Test 1, Test 2, and Test 4). Also, a sample of the students was interviewed at the end of the course.
The study analysis from stage 0 revealed that many students participating in the study graduated from the school system with low self-efficacy and motivation levels towards studying mathematics, which may not have been helpful for their future studies. The study also found that the students were mathematically-procedurally driven more than conceptually and that they found it difficult to apply the mathematics knowledge that they acquired at school.

During the course, the researcher applied educational approaches that students had not been exposed to during their high school nor previous college mathematical courses. The educational approaches included group work, gamification and puzzle sheets, revision notes, small boards, and correcting the students’ own errors, online homework, and social media (WhatsApp) group application (outcome). The researcher used these educational approaches to develop the ‘Successful Mathematics Implementing Classroom’ (SMIC) framework. The SMIC framework explained how the approaches from the relevant literature used could improve students’ mathematical self-efficacy, motivation, and mathematical understanding in order to improve students’ mathematical achievement.

The students participating in the study showed noticeable improvements in their self-efficacy, motivation, and mathematical understanding levels during the course, most noticeably from stages 0 to 1. Also, the students showed a major improvement in their test scores especially from stages 0 to 1. There was a positive correlation between students’ self-efficacy and their test scores as well as a positive correlation between students’ motivation and their test scores in this study. Concept maps analysis showed improvements in the students’ conceptual understanding during the course. The students’ interviews confirmed that each educational approach used in the course had positively influenced students’ self-efficacy, motivation, and
their mathematical understanding during the course. This improved students’ mathematical achievement at the end of the course.

The study provided different recommendations for school and college educators such as using the SMIC framework or other similar frameworks that focus on improving students’ self-efficacy, motivation, and mathematical understanding in order to improve their mathematical achievement.
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<th>Description</th>
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<td>GUST</td>
<td>Gulf University for Science and Technology</td>
</tr>
<tr>
<td>MFU</td>
<td>Mathematics Foundation Unit</td>
</tr>
<tr>
<td>TIMSS</td>
<td>Trends in International Mathematics and Science Study</td>
</tr>
<tr>
<td>PIRLS</td>
<td>Progress in International Reading and Literacy Study</td>
</tr>
<tr>
<td>MENA</td>
<td>Middle East and North Africa</td>
</tr>
<tr>
<td>IBRD</td>
<td>International Bank for Reconstruction and Development</td>
</tr>
<tr>
<td>LSE</td>
<td>London School of Economics</td>
</tr>
<tr>
<td>MESA</td>
<td>Mathematics/English language/Science/Arabic language</td>
</tr>
<tr>
<td>SMIC</td>
<td>Successful Mathematics Implementing Classroom</td>
</tr>
<tr>
<td>CUF</td>
<td>Conceptual Understanding analytical Framework</td>
</tr>
<tr>
<td>NCTM</td>
<td>National Council of Teacher of Mathematics</td>
</tr>
<tr>
<td>PCK</td>
<td>Pedagogical Content Knowledge</td>
</tr>
<tr>
<td>NCES</td>
<td>National Centre for Education Statistics</td>
</tr>
<tr>
<td>CAI</td>
<td>Computer-Assisted Instruction</td>
</tr>
<tr>
<td>BERA</td>
<td>British Educational Research Association</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
</tr>
<tr>
<td>HW</td>
<td>Homework</td>
</tr>
<tr>
<td>BEDMAS</td>
<td>Bracket, Exponent, Division, Multiplication, Addition, Subtraction</td>
</tr>
<tr>
<td>LCD</td>
<td>Least Common Denominator</td>
</tr>
<tr>
<td>P</td>
<td>Pass</td>
</tr>
<tr>
<td>NP</td>
<td>Not Pass</td>
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<tr>
<td>W</td>
<td>Withdrawal</td>
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<tr>
<td>S.E.</td>
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<td>Acronym</td>
<td>Description</td>
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<td>---------</td>
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</tr>
<tr>
<td>Mt.</td>
<td>Motivation</td>
</tr>
<tr>
<td>GCF</td>
<td>Greatest Common Factor</td>
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<td>GPA</td>
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<tr>
<td>PR</td>
<td>Public Relations</td>
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ACKNOWLEDGEMENT

I have had very successful teaching years at Gulf University for Science and Technology since 2010. When Dr. Munir Mahmoud (co-author for my first published research paper) requested that I assist him in the analysis of our first research paper together, I felt that I could accomplish everything he requested with full understanding and ease. I also felt that it was something that I enjoyed working on. I realised that I am capable to work on research and actually enjoy it.

The total belief of my mother who has been a great source of encouragement, helped me to overcome my fears to make the first tentative steps to further my education and apply for my doctorate degree. I contacted Dr. Ted Graham at Plymouth University and he welcomed me easily on board to join the MPhil/PhD program. I remember asking Ted twice on Skype if he was sure that I was capable to join the PhD program and he said a very sound and clear ‘yes’. I knew at that point that whatever else happened, I could not let him and my mother down for having such faith in me.

I had a goal in mind that I wanted to complete my PhD in four years rather than six. There were several difficult occasions occurred during those four years when I have felt like giving up, particularly during my father’s illness several times, and his death during the thesis submission period. Without the support and encouragement of Ted Graham, Annette Tailor and Christos Demetrious, there is no way that I would have got as far. Ted played an extra ordinary role of being a director of studies for my study. He had endless patience teaching me how to become a researcher. He always knew how to solve any problem I had. He taught me details into research and showed me how to make sense of it. Not only he encouraged my research, but also he visited me at my work place in Kuwait in order to practically show me how to deal with critical students’ case studies. He added many valuable points to my teaching skills. Also, he organized the annual Graduate Student Workshop (GSW) where PhD students could share knowledge of each other’s research and other supervisors’ work from Plymouth University, University of Exeter, Kingston University, and other universities in in the United Kingdom. He provided professional directorship, social, and friendship between the PhD students and supervisors. I could never have accomplished the PhD without his support.

I have to mention the hard work and support of Dr. Annette Tylor. She is a great supervisor, and a brilliant editor and reviewer of my transcribes interviews and thesis. She is super organized and precise in her work. When I had to start any chapter, Annette used to help me to write down my thoughts and structure them into a chapter. She is very organised and very professional with her appointments and deadlines. She was an amazing support setting there at the back of the room during the VIVA. Also, she provided me with excellent detailed notes and reviews before and after the VIVA. Annette was always there when I was timely pressured. I truly appreciate all her support to my study. Another big thank you to Dr. Jenny Sharp for her support in my final year of my PhD.

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Thank you all for everything….
Author’s Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

The author attended a variety of mathematics education conferences, presentations, and workshops in Kuwait, Turkey, and the United Kingdom throughout the duration of this research study as listed below.

Seminar/Conference/Performance presentations attended

- 5-7th November 2015, TESOL- Kuwait conference: Reshaping English in an Age of Innovation, Gulf University for Science and Technology, Kuwait.
- 11th July 2016, Mathematics Teachers Conference, University of Plymouth, U.K.
- 28th April –May 1st 2018, International Conference on Education in Mathematics, Science and Technology (ICEMST), Marmaris, Turkey.
- 11th December 2018, Web of Science, JCR, and Endnote, by Mr. Iulian Herciu - Consultant and Client Education Specialist, Gulf University for Science and Technology, Kuwait.
- 27th March, 2019, Cengage presentation, by Mr. Ahmed EL Shawarby – Senior Learning Consultant, Gulf University for Science and Technology, Kuwait.
- 14th to 16th February 2019, TESOL-Kuwait conference: Together Towards Tomorrow Teaching and Learning Languages: Innovation and Creativity, Gulf University for Science and Technology, Kuwait.
- One week in July from 2015 to 2019, Graduate Student Workshop programme, Plymouth University, Plymouth, U.K.

Subject Specific Skills Training completed

- 8th January 2016, How to use graphic calculator in the classroom while teaching (CASIO) by Dr. Ted Graham, Plymouth University, U.K.
- 15th February 2016, How to use learning Catalitics, by PEARSON team, Gulf University For Science and Technology, Kuwait.
- 26th October 2016, How to create quizzes, tests or worksheets on Moodle, GUST, Kuwait.
- 15th April 2017, Research course: Course Design Institute by University of Missouri–St. Louis, J. Andy Goodman and Keeta Holmes, Gulf University for Science and Technology, Kuwait.
- 8th to 11th October, 2017, Research course: Integrate Mathematics in the Classroom by Dr. Paul Nolting, Gulf University for Science and Technology, Kuwait.
- 18th October 2017, PEARSON: Blended learning and Learning Catalitics, by PEARSON team, GUST, Kuwait.
- 24th January 2018, PEARSON MyMathLab, Gulf University for Science and Technology, Kuwait.
- 24th September 2018, Using the Study Plan on PEARSON by Dr. Nadeem, Gulf University for Science and Technology, Kuwait.
21st November 2018, Pedagogy, Interactive figures, and Best practices using PEARSON, by Eric Schulz, GUST, Kuwait.

Sali Hammad: 10525026

Word Count: ..........77363.......... 

Signed...........S.H.........................

Date:  November 6th, 2019.
Chapter One: Introduction to the study

1.0 Introduction

This chapter introduces the research study. It discusses the motivation and the inspiration for the study, the mathematics education context in Kuwait, and especially at Gulf University for Science and Technology (GUST). The chapter ends by explaining the aim of the study.

1.1 Motivation Behind the Study

In the fall semester of 2011, I was starting to teach the very first session of the course Math 095, in the Mathematics Foundation Unit (MFU), at the Gulf University for Science and Technology (GUST). I introduced myself to my new students and discussed the planned syllabus for the course. Yousef, one of these students, approached me at the end of the session and told me: “I have hated mathematics since my childhood. I come from a high school background with a Liberal Arts major and I know that I will never understand math”.

On the second day, I started talking to all of the students in the class and told them that I understood that they might struggle with this course because of their mathematics backgrounds. I asked them to give themselves the chance during the course to ‘accept’ learning mathematics only and not necessarily to ‘love’ it. Four months later and after the final exams period, Yousef came to visit my office and told me that not only had he accepted learning mathematics during the course, but that he had also enjoyed it as he now understood mathematics. He explained that taking this course had shaped his mathematical learning skills. Yousef passed the Math 096 course with a score of 88%. Also, his lowest grade across all his mathematics courses during his four years of his study at GUST was a B+. He was on the honours list for his accounting degree major at GUST and graduated in the summer of 2015.
I have been teaching at the Mathematics Foundation Unit for the past eight years and have taught many students like Yousef. Such students join GUST with Liberal Arts major backgrounds, to study business majors. To accomplish these business majors, the students are required to pass three college level mathematics courses such as College Algebra, Calculus, and Statistics, and/or the possibility of taking one or two foundation mathematics courses such as Math 095 and Math 096, based on their university entrance exam (Accuplacer).

Yousef and many other students join MFU at GUST with low self-efficacy. They believed that they had a low capability towards studying mathematics as described by Bandura (1977, and 1982) and Bandura and Wessels (1997). I noticed that when Yousef learned the necessary learning skills, mathematics understanding, motivation, care and attention in class, this might have increased his self-efficacy and motivation, and equipped him to pass this course and maybe other mathematics courses in the future. Yousef’s story and many others have inspired me to investigate this particular area in this research study. I am looking to explore a framework that may assist students at MFU or any other foundation course to greater achievement in mathematics.

1.2 Kuwait Context

Kuwait’s educational leaders have been putting efforts into improving the educational systems for the past 30 years. There has been a long-term relationship between Kuwait and the World Bank as Kuwait has been participating in different international testing projects since 1995 such as the Trends in International Mathematics and Science Study (TIMSS) and Progress in International Reading and Literacy Study (PIRLS), as reported by Winokur
Soliman and Hilal (2016) stressed, in their research, that the results of the Kuwait University mathematics entrance exam (Aptitude Mathematics Test) only had a 26% success rate. Alajmi (2009) applied a study that included 59 elementary and middle school teachers in Kuwait, which concluded that more than 60% of teachers equate computational estimation with rounding “while two-thirds of the teachers viewed computational estimation to be an important skill for daily life; only one-fifth (20%) saw it as important in mathematics education” (2009, p. 263). Alajmi, (2009) noticed that more than half of the teachers either disagreed with the idea of teaching computational estimation or only wanted to teach it in limited situations which may have “caused problems with students' development of standard algorithms for determining an exact answer” (2009, p.263). Computational estimation was one particular topic that Alajmi studied because it did cause problems with students’ computational development according to the results found in her study. Could the weakness of this topic, and maybe others, influenced some students’ mathematics knowledge to be procedural?

Alajmi and Reys (2009) studied Kuwaiti eighth grade students’ performance in mathematics in order to determine the extent to which students could recognise reasonable answers and to
identify the strategies students used to determine reasonableness. The results of their study
discovered that over 200 eighth grade students were

“generally unable to recognize reasonable answers. Students’
performance was consistently low across all three number domains
(whole numbers, fractions, and decimals). There was no significant
difference in students’ performance on items that focused on the
practicality of the answers or on items that focused on the relationships
of numbers and the effect of operations, or on both. Interview data
revealed that 35% of the students’ strategies were derived from two
criteria for judging answers for reasonableness: the relationships of
numbers and the effect of operations, and the practicality of the answers.
They used strategies such as estimation, numerical benchmarks, real-
world benchmarks, and applied their understanding of the meaning of
operations. However, over 60% of the students’ strategies were
procedurally driven. That is, they relied on algorithmic techniques such
as carrying out paper-and-pencil procedures. Additionally, some of the
students’ strategies reflected misunderstandings of how and when to
apply certain procedures” (2009, p. 117).

Skemp (1976) described two important mismatches students experience while learning
mathematics: “1. Pupils whose goal is to understand instrumentally, taught by a teacher who
wants them to understand relationally. 2. The other way about” (1976, p.23). He explained
each mismatch in detail and how more damaging the second case would be when teachers
teach instrumentally as students may keep procedures in their memories without knowing
why they should use these procedures. This could cause them to fail to answer questions
correctly if they forget how to apply the exact steps required to solve this type of question.

Skemp (1976) explained that some mathematics teachers may think that they use relational
understanding in the classroom while they use instrumental. In other words, teachers may
lack or have weak pedagogic knowledge that may lead them to teach the students
procedurally without connecting with any associated concepts. This may increase the level of
procedural understanding for these students and explain their lack of conceptual
understanding. Also, Byers and Herscovics (1977) added that teachers might be able to take
the students from instrumental understanding to relational understanding with their professional skills. This was supported by Alajmi and Reys (2009) who found in their study that 60% of the students were procedurally driven because of their teacher’s procedural teaching methodology, which could have influenced their mathematical understanding at earlier stages and then later at the college preparation stages.

How can colleges and foundation institutions overcome this basic weakness in the students’ mathematics knowledge? This study explores answers to this question through the use of data collected from MFU at GUST.

1.3 GUST Context

GUST is a private university in Kuwait that is affiliated to an American university. When joining GUST, students take the university’s entrance exam (Accuplacer) and are assigned to courses either at the foundation or academic programmes according to their Accuplacer scores in the Arithmetic and Algebra tests as shown in Table 1.2. GUST statistics for the past five academic years revealed that an average of 26% of the total number of students applying to GUST passed the Accuplacer exam and proceeded directly to academic courses while 74% of the students were required to take the mathematics foundation courses at the MFU. This means that most students joining MFU for the past five years have showed weak mathematics knowledge.

<table>
<thead>
<tr>
<th>Accuplacer score</th>
<th>GUST equivalent course</th>
<th>Degree major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic &lt;73</td>
<td>Math 094: Beginning Contemporary Algebra</td>
<td>English Major</td>
</tr>
<tr>
<td>Arithmetic &lt;72 and Algebra &lt;82</td>
<td>Math 095: Beginning Algebra</td>
<td>Business/MCM Major</td>
</tr>
</tbody>
</table>
Students graduate from the Kuwait public school system with either a Science or Liberal Arts major. High school Liberal Arts major students do not study higher levels of algebra between grade nine and their graduation year. In contrast, Science major students graduate with a minimum course level of Calculus at grade 12. GUST statistics showed that the average percentage of students joining MFU with Liberal Arts major has been 53% while the Science major students has been 47% for the past five years. This, coupled with the low Accuplacer scores, indicates that many of those students in the study who have studied mathematics as high as grade 12 have been joining MFU with low mathematical knowledge that is below the Accuplacer standard mathematical level, suggesting that their school experience has not prepared them for the mathematical demands of the admission process. The low initial scores that the students obtain when taking the Accuplacer examination show that they can't effectively apply and use the mathematics that they have studied at school. Consequently, many students graduating with either a Liberal Arts or Science major, join the MFU at GUST with significant weakness in their mathematical knowledge.
This study investigates the approaches from the relevant literature that can be used to improve the students’ mathematical achievement at the freshmen level. It measures students’ self-efficacy, motivation, and mathematical understanding levels when joining MFU in order to improve the students’ achievement and preparation for college level courses. This study was based on two cohorts of freshmen students; one was from Spring 2016-2017 and the other from Fall 2017-2018. Both cohorts of students included the Math096 course. Most students joining GUST register in business majors, which require passing the Math096 course. This course is considered to be the highest level mathematics course required at MFU by all business major students. The first cohort consisted of four groups (1, 2, 3 and 4) with a total number of 66 students. The second cohort consisted of groups (5, 6, 7 and 8) with a total number of 64 students. This meant that the study included a total number of 130 students.

Teachers at MFU have noticed students’ weaknesses when applying simple mathematics and algebraic operations when joining the unit. For example, students are not able to carry out mental arithmetic operations such as (+, -, ×, ÷) as they have over used the calculators during their school years. The students are not able to use simple algebraic techniques, for example to solve equations with one variable, or find the slope of a line. The students, also, express their feelings regarding their inability to solve algebraic problems, their lack of interest in studying mathematics, and their weak mathematics knowledge. Some also say that they ‘hate’ mathematics or studying it.

Also, the students show more procedural than conceptual understanding when solving algebraic problems. For example, when asked to solve an equation such as \( x + 5 = 10 \), the first reaction from the students would be “move the five to the other side”. When asked “what do you mean by moving?”, most students surprisingly provide no answer, or they might
explain that they were told that this is the way to solve the problem. This means that students probably do not have a good understanding of the nature of an equation and have learned a procedure to find the value for $x$.

One emphasis of this study is about exploring the meaning of teaching for understanding in the classroom. Skemp (1976), Askew et al. (2010), Hiebert and Lefevre (1986), Sfard (1991), Swan (2005), Bush and Karp (2013), Tall and Thomas (1991) and (Tall et al., 2001) have discussed the meaning of mathematical understanding in different contexts. One focus of this study is on combining ‘conceptual’ and ‘procedural’ knowledge together in order to achieve mathematics understanding. Also, the study explores implementing teaching approaches that could improve students’ mathematical understanding.

Bandura (1977, 1982), Pajares (2002), El-Anzi (2005), and Peters (2013) discussed self-efficacy and its influence to students’ achievement. The researcher in this study aims to improve the students’ achievement by improving their self-efficacy, and motivation levels through implementing the ‘Successful Mathematics Implementing Classroom’ (SMIC) framework. She also aims to engage both conceptual and procedural methods in order to improve the student’s mathematical understanding through implementing the SMIC framework. Kuwaiti academic research does not provide enough resources on educational approaches that would improve students’ mathematical self-efficacy, motivation, and understanding.

This study explores the educational approaches from the relevant literature that could improve students’ 1) self-efficacy, 2) motivation, and 3) mathematical understanding levels. These approaches include implementing the use of a) the mathematics teacher’s pedagogic
content knowledge, b) technology to support mathematics education, c) cooperative learning environments through the use of group work and different in-class activities, and any other ideas that might be explored in the study.
Chapter Two: Literature Review

2.0 Introduction

This chapter examines previous literature from different studies conducted globally that relate to students’ mathematical self-efficacy, motivation, and teaching for understanding and their influence on students’ achievement in mathematics. There is very little available literature that is specific to Kuwait, where the research study will take place.

This chapter also explores different ideas and theories from various mathematics education researchers in order to explain the development of teaching for understanding in mathematics and its elements. Also, it shows different theories of the development and nature of student understanding. In particular, it compares the theories of understanding relationally/conceptually compared to understanding instrumentally/procedurally. Also, it discusses the development of students’ understanding through the use of technology and other different educational approaches and instruments.

This chapter uses the theories discussed in the earlier sections to create the theoretical framework for the study. The chapter ends by listing the research questions for the study. The researcher in this study appreciates the sub-elements used in Fink (2003)’s Taxonomy for significant learning as shown in figure 2.1. She noticed that the taxonomy included improving students’ knowledge, social skills, creativity, and care. In general, many researchers might focus on improving students’ skills and knowledge, or attitudes and beliefs. This taxonomy was inspiring for this researcher to focus on improving student’s mathematical knowledge, self-efficacy, and motivation together in one framework.
2.1 Students’ Self-efficacy

Bandura (1977) defined self-efficacy as the individual’s belief of their own capability to organise and perform the actions needed to achieve certain tasks. Also, Bong (1999) defined self-efficacy as “one’s convictions about performing a given academic task at a designated level” (1999, p. 315). If an individual is able to connect their self-efficacy beliefs, and understand the results of their actions, then they can use the meaning of their results to create and improve their self-efficacy beliefs and their related capabilities.

Bandura (1977) believed that self-efficacy is an important and powerful motivator of recognising goals, as goals provide the basis for self-regulation of effort. Chemers, Hu, and Garcia (2001) maintained that awareness self-efficacy may lead students to higher goals,
which may also lead to better self-evaluation and then self-direction and performance. Self-efficacy is partly about self-judgment that may support someone to successfully complete a certain act at a particular academic level in a school or college, which, in turn, may be the reason for their success or failure in future mathematical activity. This is further supported by different researchers who have defined self-efficacy as “one’s self-judgments of personal capabilities to initiate and successfully carry out specified tasks at designated levels, expend greater effort, and persevere in the face of adversity” (Akinsola & Awofala, 2008, p. 390).

2.1.1 Self-efficacy and Academic Achievement

Is self-efficacy related to academic achievement? Bandura (1982) explained that self-efficacy might be influenced by the individual’s stress or anxiety. Researchers have noted the effect of self-efficacy on academic achievement, which has been studied in the field of educational psychology (Bong and Skaalvik (2003), Diseth, Danielson, and Samdal (2012), Phan (2012), and Stankov, Lee, Luo & Hogan (2012)). Considering the psychological aspect, there can be a positive psychological correlation between academic self-efficacy and academic achievement according to Richardson, Abraham, and Bond (2012). Moreover, Fan & Wolters (2014), explained that “students, who are confident in their learning abilities and are intrinsically interested in learning activities, are more likely to have higher expectations for obtaining desired academic goals” (2014, p.24). This means, students with high self-efficacy might feel better psychologically and then reach a higher level of academic success in comparison to students with lower self-efficacy.

Pajares and Miller (1994) explained that if students have higher self-efficacy while approaching their academic tasks, they will apply more effort and work harder, sustaining this for longer periods of time to accomplish their set task. Many students may leave the
school level with low self-efficacy towards learning a certain subject. The question that then emerges is how important is self-efficacy towards reaching students’ higher achievement in mathematics?

2.1.2 Self-efficacy and Mathematical Achievement

What role does self-efficacy play in advancing mathematical achievement for freshmen students? Researchers such as Hackett (1985), Pajares and Miller (1994), and Siegle and McCoach (2007) explained that there is a positive relationship between mathematical self-efficacy and students’ academic achievement. Siegle and McCoach (2007) emphasised that certain teacher’s talk and feedback can have a significant effect on students’ perceptions of their own effort and ability. Also, Pietsch, Walker and Chapman (2003) explained that it is important to enhance self-efficacy in students’ beliefs in order to achieve fundamental mathematical outcomes. They added that self-efficacy is associated with academic performance. “Self-efficacy is related to different domains of functioning, in contrast to domain-specific self-concept, deal primarily with cognitive perceptions of capability (Bong & Clark, 1999) and are formed through reflecting on enactive mastery experiences, various experiences, precursory messages and physiological information” (2003, p. 590).

Chemers, Hu, and Garcia (2001) added that “the contribution of self-efficacy to educational achievement is based both on the increased use of specific cognitive activities and strategies and on the positive impact of efficacy beliefs on the broader, more general classes of metacognitive skills and coping abilities.” (2001, p. 55). This suggests that improving self-efficacy is an important factor to help improve mathematical performance at the foundation level. Students with high self-efficacy spend more time studying and use more problem-solving strategies than students with lower self-efficacy. Also, students with high self-
efficacy may participate more actively in the classroom and show more flexibility searching for solutions. This may assist students to reach higher levels of attainment than students with lower self-efficacy.

Also, if students move from the school level to the college level with low self-efficacy towards studying mathematics, this might influence their choice of future mathematics college courses, which may in turn determine their college majors and then their career choices negatively. There are different contributors to students’ choices of mathematics-related college majors such as: students’ mathematics self-efficacy, gender, and years of high school mathematics, mathematics test scores, or mathematics anxiety according to Hackett (1985). This means, students with positive mathematical self-efficacy at the freshman level may accept the challenge of working on difficult materials presented in the classroom, perform highly while solving assignments, improve their skills, and receive better mathematics scores at the course level.

2.2 Students’ Motivation

Guay et al. (2010) defined motivation as “the reasons underlying behaviour” (2010, p. 712). Other researchers such as Gredler, Broussard and Garrison (2004) defined it as “the attribute that moves us to do or not to do something” (2004, p. 106). According to Fan & Wolters (2014), researchers such as (Anderman & Wolters, 2006; Robbins et al., 2004; Skaalvik & Valas, 1999) explained that motivational beliefs are very important elements in students’ academic success. They added that “students’ interest in learning (i.e. intrinsic value) play important roles in shaping their expectations regarding how they will perform in school tasks, which in turn influence their achievement-related choices and behaviours” (2014, p.23). In other words, the more students are motivated, the more they will value their educational
experiences and learning environments, which might positively influence their academic
goals and achievement.

Wigfield & Eccles (2000) added that certain expectancies and values may have a direct
influence towards achievement choices such as performance, effort and persistence. In other
words, different individual’s ability beliefs, goals, own self-challenge, and effective memory
may influence their amount of effort and performance they put into studying a course. Also,
Kim & Keller (2010) showed that motivation is an important element in education as it
enables students to make learning-related decisions. Areepattamannil (2014) added that the
more the students are intrinsically motivated, the more they are engaged in learning activities
to fulfill their satisfaction, fun and enjoyment.

Fan & Wolters (2014) referred to researchers such as Tinto (1975, 1993, 2003) who proposed
a model that combined using interaction with academic and social systems “along with
individual characteristics such as educational expectation, values, and other motivational
attributes to understand their decision to leave or persist in college” (2014, p. 23). They found
that the more students are involved and engaged in their learning while applied to an
academic task, the more interested and determined that they will be to complete the task,
which is referred to as ability belief or self-efficacy. Both intrinsic value and ability beliefs
have been shown to play an important role in adolescents’ academic development according
to researchers such as

“(Pajares, 1996; Ryan & Deci, 2000; Schiefele, 2001; Zimmerman, 2000)
by positively relating to student persistence and effort (Renninger, Ewan
& Lasher, 2002; Zimmerman and Schunk, 2006), academic achievement
(Renninger et al., 2002; Robbins et al., 2004) and achievement- related
In other words, the more students are engaged in the learning process, the more they are interested and motivated to succeed and the higher their self-efficacy.

Another type of motivation is extrinsic motivation. Hannula (2006) explained that it is important to distinguish between extrinsic and intrinsic motivation. Other researchers such as Sansone & Harackiewicz (2000) discussed extrinsic motivation. They explained that “individuals are extrinsically motivated when the source of the motivation is external to the person” (2000, p. 446). They explained that extrinsic motivation can emerge when motivation is based on something extrinsic to the activity, and when something extrinsic occurs to the person. They also defined intrinsic motivation as the motivation resulted from enjoying an activity or considering it as an opportunity to explore, learn, and actualise the individual’s potentials.

2.2.1 Motivation and Mathematics Achievement

Areepattamannil (2014) referred to Gilman, Huebner, and Furlong (2009) remarked that “if the ultimate goal of schools is to educate young people to become responsible and critically thinking citizens who can succeed in life, understanding factors that stimulate them to become active agents in their own learning is critical” (2014, p. 248). It is important for educators to assist students to identify the factors that may stimulate their own learning and understanding.

Also, Kim & Keller (2010) discussed an important challenge that many mathematics teachers go through when teaching undergraduate college students. For example, they explained how some students take certain mathematics courses only because these courses are pre-requisites for certain college majors. They added that this creates challenges for the students as they go
through difficulties in learning because of inadequate motivation, especially when they major in a discipline other than mathematics. Some of this difficulty might be attributed to inadequate motivation and their lack of vision to see how mathematics is related to their college major and future career. These ideas apply to the students at MFU, as GUST offers mostly business school disciplines and some students take mathematics courses, only because those courses are assigned as pre-requisites for their different business majors. Researchers such as Kim & Keller (2010), indicated that “lack of initial interest in mathematics may have led to poor performance in previous mathematics courses, which often results in a lack of confidence and may increase mathematics anxiety” (2010, p. 407) and as a consequence low levels of attainment or even course failure. Other researchers such as Areepattamannil (2014) considered different studies that discussed other types of motivational perspectives such as; achievement motivation, achievement goal and academic intrinsic motivation. They explained that intrinsically motivated students may attain higher academic achievement in different disciplines, higher intellectual performance levels, lower levels of academic anxiety, and higher levels of accepting and handling failure.

In regard to the relation between self-efficacy, motivation and mathematical achievement, Fan & Wolters (2014) mentioned that “Bandura et al. (2001) conducted a longitudinal study to examine a structural model of the socio cognitive influences that shape students’ educational expectations and career trajectories. Their results revealed that students’ academic expectations were positively linked to their ability belief and were also a key determinant of their preferred choice of career” (2014, p.24). Kim & Keller (2010) added that students relate their personal beliefs about mathematical knowledge to their ability to acquire mathematical knowledge, which may influence their achievement. This relates to many MFU students as they join MFU believing that ‘I am not good at mathematics’, ‘I am not a
mathematics person’ or ‘mathematics is not my thing’. The more that they believed in their lack of ability to understand mathematics, the lower their score in the Accuplacer exam when they joined GUST. Fan & Wolters (2014) added that “it seems reasonable to postulate that students’ ability beliefs and intrinsic values positively predict their educational expectations” (2014, p. 25). In other words, if a student is motivated to develop their mathematical understanding, then they may seek help to improve their understanding of mathematics and then succeed. Alternatively, when a student is not motivated to develop their mathematical knowledge and understanding, they may not seek help which may lead to low attainment and even failure.

Moreover, Kim & Keller (2010) referred to other researchers such as (e.g. Kloosterman 1996; Hofer 1999; Alexander et al. 2000; Pintrich & Schunk 2002; Cavallo et al. 2004; Cady et al. 2006) who claimed that beliefs about gaining knowledge affect students’ motivation and achievement. Frequently this is in regard to epistemological beliefs which have been identified by Schommer (1990) in five dimensions such as beliefs about 1) the structure of knowledge, 2) source of knowledge, 3) stability of knowledge, 4) speed of learning and 5) ability to learn. They concluded at the end of their study that “there were negative trends in participants’ attitudes towards mathematics except for the group receiving belief change strategies with personal messages. There were also negative trends in participants’ study habits except for the group receiving motivation, volition and belief change strategies with personal messages” (1990, p. 407). This means the higher the motivation and the self-efficacy beliefs for the students, the better the study habits they may apply towards studying mathematics.
Fan & Wolters (2014) connected students’ beliefs to their success or failure in their future careers as they mentioned that “Bandura et al. (2001) showed that students’ educational expectations mediated the effects of children’s ability belief on their occupational pursuits and perceived career efficacy” (Fan & Wolters, 2014, p.25). Individual students’ beliefs and motivation to study mathematics and improve their knowledge may lead to their success or failure in their chosen major/discipline. Not passing some pre-requisite college courses in their college discipline/major, may lead students to change their major/discipline which may influence their future career options.

Mathematics and English courses are considered the most important college pre-requisites. Fan & Wolters (2014) explained that “when students are genuinely interested in the tasks involved in learning math and English, they tend to expect themselves to graduate from high school, and attend college” (2014, p.34). In other words, the higher the students’ motivation towards learning mathematics, the more that they will be encouraged to attend college, and the more successful they will be in their chosen discipline.

2.3 Mathematical Understanding

Knowledge is about being familiar with, aware of, or understanding someone or something. For example, we can be aware of facts, information, skills, or descriptions. This can be acquired through experience or education or by discovering, recognising, or learning.

Understanding is a psychological process related to an abstract or physical object. This might include the use of concepts to deal with that object. Researchers such as DeCaro (2016) clarified the relationship between knowledge and understanding in mathematics. DeCaro (2016) explained that “numerous studies have demonstrated that knowledge of a variety of solution strategies is associated with deeper conceptual understanding of how these strategies
are used (see Baroody, 2003; Heinze, Star, & Verschaffel, 2009; Schneider et al., 2011; Siegler, 1994; Verschaffel et al., 2009)" (2016, p. 1139). This means that a wide range of knowledge can lead to better understanding in mathematics. This section describes (procedural/instrumental and relational/conceptual) understanding. Also, it provides examples of the similarities and differences between the different types of understanding. Developing this further, it explores the influence of the use of different educational tools such as cooperative learning environments, teacher’s teaching methodology and techniques, tutor’s attitude, bonus marks, and the use of technology on students’ self-efficacy, motivation, and/or their mathematical understanding.

2.3.1 Types of Mathematics Understanding

This section describes the different types of mathematics understanding according to different research studies.

2.3.1.1 Relational and Conceptual Understanding

Skemp was one of the first researchers who discussed ‘understanding’ and divided it into two types; relational and instrumental understanding. Skemp (1976) defined relational understanding as “knowing both what to do and why” (1976, p. 2). He considered relational understanding to be the real understanding and the understanding needed for the students. He listed the following advantages for the use of relational understanding:

- “It’s more adaptable to new tasks” (1976, p. 8),
- “It’s easier to remember” (1976, p. 9),
- “Relational knowledge can be effective as a goal of itself” (1976, p.10) and
- “Relational schemas are organic in quality” (1976, p. 10).

Connecting the first two points together in a frequent approach in practice, Skemp (1976) provided an example of asking a student to find the area of a triangle. The student in this case
could memorise the formulas and may not need to understand how to answer the question relationally. On the other hand, he recommended that students extend their understanding, for example, when learning how to find the areas of parallelograms and trapezoids, as their formulae and rules, are more difficult to remember. This can be done through teaching students how to derive the area of a parallelogram from the area of a rectangle, which can be considered relational understanding. Also, Skemp (1976) stated that when students develop relational understanding, this may inspire them to explore new areas.

Tall et al. (2001) added to this argument and discussed a case where a group of students were requested to express the way they think while solving mathematical problems during a 16 weeks course of preliminary algebra course. They explained how one low achieving group of students kept changing their concept maps when solving mathematical problems. They kept changing the way they thought every few weeks and did not build up new concepts from their existing concepts. Tall et al. (2001) found that these low achieving students were not only “unable to develop mastery but, despite many opportunities for reflective practice, were unable to develop any degree of proficiency on material they had already seen previously in the mathematics course by the end of a sixteen-week semester” (2001, p. 7). On the other hand, they could solve other mathematics problems procedurally up to a certain difficulty level. Contrastingly, a high achieving group of students showed very interesting concept maps as the students “could construct an appropriate schema which remained stable throughout the semester” (2001, p. 2). Added to this, high achieving students demonstrated the ability to work on reversal questions that were conceptual and required two kinds of “flexible thinking” (2001, p.5). This illustrates the ability “to reverse someone’s train of thought and the ability to think proceptually” (2001, p. 5), by distinguishing between the
question part that requires the use of conceptual steps and the other part that requires the use of procedural steps.

In other words, high achieving students who understand relationally may use conceptual thinking and process problems in an organised manner, while the low achieving students who may understand procedurally/instrumentally (which will be discussed in the next section) may show a lack of stable connections between learning objectives and focus on procedures only. Skemp (1976) maintained that learning relational mathematics is about “building up conceptual structure (schema) from which its possessor (in principal) can produce an unlimited number of plans from getting to any starting point within this schema to any finishing point” (1976, p. 14).

Byers and Herscovics (1977) reviewed Skemp’s ideas and agreed about both types of understanding (relational and instrumental) but also suggested that there are other types of understanding that did not fall into either of Skemp’s categories. They recommended that there are four categories of understanding such as:

- **Instrumental understanding** is the ability to apply an appropriate remembered rule to the solution of a problem without knowing why the rule works.
- **Relational understanding** is the ability to deduce specific rules or procedures from more general mathematical relationships.
- **Intuitive understanding** is the ability to solve a problem without prior analysis of the problem.
- **Formal understanding** is the ability to connect mathematical symbolism and notation with relevant mathematical ideas and to combine these ideas into chains of logical reasoning” (1977, p. 26).

Skemp (1987) modified Byers and Herscovics’s (1977) model of understanding as follows:

- “Instrumental Understanding is the ability to apply an appropriate remembered rule to the solution of a problem without knowing why the rule works”
- “Relational understanding is the ability to deduce specific rules or procedures from more general mathematics relationships”
• “Formal understanding is the ability to connect mathematical symbolism and notation with relevant mathematical ideas and to combine these ideas into chains of logical reasoning”. (Skemp, 1987, p. 166).

Other researchers such as Sfard (1991); Gray and Tall (1994); Peled and Segails (2005) and Kazemi and Stipek (2001) discussed and built a notion about conceptual and instrumental understanding which will be discussed later in this chapter.

Considering another perspective, Kasmer and Kim (2011) listed the Conceptual Understanding analytical Framework (CUF) which was developed by “synthesising ideas presented in the current research related to conceptual understanding (e.g., Heibert & Carpenter, 1992; National Council of Teacher of Mathematics [NCTM], 1999) and the mathematics curriculum that the participant classroom used (Lappan, Fey, Fitzgerald, Friel, & Philips, 1998)” (2011, p. 22) as follows:

“CU1. Represent patterns in tables, graphs, words, and equations” (2011, p. 22).
“CU2. Understand and recognise patterns as linear, exponential, or something else” (2011, p. 22).
“CU3. Understand the meaning of a representation (an equation, a table, or a graph) as a whole and part of it” (2011, p. 22).
“CU4. Understand and use the relationship among a table, an equation and a graph” (2011, p. 22).
“CU5. Use equations, graphs, and tables to solve problems and relate the answers to problem situations” (2011, p. 22).
“CU6. Find a pattern (linear, exponential, or something else) in a table/graph and use the pattern to predict for a particular incident” (2011, p. 22).
“CU7. Identify and compare characteristics of tables and graphs of various algebraic relationships” (2011, p. 22)

2.3.1.2 Instrumental and Procedural Understanding

Skemp (1976) defined instrumental understanding as following “rules without reasons” (1976, p. 2). He listed advantages for the use of instrumental understanding to be
• “Easier to understand”,
• “Rewards are more immediate and more apparent”, and
• “One can often get the right answer more quickly and reliably” than using relational understanding (1976, p. 8).
He provided examples such as it is always easy to know that when multiplying similar integers with the same sign, the answer would be positive. Also, it’s always been noticed that when students use instrumental understanding, they use memorisation which leads to immediate and fast results when questions are answered correctly.

Skemp (1976) explained that instrumental understanding is easy to follow for most students, including high and low achieving students. On the other hand, students can use instrumental understanding up to a certain stage before being confused and stopping because they have not memorised the next step that needs to be applied. This means, that when the mathematics problems become difficult at higher stages, the students may struggle to solve them. Instrumental understanding does not facilitate the ability to manipulate a range of connected concepts or to problem solve effectively.

Skemp (1976) had already discussed the issue with instrumental understanding. He explained that when students use instrumental learning, they memorise mathematics rules instead of exploring and learning the principles related to them.

Other researchers discussed procedural understanding such as Sfard (1991); Gray and Tall (1994); Peled and Segails (2005) and Kazemi and Stipek (2001) and showed that instrumental and procedural understanding are very much related.
2.3.1.3 Other types of understanding

Skemp (1987) also defined formal understanding as “the ability to connect mathematical symbolism and the notation with relevant mathematical ideas and to combine these ideas into chains of logical reasoning” (1987, p. 166).

Buxton (1978), and Byers and Herscovics (1977) used their own experiences in the topic to define different types of understanding. For example, they defined understanding as:

- **Instrumental understanding** where students are able to use a certain rule in order to solve a mathematical problem without knowing reasons for using it,
- **Relational understanding** where students are able to use certain rules or procedures after finding them from general mathematics relationships,
- **Intuitive understanding** where students are able to solve problems without being exposed to previous analysis of problems, and
- **Formal understanding** where students are able to solve mathematical problems through the use of mathematics symbolism and notation related to mathematics ideas, and are able to connect these ideas into logical analysis.

There is a relation between Byers and Herscovics’s (1977) ideas and how students try to solve a simple algebraic problem at an MFU class. For example, to solve the question such as $x + 5 = 12$, an instrumental approach would be when students say in class ‘let’s move the 5 to the other side’, while a relational approach is understanding the meaning of the equal sign and applying -5 to both sides of the equation in order to keep $x$ at one side, and explore the value on the other side.

Buxton (1978) proposed four different levels of understanding such as:

- Rote where students use instrumental understanding without the need to think through the process leading to it,
- Observational where students use some concept thinking but it is mostly instrumental,
• Insightful where students feel that they understand why specific concepts work rather than just knowing how, and

• Formal understanding where an “insightful or relational understanding is achieved and at a stage in the student's development where some idea of the need for and the nature of proof is accepted” (1978, p. 36).

2.3.1.4 Combining Procedural/Instrumental and Relational/Conceptual Understanding

Similarities and differences between the different theories of understanding has created debates among researchers, especially with regard to which is the more important and necessary to be developed in the classroom. Skemp (1976) and Byers and Herscovics (1977) believed in the influence the teacher can have on the development of students’ understanding. Tall (2004) discussed the importance of the teachers’ approaches to cope and correct previous errors in students’ earlier experiences when solving algebraic equations. This may mislead the students when they solve different types of equations. For example, when teachers in the classroom use one method to solve an algebraic equation, this might encourage the students to memorise steps and apply them procedurally. While the students need to learn to solve mathematical problems using manipulation and symbolism, they also need to imagine how to solve them and learn how to explore their solutions. Skemp (1976) also explained that some mathematics teachers may think that they use relational understanding in the classroom while they actually use instrumental. In other words, teachers with weak pedagogic knowledge may teach the students procedurally without including the necessary concepts in their teaching. This may increase the level of procedural understanding and the lack of conceptual understanding in their classroom. Also, Byers and Herscovics (1977) added that teachers might be able to take the students from instrumental understanding to relational understanding levels with their professional skills. They concluded that it is best to use both
types of understanding in the classroom as students need to encounter these “consecutively and repeatedly” in order for them to reach deeper levels of understanding (1977, p.27).

Also, Hiebert and Lefevre (1986) tried to link between both types of understanding and believed that “it is not so easy to imagine conceptual knowledge that is not linked with some procedures” (1986, p. 9). They added that it is important for teachers to use procedures added to the concepts taught as this may lead students to reach the appropriate levels of understanding.

Byers and Herscovics (1977) also acknowledged that it is important to understand the relationship between both types of understanding not only for teachers but also for students. They emphasised that using both types of understanding might improve students’ knowledge base, and assist them to avoid ignorance towards some educational relationships that are obvious to adults. This was especially where it is common to see a tendency for compartmentalising knowledge.

Sfard (1991) has put a new standing point into the procedural/conceptual discussion as she referred to different types of understanding but also considered the dual nature of mathematics conceptions. She believed that certain abstract mathematics topics can be understood ‘structurally’ and “operationally” (1991, p. 1). She focused on the ‘duality’ of the use of operational and structural conceptions. An example would be considering a number or a function that can be considered structurally as an object and operationally as a process. This can be related to what Gray and Tall (1994) and Tall (1992) reported when combining process and concept by using the term procept. Also, Tall et al. (2001) discussed an example of using procept while solving algebraic expressions shown by Anderson (1997). When the
teacher asks the student to simplify 12/6, this reflects the symbol of division and the process of fraction. Sfard (1991) continued and suggested a model of three stages for concept development:

1. Interiorisation: where the students deal with the familiarity of solving the problem.
2. Condensation where students think about the whole process
3. Reification where students realise something after using the process.

This model contradicts what is known in common practice where new concepts are being taught with structural definitions without referring to the process that underlies the concept.

Researchers such as Hiebert and Carpenter (1992), clarified that it is not important to distinguish whether conceptual knowledge is more important than procedural or the other way around, but what is more important is to acknowledge the relationships between them. Furthermore, Rittle-Johnson and Alabali’s (1999) explained the relationship between conceptual and procedural knowledge, which appears “to develop iteratively, with gains in one type of knowledge leading to gain in another” (1999, p. 188). They also suggested that conceptual knowledge may influence procedural knowledge more than the other way around. Considering DeCaro’s (2016) clarification about the relationship between knowledge and understanding in mathematics, this might imply that conceptual understanding may influence procedural understanding. Also, Kadijevich and Haapasalo (2001) introduced some approaches that discuss the connection between conceptual and procedural knowledge: 1) ‘developmental approach’ where procedural knowledge is used and the result leads to better students’ conceptual knowledge, and 2) ‘educational approach’ where students build meanings for procedural knowledge before they master it. They basically recommended that mathematics teachers should be open to use any approach based upon the need and the situation. For example, if there is a need in the classroom to introduce a concept that involves
a definition, then the developmental approach would be appropriate to use. While, if there is
a need to use the meaning of fractions or decimals, then an educational approach would be
more appropriate to use. Kadijevich and Haapasalo (2001) concluded that “the educational
approach may be more relevant than the developmental one. However, the utilisation of an
interplay of these approaches may, for some topics, be a better strategy than the application
of one of them” (2001, p.57).

Kasmer and Kim (2011) added to this identifying that concepts and procedures can be
connected through the use of prediction in the classroom. They explained that prediction
might be one way to develop mathematical understanding as the students are able to connect
information about what they have understood from their previous explorations and connect
this to new concepts concerning the current problem. Also, they explained that teachers are
able to use prediction to assess students’ misunderstandings as they explore the solution to a
particular problem.

(Kasmer and Kim (2011); Gamoran, 2001, Heibert and Carpenter, 1992; Kilpatrick,
Swafford, & Findell, 2001) determined that students are able to attain conceptual
understanding and mathematical reasoning [which “requires the attainment of abilities to
construct mathematical conjectures, develop and evaluate mathematical arguments, and select
and use various types of representations” according to Kramarski and Mevarech (2003, p.
282)] when they are able to connect to previous mathematics knowledge. Wigley (1992)
recommended the use a different kind of connection in the classroom through the use of two
kinds of teaching and learning models which are common in mathematics as follows:

a) **The path-smoothing model:** which consists of smoothing the path for the learner by:
   1) “The teacher or text states the kind of problem on which the class will be
      working” (1992, p. 4)
2) “Pupils are lead through a method of tackling the problems” (1992, p. 4).
3) “Pupils work on exercises to practice the methods given aimed at involving learners more actively” (1992, p. 5).
4) “Revision” (1992, p. 5).

b) **The challenging model:** which consists of the following features:
   1) “The teacher presents a challenging context or problem and gives pupils time to work on it and make conjectures about methods or results” (1992, p. 6).
   2) “Out of pupils’ working is established a variety of ways which help to deal with the situation” (1992, p. 6).
   3) “Strategies which evolve are applied to a variety of problems – testing special cases, looking at related problems or extending the range of applications, developing some fluency in processes” (1992, p. 6).
   4) “A variety of techniques is used to help pupils to review their work, and identify more clearly what they have learned, how it connects together and how it related to other knowledge” (1992, p. 7).

Wigley (1992) believed that most teachers use the path-smoothing model in the classroom as it is considered the most basic approach that connects the teacher to the learner. She also explained that such a model relies on teachers offering several practice problems for every topic taught while the classroom time may not be enough to work through enough practice problems. She added that when students fail to answer a question, teachers tend go over the same problem the same way it was taught. This means, the model is more about repeating steps and not encouraging the students to use insightful thinking in order to explore easier solutions according to their understanding. Considering the challenging model, Wigley (1992) explained that using such a model for classroom practice assists in engaging learners in a ‘conjugure atmosphere’. She added that when using such a model, it supports the use of different point of views and not just to go over the same grounds related to the problem and the same way it was taught. This might encourage students to gain new insights and reflect their understanding without relying on memorising steps.

In summary, it has been mostly recommended by research educators that it is best for students’ understanding to combine the conceptual and procedural understanding. The
researcher considered to apply this through the use of cooperative learning, teacher’s teaching methodology, and the use of technology in the classroom. This process will be explored and discussed later in this chapter.

2.4 Theoretical Framework

This section describes the theoretical framework for the study. Also, it describes how different researchers studied a variety of mathematics teaching factors and approaches from the relevant literature that might influence students’ learning and understanding. This can be applied into the planned framework in this research study.

Also, this section describes the similarities and differences between the themes that have been proposed by different researchers. This study will use the selected elements to create the framework used in this study.

2.4.1 Students’ Self-efficacy, and Motivation

When creating a cooperative and active classroom, students could develop their own learning strategies that might lead them to develop their understanding according to Askew et al. (1997) and Skemp (1976). Other researchers such as (e.g. Kloosterman 1996; Hofer 1999; Murphy and Alexander 2000; Pintrich and Schunk 2002; Cavallo et al. 2004) explored the correlation between students’ self-efficacy and motivation levels, and claimed that beliefs about gaining knowledge affect students’ motivation. The higher the students’ self-efficacy, the more motivated they are to work hard and willing to engage in mathematical activity problem which might increase the level of students’ mathematical achievement. Stevens, Olivarez, Lan, & Tallent-Runnels (2004) added that “students’ beliefs and motivation played an important role in mathematics achievement” (2004, p. 218). Self-efficacy is an important
predictor of students’ motivation. Stevens, Olivarez, Lan, & Tallent-Runnels (2004) also explained that “the influence of self-efficacy is important because self-efficacy predicts not only students’ mathematics performance but also other motivational variables that influence aspects of overall mathematics achievement. As suggested by Bandura (1997), mathematics self-efficacy predicts changes in students’ motivational orientation. Students who report higher self-efficacy also report greater intrinsic motivation” (Stevens, Olivarez, Lan, & Tallent-Runnels, 2004, p. 219).

Other researchers such as Greene, Miller, Crowson, Duke, and Akey (2004) showed that students’ self-efficacy and motivation can positively influence students’ achievement. They explained that the “causal relationship between students’ perceptions of the classroom climate and their adaptive motivation (i.e., high self-efficacy, high mastery goals, and perceived instrumentality) is a plausible one. Although previous research had supported the influence of perceived classroom goal structures on student goal adoption and self-efficacy (Anderman & Midgley, 1997; Roeser et al., 1996), the present findings are the first to support the claim that perceptions of classroom tasks as meaningful, relevant, and interesting (motivating tasks) also influence the extent to which students perceive current learning as instrumental to their future success.” (Greene, Miller, Crowson, Duke, and Akey, 2004, p. 474).

2.4.2 Cooperative Learning Environment

Different researchers considered studying collaborative and cooperative learning. For example, Kotsopoulouos (2014) defined collaborative learning as “learning environments where small groups of students (i.e., in pairs, groups of three or more) work together to complete a mathematical task (Dekker, Elshout-Mohr, & Wood, 2006; Gabriele, 2007; Kieran, 2001;
Kramarski & Weiss, 2007; Mercer, 1996; Pijls, Dekker, & van Hout-Wolters, 2007). Through the process of working together, students solve the mathematical tasks and also have the opportunity learn, although this cannot be assured simply from the process of engaging in collaborations” (2014, p. 35). Other researchers such as Hossain and Ariffin (2018) defined cooperative learning as working together with each other in order to achieve common benefits and goals. They added that cooperative learning consists of the instructional use of small groups where students work together and improve their own and each other’s learning. Also, they explained that cooperative learning is about structuring cooperative groups of students in order to help and encourage each other to learn, and share the knowledge in order to solve the assigned mathematical problems.

This section summarises the ideas and definitions related to creating a cooperative, and less teacher-dependent learning environment in the classroom through the principle of ‘Mathematical Understanding’:

2.4.2.1 Mathematics Teaching and Teacher’s Pedagogic Knowledge

Askew et al. (1997) explained that it is important to connect teaching and learning together as they complement each other. Also, Barnes (2005) discussed the basic objectives of combining teaching and learning of mathematics as this enables the students to:

- “develop an awareness of the diverse historical, cultural and social practices of mathematics;
- recognise that mathematics is a creative part of human activity;
- develop deep conceptual understandings in order to make sense of mathematics; and
- acquire the specific knowledge and skills necessary for:
  - The application of mathematics to physical, social and mathematical problems,
  - The study of related subject matter, and
  - Further study in mathematics” (2005, p.43)
Barnes (2005) believed that there are three main reasons for learning mathematics. “Useful: as a tool for the individual and society”, “Cultural: as part of our culture, of which all pupils should have knowledge and experience”, and “Pleasurable: as a potential source of enjoyment” (2005, p. 43). Also, Askew et al. (1997) and Swan (2005) explained that mathematics teaching is about collecting and connecting different mathematical ideas by using different symbols and shapes. They added that it is important for teachers to have students involved in the problem solving process so that they can develop conceptual understanding through the use of strategies, group discussions and challenges that link between different meanings.

Kleickmann et al. (2015) noted that teachers need a wide understanding of the subject taught in schools as well as a knowledge of how to make this content accessible to students. Shulman (1987) was the one of the first researchers to connect ‘what to teach’ and ‘how to teach it’ using the expression ‘Pedagogical Content Knowledge’ (PCK). Shulman (1987) added that it is important for the teacher to transfer the knowledge into teachable knowledge and materials. He divided this task into the three actions verbal instructions and representations, demonstrations, and instructional tasks.

Also, Ayvazo and Ward (2011) stated that “the merger of these two knowledge bases crafts a new understanding of how the subject matter is “organized, represented and adapted [emphasis added] to the diverse interests and abilities of learners and presented for instruction” (2011, p. 675). Shulman (1987) explained how important it is for a teacher to transform their content materials into teachable materials in order to meet the students’ needs when teaching. Moreover, researchers such as Siedentop & Eldar (1989), related the teachers’ experience, to the skills and knowledge they might develop which will ease the delivery of
the content materials to the students. If the teachers’ experience involved teaching similar groups the same subject matter, this may enable them to predict their students’ characteristics and particular difficulties. Also, Krauss et al. (2008) added that “mathematics teachers with an in-depth mathematical training (i.e., teachers qualified to teach at the academic-track Gymnasium) outscore teachers from other school types on both knowledge categories and exhibit a higher degree of cognitive connectedness between the two knowledge categories” (2008, p. 1).

Kleickmann et al. (2015) added that PCK “includes knowledge of students' subject-specific conceptions and misconceptions as well as knowledge of subject specific teaching strategies and explanations (see also Ball et al., 2008; Borko & Putnam, 1996; Depaepe, Verschaffel, & Kelchterman, (2013)” (2015, p. 116). For example, PCK means that experienced teachers should always be ready and prepared to answer any question that a student asks or at least able to find a solution for any misunderstanding or misconception the students acquire.

Also, Kleickmann et al. (2015) referred to other researchers and added that teachers' subject knowledge can influence both the teachers’ instructional practice and their students' achievement in mathematics.

Other researchers such as Hill, Rowan, and Ball (2005) explained that teaching mathematics is not valued only by the number of courses taken by the teacher, but also it is related to the teachers’ practices in mathematics classroom. They added that being a mathematics teacher is never related for being only able to calculate, but also it is being able to know how to use pictures or diagrams to represent mathematics concepts, using procedures to explain different mathematical methods to the students, providing the students with enough explanations for
different mathematical rules, mathematical procedures, and analysing students’ different solutions. This means, it is important for teachers to be able to explain mathematics through the use of a variety of teaching approaches that may allow the students to create their own learning techniques and become less teacher dependent.

Bush and Karp (2013) noticed that for algebra it is important for teachers to have some background experience in teaching algebra so that 1) they avoid going over a topic by repeating similar unsuccessful methods and instead identify misconceptions explicitly, and 2) they realise the critical connections between students’ algebraic thinking and different mathematics content ideas.

2.4.2.2 Teacher’s Teaching Methodology

Barnes (2005) recommended important elements teachers need to implement when teaching in order to reach students’ understanding, especially low attainers. Barnes (2005) explained that

“in order for mathematics instruction for low attainers to improve, it needs to focus on understanding, encourage active and purposeful learning, foster informal knowledge, link formal instruction to informal knowledge, encourage reflection and discussion and include Socratic teaching” (2005, p. 45).

Also, Hiebert et al. (1997) believed that teachers need to be careful with their task selection and how they create a classroom culture when assigning students to answer different tasks. They indicated that teachers could consider the use of teacher’s pedagogic knowledge as a source of tasks in order to encourage the students to struggle with key ideas when answering different tasks. This might link with students’ experiences, ideas, and skills together. Similarly, Peled and Segalis (2005) noted that teachers need to carefully use comparison tasks after exploring a topic in order to bridge conceptual and procedural knowledge. Swan
(2005) divided the questioning types into two: 1) ‘closed’ where the question promotes one answer, which may encourage the students more towards procedural understanding, and 2) ‘open’ where the question invites a range of answers and different ways of thinking in order to solve the problem. Swan (2005) added that when teachers develop effective questioning, they may increase students’ understanding as this may encourage higher-level reflective thinking. Furthermore, Mason (2002) explained how

“The key to effective questioning lies in rarely using norming and controlling questions, in using focusing questions sparingly and reflectively, and using genuine enquiry-questions as much as possible. This means being genuinely interested in the answers you receive as insight into learners’ thinking, and it means choosing the form and format of questions in order to assist learners to internalise them for their own use (using meta-questions reflectively)” (2002, p.1).

This means, it is important for teachers need to study and prepare the questions they plan to use while teaching. This might assist students’ learning in the classroom.

Hiebert and Lefevre (1986) discussed classroom tasks. They recommended that teachers need to create connections between formal knowledge and the formal mathematical symbolic system in order for students to find meanings for symbols. They explained that procedures can be used to reach concepts. Also, they added that connecting conceptual knowledge to procedural knowledge, might simplify procedural demands, control procedural selection and might lead to fewer procedures being required. Lastly, Wigley (1992) believed that it is important for teachers to be able to connect mathematics problems with our daily experience and environmental aspects in order to assist students to understand the topic and be able to apply it in different practical contexts. This can be done through the use of variety of mathematics word problems while teaching.
Falk (2011) discussed approaches and their impact on students’ learning. For example, teacher’s approaches include providing the students with feedback on their performance, involving group discussions among the students when using in-class activities, and addressing students’ needs according to their performance on in-class activities. He explained that “teachers can provide students with specific feedback about how to improve their subsequent work based on their current performance. Students can assess themselves or their peers to suggest modifications to subsequent learning activities. And teachers can interpret evidence of their students’ thinking to modify subsequent instructional activities to address students’ learning needs” (2011, p. 266). Falk (2011) added that teachers’ formative assessment can be used as an influential instrument for students’ learning, considering teachers’ appropriate content knowledge. In contrast, researchers such as Garfield (1993) showed some concerns regarding using activities in the class to promote students’ learning. She explained that some teachers might be discouraged to 1) to lose their position as center attention and knowledge provider in the classroom when using the activities, and 2) to continue using challenging activities in the classroom by some students who resist to be involved in the activities whether they prefer to work alone or they prefer to receive the knowledge from the teacher and not from their classmates.

Later in this study, the researcher will discuss these opinions in the light of the results obtained and will relate them to these researchers and their discussions in the literature review. More researchers supported the view that the teacher’s teaching methodology can be an important key element towards improving students’ mathematical understanding and achievement, especially at the freshmen college level courses. This will be taken in consideration when implementing the SMIC framework in this study.
2.4.2.3 Teacher’s Attitude

The teacher’s attitude in the classroom has been shown to be an important influence on students’ beliefs and their interest in learning. Fan & Wolters (2014) explained that

“research has shown that students are likely to foster stronger competence beliefs and intrinsic value in learning when they have teachers who are supportive and warm, friends who value academics, and parents who are involved in their children’s academic learning (Fan, Lindt, Arroyo-Giner & Wolters, 2009; Fan & Williams, 2010; Wentzel, 1998)” (2014, p. 35).

When students receive the appropriate academic support, they will increase their appreciation and motivation to learn mathematics.

Other researchers such as Klem & Connell (2004) related students’ achievement to both their engagement in the classroom and their teacher’s positive attitude in the classroom. They explained that the more support they receive from their teacher, the higher their engagement and participation in the classroom, which may increase or improve their achievement and success. They showed that

“teacher support is important to student engagement in school as reported by students and teachers. Students who perceive teachers as creating a caring, well-structured learning environment in which expectations are high, clear, and fair are more likely to report engagement in school. In turn, high levels of engagement are associated with higher attendance and test scores - variables that strongly predict whether a youth will successfully complete school and ultimately pursue postsecondary education and achieve economic self-sufficiency” (2004, p.270).

Sokol, Gozdek, and Figurska (2015) discussed college teachers’ influence on students’ achievement, including providing the students with the sense of emotional support and assisting them to regulate their academic progress. They explained that

“The study demonstrated that college students of West Pomeranian Province especially appreciate when teacher gives students a sense of emotional support, efficiently monitor their work, give feedback in due time … It seems that the obtained results should be evaluated very positively” (2015, p. 1981).
They indicated that teachers are required to use creativity while dealing with different students with different abilities. The tutor’s attitude can be an important factor contributing to students’ success and achievement, which will be taken into consideration when implementing the SMIC framework in this study.

2.4.2.4 Group Work

Ryve, Nilsson & Pettersson (2013) explained that some researchers “examine how learning opportunities of content are established in interactions (e.g., Kieran, 2001; Nilsson & Ryve, 2010; Weber et al., 2008)” (2013, p. 498). They added that the interactions include the use of face-saving, social rules, and high status among participants as they are important for the students’ effective communication in mathematics group work. They concluded that “there thus seems to be a complicated relationship between effective communications in group work, the appropriate time to introduce students to technical terms, and the role of group work in a teaching sequence.” (2013, p. 511).

Martin and Towers (2015) explained that “We thus see the growth of collective mathematical understanding as a dynamical ever-changing interactive process, where shared understandings exist and emerge in the discourse of a group working together”. (2015, p. 6).

Also, Francisco (2013) discussed by referring to different research studies that collaborative activity remains a key concept and a promoting tool in the field of mathematics education. Group work is based on discussions. Francisco (2013) explained that through the use of discussions, students can test ideas, receive and provide ideas to each other, put together their ideas into words, communicate mathematically and involve in mathematical arguments, make new claims, and construct a deeper understanding of concepts. He showed in his study that
using collaborative activities through group work can help promote students’ mathematical understanding as this provide opportunities for the students to reexamine how the problem was solved by considering available facts, and also enable them to build on one another’s ideas and construct new strategies of reasoning.

Chambers & Timlin (2013) provided some detail about using group work. They recommended using group work in small groups as this provides the students with greater progress in learning compared to when they are taught using many other methods. Using small group work also provides greater recollection of learning through the interaction of the group members with each other. Also, Chambers & Timlin (2013) recommended that it is important for teachers to consider how to create small groups of students in the classroom in order to be most effective. They also recommended dividing them into groups with four to six members while keeping the same number of members in each group. They added that each group should be assigned a task to accomplish and then reassign high achievers into different groups in order to have an expert in each group. Also, they considered rotating group members around other groups in order to spread the knowledge.

Sahlberg & Berry (2003) summarised the critical elements for the benefits for using small group work in mathematics:

1) Sufficient positive interdependence: “Students can perceive that they can reach their learning goals if and only if other students in their learning group also reach their goals” (2003, p. 35). This may provide positive interdependence in small groups of students,

2) Individual accountability and personal responsibility: Individual accountability is considered an important social phenomenon. This means, “the performance of each
individual is assessed and the results given back to the group and the individual” (2003, p. 37). Providing feedback to the students could enable group members to help each other to achieve their group goals.

3) Recognizing and practicing of social skills: Many teachers assume that most students develop their social skills in small learning groups in the classroom. Teachers need to realise that “mathematics is commonly seen as a subject and field of human culture that is characterised by individual efforts and practice” (2003, p. 38), and

4) Interactive tasks: Cooperative learning is all about team effort where students assist each other and break different barriers among group members.

In the field of group work and adult learning, Steinberg & Vinjamuri (2014) emphasised the positive influence of group work on adult learning. The study used a practice-based approach to teaching research to social work students in order to connect the perceived gap between research and practice. This might help social work students experience the capacity of research to improve their practice by connecting the content to their everyday work experience as closely as possible. This also enabled them to integrate new course content that can be useful for their social work environment. They added that looking at the “findings of adult-education studies, which suggest that experiential learning (Edmond, McGivern, William, Rochman, & Howard, 2006) and opportunities to connect classroom content with real-life application (Dunst & Trivette, 2009) are critical to knowledge and skill development … Such opportunities are precisely what group process offers the research classroom (Gitterman, 2005; Kolb, 1984; Schein, 1995; Shulman, 2006, 2010; Steinberg, 2008, 2014; Ullman, 2000)” (2014, p. 364).

During their study, Steinberg & Vinjamuri (2014) discussed four types of small-group activities that attempted the use of certain adult learning principles. They mentioned activities
included quizzes, structured discussions, individual small-group presentations, and group presentations to the class.

In contrast, Martin and Towers (2015) emphasised that that not every group working together will automatically result in students’ engagement in collective acts of “Image Making, Image Having, or Property Noticing” as there are different factors that might contribute to this (2014, p. 16). Also, Wegerif et al. (2017) explained that “There is some inductive evidence of processes that appear to be effective in group work and there is some indirect evidence of effective pedagogy promoting group thinking gained from measures of success on various tasks, usually curriculum related” (2016, p. 4). They recommended that teachers cannot assume that a model of students’ dialogue in the classroom will always result in good and effective dialogues, as this does not does not measure the effectiveness of the group thinking. They found that “Inductive approaches such as interpretative discourse analysis hold out more promise of describing causal mechanisms in talk” (2016, p. 9). Also, Fransisco (2013) indicated that “just asking students to work in groups may not be enough” (2013, p. 436). This means that teachers need to facilitate students’ mathematical groups in class without taking away the students’ initiative and ownership of the mathematical activity.

Considering different learning processes in this study, it is important to consider metacognitive learning. Veenman, Van Hout-Wolters & Afflerbach (2006) defined metacognitive learning to be “the knowledge about and regulation of one’s cognitive activities in learning processes” (2006, p. 3). In other words, metacognitive learning is concerned with thinking about how to think and learning how to learn. Kramarski and Mevarech (2003) carried out a study investigating the effects of four instructional methods on students’ mathematical metacognitive knowledge and mathematical reasoning. They selected
384 grade-8 students. They divided the participating students into four groups: a group that received cooperative learning with metacognitive training, an individualised learning group without metacognitive training, a group with a cooperative learning without metacognitive training, and an individualised learning group with a metacognitive training. The results of their study revealed that the group that received cooperative learning and metacognitive training performed significantly better than the individualised learning group and the cooperative learning group separately. Also, both groups using metacognitive learning performed better on graph constructions than the individualised learning group and the cooperative learning group. This means, it is important for general mathematics educators, especially in foundation programs to consider developing the cooperative and metacognitive learning skills of their students in order to improve their mathematical understanding. This will be considered in this study.

Other researchers such as Burke (2011) listed some disadvantages of using group work in the classroom as follow:

1. For some students, group work might cause pressure to interact with the other group members. This may lead the students to agree to bad solutions to avoid the interaction or having conflicts with other group members.

2. An individual student might dominate the discussion and solving assigned problems. This might lead to other group members’ dissatisfaction for not being able to participate in the discussion.

3. Some group members might rely on other members and wait for them to solve the questions. This might lead some members not to participate nor benefit from the group discussion.

4. Working in groups might take longer time than having students working on their own.
Later in this study, the researcher will discuss how could she coped with these potential disadvantages.

2.4.2.5 Using Different Activities in The Classroom

**Playing Games**

Researchers such as Lazarides, Buchholz, and Rubach (2018) encouraged teachers to use different mastery oriented activities in the classroom in order to enhance the students’ motivation. They added that mastery goal orientation activities focus on students' learning and understanding. Also, students with high mastery goal orientation and motivation show high achievement.

Other researchers such as Topîrceanu’s (2017) explained that using gamification with the students in the classroom could provide instant feedback, engagement between the students which could improve the students’ intrinsic motivation. This might increase the students’ learning and encourage them to attend regularly. In contrast, other researchers such as Cruickshank and Telfer (1980) listed some disadvantages for using gamification in the classroom. They explained that 1) when teachers are not familiar with playing games, they might hesitate to use them, 2) creating the games might be time consuming, and this could discourage the teachers to use them and encourage them to use traditional teaching methods, 3) playing some games might not be critical to what must be learned by the students, 4) It might be difficult for some teachers to find the appropriate games related to the taught topic, 5) Purchasing some games might be costly for some teachers, 6) Using them in the classroom might be noisy which might distract other teachers and administrators, and 7) directions
provided in some games might be poor and incomplete which might lead to some students’ failure and frustrations, and 8) Not all students might accept playing games.

Rowe (2001) explained how other researchers such as Ainley (1988) and Hatch (1998b) recognise that using games to introduce a topic at the start of the class time might not be productive and noisy and recommended using them as a reward after teaching the lesson noting that “real mathematics cannot be fun and that games are not difficult ’work’” (Rowe, 2001, p. 6).

Although Lazarides, Buchholz, and Rubach (2018), Topîrceanu’s (2017), Cruickshank and Telfer (1980), and Rowe (2001) listed different advantages and disadvantages for using gamification, they all agreed that it could positively influence the students’ learning in the classroom if used according to students’ needs.

**Small Board**

Hagger et al. (2016) emphasized that “autonomous motivation, in particular, has been consistently shown to be related not only to engagement in class activities and adaptive educational outcomes, such as better overall grades, among school children (Deci, Vallerand, Pelletier, & Ryan, 1991; Pintrich & Degroot, 1990), but also self-directed learning activities outside of the class, such as homework effort and attainment (Reeve, 2002)” (2015, p. 166).

**Revision Notes**

Lupu (2013) recommended that keeping records of independent students’ work not only improves according to the taught objectives, but also it allows the students to review their knowledge and improve their skills while learning the course materials. This can assure
students’ knowledge assimilation and develop forms of thinking such as operations, analysis, synthesis, comparison, abstraction, generalization, classification, organization, construction of hypotheses and problem solving at the appropriate level of operational information (2013, p. 1673).

**Reward**

Miendlarzewska, Bavelier, and Schwartz (2016) explained the positive correlation between the reward system and improving students’ motivation in the learning process. The results explored in their study showed that gaining the bonus grades improves students’ motivation and mathematical understanding. They indicated that

> “motivation and memory guide adaptive behaviours. Motivational states direct goals, while memory can inform decision making and actions by recalling information on when and how goals had been obtained or not in the past. … … the mere stimulation of dopaminergic neurons in the VTA/substantia nigra (SN) at the time of reward delivery leads to learning about the predictive value of the preceding cue (Steinberg et al., 2013)” (2015, p. 158-159).

This indicates that improving students’ motivation through using the reward system can improve their learning.

**2.4.2.6 Correcting Own Students’ Errors**

Kazemi and Stipek (2001) explained that students are able to explore their own mistakes as opportunities for them to gain conceptual knowledge, and discover alternative methods. Askew et al. (1997) recommended that students need to recognise their mistakes and be challenged to explore solutions for their mistakes. Also, Swan (2005) added that teachers need to transfer students’ trials and mistakes into learning tools towards mastering certain topics and reaching a deeper understanding. Kasmer and Kim (2011) added to the discussion that “through prediction, teachers can potentially assess students’ misunderstandings and
2.4.2.7 Use of Technology

Hiebert and Lefevre (1986), Swan (2005) and Hiebert et al. (1997) pointed out the importance of using different mathematics approaches in the classroom as they may assist organising and operating conceptual knowledge. (Bottoms, 2003; Bush and Karp, 2013; Banerjee and Subramaniam, 2012) believed that it is important to implement the use of technology in the classroom such as graphic calculators or some computer programs, in order for students to understand algebraic symbols and solve some algebraic problems successfully.
Handal & Herrington (2003) discussed important features and categories of computer-based learning in mathematics education. They listed the features used in different computer programs and their influence on students’ mathematical learning through the use of approaches such as tutorials, hypermedia, drills, simulations, games, tools and open-ended learning environments, and web-based learning. They added that all of the categories of computer based learning assist the students to engage with each other and in a teacher and student led in-class discussions. They explained each feature as follows:

1) “A typical drill-and practice exercise presents learners with a question, followed by response entry and corresponding evaluation of the question and feedback … An enriching drill and practice activity should provide opportunities to increase understanding of a mathematical concept as the learner progresses through the activity” (2003, p. 279).

2) Tutorials do “not only present information but also guide students through their learning processes … The tutorial starts with an introduction to the lesson and information is presented. Next, the learner answers a series of questions and the program evaluates them. Typical responses are “sorry,” “very good,” “try again,” and “right answer is,” among others … the tutorial will give feedback on the procedure to get the correct answer (2003, p. 280).

3) Simulations is considered a goal-oriented activity that provides a multimedia simplification of reality. “One of the greatest advantages of simulators is their capacity to represent and connect huge amounts of information through multimedia (Alessi & Trollip, 1991; Gibbons & Fairweather, 1998) … The major advantage of simulations is their capacity to represent the real-world in circumstances when learning cannot be enacted in real terms” (2003, p.281)

4) “Hypermedia approaches combine hypertext and multimedia. Multimedia delivers content using several formats, such as text, sound, graphics, and video that work to reinforce each other (Hall, 2000). Ayersman and von Minden (1995) have argued that HBI allows students to acquire more holistic understanding, participate actively in explorative learning, and construct quality knowledge” (2003, p. 283).
5) “Alessi and Trollip suggested web-based learning as another approach, because in their own words, “Web based learning can be combined with any of these other methodologies (for the web is essentially a delivery medium)” (Alessi & Trollip, 2001, p. 12)” (2003, p. 278).

Some computer programs might include all the mentioned features such as PEARSON MyMathLab. Including those features can influence students’ mathematical understanding.

Assessing mathematics through the use of some computer software mediums may not be unproblematic. According to their research, Hargreaves, Shorrock-Taylor, Swinnerton, Tait, & Threlfall (2004) studied two groups of children (10 years old) where one group was being assessed using pencil and paper and the other group was assessed using a computer program. The children who were assessed using the computer program scored higher than the children using paper and pencil. Some younger generations of students have showed a positive interaction in their mathematics learning through the use of technology.

Considering the educational systems in Kuwait, Soliman and Hilal (2016) noted that grade 8 mathematics students in Kuwait scored at the lowest levels in mathematics achievement as they ranked 49th out of the 50 participating countries in the National Centre for Education Statistics (NCES) study in 2011. Soliman and Hilal (2016) tried to study elements that may assist in increasing mathematics achievement such as the effectiveness of the use of Computer-Assisted Instruction (CAI) in the classroom. They explained that over the years, teachers have varied in their opinions with regard to the use of computer programs through the educational system and their influence on students’ success in mathematics. Also, they indicated that the past 20 years have seen more advanced “user-friendly” mathematics teaching systems developed on computers. Also, they discussed how some employers consider that being CAI friendly could benefit their workforce and enhance job opportunities.
where new computer skills are required. They added that with time, the education market increased the pressure for a “need for time-efficient, effective teaching modalities that maintained the quality of teaching. Seeking viable solutions to these problems, educators and programmers considered computer-assisted instructional methods (Kausar, Choundhry & Guijar, 2008)” (2016, p. 145). There has been more demand for the use of some computer based programs and assessments in the field of education, especially in mathematics education.

Moreover, with the integration of algebra and geometry programs within multimedia software, students can now have more enriched learning experiences. This has led to the recent integration of computer technologies into different mathematics curricula so that is important to examine “the effectiveness of computer-assisted instructional methods in teaching rather than different mathematics lessons and to know what technologies are best suited for different grade levels” (2016, p. 145).

Soliman and Hilal (2016) compared two groups of grade seven mathematics students in Kuwait’s public schools. One group was taught through the use of traditional classroom instruction and without the use of computers. The second group was supported by CAI for the same grade level. Their results showed higher mathematics achievement from the CAI supported group than the other group with the traditional teaching instruction. Also, the group supported by CAI showed increased mathematical comprehension and application skills.

Other researchers such as Banerjee and Subramaniam (2012) believed that there are many available teaching approaches that can be used in the classroom. They suggested using specially designed computer environments and spreadsheets have been found to be very
useful tools in arithmetic and algebra and “in making sense of algebraic representations and transformations in algebra” (2012, p. 353). Using some computer programs might be useful to increase the level of algebraic understanding in the classroom. They added that it is important to use some technology tools and computer software in order for students to understand algebraic symbols. Using technology might be a very useful tool to assist students to understand algebra and practice its properties especially in the context of real life applications.

Other researchers such as Monson and Judd (2001) listed some disadvantages for using certain types of software while teaching mathematics such as CalMaeth as “using it as a substitute for teaching rather than as an aid to teaching, would leave students lacking in more complex aptitudes” (2001, p. 38). They explained that this software can be used to diagnose students’ misconceptions in routine skills rather than improving their abilities to form mathematical arguments. Also, it could lead students to focus on finding final answers rather than understanding methods. Another disadvantage would be that if the software does not permit students to enter algebraic expressions accurately this can lead to several typing mistakes while the students use it. Another disadvantage they listed is that this program might accept ‘bugs’ which might lead to producing ‘in appropriate diagnostic’ for some of the students using the system.

In summary, different researchers have identified advantages and disadvantages for using computer based programs as supporting tools in mathematics teaching. The results shown in this study will discuss how technology was used to improve students’ mathematical understanding and achievement in this study.
2.5 Summary

The table 2.1 summarises the key features for the theoretical framework for this research study:

| Students’ Self-efficacy, and Motivation | ➢ Self-efficacy is the individual’s capability to organise and perform an action needed to achieve assigned tasks. Students with higher mathematical self-efficacy might accept the challenge of difficult materials presented in the classroom, perform highly while solving assignments, master skills taught in the classroom.

➢ Motivation is the attribute that moves the students to do or not to do a certain action. Group work and using varied activities in the classroom might motivate the students to attend class and/or work harder to improve their achievement.
 |
| Mathematical Understanding | ➢ Learning mathematics consists of combining conceptual and procedural structure whereby ideas and knowledge are revisited.

➢ Students’ errors could be used to as an educational tool to improve students’ conceptual understanding and allows the students to explore their own solutions.

➢ Learning is the acquisition of knowledge or skills through study, experience, or the use of students’ engagement and cooperative activities. Cooperative learning involves challenging students to arrive at understanding through discussion.

➢ Metacognitive students’ training is about focusing on 1) the nature of the problem or task, 2) the construction of relationships between previous and new knowledge, and 3) the use of strategies appropriate for solving the problem or task.

➢ Working on tasks together in group work allows the students to share ideas together. This encourages students to explore their own learning techniques, improve students’ mathematics learning, and bring the students together to the same level of understanding.

➢ Real life applications challenge the students which allows them to explore and analyse the problems before solving them mathematically.

➢ Cooperative classroom involves the use of students’ engagement in different activities (including games).
where students are involved to explore their own learning strategies to solve a problem. The activities can include playing different games, using revision notes and record keeping, using the bonus system at the end of the activity.

- Group work creates discussions among group members, between the teacher and the students, and between the teacher and individual students. This brings the students together socially and academically.

- Teacher’s attitude allows the students to ask ‘why’ and ‘how’ before solving the task. This leads the students to realise the connections within mathematics and improve their understanding.

- Allowing the students to explore effective strategies when correcting their own errors. This might assist them to improve their mathematics understanding.

- Using technology programs allows the students to practice online at any time needed. This might improve students’ understanding.

Table 2.1: Key features of the theoretical frame work of the study

Figure (2.2) shows the major elements for the theoretical frame work of this study

![Figure 2.2: Major elements for the theoretical framework of this study](image)

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2.6 Development of the Successful Mathematics Implementing Classroom (SMIC) Framework

The researcher in this study considered the major three elements discussed in the framework; Improving students’ self-efficacy, motivation, and mathematical understanding. She studied the literature review related to improving each major element as shown in (2.6.1, 2.6.2, and 2.6.3) and tested different strategies during the pilot study in order to improve students’ self-efficacy, motivation and mathematical understanding. The strategies were modified in the main study and became the sub-elements of the SMIC framework.

This section shows the elements and sub-elements of the SMIC framework that will be implemented in this study:

1) Self-efficacy
2) Motivation
3) Mathematical Understanding
   a) Cooperative Learning Environment
      1) Group Work
      2) Gamification and Puzzle Sheets
      3) Revision Notes
      4) Small boards
      5) Correcting The Students’ Own Errors
   b) Teacher’s Teaching Methodology
   c) Tutor’s attitude
   d) Bonus marks
   e) The Use of Technology:
      1) Social media (WhatsApp) Group
      2) Online Homework

2.6.1 Students’ Self-efficacy

Researchers such as Bandura (1977), Bong (1999), and Pajares (1996) defined self-efficacy as a person’s own belief in his/her ability towards achieving a certain task. Many researchers have correlated high student self-efficacy with their mathematical achievement which is the
reason for planning to work on improving students’ self-efficacy as one of the main elements of the SMIC framework.

Students join MFU at GUST with weak basic mathematical skills and low self-efficacy levels. The SMIC framework focuses on improving students’ self-efficacy as one major element towards increasing students’ achievement in MFU. Table 2.2 shows the researcher’s approaches that will be used in order to improve students’ self-efficacy in this study.

<table>
<thead>
<tr>
<th>Major Elements to Improve Students’ Self-efficacy</th>
<th>Application Plans</th>
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| **1) Providing The Students with Different Teaching Approaches** | • Allowing communication with the students in class, after class, and during office hours for extra help.  
• Allowing open questions in the classroom when needed.  
• Asking the students to measure their level of acceptance or dislike of mathematics during the course.  
• Allowing the students to give themselves the chance to pass the course.  
• Reflecting individual students’ care and monitoring their progress during the course. |
| **2) Improving Students’ Mathematical Understanding Through The Use of Cooperative Learning Environment** | • Using different teaching techniques to solve the same problem.  
• Using group work as an important tool to create social bonds and a supporting system among students, and between the teacher and the students.  
• Using different activities, games, and revision notes in the classroom in order to motivate the students to prepare materials and seek better understanding.  
• Using technology programs (MyMathalab) in order to provide an online available practice for the students.  
• Correcting own students’ errors allows the students to realise their mistakes in tests and how to correct them.  
• Using different tools such as summarised revision notes or interesting boards in
class in order to connect old to new taught materials.

| 3) Motivating The Students to Improve Their Grades. | • Offering bonus marks when accomplishing the assigned task in the classroom. For example, providing bonus marks when winning some in class activities or correcting own mistakes when reviewing tests. |

Table 2.2: Major elements will be used to improve students’ self-efficacy in this study

2.6.2 Students’ Motivation

Different researchers such as Guay et al. (2010), Gredler, Broussard and Garrison (2004), and Fan & Wolters (2014) defined motivation to be an attitude that may move the individual to do a certain task. They also correlated students’ motivation to their academic success. In order to improve students’ motivation in mathematics, Huang, Su, Yang, Liou (2017) showed in their research what tools can be implemented in order to improve their motivation. They explained that “student-centered learning activities can allow students to complete their learning tasks by engaging in discussions and sharing thoughts with each other. Moreover, it is easier for students to learn from their mistakes during discussions and to learn different ways of thinking from their peers. As a result, their learning achievement can be improved” (2017, p. 42). Table 2.3 shows the researcher’s approaches will be used in order to improve students’ motivation in this study.

<table>
<thead>
<tr>
<th>Major elements</th>
<th>Application Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Improving Students’ Mathematical Understanding Through The Use of Cooperative Learning Environment</td>
<td>• Using different teaching methods and offering different techniques to solve the same problem.</td>
</tr>
<tr>
<td></td>
<td>• Using group work as an important tool to create social bonds and a supporting system among students, and between the teacher and the students.</td>
</tr>
<tr>
<td></td>
<td>• Using different activities, games, and revision notes in the classroom in order to connect old to new taught materials.</td>
</tr>
</tbody>
</table>
to motivate the students to prepare materials and seek better understanding.

- Using technology programs (MyMathalab) in order to provide an online available practice for the students.
- Correcting own students’ errors allows the students to realise their mistakes in tests and how to correct them.
- Using different tools such as summarised revision notes or interesting boards in class in order to connect old to new taught materials.

| 2) Motivating The Students to Improve Their Grades. | • Offering bonus marks when accomplishing the assigned task in the classroom. For example, providing bonus marks when winning some in class activities or correcting own mistakes when reviewing tests. |
| 3) Improving Students' Self-efficacy | • Working on students’ self-efficacy as mentioned in table 2.6.1. |

Table 2.3: Major elements will be used to improve students’ motivation

### 2.6.3 Mathematical Understanding

Brown and Benken (2009) explained that

“Teachers’ thinking about mathematics teaching and learning are challenged by expectations and ideals endorsed by current reform efforts in mathematics education (e.g., NCTM, 2000). Such recommendations call for an approach to mathematics teaching that allows students to communicate, problem solve, and engage in conceptual mathematics. Teachers are asked to teach in ways that promote an integrated, connected view of mathematics, rather than a procedural, rule-based view.” (2009, p. 56).

This section discusses the sub-elements which will be used in order to improve students’ mathematics understanding. Table 2.4 shows the researcher’s approaches that will be used in order to improve students’ mathematics understanding in this study.
<table>
<thead>
<tr>
<th>Major elements</th>
<th>Application Plans</th>
</tr>
</thead>
</table>
| **1) Implementing the Use of Different Teaching Approaches** | • Using different teaching methods and offering different techniques to solve the same problem.  
• Using group work as an important tool to create social bonds and a supporting system among students, and between the teacher and the students.  
• Using different activities, games, and revision notes in the classroom in order to motivate the students to prepare materials and seek better understanding.  
• Correcting own students’ errors allows the students to realise their mistakes in tests and how to correct them.  
• Using different tools such as summarised revision notes or interesting boards in class in order to connect old to new taught materials. |
| **2) Motivating the Students to Improve Their Grades.** | • Offering bonus marks when accomplishing the assigned task in the classroom. For example, providing bonus marks when winning some in class activities or correcting own mistakes when reviewing tests. |
| **3) Use of Technology: PEARSON MyMathLab (PEARSON, 2018)** | • Providing easy, medium and high level of practicing online homework questions related to every topic taught in class.  
• Providing different online features that might ease students’ learning and understanding. For example, the program provides online e-text, teaching videos, questions with different levels of difficulties, and partial grades count when solving the homework problems. |
| **4) Improving Students’ Self-efficacy** | • Working on students’ self-efficacy as mentioned in table 2.6.1. |

Table 2.4: Major elements will be used to improve students’ mathematics understanding
2.7 Successful Mathematics Implementing Classroom Framework

The final conclusion for this case study explored the use of the SMIC framework and showed significant improvement in students’ mathematical self-efficacy, motivation, and understanding which improved students’ mathematical achievement at this freshmen level course at MFU. The researcher recommends the use of this framework in order to improve students’ mathematical achievement at the school and freshmen mathematics levels in Kuwait. The researcher divided all the approaches used in the study into categories. For example, cooperative learning environment included the use of; group work, gamification (Kahoot) and puzzle sheets, revision notes, small boards, and correcting the students’ own errors. Also, the use of technology included the use of; online homework and social media (WhatsApp) group application. Other categories included, teacher’s teaching methodology, tutor’s attitude, and bonus marks. The researcher recommends the use of the SMIC framework at the school and freshmen college level mathematics courses. Figure 2.3 shows the final form of the SMIC framework.

![SMIC framework diagram]

Figure 2.3: SMIC framework

- **a) Cooperative Learning Environment**
  1) Group Work
  2) Gamification and Puzzle Sheets
  3) Revision Notes
  4) Small boards
  5) Correcting The Students’ Own Errors
- **b) Teacher’s Teaching Methodology**
- **c) Tutor’s attitude**
- **d) Bonus marks**
- **e) The Use of Technology:**
  1) Social Media Application (WhatsApp Group)
  2) Online Homework

1) Self-efficacy
2) Motivation
3) Mathematical Understanding

Mathematics Achievement
2.8 Research questions

Maxwell (1995) stated that it is important for researchers to start their study with open mind sets towards exploring what needs to be investigated in their study. Also, it is important for educational researchers to start their research studies with goals, work experience and pedagogic knowledge. This will enable the researcher to see how and why to use every technique, and what gaps can be found in the study. Maxwell (1995) explained that the research questions are important to frame the features of the study. The questions provide the researcher with the theoretical guidance to explore the appropriate methods to be used in the study.

The research questions being addressed within this study are:

- What mathematical backgrounds do students have when they join an MFU course and what is the relationship between their backgrounds and their self-efficacy?
- What was the relationship found (if any) between the use of the SMIC framework in MFU classrooms and students’ mathematics achievement?
- What features within the SMIC framework promoted improved student’ self-efficacy?
Chapter Three: Research Methodology

3.0 Introduction

This chapter explains the reasons for using a case study approach and discusses the instruments used within this study. The first part discusses the research methodology used and why this methodology was appropriate. Also, it lists the advantages and disadvantages of using this methodology within this context. It looks at the role of the researcher in this study and discusses the important factors of reliability, validity and trustworthiness within the study.

The research design discusses the ethical procedures used during the study, the participants, medium language, the instruments used in the study, the reasons for using each instrument, the approaches implemented in the study, and the procedure implemented when the study was conducted.

3.1 Research Methodology

Headlam (2013) summarised different paradigms for research methods and explained the two major educational research perspectives which are normative and interpretive, or qualitative or quantitative. She continued that

“the normative paradigm is based around the view that human behavior is essentially rule-governed and that it should be investigated by the methods of natural science. Quantitative research involves the use of scientific techniques to produce quantified data and possibly leads to generalizable conclusions. The interpretive paradigm is characterized by a concern for the individual; qualitative research involves the investigation of individuals’ perceptions of the world and its aim is to use data to seek insight rather than to carry out statistical analysis” (2013, p.72).

This study includes the use of quantitative data analysis which is the subject of a statistical analysis. It includes also the qualitative data analysis that provides insights and tracks...
observations of human behaviours. Punch (2009) discussed two major approaches to planning a research project. The first approach is to begin with the paradigm, articulate it and then to develop research questions and methods from it. The second approach is a practical one where the researcher starts with the research questions. From the research questions, the researcher may choose the methods and instruments that need to be implemented in order to answer the research questions. The researcher in this study used her educational background and teaching experience to explore improving students’ mathematical understanding, self-efficacy and motivation levels in order to increase their achievement in mathematics. Also, she considered following the pragmatic approach through combining the qualitative and quantitative research methodologies and answering her research questions.

Researchers such as Wallen & Fraenkel (2001), Layder (1993), Cohen, Manion, and Morrison (2000), and Morgan (1998) suggested that the use of a mixed methods approach which utilises the strengths of both qualitative and quantitative methods. The qualitative research instruments included semi-structured interviews and concept maps. The quantitative data instruments included a background questionnaire, self-efficacy and motivation questionnaires and tests scores.

Creswell (2009) indicated that “all methods have limitations, researchers felt that biases inherent in any single method could neutralize or cancel the biases of other methods. Triangulating data sources means for seeking convergence across qualitative and quantitative methods was born (Jick, 1979)” (2009, p. 14). Triangulating data sources combines different qualitative and quantitative data collection methods in order to achieve more accurate and valid results in this study. This will be discussed in further detail in later sections of this chapter. Also, Creswell and Clark, (2007) and Creswell (2013) added that merging the
quantitative and qualitative data into one large database could reinforce the strength of the findings and identify the themes to look for in the data. They explained that this might assist the researchers to investigate real-life contemporary bounded systems or multiple bounded systems over time, through detailed data collection using multiple sources of information. Furthermore, the use of a multi-method approach has been recommended by Cohen et al. (2013) and Brown and Benken (2009). They indicated that using different data collection tools such as students’ quizzes and interview notes, meeting notes with participants, participants’ journal entries, course assignments and surveys could provide further insights into the conclusions. They added that the use of semi-structured interviews can provide an in depth analysis of the participants’ learning approaches, how students’ work was impacted, and how the analysis of different findings could be related to their teaching and learning experiences. In Table 3.1, Creswell (2009) summarizes the elements that make each data collection method:

Figure 3. 1: Data collection methods and each of their elements according to Creswell (2009)

The researcher in this study considered exploring whether combining both data analyses could lead to the same interpretations and conclusions. This could assist in developing
answers to the research questions related to testing students’ self-efficacy, motivation and mathematical understanding as a consequence of the implementation of the SMIC framework.

3.1.1 Case Study Methodology

The main goal for this study is to find how the teacher can develop teaching strategies by using the SMIC framework in order to improve students’ achievement in mathematics.

Yin (2014) listed five major methods that can be used when conducting a research study such as experiment, survey, archival analysis, history, or case study. He explained that ‘How’ and ‘Why’ are the most rationale questions related when conducting a case study. In order to distinguish when to use each of the methods, Yin (2014) recommended the use of three conditions such as “a) the type of research question posed, b) the extend of control a researcher has over actual behavioral events, and c) the degree of focus on contemporary as opposed to entirely historical events” (2014, p. 9). For example, he explained that

1) An experimental method is about asking (how, and why), requires a control of behavioral events, and focuses on contemporary events.

2) A survey method is about asking (who, what, where, how many, and how much), does not require control of behavioral events, and focuses on contemporary events.

3) An Archival Analysis is about asking (who, what, where, how many, and how much), does not require control of behavioral events, and can focus on contemporary events.

4) A history is about asking (how and why), does not require control of behavioral events, and does not focus on contemporary events.

5) A case study is about asking (how and why), does not require control of behavioral events, and focuses on contemporary events.
3.1.2 Reasons to Use a Case Study Methodology

Gerring (2004) defined the use of case study as “(a) that its method is qualitative, small-N (Yin 1994); (b) that the research is ethnographic, clinical, participant-observation, or otherwise “in the field” (Yin 1994); (c) that the research is characterized by process-tracing (George and Bennett 2004); (d) that the research investigates the properties of a single case (Campbell and Stanley 1963, 7; Eckstein [1975] 1992); or (e) that the research investigates a single phenomenon, instance, or example (the most common usage)” (Gerring, 2004, p. 342).

The researcher in this study considered the use of the case study methodology in order to focus on individual students’ changes in mathematical understanding, self-efficacy and motivation. The case study approach could provide detailed analysis in a specific field case that may include participant observation and process-tracking.

Creswell (2013) identified two kinds of case studies; concrete or less concrete. Creswell (2013) specified one type of case study which might be a bit concrete such as an individual, a group or an organisation. The less concrete case study could include studying a community, a relationship, a decision process or a specific project.

This study is bounded by the results obtained after implementing the SMIC framework in the context of the participants in the study. Using case study methodology could allow the study to retain the holistic and meaningful characteristics of real live events as recommended by Yin (2014). Applying Yin’s (2014) definition of case study, this study requires the ‘how’ and ‘why’ as base questions, it can include contemporary set of events, and over which the researcher has little or no control of behavioral events.
Also, the researcher considered different research approaches as expressed by Cohen, Manion and Morrison (2013). For example, she considered the following six approaches that explained the reasons for using a case study approach:

1. A survey would provide extensive data, but the researcher considered that because of the need to make use of personal experiences, this was not a suitable method.

2. The conditions used in this study would not be controlled, so an experiment would not be suitable.

3. The ethnography approach studies events from the students’ viewpoint, so this was not a possible method as the research will not be based around ethnics, cultures, and personal experiences and viewpoints. However, there will be elements of personal experiences and viewpoints included where appropriate, but these are not the main focus.

4. Cohen, Manion and Morrison, (2000) defined action research as “a small-scale intervention in the functioning of the real world and a close examination of the effects of such an intervention” (2000, p. 227-227). This study does not require the use of context specific implementations and reviews which would have an impact across the whole curriculum in terms of policies and strategies in a cycle of action research. Also, there were no changes needed to be applied from the pilot to the main study or from one stage to another within the study. This means, an action research approach cannot be considered in this study.

5. The case study approach would be looking at local situations and individuals, so this is a possible method, as the research is based around a specific institution and specific courses.

6. Testing and assessment is also a possible method as this occurs regularly within the area to be researched.
Overall, of the six approaches described above, the possible choices are between a case study, testing and assessment, and a survey approach. Moreover, the researcher aimed to use the case study approach in order to investigate the case in depth and find all possible complexities in the study. This can be done through long term involvement as recommended by researchers such as Ashley (2012), considering that the data was collected in two academic terms and each term lasted for four months. Also, the case study approach could allow the researcher to analyse the complexity of situatedness and behavior of students’ reactions towards the use of any educational approach as recommended by Cohen et al., (2013). Also, using the case study approach may allow studying the situations of individualized student’s case studies to speak for themselves instead of being interpreted as recommended by Cohen et al. (2013), including finding unique features that could be lost in larger scale data as recommended by Headlam (2013). Lastly, using the case study approach may allow generalisations for either about instance or from an instance explored to a class as recommended by Headlam (2013).

In contrast, the researcher was aware of the disadvantages of using a case study. For example, the results may not be generalised except where other researchers see their application as recommended by researchers such as Headlam (2013) and Cohen et al. (2013). Also, the researcher realised that it is not easily to do a cross-checking when using the case study, which might lead to biased, personal, and subjective results as recommended by Headlam (2013).

In order to use the three methods, a case study approach will be considered through the use of surveys, and testing and assessments as instruments as recommended by Yin (2014).
3.1.3 The Role of the Researcher in this Study

Researchers might choose to have different research positions in their own study. Whether the researcher plays an insider or an outsider role, there could be different strengths and weaknesses with regard to every case. Unluer (2012) defined the term insider-researcher as “those who choose to study a group to which they belong” (2012, p.2). In this case study, the researcher plays both the teacher’s and researcher’s role as an insider in the study. The researcher in this study observed the participants as an active researcher. Punch (2009) supported the idea as it allows the researcher to have access to the research situation and connects it easily to relevant contents and their own professional issues in order to reach an insider’s understanding of the social and cultural aspects of the study.

Also, Punch (2009) pointed out that when a researcher is an insider, this could bring bias and subjectivity to the study, especially if the researcher may have an interest which leads the results in the study. In contrast, Coe (2012) pointed out that it is important for researchers to avoid any influence by other superiors or inappropriate features when interpreting and analysing the data collected in the research study. In order to avoid misinterpretation during the process of interpretation, Coe (2012) recommended the use of bracketing which is a process in which “the researcher attempts to identify, state, suspend or disassociate from the research process aspects such as their own ontological and epistemological positions and theoretical frameworks, supposition cultures, assumptions, beliefs, experiences, values and viewpoints, supposition base on the academic and scientific theoretical orientation and theories, and pre-existing assumptions about the phenomenon being investigated” (2012, p. 47).
Other researchers such as Unluer (2012) listed some disadvantages of being an insider-researcher:

• “Role duality (instructor/researcher)
• Overlooking certain routine behaviours
• Making assumptions about the meanings of events and not seeking clarification
• Assuming he/she knows participants’ views and issues
• The participants may tend to assume you already know what they know
• Closeness to the situation hindering the researcher from seeing all dimensions of the bigger picture while collecting the data”. (2012, p. 6).

In order to avoid biases in this study, the study framework involved exploring themes in the study, reasons for finding them, and how they could influence students’ mathematical achievement. This included the following considerations in order to meet with Unluer’s (2012) points:

1) The researcher kept a research journal of detailed records of events, strengths and weaknesses of the pilot study as recommended by researchers such as Watt (2007). Watt (2007) explained that “Since the researcher is the primary “instrument” of data collection and analysis, reflexivity is deemed essential (Glesne, 1999; Merriam, 1998; Russell & Kelly, 2002; Stake, 1995)” (2007, p. 82). The researcher in this study shared her research journal comments with her director of studies and MFU supervisors and explained her plan on how to apply the main study. This assisted her to use reflexivity during the study and design the educational approaches needed. This will be discussed in details in section 8-1 of the limitations of the study.

2) She obtained approvals from Plymouth University and GUST administrations, and MFU supervisors. Also, she considered being involved in a testing committee instead of creating and using her own tests. Also, the semi-structured interviews during the pilot and main study, were supervised by the director of study.

3) The researcher used the pilot study as road map and an important source of information, strengths, weaknesses, and limitations in order to prepare for the main study. She considered collecting data from two different cohorts at different academic semesters such as Summer, Fall, and Spring semesters in order to assure the validity and richness of the data collected.

Later in Chapter 8, the researcher will discuss how she overcame this issue. (8.1)
3.1.4 Validity and Reliability of a Case Study

Joppe (2000) defined reliability as “the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable” (2000, p. 1). Bush (2007) explained that research validity is about determining whether the research study describes the phenomenon accurately. Also, Yin (2009) recommended that researchers should connect their chains of evidences in the study which may increase the reliability of the study. This might lead to “follow the derivation of any evidence from initial research questions to ultimate case study conclusions” (2009, p. 122).

Also, Bassey (2007) suggested that reliability is about:

1) Collecting and saving evidence by what he refers to as an ‘audit trial’ where a flow chart of data, data analysis and the interpretation is saved.
2) When researchers use a number of tests in a case study, this may increase the ‘trustworthiness’ of the study.
3) having enough triangular data to support analytical statements.

In this study, the researcher described the stages and procedures of the study in a chain of steps in order to show the reliability of the study. Also, she connected and interpreted the data evidences and analyses in order to show reliability in the study. A pilot study was conducted in order to refine the instruments, to collect evidence for the methods that were to be applied, to avoid using inappropriate methods, to confirm the use of a number of tests and assessments for the main study, and to use square source data analysis.
3.1.5 Ethics Used in this Study

This study follows the guidelines and ethical principles of both Plymouth University and GUST. The ethical procedures included:

- **Approvals**

  The researcher applied and received the ‘Certificate of Ethical Research Approval’ to conduct the study from Plymouth University as shown in appendix A. Also, she applied and received the ‘Institutional Review Board’ (IRB) clearance from GUST in order to conduct the study there as shown in appendix B. Also, the researcher applied and received the approval to conduct the study from the MFU director at GUST as shown in appendix C. The students were offered the chance to decide to participate in the study. The students were offered the chance to read and keep a copy of the research information sheet as shown in appendix E. The research information sheet provided an explanation of the purposes of the research, offered the right to withdrawal, the rights and obligations to confidentiality and provided opportunities to allow participants to ask questions about any part of the research as recommended by Cohen et al. (2013). If they did choose to participate, they were asked to sign the Plymouth University Consent Form as shown in appendix F. Each participant was able to keep a copy of the form and sign a copy that the researcher collected. This informed consent is required by Plymouth University and the British Educational Research Association (BERA).

Also, the researcher followed the BERA ethics procedures such as: “The participants in research may be the active or passive subjects of such processes as observation, experiment, auto/biographical reflection, survey or test. They may be collaborators or colleagues in the research process or they may simply be part of the context e.g. where students are part of the
context but not the subjects of a teacher’s research into his or her own professional practice”. (BERA, 2011, p.5).

Other BERA guidelines included “educational researchers should operate within an ethic of respect for any persons involved in the research they are undertaking. Individuals should be treated fairly, sensitively, with dignity, and within an ethic of respect and freedom from prejudice regardless of age, gender, sexuality, race, ethnicity, class, nationality, cultural identity, partnership status, faith, disability, political belief or any other significant difference” (BERA, 2011, p.5).

- **Openness and honesty, and the right to withdraw from the study**

Lichtman (2013) explained that “individuals participating in a research study have a reasonable expectation that they will be informed of the nature of the study and may choose whether or not to participate. They also have a reasonable expectation that they will not be coerced into participation. On the face of it, this might seem to be relatively easy to follow. But if a study is to be done in an organisation, individuals within that group (e.g. students, workers) might feel that they cannot refuse when asked. There might be pressure placed on them by peers or superiors” (Lichtman, 2013, p. 53). While applying the pilot and main studies, the students were offered the chance to withdraw from the study at any time they felt uncomfortable to continue.

- **Confidentiality**

The researcher assured the participating students in the pilot and main study that their information will be treated confidentially, and the information collected in the study will be
shared with the supervisors of the study only. Also, the researcher will store the data collected until the completion of the degree of study before destroying them.

In order to control the level of anxiety while filling out the questionnaires, the supervisor explained the data collection process in each classroom by reading the questions carefully for the students, offering them the option to choose to participate in the study or not, allowing them to use the Arabic or the English versions, offering students the option to leave the classroom if they did not feel comfortable filling out the survey questions, and clarifying to the students that there will be no risk by answering the survey questions. Clear instructions were provided on the first page of each questionnaire.

The students were provided with the time they needed while being interviewed. Audio recording was used while conducting the interviews. The ethical points related to the study were stated to each student before starting the interview in order to provide them with a relaxed atmosphere to make them feel at ease during the interview.

3.1.6 Validity and Reliability of the Instruments Used in this Study

The validity for the instruments used in the study was assessed as follows:

1) Validity of the self-efficacy questionnaire used in the pilot and main studies: The researcher in this study designed the self-efficacy questionnaire based on the work of previous used questionnaires found in literature by researchers such as [Pintrich (1991), Rahimi & Abedini (2009), Liu & Koirala (2009), Ferla, Valcke, & Cai, (2009), Zimmermann, Bescherer, & Spannagel (2011), and Cheng (2001)]. The 5-point Likert scale was used to measure students’ mathematical self-efficacy during the course stages. The reliability of the self-efficacy questionnaire was tested on the data
collected when answering the study questions according to results discussed by researchers such as Oppenheim (1992). Furthermore, Hinkin (1998) explained that “reliability is the accuracy or precision of a measuring instrument and is a necessary condition for validity. The reliability of a measurement should be assessed after unidimensionality has been established” (1998, p. 113). The questionnaire are shown in appendix G. Also, Cronbach Alpha was used in order to indicate the inter-item correlations where 0.0 shows no reliability and 1.0 shows perfect reliability according to Cronbach’s (1951) seminal article.

2) Validity of the motivation questionnaire used in the main study: The researcher in this study designed the motivation questionnaire based on the work of previous used questionnaires found in literature by researchers such as [Pintrich (1991), Zerpa, Hachey, Barneveld, and Simon (2011), Duda and Nicholls (1992), Githua & Mwangi (2003), Sundre, Barry, Gynnild and O斯塔rd (2012)]. The 5-point Likert scale was used to measure students’ mathematical motivation during the course stages. The questionnaires are shown in appendix G. Also, Cronbach Alpha was used in order to indicate the inter-item correlations where 0.0 shows no reliability and 1.0 shows perfect reliability according to Cronbach’s (1951) seminal article.

3) The major tests used in the study were reliable as they were all standardised tests designed by MFU members and approved by the MFU coordinator. Furthermore, Test 2 was double graded by a second instructor at all MFU courses according to MFU rules and regulations in the department. The level quiz is shown in appendix H. Other sample tests are shown in appendices J, K and L.

4) The semi-structured interviews were used at the end of the course during the pilot and main study. The use of the end of course interviews reflected usefulness and enriched the study with students’ experiences during the course and explored themes
that assisted the researcher to find the basic elements of the SMIC framework elements. The interview questions were confirmed by the supervisor of the study (Dr. Ted Graham). Also, the transcribed interviews were reviewed and approved by the second supervisor of the study (Dr. Annette Taylor). The semi-structured interview questions are shown in appendix I.

3.2 Participants and Sampling of The Main Study

Two student samples were used in the main study, all studying the Math096 course. The first cohort consisted of three groups of 18-20 male students and one group of 10 female students. These groups were randomly assigned as part of the Spring 2017 schedule. The second cohort consisted of two groups of 18-20 male students and two groups of 18-20 female students. Those groups were randomly assigned as part of the Fall 2018.

3.3 Language Medium of the Study:

The medium of instruction at GUST is the English language. In contrast, Kuwait’s official language is the Arabic language. The researcher offered all research questionnaires and semi-structured interviews in both languages to make the participating students feel as comfortable as possible while responding to them.

3.4 Instruments Used and The Triangulation Source Methodology

Creswell (2009) recommended the use of certain instruments when collecting qualitative data. Table 3.2 contains Creswell’s (2009) summary of these data collection instruments, and the advantages and disadvantages of using each of these instruments (2009, p. 179-180):

<table>
<thead>
<tr>
<th>Data Collection Types</th>
<th>Options Within Types</th>
<th>Advantages of the Type</th>
<th>Limitations of the Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>• Complete participant-</td>
<td>• Researcher has a first-hand</td>
<td>• Researcher maybe seen as intrusive.</td>
</tr>
<tr>
<td>researcher conceals role</td>
<td>experience with participant.</td>
<td>Private information may be observed that researcher cannot report.</td>
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<tr>
<td>---</td>
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<td>---</td>
<td></td>
</tr>
<tr>
<td>• Observer as participant-role of researcher is known</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Participant as observer-observation role secondary to participant role</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Complete observer-researcher observes without participating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Researcher can record information as it occurs.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• Unusual aspects can be noticed during observation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Useful in exploring topics that may be uncomfortable for participants to discuss.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Private information may be observed that researcher cannot report.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Researcher may not have good attending and observing skills.</td>
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<tr>
<td>• Certain participants (e.g., children) may present special problems in gaining rapport.</td>
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### Interviews

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<tr>
<td>Face-to-face--one-to-one, in-person interview</td>
<td>Useful when participants cannot be directly observed.</td>
<td>Provides indirect information filtered through the views of interviewees.</td>
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<tr>
<td>Telephone—researcher interviews by phone</td>
<td>Participants can provide historical information.</td>
<td>Provides information in a designated place rather than the natural field setting.</td>
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<tr>
<td>Focus group—researcher interviews participants in a group</td>
<td>Allows researcher control over the line of questioning.</td>
<td>Researcher’s presence may bias responses.</td>
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<tr>
<td>Email internet interview</td>
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<td>Not all people are equally articulate and perceptive.</td>
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### Documents

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<tr>
<td>Public documents such as minutes of meetings, or newspapers</td>
<td>Enables a researcher to obtain the language and words of participants.</td>
<td>Not all people are equally articulate and perceptive.</td>
</tr>
<tr>
<td>• Private documents, such as journals, diaries, or letters.</td>
<td>Can be accessed at a time convenient to researcher—an unobtrusive source of information.</td>
<td>May be protected information unavailable to public or private access.</td>
</tr>
<tr>
<td></td>
<td>Represents data which are thoughtful in that</td>
<td>Requires the researcher to search out the information in hard-to-find places.</td>
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| Audio-Visual Materials | • Photographs  
|• Videotapes  
|• Art objects  
|• Computer software  
|• Film | • Requires transcribing or optically scanning for computer entry.  
• Materials may be in complete.  
• The documents may not be authentic or accurate. |
|Participants have given attention to compiling them.  
• As written evidence, it saves a researcher the time and expense of transcribing. | • May be an unobtrusive method of collecting data.  
• Provides an opportunity for participants to directly share their reality.  
• It is creative in that it captures attention visually.  
• May be difficult to interpret.  
• May not be accessible publicly or privately.  
• The presence of an observer (e.g. photographer) may be disruptive and affect responses. | | |

Table 3.1: Creswell’s (2009) summary of qualitative recommended data collection instruments

This case study is about implementing the SMIC framework in order improve students’ mathematical understanding, self-efficacy and motivation levels. In order to measure the students’ mathematical achievement, different instruments were used from both qualitative and quantitative approaches. Creswell (2009) suggested that “examining the relationships between and among variables is central to answering questions and hypotheses through surveys and experiments” (2009, p. 145). He also stated that surveys provide the study with numeric trends, attitudes or opinions of the population. Thus, the quantitative data instruments included a background questionnaire, self-efficacy and motivation questionnaires, test scores, success rates and attendance rates. The questionnaires could show students’ changes in their self-efficacy and motivation. The qualitative research instruments included semi-structured interviews and concept maps.
A triangulated data source was used in this study as follows:

- Different course assessments were used during the course such as the level quiz at the start of the course, Test 1 after the first month, Test 2 after the second month, and Test 4 at the end of the course. This showed students’ change in their mathematical understanding during the course.

- Questionnaires: 1) self-efficacy questionnaires were used four times during the course stages in order to measure students’ self-efficacy, 2) the background questionnaire was used at the start of the course to obtain initial information about the students’ backgrounds in mathematics, and 3) Motivation questionnaires was used at all stages of the study in order to study students’ motivational changes during the course.

- Semi-structured interviews were used at the end of the course in order to check the different reasons for the students’ changes in self-efficacy, motivation, and mathematical understanding. Also, students could discuss the different teaching approaches used during the course and how this could have influenced their mathematical achievement.

- Concept maps were used at the start of the course, middle, and end of the course. Students were asked to map different taught objectives in order to relate each objective taught to other objectives in the course. Concept maps were used in this study in order to explore the students’ conceptual understanding.

Researchers such as Oliver-Hoyo and Allen (2005), explained that triangulation data sources “involves the careful reviewing of data collected through different method in order to achieve a more accurate and valid estimate of qualitative results for a particular construct” (2005, p. 42). The researcher can apply a cross-validation analysis through the use of triangulation source methodology. Oliver-Hoyo and Allen (2005) added that “the deficiencies of each method would then average out leaving a true estimate of a single result (Brinberg and
Kidder (1982). Therefore, triangulation yields a more accurate and valid estimate of a result when each method of measurement actually converges on the same answer (Mark and Shotland 1987)” (2005, p. 43). This study explores the results after using of triangulation of the sources in order to compare information obtained from different instruments and find corroboration and validation of the elements in the SMIC framework. The triangulated source data in this study is based on combining the quantitative and the qualitative methodologies. Figure 3.2 shows the triangulated sources data collection obtained in this study.

Figure 3. 2: Triangulation Methodology in this study.

3.4.1 Semi-Structured Interviews:

Robson (2002) defined interviewing to be a process that involves questions being asked and answers given. He added that interviews can be done face to face, on the phone or using technology devices. The facial interactions and expressions might provide comfort for the interviewee when answering the interview questions. Hardon, Hodgkin and Fresle (2004) explained that semi-structured interviews allow the exploring and listing of different issues in different fields such as medicine, research education, any health or other fields. In other
words, applying semi-structured interviews assists researchers to investigate the reasons for different issues, and discuss each issue in detail in order to reach conclusions. In this study, the researcher was looking to explore the reasons for the changes in students’ self-efficacy, motivation and mathematical understanding during the course. She was exploring how beneficial the use of each approach was in relation to the students’ self-efficacy, motivation and mathematical understanding. Also, the researcher was looking to compare students’ mathematical background knowledge and their knowledge at the end of course. This could all be explored using semi-structured interviews.

Moreover, Dearnley (2005) discussed the preparation required by the interviewer before interviewing the participants;

- Venue should offer privacy,
- To offer an informal atmosphere using comfortable decor and seating arrangements,
- To offer refreshments if possible,
- To select clean interview location,
- The interviewer should be dressed informally as formal clothes may affect the way the participant may interact during the interview, which may create an uncomfortable atmosphere for the interviewee,
- To consider the gender of the interviewee, and
- To consider the familiarity between interviewer and interviewee while asking the questions.

In this study, the researcher welcomed the students in her office. She had a simple chat with each student in order to ease any anxiety. She also explained the importance of the interviews and how this could contribute to the field of mathematics education in Kuwait.

The semi-structured interviews are considered an important source for data for qualitative research design. Hardon, Hodgkin and Fresle (2004) indicated that interviewing a variety of people is a key element (men, women, rich or poor or people with different ethnicity) for the success of the interview. In this study, different male and female students were interviewed
based on their self-efficacy level, and their willingness to take the interview. Also, Hardon, Hodgkin and Fresle (2004) suggested that the interview may contain many questions so that the interviewer may continue asking until they reach a full understanding of the research topic. In this study, major and general questions were used in order to reach full understanding of the study. The students were provided with the time they needed to answer each question.

Figure 3.3 describes the advantages and disadvantages of using semi-structured interviews:

1) Questions may vary with flexible endings.


3) The interview questions allow for testing the limits of a participant’s knowledge and allow the interviewer to investigate for the participant’s beliefs which may encourage cooperation by the interviewee to produce unexpected replies from the interviewees. Hardon, Hodgkin and Fresle (2004).

1) Interviewers may fall into judging the research case,

2) The analysis of findings is difficult as it must be done by people who did the interview,

3) Researchers may fall indirectly into taking sides while interviewing and analysing the received data,

4) Researchers need to acknowledge some of the local culture to capture the interviewee’s real meaning and perspective,

5) Analysing the received data is time consuming, and

6) It is difficult to generalise findings.


7) they might lead to loss of control by the interviewer depending on the length of the answer and might be more difficult to analyse compared to closed ending questions. According to Robson (2002).

Figure 3. 3: The advantages and disadvantages of using semi-structured interviews.
Considering the advantages and disadvantages of using semi-structured interviews, this might lead to a more successful interview and could assist the interviewer to decide whether this can make a suitable approach for the study.

Oppenheim (1992) and Hammersley (2012) recommended that recording the interviews may allow the researcher to re-analyse the data to be studied in more depth. Hammersley (2012) added that when data is recorded, this may enable readers to have it checked and be replicated by others. In this study, an audio recording system was used to record each interview. In later stages of the study, the interviews were transcribed and analysed.

Researchers such as Maxwell (1995) explained that the process of transcribing interviews is also a way of analysing the interviews. This encouraged the researcher to be careful when transcribing each interview in order to identify as much informative data as possible. This could support the triangulation data source planned in this study in order to assist the interpretation and the analysis of the study.

3.4.2 Mathematics Background, Self-efficacy, and Motivation Questionnaires:

A questionnaire is considered to be a data collection instrument and an important element in a quantitative research study. In this study, the background questionnaire was used in order to study different students’ backgrounds before deciding the different tactics to approach their learning.

The self-efficacy questionnaire was used in this study in order to reflect students’ self-efficacy changes during the course. A motivation questionnaire was used in this study in order to identify changes in the students’ motivation changes. According to Jamieson (2004),
a 5-point Likert scale provides “a range of responses to a given question or statement. Typically, there are 5 categories of response from (for example) 1 = strongly disagree to 5 = strongly agree” ((2004, p. 1217). In this study a 5-point Likert scale questionnaires were used to measure students’ self-efficacy and motivation levels changes.

The background questionnaire, was a simple questionnaire designed to captured each student’s mathematics background and assist the data analysis. This enabled the researcher to relate the study results to the students’ mathematical backgrounds. Also, the background questionnaire reflected a connection between students’ backgrounds and their self-efficacy and mathematics levels at the start of the course.

The motivation questionnaire used a 5-point Likert scale. This enabled the researcher to provide descriptions of changes to the student’s motivation. Using the motivation questionnaire at different stages enabled the researcher to answer some of the research questions as it allowed the researcher to measure the students’ motivation level at different times during the course. The questionnaires are shown in appendix G.

**3.4.2 Major Tests**

In this study, major tests were used during the course. Creswell (2009) indicated the importance of collecting private documents for every participant in the research, as shown in Table 3.4. Different major tests were used in this study. These were the level quiz, Test 1, Test 2 and Test 4. This enabled the researcher to explore students’ changes in their test scores and mathematical understanding during the course.
3.4.4 Concept Maps

In order to study the change in students’ conceptual understanding during the course, concept maps were conducted at three stages of the course. McGowen and Tall (1999) in their study tried to follow the cognitive development for each of their participating students in the study during their mathematics course in order to seek the qualitative differences between those of different levels of achievement through the use of concept maps. They asked their participating students to draw schematic diagrams “which strip the concept maps of detail and show only how they are successively built by keeping some old elements, reorganizing, and introducing new elements. The more successful student added new elements to old in a structure that gradually increased in complexity and richness. The less successful had little constructive growth, building new maps on each occasion”. (1999, p.1). In this study, the students were provided with mathematical learning objectives at the start of the course and were asked to draw their individual concept maps. As the students progressed in Math 096 materials, the researcher increased the learning objectives and asked the students to re-draw their individual maps at mid-course. The same procedure was applied at the end of the course. This enabled the researcher to track changes in their conceptual thinking during the course.

3.5 Approaches Used in The Main Study in Light of the Refinements Explored in the Pilot Study

Lee (2009) mentioned some of the characteristics of using a pilot study such as:

- “Pilot studies, or feasibility studies provide important information for design and justification of randomised controlled trials (RCTs)” (2009, p. 103).
- “the authors provide only general information on the intervention and outcome measures used but it is questionable whether future large-scale trials can be designed and performed based on the information presented in this article” (2009, p. 103).
- “they cannot provide the definite conclusion, thus analysis and presentation of results should be descriptive and/or focus on confidence interval estimation” (2009, p. 103).
The pilot study chapter implemented the SMIC framework and tested the research instruments. It provided general information about the study on a small scale. It did not provide the more definite conclusions of the main study. This assisted the researcher to summarise the refined approaches developed from the pilot study for the main study.

3.5.1 Group Work

The researcher aimed to use group work as a key source approach for students’ interactions in different activities. This included exploring different methods to solve set problems while teaching each objective, creating students’ revision notes, playing the puzzle sheets, using the small plastic boards and correcting the students’ own errors.

Using group work could encourage the students to create a support system between themselves by assisting each other to solve different questions among their groups. Also, they might assist each other to explore their own learning techniques and check if this could improve their mathematical understanding.

3.5.2 Revision Notes

Zimmerman and Kitsantas (2005) explained that “it was possible that items measuring self-efficacy for learning regarding reading, note taking, studying, test taking, and writing could form distinctive but correlated latent factors because the effectiveness of self-regulatory strategies is often affected by variations in academic tasks (Zimmerman & Martinez-Pons, 1988)” (2005, p. 399). In this study, the students were asked to make chapter summary notes at the end of each chapter. The teacher provided key ideas from the chapter and requested the students in groups to create examples which explained each of these key ideas and concepts. The students discussed the questions with each other to create different examples for each
objective. Not only did the use of revision notes express the students’ conceptual understanding for each objective, but also encouraged the reverse thinking approach and creative thinking while creating their examples. Figure 3.5.3 shows an example of the use of the revision notes for a student.

Figure 3. 4: An example of the use of the revision notes for a student.

3.5.3 Small Boards

The researcher planned to use another approach that involved the use of group work through the use of small plastic white boards. The students used these boards during the first 10 minutes of each class to review the objectives taught on the previous day. The teacher stated
key definitions and asked the students to write an example that represented the definition. These boards are easy to erase in order to achieve as many review questions as possible. The plastic boards were easy to use and quick to clean in order to answer no less than 5 to 7 questions in each class period. They can be used for the first 10 minutes of class time, or for the whole class on a review day and/or to develop new ideas from existing knowledge taught in the past. This might enable the instructor to identify students’ errors, which can strengthen the teaching approach and improve the students’ conceptual understanding. Figures (3.5) and (3.6) show two examples of how the student wrote the wrong answer figure (3.5), and how he corrected it in (3.6). His instant answer reflected a weaker understanding. He discussed his answer with his group which assisted him to correct it. This could have improved his conceptual understanding.

Figure 3.5: Instant answer of a student using the plastic individual boards.
3.5.4 The Use of Gamification and Puzzle Sheets

Kebritchi, Hirumi and Bai (2010) explained that

“Technology has also made it possible to play games on simple platforms such as mobile devices that offer access to many who may not have personal computers (Mitchell & Savill-Smith, 2004). Furthermore, instructional games create a new learning culture that better corresponds with students' habits and interests (Prensky, 2001), and more importantly, instructional games are thought to be effective tools for teaching difficult and complex procedures because they (a) use action instead of explanation, (b) create personal motivation and satisfaction, (c) accommodate multiple learning styles and skills, (d) reinforce mastery skills, and (e) provide interactive and decision making context (Charles & McAlister, 2004; Holland, Jenkins, & Squire, 2002)” (2010, p. 427).

They concluded from their study that students who played the games in the classrooms reflected higher motivation levels in comparison to the students who played the games only in their school labs (2010, p. 427). Different games were used during the pilot and main studies in order to motivate the students to attend class, feel motivated to study mathematics and understand the taught materials. For example, the teacher used Pizzaz puzzle sheets by
researchers Marcy and Marcy (1989 & 1996) and the game Kahoot as a technology game throughout study.

The researcher noticed that this generation of students tend to prefer to use technology when doing many things on a daily basis. Thus, she offered a variety of games - including computer questions using the computer game named Kahoot. When using Kahoot, the students submit an answer to each question individually using their mobile devices. Each student receives a score. The top 10 students with the highest scores will receive a bonus mark which is added to their quiz grade. This might motivate the students to attend class regularly and improve their mathematics understanding, as it can improve their grade. The three figures below show some examples of using Kahoot in the classroom:

1)  

Figure 3. 7: An example of a Kahoot question. The time is shown on the left side of the screen and the number of participating students who have answered the question is shown on the right side of the screen. It’s a multiple answer question where the students are able to select the right colour with the right answer using their individual mobile devices (Kahoot, 2018).
The other game used in the study was the puzzle sheet. Each puzzle sheet included questions related to a particular objective. In order to solve the puzzle question at the top of the page, the students had to answer another list of questions and insert the corresponding letter or word in the puzzle spaces as shown in figure 3.5.3.d. The students were requested to work on
the puzzle in groups. The first three groups completing the puzzle question correctly would receive a bonus mark. The teacher aimed to motivate the students to attend, work hard, feel able to understand mathematics, and improve their grades.

![Image of a puzzle sheet](image)

Figure 3.10: Example of a puzzle sheet used in the course.

### 3.5.5 Correcting The Students’ Own Errors

The teacher corrected each major test, photocopied it, and returned it to the students to review. The students were divided into groups and were given back each of their tests. They were asked to discuss with their group members how to correct each of their own errors in the test. The teacher asked them also to explore the reasons for making those errors and what did they thought when they made those mistakes. The students who attended class and corrected all of their errors received a bonus mark. The teacher aimed to motivate the students to attend class, realise their errors, avoid making those mistakes again, correct them, improve their mathematics understanding, improve their ability to learn mathematics, and improve their overall grades. Figure 3.5.5 shows an example for a student who corrected a question that he
had solved the wrong way in his Test 2. The colour differences between the test copy and his blue corrections are shown as well.

Figure 3. 11: An example of a student who corrected a question that he had solved the wrong way in his Test 2.

3.5.6 Teacher’s Teaching Methodology

The teacher planned to use different teaching approaches in class. Not only this included the approaches listed from sections 3.5.1 to 3.5.8, but also, she tried to use her pedagogic knowledge when implementing teaching techniques in the classroom. For example, she divided the students in groups and asked them to explore the easiest and possible methods to solve a particular problem in a limited time. Furthermore, after explaining one method to solve a problem to the students, she would ask them to explore another method that might be
easier for them. She aimed to improve the students’ mathematical understanding and self-efficacy, and to motivate them to work hard.

3.5.7 Bonus Marks

MFU teachers noticed that GUST students are grades-driven. The teacher aimed to use the bonus marks after the students completed each activity in order to motivate them to enhance their attendance and study habits, improve their ability to understand mathematics, and improve their grade. The bonus offered was 10% added to the weekly quiz which was 0.15% of the overall gradebook system for the course. This could influence the students’ behavior without inflating the overall grades of the course.

3.5.8 Use of Technology: Online Homework

MFU teachers also noticed that GUST students are very attached to the use of technology. The teacher in this study aimed to use technology as a motivating key element to improve the students’ practice and procedural understanding during the course. The students were assigned online homework using PEARSON MyMathLab. The program offered a variety of questions for each lesson taught. Also, it provided very useful features such as videos and similar examples. The teacher aimed to motivate the students to practice and improve their procedural understanding through the use of an available online homework. Figure 3.5.8.a shows the online homework assignment lists through the use of PEARSON MyMathLab, figure 3.5.8.b shows an example of an assigned question through the online homework system PEARSON MyMathLab, and figure 3.5.8.c shows the programme’s action when the right answer is entered for the question.
Figure 3. 12: The online homework assignment lists through the use of PEARSON MyMathLab. (PEARSON, 2018).

Figure 3. 13: An example of an assigned question through the online homework system PEARSON MyMathLab. (PEARSON, 2018).
3.5.9 Tutor’s Attitude

The teacher used her personal attitude in order to improve the students’ attitude to the classes. She provided care, attention, and availability to all the students during the course. She aimed to motivate them to learn mathematics properly through the use of her positive attitude during the course.

3.6 Procedure and Description of the Study

Yin (2009) recommended offering convincing criteria, access and geographic proximity for the study. The study was divided into three stages at pilot study and refined into four stages at the main study. The following sections describe the procedure used in each stage of the main study.
3.6.1. Stage 0

Start of the course: The students solved the level quiz on the first day of the course. They also answered the background questionnaire, self-efficacy, and motivation questionnaires. The three questionnaires were offered to the students in both languages (English and Arabic) in order to ensure that the students understood all ideas mentioned in the questionnaires and could answer them properly. Also, the students were asked to draw concept maps by connecting different objectives from the Math 095 together in one map.

3.6.2: Stage 1

The first month of the course: The students were exposed to educational approaches of the SMIC framework during the first stage of the course. The students ended the stage by answering the self-efficacy, and motivation questionnaires. They also conducted weekly short quizzes, and Test 1 which included the course materials covered during this stage.

3.6.3. Stage 2

Mid-course (the second month of the course): The students continued to be exposed to the approaches of the SMIC framework At the end of the stage, they completed the self-efficacy and motivation questionnaires, weekly quizzes and Test 2. Also, the students were asked to draw the second concept map using the course content taught up to this point.

3.6.4. Stage 3

End of course (Last week of the course): The students continued to be exposed to the approaches of the SMIC framework . At the end of this stage, they completed the self-efficacy and motivation questionnaires, weekly quizzes and Test 4. Also, the students were asked to draw the third concept map in the course including all the objectives taught. Also, semi-
structured interviews were conducted with students with different levels of self-efficacy. The students’ selection criteria will be discussed in sections 6.0 and 6.3.
Chapter Four: Pilot Study

4.0 Introduction

Van Teijlingen & Hundley (2002) listed some important points to consider when using pilot studies. For example, “1) Developing and testing adequacy of research instruments, 2) Assessing the feasibility of a (full-scale) study/survey, 3) Designing a research protocol, 4) Assessing whether the research protocol is realistic and workable, 5) Establishing whether the sampling frame and technique are effective, 6) Developing a research question and research plan, and 7) Identifying logistical problems which might occur using proposed methods” (2002, p. 2). Using a pilot study may assist the researcher to refine methodology and the data collection plans in preparation for the main study.

This chapter presents the procedure and description of the study, whilst also considering the emerging themes and educational approaches that developed from the pilot into the main study. Also, it includes the qualitative and quantitative results explored in the study.

4.1 This pilot study

The sample used in this pilot study consisted of one group of 15 male students from Math-096. This group was randomly assigned as part of my summer teaching allocation by MFU. The policy of the GUST institute is to use gender segregated classes. The age range of the students was between 18 and 30 years.

During the stage, the students were exposed to educational approaches of the SMIC framework. The educational approaches included the use of group work, bonus marks, online homework, puzzle sheets, revision notes, social media (WhatsApp) group application (outcome), correcting the students’ own errors, playing games, and tutor’s attitude. The medium of instruction at GUST is the English language. In contrast, Kuwait’s official
language is Arabic. The researcher offered all the research questionnaires and semi-structured interviews to students in both these languages to make the participating students feel as comfortable as possible while responding to them.

4.2 Procedure and description of the pilot study

Stage 0 (Start of the course): The students took the level quiz on the first day of the course. They also completed the background and self-efficacy questionnaires. During this stage, the students were exposed to educational approaches of the SMIC framework.

Stage 1 (Mid-course): The students completed the self-efficacy questionnaire, weekly quizzes and Test 2.

Stage 2 (End of course): The students completed the self-efficacy questionnaire, weekly quizzes and Test 4. The students were asked to volunteer to be interviewed. Ten students volunteered to be interviewed. The researcher divided them into three categories: high, middle, and low achieving students according to their overall scores.

4.3 Quantitative Data analysis

Self-efficacy: Statistical Package for Social Sciences (SPSS) was used to analyse the quantitative data collected. Figure 4.3.1.a shows the boxplots of the changes in students’ self-efficacy level at each of the three phases of the course.
Figure 4.1: Students’ self-efficacy level changes during the course

It can be seen that the students’ self-efficacy improved and the box-plots’ ranges reduced during the three stages of the course. The decreasing scores resulted from the use of reversed Likert scale with 5 at strongly disagree.

**Test scores:** Also, figure 4.3.1.b, shows the boxplots of the level quiz score changes, Test 2 (midterm exam), Test 3, and T4 (Final exam) during the course.
Figure 4.2: The level quiz and test score changes during the course

There is a noticeable increase in their scores from the level quiz to other major tests in the course.

**Correlation:** Table 4.1 shows the Pearson Correlation between the students’ self-efficacy and test scores at all stages.

<table>
<thead>
<tr>
<th>Correlations</th>
<th>Self-efficacy all stages</th>
<th>Tests all stages</th>
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<tr>
<td><strong>Self-efficacy all stages</strong></td>
<td>Pearson Correlation</td>
<td>-.617**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
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<td>45</td>
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<tr>
<td><strong>Tests all stages</strong></td>
<td>Pearson Correlation</td>
<td>-.617**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>45</td>
</tr>
</tbody>
</table>

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

Table 4.1: Pearson Correlation between students’ self-efficacy and Test scores at all stages
There is a significant correlation between the students’ self-efficacy and test courses in the study. The use of reversed Likert scale with 5 at strongly disagree resulted in the negative correlation in the analysis. This means, there is a positive relationship between students’ self-efficacy and test scores in the study which shows that there is a positive relationship between students’ self-efficacy and their mathematical understanding as shown in the tests during the course.

**Pass/Fail ratio:** A total of 14 students passed the course with only one student failing the course.

![Figure 4.3: The students’ attendance rates during the pilot study.](image)

GUST attendance history has shown low attendance rates for all courses. One important outcome that was noticeable during the study was the high attendance rates for the students during the course. George (2012) pointed out that increasing the attendance rate of students at remedial mathematics courses shows higher level of students’ motivation. This encouraged the researcher to test students’ motivation in the main study and its correlation with the test scores.
4.4 Qualitative Data Analysis

Based on their willingness to take the semi-structured interview, ten students were interviewed. The researcher divided the students into three categories; high, middle, and low achievers. The interviews were transcribed and the content divided into categories. For example, the categories included; attendance, online homework, feelings before and after the course, teacher’s teaching methodology, group work, correcting own errors, social media (WhatsApp) group, revision notes, and small boards. The supervisor of the study (Dr. Ted Graham) attended the interview sessions while visiting Kuwait and GUST. The transcribed interviews were reviewed by the second supervisor of the study (Dr. Annette Taylor) and other Plymouth University faculty members at an annual seminar meeting.

Case studies were created for the best six students who could express their feelings and experiences during the course and were categorised into high, middle, and low achieving categories. Each case study included the emerging themes explored in the study. Also, the case studies included students’ interview quotes where the students described the influence of group work, bonus marks, online homework, puzzle sheets, revision notes, small boards, social media WhatsApp group application which came up as an outcome, correcting the students’ own errors, teacher’s attitude, and playing games into their self-efficacy and/or mathematical understanding. Also, the students’ interviews discussed how each aspect of the SMIC framework influenced their motivation. This encouraged the researcher to measure students’ motivation levels in the main study. The researcher used the collected emerging themes from the pilot study to make the educational approaches and sub-elements of the SMIC framework in the main study.
4.5 Refinements from The Pilot to the Main Study

4.5.1 Students’ Motivation

George (2012) showed that “student autonomy should be taken into consideration when choosing strategies through which students are motivated for achievement” (2012, p. 255). In their interviews, the students talked about their motivation during the course. Also, their level of attendance was high and they were more involved in class with the social and classroom interactions than in their previous experience. Also, 93% of the students passed the course and only one student (7%) failed, with the failing student having a clear lack of motivation. Hence, motivation was one important emerging theme in the study. The students explained in the course interviews that they were highly motivated to learn mathematics during the course and how this positively influenced their mathematical understanding and achievement. Based on this, a motivation questionnaire was designed based on previous motivation questionnaires found in the literature as referenced in the methodology chapter. This questionnaire will be implemented during the main study.

4.5.2 Concept Maps

The data collected in the pilot study did not provide enough information about the conceptual understanding of the students. Concept maps have been added to the plans for the main study in order to gain insights into the students’ conceptual understanding and how it changes during the course. The students will be given a list of conceptual ideas that they would have encountered in the Math095 course and will be asked to connect them in a map according to their understanding at the start of the course. This will be repeated at middle and end of the course adding more topics covered from Math096. Tall et al. (2001) followed similar techniques used by McGowen (1998) who implemented the use of concept maps analysis to a
class of college students studying a preliminary algebra course based on the function concept. According to Tall et al. (2001), students might maintain similar concept maps throughout the course or build on their previous maps as they develop a better conceptual understanding. In contrast, students who keep changing their map shapes and produce disjoint maps might reflect more procedural understanding and knowledge. This could provide evidence about the nature of the students’ understanding of mathematics.

4.5.3 Comparing Small Sample Statistics Analysis to Bigger Size Sample Analysis

The pilot study was implemented to one a group of 15 students. The small number of students used in the pilot study did not allow for a wide range of statistical analysis. The main study will be implemented with a larger number of groups and students. This might enable the study to include a wider statistical analysis including coding.

4.5.4 Different Gender Participation

The pilot study was implemented to one group of 15 male students, which did not allow for a wider statistical analysis that includes both genders. The main study will be implemented to a wider variety including at least one group of female students.

4.5.5 Course Duration and Taught Objectives

The pilot study was implemented in a 6 weeks condensed Summer 2016 course. The teacher had to teach two lessons which included 5 or 6 objectives each day. The main study will be applied to a three and a half month semester where the teacher will be able to teach one lesson a day which will include two or three objectives. The course in the main study will not be as condensed as the pilot study was.
4.5.6 The Duration of Class Time a Day

The pilot study was implemented during the summer session where the students were meeting in class every day for two hours and twenty minutes. The main study will be implemented in a normal semester where the students will meet in a 50 minutes’ period a day. Also, the pilot study was implemented during the holy month of Ramadan. This means, that students were attending the course everyday whilst fasting. Muslims in Ramadan start fasting at dawn and break their fast when the sun sets, which could have influenced their performance during the course. In Kuwait, young people stay up till dawn. This did have a negative influence on one students’ focus and attention in class during the pilot study. Based on that, the main study will be implemented in Fall and Spring semesters in order to avoid Ramadan.

4.5.7 Semi-structured Interview Questions

Some of the semi-structured interview questions used in the pilot study were found to be directing the students, which could have biased the results in the study. Some interview questions were changed to be implemented in the main study.

The list of semi-structured questions used at the end of the pilot study:

1) What were the differences (if any) that you found in this course that you could not see in your previous mathematics course? Please list them if possible.

2) How beneficial (or not) was your interaction with other students in group work and playing games in the classroom towards reaching your understanding so far?

3) How useful (or not) was using the online HW (PEARSON MYMATHLAB) to your mathematics understanding in this course? Why?
4) Let’s discuss your attendance and absences and their affect to your overall understanding and overall achievement in this course.

5) How do you feel about your overall grade so far? How will this affect (if any) your soon future when taking other mathematics course?

6) What happened that affected your grades in the course? What recommendations do you suggest to teachers or to yourself in order to assist you to understand the subject more and pass the course in the future?

The list of new questions that will be used in the main study:

1) How does this course compare to your previous study of mathematics, have you noticed any differences? Why?

2) Have you done better in this course than you expected? Why?

3) Let’s discuss your attendance and absences and their affect to your overall understanding and overall achievement in this course.

4) How has this course changed your view (or not) towards mathematics? Why?

5) Explain the differences between your concept maps across the course.

6) How do you feel about your overall grade so far? How do you feel about studying more mathematics courses in the future?

7) How has the online HW (PEARSON MYMATHLAB) changed your understanding? Why?

8) Let’s discuss the changes you can see in your concept maps across the course period.

9) What recommendations would you suggest to teachers in order to improve the course in the future?

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4.5.8 More Stages

In order to include a wider and more adequate analysis in the main study, data collection of the questionnaires will be implemented in four stages during the main study instead of three. The four stages of the main study data collection will include: Stage 0: start of the course, Stage 1: after the first month of the course, Stage 2: Middle of the course (after two months since the start of the course), and Stage 3: the last week of the course. This might allow better statistical analysis and clarification of students’ changes in their self-efficacy, motivation, or mathematical understanding levels.

4.6 Section Summary

The quantitative data analysis showed a noticeable improvement in students’ self-efficacy during the pilot study. Also, it showed an improvement in their test scores during the course. The study analysis showed that there was a positive correlation between students’ test scores and their self-efficacy.

The qualitative data analysis showed that students improved their mathematical understanding during the course. The students’ semi-structured interviews showed that the students improved their motivation during the course although the researcher did not attempt to measure the students’ motivation during the pilot study. The emerging themes explored in the study included group work, bonus marks, online homework, puzzle sheets, revision notes, small boards, social media (WhatsApp) group application (outcome), correcting the students’ own errors, teacher’s attitude, and playing games such as Kahoot. In their interviews, the students explained how each of these educational approaches influenced their mathematical self-efficacy and understanding.
The researcher refined the elements and stages used in the pilot study ready to be implemented in the main study. Figure 4.6 summarises the major elements and sub-elements explored in the pilot study.

Figure 4.4: Major SMIC framework elements and sub-elements explored in the pilot study.
Chapter Five: Numeric and Concept Maps Data Analysis

5.0 Introduction

This chapter presents and analyses the numeric data and concept maps collected during the study. The data includes students’ self-efficacy, motivation, and test scores. The data was collected from the background questionnaire, self-efficacy and motivation Likert scale questionnaires, and students’ test scores. Students’ self-efficacy and motivation data is considered ordinal data while the test scores are considered ratio data. Students’ self-efficacy and motivation were analysed using the median and box plots for each data group.

Descriptive data analysis such as mean, median, or standard deviation cannot be used to analyse ordinal data such as self-efficacy and motivation. On the other hand, test scores are considered ratio data. The means, standard deviation, median, and boxplots can be used to describe the average students’ scores for each group and for all groups.

Students’ tests were also analysed from the procedural and conceptual perspectives. Concept maps were examined in order to obtain the changes in students’ mathematics understanding during the course. At the end of the chapter, bridging points will be reported in order to be supported by the qualitative data collected and explored in Chapter 6 of this study. The numeric data analysis showed a clearer view of the study and the needed questions to be added to the semi structured interviews in order to show a better connection between the qualitative and quantitative data analysis in this study.
5.1 Students’ Backgrounds Related to Their Self-efficacy in Each Type of Question

Data about the students’ type of high school diploma and their corresponding self-efficacy medians at stage zero is shown in Table 5.1a.

<table>
<thead>
<tr>
<th>High School Diploma Type</th>
<th>Number of Students</th>
<th>Percentage %</th>
<th>Stage Zero Self-efficacy Median/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liberal Arts</td>
<td>61</td>
<td>46.9</td>
<td>17.0</td>
</tr>
<tr>
<td>Science</td>
<td>69</td>
<td>53.1</td>
<td>24.0</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>100.0</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Table 5.1a: Students’ types of high school diploma and their corresponding self-efficacy.

As can be seen in Table 5.1, the background of the students was at an even split between both majors and is not dominated by either Liberal Arts or Science students’ majors. On the other hand, Science students’ majors had low self-efficacy but this was higher than Liberal Arts students’ majors.

Table 5.2 shows the highest mathematics course taken at school and their corresponding self-efficacy medians.

<table>
<thead>
<tr>
<th>Highest Mathematics Course Taken at School</th>
<th>Overall Number of Students</th>
<th>Percentage %</th>
<th>Stage Zero Self-efficacy Median/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra1</td>
<td>43</td>
<td>33.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Algebra2</td>
<td>20</td>
<td>15.0</td>
<td>19.0</td>
</tr>
<tr>
<td>Pre-Calculus</td>
<td>22</td>
<td>17.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Calculus</td>
<td>45</td>
<td>35.0</td>
<td>61.0</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>100.0</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Table 5.2: Highest mathematics course taken at school and their corresponding self-efficacy medians.
Table 5.2 shows that 33% of the students participating in the study had only studied to the Algebra I level at school and had the lowest self-efficacy of the students. Further, 67% had studied at a level higher than Algebra I and should have been expected to use their mathematics knowledge to progress from the Accuplacer examination directly to college courses. This data finding does raise the possibility that these students may have been taught procedurally rather than conceptually and passed the school examinations as a consequence of learning specific techniques rather than having a deep understanding of mathematics.

In regards to self-efficacy, students with a Pre-Calculus mathematics background, as shown in Table 5.1.b, the lower backgrounds (65%) had lower self-efficacy than the rest of the students. Also, students with a Calculus background had the highest self-efficacy compared to the rest of the students.

The background questionnaire asked the students if they had taken the Math 095 course or joined the Math 096 course directly. It also asked them if they had repeated either of these courses. The results are shown in Table 5.3.
The data in Table 5.3 showed that most students participating in the study had to take a foundation course that revises very basic mathematical skills and could not pass Arithmetic in the Accuplacer examination. It is also possible that these students experienced a mathematical education that was procedurally focused and did not seem to be able to apply this knowledge after their school experiences. Some reasons to support this poor mathematical knowledge will be discussed in Chapter 6 through the individual students’ profiles and interviews.

Table 5.3 also showed that students who passed the Arithmetic section and joined Math 096 directly had higher self-efficacy than other students in the study. In contrast, student repeaters of Math 095 and/or Math 096 had lower self-efficacy than other students in the course. This
means that the higher the Arithmetic background the students had, the higher the self-efficacy he/she had at stage zero.

<table>
<thead>
<tr>
<th>Number of responses to The Statement</th>
<th>Percentage %</th>
<th>Stage Zero Self-efficacy Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>120</td>
<td>92.3</td>
</tr>
<tr>
<td>Yes</td>
<td>10</td>
<td>7.7</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 5.4: Number of students’ responses whether Maths was their favourite subject in high school and the corresponding self-efficacy medians.

The questionnaire asked the students if “Mathematics was my favourite subject taken during my high school diploma” and allowed them to answer yes or no. Table 5.4 shows that most students answered no and that these students had lower self-efficacy than the rest of the students in the study. In contrast, students who answered yes, had higher self-efficacy than the rest of the students. Chapter 6 will discuss some of the reasons for this which were revealed through students’ interviews.

<table>
<thead>
<tr>
<th>Number of students’ Responses to The Statement</th>
<th>Percentage %</th>
<th>Stage Zero Self-efficacy Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>19</td>
<td>14.6</td>
</tr>
<tr>
<td>Yes</td>
<td>111</td>
<td>85.4</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 5.5: Number of students’ responses whether they could solve any mathematics problem without the help of a calculator and the corresponding self-efficacy medians.

Also, the questionnaire asked the students “I cannot solve any mathematics problem without the help of a calculator” and allowed them to answer yes or no. The data in Table 5.5 shows that most students answered yes and had lower self-efficacy than the rest of the students. In
contrast, students who answered no had higher self-efficacy than the rest of the students in the course. This suggests that those students participating in the study graduated with poor mental Arithmetic skills and high levels of calculator dependence. This could have been a contributing factor for the high failure rate on the Arithmetic section of the Accuplacer examination where calculators are not permitted.

<table>
<thead>
<tr>
<th>Number of Students’ Responses to the Statement</th>
<th>Percentage %</th>
<th>Stage Zero Self-efficacy Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>120</td>
<td>92.3</td>
</tr>
<tr>
<td>Yes</td>
<td>10</td>
<td>7.7</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 5.6: Number of students’ responses whether they enjoyed using different computing programs when solving an algebraic problem

Another question the questionnaire asked the students was “I enjoy using different computing programs when solving an algebraic problem” and allowed them to answer yes or no. The data in Table 5.6 showed that most students answered no and had lower self-efficacy than the rest of the students. On the other hand, students who answered yes had high self-efficacy. The reasons behind this will be explored in Chapter 6 using the interview data.

<table>
<thead>
<tr>
<th>Number of Students’ Responses to the Statement</th>
<th>Percentage %</th>
<th>Stage Zero Self-efficacy Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>22</td>
<td>17.0</td>
</tr>
<tr>
<td>Yes</td>
<td>108</td>
<td>83.0</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 5.7: Number of students’ responses whether they believed that it is important to take a foundation mathematics course before joining the academic program at GUST.
Lastly, the questionnaire asked the students if they believed that “It is important for me to take a foundation mathematics course before joining the academic program at GUST”. The data in Table 5.7 shows that most students answered yes and had low self-efficacy. On the other hand, students who answered no had high self-efficacy. This means that students with low self-efficacy realised their weaknesses in mathematics and are keen to improve their mathematical knowledge in preparation for college courses. This also means that students with high self-efficacy realised that they did not require to take any mathematics foundation course in order to prepare for college courses. More related information will be provided in Chapter 6 from the students’ interviews.

5.2 Students’ Self-efficacy

This section discusses the changes which occurred in students’ self-efficacy from stages 0 to 3 with self-efficacy being scored out of 70. Table 5.8, and Figures 5.1 to 5.4 show self-efficacy changes during the study. The eight participating groups in the study are presented by G1 to G8. Each group represents a Math 096 class section. Students were divided randomly into each group from the GUST registrar’s office and students’ enrollment system.
<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
<th>Median for total students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>24.0</td>
<td>20.5</td>
<td>27.5</td>
<td>21.0</td>
<td>18.0</td>
<td>22.0</td>
<td>22.5</td>
<td>20.5</td>
<td>21.0</td>
</tr>
<tr>
<td>Stage 1</td>
<td>38.5</td>
<td>37.5</td>
<td>42.5</td>
<td>37.5</td>
<td>36.0</td>
<td>38.5</td>
<td>38.0</td>
<td>38.0</td>
<td>38.0</td>
</tr>
<tr>
<td>Percentage Increase From Stage 0 to 1</td>
<td>60.4</td>
<td>82.9</td>
<td>54.5</td>
<td>78.6</td>
<td>100.0</td>
<td>75.0</td>
<td>68.9</td>
<td>85.4</td>
<td>81.0</td>
</tr>
<tr>
<td>Stage 2</td>
<td>65.0</td>
<td>59.0</td>
<td>54.0</td>
<td>54.5</td>
<td>50.0</td>
<td>55.0</td>
<td>56.5</td>
<td>50.5</td>
<td>54.0</td>
</tr>
<tr>
<td>Percentage Increase From Stage 1 to 2</td>
<td>68.8</td>
<td>57.3</td>
<td>27.1</td>
<td>45.3</td>
<td>38.9</td>
<td>42.9</td>
<td>48.7</td>
<td>32.9</td>
<td>42.1</td>
</tr>
<tr>
<td>Stage 3</td>
<td>66.0</td>
<td>65.5</td>
<td>65.0</td>
<td>64.0</td>
<td>65.0</td>
<td>67.5</td>
<td>66.0</td>
<td>67.0</td>
<td>66</td>
</tr>
<tr>
<td>Percentage Increase From Stage 2 to 3</td>
<td>1.5</td>
<td>11.0</td>
<td>20.4</td>
<td>17.4</td>
<td>30.0</td>
<td>22.7</td>
<td>16.8</td>
<td>32.7</td>
<td>22.2</td>
</tr>
<tr>
<td>Percentage Increase From Stage 0 to 3</td>
<td>175</td>
<td>219.5</td>
<td>136.4</td>
<td>204.8</td>
<td>261.1</td>
<td>206.8</td>
<td>193.3</td>
<td>226.8</td>
<td>214.3</td>
</tr>
</tbody>
</table>

Table 5. 8: Students’ self-efficacy medians at each stage of the course.
Figure 5.1: Self-efficacy boxplots at stage 0

Figure 5.2: Self-efficacy boxplots at stage 1

Figure 5.3: Self-efficacy boxplots at stage 2

Figure 5.4: Self-efficacy boxplots at stage 3
Considering Figures 5.1 to 5.4, self-efficacy for all participating groups gradually improved from stage 0 to 3. Also, this can be seen from the range of the box-plots as they started at wide ranges (stage 0 and 1), then decreased at stage 2 and 3. Although self-efficacy increased throughout the course, the highest percentage increase was between stage 0 and 1. This improvement also can be seen in Figure 5.5. This improvement and further discussions to support it will be discussed in the details with the qualitative data analysis in Chapter 6.

![Boxplots of self-efficacy at each stage](image)

**Figure 5.5: Self-efficacy boxplots at each stage.**

Table 5.9 shows the results of testing the internal consistency of self-efficacy results using Cronbach’s Alpha

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha Based on Standardized Items</td>
</tr>
<tr>
<td>.728</td>
</tr>
</tbody>
</table>

Table 5.9: Cronbach’s Alpha for self-efficacy questionnaire results

This shows that 73% of the variance in self-efficacy questionnaire results is reliable
5.3 Students’ Motivation

This section discusses the changes that occurred in students’ motivation from stages 0 to 3 with motivation being scored out of 50. Table 5.10, and Figures 5.6 to 5.9 show the motivation changes which occurred during the study as described in section 5.0.
<table>
<thead>
<tr>
<th>Stage</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
<th>Median for total students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>17.0</td>
<td>14.0</td>
<td>19.5</td>
<td>15.0</td>
<td>13.0</td>
<td>14.5</td>
<td>15.5</td>
<td>15.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Stage 1</td>
<td>31.5</td>
<td>33.5</td>
<td>28.5</td>
<td>26.5</td>
<td>26.0</td>
<td>27.0</td>
<td>26.5</td>
<td>26.5</td>
<td>27.0</td>
</tr>
<tr>
<td>Percentage Increase From Stage 0 to 1</td>
<td>85.3</td>
<td>139.3</td>
<td>46.2</td>
<td>76.7</td>
<td>100.0</td>
<td>86.2</td>
<td>71.0</td>
<td>76.7</td>
<td>80.0</td>
</tr>
<tr>
<td>Stage 2</td>
<td>45.0</td>
<td>43.5</td>
<td>39.5</td>
<td>39.5</td>
<td>36.0</td>
<td>40.5</td>
<td>44.0</td>
<td>35.5</td>
<td>39.0</td>
</tr>
<tr>
<td>Percentage Increase From Stage 1 to 2</td>
<td>42.9</td>
<td>29.9</td>
<td>38.6</td>
<td>49.1</td>
<td>38.5</td>
<td>50.0</td>
<td>66.0</td>
<td>34.0</td>
<td>44.4</td>
</tr>
<tr>
<td>Stage 3</td>
<td>47.0</td>
<td>47.5</td>
<td>47.0</td>
<td>46.0</td>
<td>46.0</td>
<td>47.0</td>
<td>46.5</td>
<td>48.0</td>
<td>47.0</td>
</tr>
<tr>
<td>Percentage Increase From Stage 2 to 3</td>
<td>4.4</td>
<td>9.2</td>
<td>19.0</td>
<td>16.5</td>
<td>27.8</td>
<td>16.0</td>
<td>5.7</td>
<td>35.2</td>
<td>20.5</td>
</tr>
<tr>
<td>Percentage Increase From Stage 0 to 3</td>
<td>176.5</td>
<td>239.3</td>
<td>141.0</td>
<td>206.7</td>
<td>253.8</td>
<td>224.1</td>
<td>200.0</td>
<td>220.0</td>
<td>213.3</td>
</tr>
</tbody>
</table>

Table 5. 10: Students’ motivation medians at each stage of the course.
Figure 5.6: Motivation boxplots at stage zero

Figure 5.7: Motivation boxplots at stage 1

Figure 5.8: Motivation boxplots at stage 2

Figure 5.9: Motivation boxplots at stage 3
Considering Figures 5.6 to 5.9, that students’ motivation for all participating groups gradually improved from stage 0 to 3. Also, this can be seen from the range of the box-plots as they started at wide ranges (stage 0 and 1), then decreased at stage 2 and 3. Although student’s motivation increased throughout the course, the highest percentage increase was between stage 0 and 1. This improvement also can be seen in figure 5.10. This improvement and further discussions to support it will be discussed further with the qualitative data analysis in Chapter 6.

![Boxplot Image]

Figure 5.10: Motivation boxplots for the total score for all groups of students participating in the study for all stages.

Table 5.11 shows the results of testing the internal consistency of the motivation questionnaire results using Cronbach’s Alpha

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha Based on Standardized Items</td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
</tr>
</tbody>
</table>

Table 5.11: Cronbach’s Alpha for motivation questionnaire results
This shows that 75% of the variance in the motivation questionnaire results is reliable.

5.4 Self-efficacy Outliers

This section discusses self-efficacy student outliers explored in Figures 5.11 to 5.14 from stage 0 to 3. Twelve student outliers were found from Figure 5.4 with the lowest self-efficacy compared to self-efficacy for the rest of the students in the study. The 12 outliers found in stage 3 were also noticed in previous stages. It is interesting to track their academic information during the course in order to find reasons for being outliers in the figure and the last stage of the course.

Also, another 8 student outliers with the highest self-efficacy were found in Figure 5.1 at stage 0. Their academic changes were tracked during the course in order to compare them with outliers with low self-efficacy and to find reasons for being outliers in the figure.

The discussed academic information includes:
1) Self-efficacy (SE)
2) Motivation (Mt)
3) Test scores
4) Success status (P = Pass or NP = Not Pass)
5) Number of times taken Math 095 and/or Math 096
6) High school major type
7) Attendance records (out of 75 days a course)

5.4.1 High Self-efficacy Outliers

Table 5.12 shows the academic changes for high self-efficacy outliers. All students’ names have been changed and the names being used are just labels for different students.
<table>
<thead>
<tr>
<th>Name</th>
<th>Salem</th>
<th>Atiq</th>
<th>Lulu</th>
<th>Azizah</th>
<th>Modhif</th>
<th>Modhish</th>
<th>Komairi</th>
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<td>97.33</td>
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Table 5. 12: Academic changes for high self-efficacy outliers.
Figure 5.11: Lulu’s academic changes

Figure 5.12: Azizah’s academic changes

Figure 5.13: Atiq’s academic changes

Figure 5.14: Salem’s academic changes
Figure 5.11 to 5.14, compared students’ self-efficacy, motivation and test score changes at each stage. Figure 5.11 showed how Lulu started at high self-efficacy and motivation levels from the start to the end of the course. She passed Arithmetic in the Accuplacer examination and was admitted directly to Math 096. Lulu passed the course and had a high attendance total.

Atiq shown in Figure 5.13 started the course with a noticeably high self-efficacy and high motivation levels. He passed Arithmetic in the Accuplacer examination and was admitted directly to Math 096. He was a Math 096 repeater. He passed the course and had a high attendance total.

Similarly, Salem started the course with high self-efficacy and motivation levels shown in Figure 5.14. She passed Arithmetic in the Accuplacer examination and was admitted directly to Math 096. She passed the course and had a high attendance total.

Lastly, Azizah as shown in figure 5.12 started the course with high self-efficacy and motivation levels. He took Math 095 once and Math 096 once. He passed the course with a high attendance total and number of days.

In summary, it was noticeable that all high self-efficacy students’ outliers started and continued the course with high self-efficacy and motivation levels. They also started with higher level quiz scores and continued the course with high testing scores. Moreover, they were all Science high school major students and passed the course with high attendance totals. This means, high self-efficacy outliers were able to maintain their high self-efficacy, motivation, and test scores along the course. In regards to the attendance percentages, it is
shown to be between 94% and 100%. This shows that all high self-efficacy students had a high attendance percentage. Reasons behind their continuous high mathematics achievement will be discussed in the following chapter when studying individual students’ profiles and finding the study’s emerging themes.

5.4.2: Low Self-efficacy Outliers

Table 5.13 show the academic changes for low self-efficacy outliers.
<table>
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<th>Name</th>
<th>Fadel</th>
<th>Salah</th>
<th>Ajmi</th>
<th>Duwail</th>
<th>Nawal</th>
<th>Sareen</th>
<th>Hawree</th>
<th>Sara</th>
<th>Athba</th>
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<td>74.67</td>
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Table 5.13: Academic changes for low self-efficacy outliers.
Figure 5.15: Salah’s academic changes

Figure 5.16: Fadel’s academic changes

Figure 5.17: Nawal’s academic changes

Figure 5.18: Sara’s academic changes
Salah as shown in Figure 5.15 started the course with low self-efficacy but gradually improved it during the course. He started with a low motivation level as well but also gradually improved it during the course. Also, he started with a low level quiz score but improved his test scores and the final exam towards the end of the course. He took Math 095 course once and Math 096 course once. He failed Math 096 with a low attendance rate.

Fadel as shown in figure 5.16 started the course with low self-efficacy but he gradually improved it during the course. He started with a low motivation level as well but gradually improved it during the course. He took Math 095 course once and Math 096 course once. Even though he attended the course with low motivation and self-efficacy he continued to improve them as well as his test scores towards the end. He failed Math 096 with a low attendance rate.

Nawal as shown in figure 5.17 started the course with low self-efficacy and motivation level but gradually improved them during the course. She took Math 095 course once and Math 096 course twice. She was considered to be a student with disability. Also, she started with a low score in her level quiz but improved her test scores towards the end of the course. She was a Liberal Arts major student. She failed Math 096 with a low attendance rate.

Sara as shown in figure 5.18 started the course with low self-efficacy and motivation level but she continued to improve them towards the end of the course. Also, she started with a low score in her level quiz but improved her test scores towards the final exam. Sara was (and still is) the carer of her ill grandmother. She could not attend the course on a regular basis because of her grandmother’s illness. She failed all of her courses in the Fall 2017. She took Math 095 twice and Math 096 course once. She was a Liberal Arts major student. Her attendance total was low. She failed the course.
In summary, it was noticeable that all low self-efficacy students started the course with low self-efficacy and motivation levels. They improved their self-efficacy and motivation over the course, and particularly towards the end of the course. They also improved and continued improving their test scores towards the final exam. Moreover, most low self-efficacy students were Liberal Arts high school majors and took Math 095 course and Math 096 more than once.

In regards to the attendance percentage, GUST history has shown very low attendance rates for all courses. GUST started 14 years ago with no attendance recording system. Three years later, they started using the automated swiping record system and assigned penalties for exceeding the allowed number of absence days. In this study, high self-efficacy students’ outliers showed attendance rates from 94 to 100%, while low self-efficacy outliers’ students showed 73 to 84%. This means, the lower the attendance rate, the lower the students’ grades. Also, the higher the students’ attendance rates, the higher the students’ grades and achievement in this course. Lent, Lopez, Brown, and Gore (1996) mentioned part of Bandura’s (1986) research which found that “efficacy percepts are acquired and modified largely through four major informational sources: (a) personal performance accomplishments, which include one’s pattern of successes and failures at particular tasks or activities; (b) vicarious learning, or observation of other people’s performance attainments; (c) social persuasion, involving the encouragement or discouragement that one receives from significant others for engaging in particular activities; and (d) physiological states and reactions, including the pleasant or unpleasant emotional and physical sensations (e.g., anxiety, fatigue, composure) that one experiences while performing particular tasks. These four sources are seen as interacting dynamically to affect self-efficacy judgments” (p. 293). It also can be seen that, low self-efficacy students’ outliers were able to improve their self-
efficacy, motivation, and test scores during the course with more than a 50% rate but not enough to pass the course. Some of them had personal circumstances that could have influenced their attendance rates and their understanding in the course. Further discussions will be provided in the following chapter when individual students’ profiles and interviews are studied.

5.5 Level Quiz and Tests

This section reports on the students’ mathematical knowledge revealed through students’ test scores at each stage of the course in percentages. These scores are shown in Table 5.14, and Figures 5.19 to 5.22. All the course tests are cumulative. This means that some Test 2 students’ learning objectives were included in Test 1. Similarly, Test 4 included students’ learning objectives from Test 1 and 2. The syllabus was designed in order to connect the course contents from the start to the end of course. This assisted the teacher to observe students’ progress in understanding course contents, and particularly to identify their strength and weaknesses at each stage.
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<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>G7</th>
<th>G8</th>
<th>Mean for all Groups Together</th>
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<td>48</td>
<td>41</td>
<td>46</td>
<td>46</td>
<td>30.6</td>
<td>28</td>
<td>39.5</td>
<td>27</td>
<td><strong>38.6</strong></td>
</tr>
<tr>
<td>Mean (%) for Stage 1</td>
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<td>73.5</td>
<td>63.5</td>
<td>67.3</td>
<td>75</td>
<td>58</td>
<td><strong>67.6</strong></td>
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<tr>
<td>Percentage Increase From Stage 0 to 1</td>
<td>54.2</td>
<td>63.4</td>
<td>34.8</td>
<td>59.8</td>
<td>107.5</td>
<td>140.4</td>
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<td>Mean (%) for Stage 2</td>
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<td>Percentage Increase From Stage 2 to 3</td>
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<td>7.3</td>
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<td>18.2</td>
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</table>

Table 5.14: Students’ test scores (mean in percentage) at each stage of the course.
Figure 5.19: Level quiz boxplots at stage 0

Figure 5.20: Test 1 boxplots at stage 1

Figure 5.21: Test 2 boxplots at stage 2

Figure 5.22: Test 4 boxplots at stage 3
Test scores are considered ratio data. The means, the mean and standard deviation, median, and boxplots can be used to describe the average students’ scores for each group and for all groups. It can be seen in table 5.14 and figures 5.19 to 5.22 that these students’ scores gradually improved from stages 0 to 3. The highest percentage increase was from stages 0 to 1. This might be an indicator that a significant change occurred in the students’ mathematics knowledge during the first month of the course. More information regarding this will be provided in students’ interviews in Chapter 6.

Figure 5.23: Level quiz and test scores (%) for all students together participating in the study.

Figure 5.23, shows that the ranges of the test scores decreased from stages 0 to 3 and the medians increased. This supports the results shown in figures 5.19 to 5.22 for the individual teaching groups. Not only does the increasing mean indicate better understanding but the decreasing variations support this. The reasons to support this finding will be discussed from the students’ interviews in the next chapter.
5.6 Correlations

This section explores whether there is a correlation between students’ test scores and their self-efficacy and/or motivation during the study. This will reflect the meaning of the correlation in the study if exists.

5.6.1 Students’ Self-Efficacy and Test Scores

SPSS was used to analyse the numeric data in this study. Table 5.15 shows Pearson Correlation between students’ self-efficacy and their test scores.

<table>
<thead>
<tr>
<th>Correlations</th>
<th>All S.E. Total Scores (%)</th>
<th>All Test Scores (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All S.E. Total Scores (%)</td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.654**</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>520</td>
</tr>
<tr>
<td>All Test Scores (%)</td>
<td>Pearson Correlation</td>
<td>.654**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>520</td>
</tr>
</tbody>
</table>

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

Table 5.15: Pearson Correlation between students’ self-efficacy and their test scores.

The table shows that there is a noticeable positive correlation between students’ self-efficacy and test scores during the study.

5.6.2 Students’ Motivation and Test Scores

Table 5.16: Pearson Correlation between students’ motivation and their test scores.

<table>
<thead>
<tr>
<th>Correlations</th>
<th>All MT. Total scores (%)</th>
<th>All Test Scores (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All MT. Total scores (%)</td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.684**</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>520</td>
</tr>
<tr>
<td>All Test Scores (%)</td>
<td>Pearson Correlation</td>
<td>.684**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>520</td>
</tr>
</tbody>
</table>

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

Table 5.16: Pearson Correlation between students’ motivation and their test scores.
The table shows that there is a noticeable positive correlation between students’ motivation and test scores during the study.

5.7 Procedural and conceptual understanding

The data collected was also analysed by looking at the mathematics knowledge included in each test from procedural and conceptual perspectives. A question is considered conceptual if it is based on devising a strategy/strategies or technique(s) in order to answer the question rather than simply recalling a method. Also, conceptual questions are higher-order thinking questions. An example of a conceptual question is “Solve and Graph: $-19 \leq -2y - 7$ and $-7 - 2y < -20$” where the students have to solve each inequality separately, graph the solutions on the number line and devise a technique in order to translate ‘and’ into a solution using interval notation. This is not typical of a question that students have studied in class.

A question is considered procedural if it is based on recalling familiar strategies. An example of a procedural question is “Solve: $10 - 3(2x - 1) - 5 = 1 - 5$”. This is a typical question that students have practiced in class sessions and using MyMathLab.

Tables 5.17 to 5.20 show the style (procedural or conceptual) and description of each question in each test.

<table>
<thead>
<tr>
<th>Question number and type</th>
<th>Style</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a)-Simplify BEDMAS</td>
<td>Procedural</td>
<td>Use BEDMAS properties to simplify the question.</td>
</tr>
<tr>
<td>b)- Simplify using</td>
<td>Procedural</td>
<td>Use exponential properties to simplify the expression.</td>
</tr>
</tbody>
</table>
2 a) Arithmetic
Conceptual
Substitute the given value of \( x \) and demonstrate the issues of the concept of \( x/0 \)

b) Arithmetic
Conceptual
Substitute the given value of \( x \) and demonstrate the issues of the concept of \( 0/x \)

3-Solve Linear equation with one variable.
Procedural
Use algebraic properties to find the value of the unknown.

4- Word problem (%).
Conceptual
Translate words into algebraic equation (using percentage) and solve for the unknown.

5-Solving algebraic equation using operations on polynomials.
Conceptual
Translate the meaning of equilibrium into an equation (Revenue = Cost). Use the appropriate technique to solve the algebraic equation in order to find the number of cellphones produced.

<table>
<thead>
<tr>
<th>Question number</th>
<th>Style</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a) Solve inequality</td>
<td>Procedural</td>
<td>Use algebraic properties to solve the given inequality. Graph the solution on the number line, and express the solution using interval notation.</td>
</tr>
<tr>
<td>b) Solve two inequalities (and)</td>
<td>Conceptual</td>
<td>Select the appropriate technique to solve the simultaneous inequalities. Graph both solutions on the number line. Express the meaning of (and) using interval notation.</td>
</tr>
<tr>
<td>2- Substitution (word problem)</td>
<td>Procedural</td>
<td>Substitute a given value in the ‘x’ and find the value of ( y ).</td>
</tr>
<tr>
<td>3- Solve two inequalities (or)</td>
<td>Conceptual</td>
<td>Select the appropriate technique to solve the simultaneous inequalities. Graph both solutions on the number line. Express the meaning of (or) using interval notation.</td>
</tr>
<tr>
<td>4- a) Translate and solve</td>
<td>Procedural</td>
<td>Find the given percentage of a given quantity ‘What is 8% of 220?’</td>
</tr>
<tr>
<td>4-b) Translate and solve in % (word problem.)</td>
<td>Conceptual</td>
<td>Translate words into algebraic equation (using percentage) and solve it.</td>
</tr>
<tr>
<td>Question number</td>
<td>Style</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1) Multiply polynomials (a, b, &amp; c)</td>
<td>Procedural</td>
<td>Perform algebraic and exponential properties in order to multiply polynomials.</td>
</tr>
<tr>
<td>2) Divide polynomials</td>
<td>Procedural</td>
<td>Perform algebraic and exponential properties in order to divide polynomials.</td>
</tr>
<tr>
<td>3) Add or subtract polynomial</td>
<td>Procedural</td>
<td>Use algebraic properties to add or subtract polynomials.</td>
</tr>
</tbody>
</table>

Table 5. 18: Test 1 procedural and conceptual question styles and descriptions.
<table>
<thead>
<tr>
<th>Question number</th>
<th>Style</th>
<th>Description</th>
<th>Stage taken at</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Solve linear equation with one variable</td>
<td>Procedural</td>
<td>Use algebraic properties and steps to find the value of the unknown.</td>
<td>0 to 1</td>
</tr>
<tr>
<td>2) Function properties (domain, range) (a, b, c, d, and e)</td>
<td>Procedural</td>
<td>For the given graph, find the domain, range and f(x) when x is given.</td>
<td>2 to 3</td>
</tr>
<tr>
<td>3) Word problem (%)</td>
<td>Conceptual</td>
<td>Translate words into algebraic equation (using percentages) and solve for the unknown.</td>
<td>0 to 1</td>
</tr>
<tr>
<td>4) Solve two inequalities (or)</td>
<td>Conceptual</td>
<td>Select the appropriate technique to solve the simultaneous inequalities. Graph both solutions on the number line. Express the meaning of the solution using interval notation.</td>
<td>0 to 1</td>
</tr>
<tr>
<td>5) Multiply polynomials (a, b, and c)</td>
<td>Procedural</td>
<td>Perform algebraic and exponential properties in order to multiply polynomials.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>6) Add and subtract polynomials</td>
<td>Procedural</td>
<td>Use algebraic properties in order to add or subtract polynomials.</td>
<td>1 to 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>7) Divide polynomials</td>
<td>Procedural</td>
<td>Perform algebraic and exponential properties in order to divide polynomials.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>8) Factor polynomials (a, and b)</td>
<td>Procedural</td>
<td>Use the appropriate algebraic and exponential properties to divide polynomials.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>9) Solve quadratic equations (a, and b)</td>
<td>Procedural</td>
<td>Use factoring property in order to solve the quadratic equation for the unknown.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>10) a) Add or subtract rational expressions</td>
<td>Procedural</td>
<td>Find the LCD and add or subtract rational expressions.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>10b) Multiply or divide rational expressions</td>
<td>Procedural</td>
<td>Use factoring property, multiply or divide rational expressions.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>11) Solve rational equations</td>
<td>Procedural</td>
<td>Find the LCD and use the required steps (including factoring quadratic equation) to solve for the unknown.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>12) a) Find the break-even point</td>
<td>Conceptual</td>
<td>Translate the meaning of break-even point by using the Revenue and Cost equations in order to solve the quadratic equation for the unknown.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>12b) Simplify rational expression</td>
<td>Procedural</td>
<td>Use LCD and algebraic properties to simplify the rational expressions.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>13a) Substitution (word problem)</td>
<td>Procedural</td>
<td>Substitute a given value for ‘x’ and find the value of y.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>13b) Solve quadratic equation</td>
<td>Conceptual</td>
<td>Translate the meaning of no profit into a strategy in order to solve the quadratic equation for the unknown.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>14) Solve linear equation with one variable.</td>
<td>Conceptual</td>
<td>Translate the words into an algebraic equation and solve it. It involved changing currency between Dinar and Fils.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>15) Divide and simplify rational and exponential expressions</td>
<td>Procedural</td>
<td>Use exponential properties to divide and simplify the rational expressions.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>16) Simplify radical expressions (a and b)</td>
<td>Procedural</td>
<td>Use exponential properties to simplify the given expression.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>17) Find the slope, y-intercept and x-intercept for the given linear equation. (a, b, c, and d)</td>
<td>Procedural</td>
<td>For the given linear equation, rearrange the equation into y = mx + b form. Find the slope, x and y-intercepts. Then graph the equation.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>18) Solve the quadratic equation</td>
<td>Procedural</td>
<td>Solve the given quadratic equation using the quadratic formula.</td>
<td>1 to 2</td>
</tr>
<tr>
<td>19) Solve quadratic equation (word problem).</td>
<td>Conceptual</td>
<td>Find a strategy to assume the length of the office. Translate the given area, width and assumed length of the office into an equation. Use the appropriate techniques to solve the quadratic equation using factoring or quadratic formula for the unknown.</td>
<td>1 to 2</td>
</tr>
</tbody>
</table>

Table 5. 20: Test 4 procedural and conceptual question styles.
Since the course tests were cumulative, the final exam included a total of 34 questions that students were exposed to at different stages as follows:

- 8 questions from stages 0 to 1
- 10 questions from stages 1 to 2
- 16 questions from stages 2 to 3

Students were exposed to the question types included in stages 0 to 1 and 1 to 2. On the other hand, they were not exposed to the question types included from stages 2 to 3. This means, they were not exposed to 47% of the question types included in Test 4. This percentage of questions included both procedural and conceptual questions.

Table 5.21 shows the average success rate for procedural and conceptual questions in each test. Success rate is defined as students gaining 70% or more of the marks for procedural or conceptual questions in each test.

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Procedural: Average Success Rate in The Level Quiz</th>
<th>Conceptual: Average Success Rate in The Level Quiz</th>
<th>Procedural: Average Success Rate or in Test 1</th>
<th>Conceptual: Average Success Rate in Test 1</th>
<th>Procedural: Average Success Rate in Test 2</th>
<th>Conceptual: Average Success Rate in Test 2</th>
<th>Procedural: Average Success Rate in Test 4</th>
<th>Conceptual: Average Success Rate in Test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>46.0</td>
<td>20.0</td>
<td>70.7</td>
<td>71.5</td>
<td>83.7</td>
<td>82.7</td>
<td>91.7</td>
<td>85.0</td>
</tr>
<tr>
<td>G2</td>
<td>37.8</td>
<td>16.5</td>
<td>69.7</td>
<td>71.4</td>
<td>80.7</td>
<td>77.1</td>
<td>83.9</td>
<td>81.2</td>
</tr>
<tr>
<td>G3</td>
<td>45.1</td>
<td>21.6</td>
<td>61.3</td>
<td>57.8</td>
<td>78.1</td>
<td>76.3</td>
<td>100.0</td>
<td>95.4</td>
</tr>
<tr>
<td>G4</td>
<td>40.0</td>
<td>14.0</td>
<td>68.8</td>
<td>75.3</td>
<td>87.1</td>
<td>85.4</td>
<td>85.3</td>
<td>83.5</td>
</tr>
<tr>
<td>G5</td>
<td>31.4</td>
<td>4.9</td>
<td>60.5</td>
<td>66.9</td>
<td>81.6</td>
<td>78.6</td>
<td>82.1</td>
<td>79.5</td>
</tr>
<tr>
<td>G6</td>
<td>27.0</td>
<td>6.0</td>
<td>61.0</td>
<td>64.1</td>
<td>78.0</td>
<td>75.0</td>
<td>79.9</td>
<td>78.8</td>
</tr>
<tr>
<td>G7</td>
<td>31.3</td>
<td>16.7</td>
<td>67.1</td>
<td>73.4</td>
<td>83.8</td>
<td>81.5</td>
<td>81.7</td>
<td>81.3</td>
</tr>
<tr>
<td>G8</td>
<td>26.0</td>
<td>14.4</td>
<td>39.0</td>
<td>44.2</td>
<td>78.6</td>
<td>72.1</td>
<td>79.1</td>
<td>77.5</td>
</tr>
<tr>
<td>Average of All Groups</td>
<td><strong>35.6</strong></td>
<td><strong>14.3</strong></td>
<td><strong>62.3</strong></td>
<td><strong>65.6</strong></td>
<td><strong>81.5</strong></td>
<td><strong>78.6</strong></td>
<td><strong>85.5</strong></td>
<td><strong>82.8</strong></td>
</tr>
</tbody>
</table>

Table 5.21: Procedural and conceptual average success rate in all tests in the course.

Figure 5.25 shows the procedural and conceptual average success rate in all tests in the course.
The results in Figure 5.24 seem to show that the success rates at the stage 0 are procedural more than conceptual. This means that students started the course with procedural understanding more than conceptual understanding as the procedural average success rate is almost double the value of the conceptual average success rate.

The noticeable change in the procedural and conceptual success rates shown in Figure 5.6.e occurred between stages 0 to 1. The procedural success rate improved by almost double the value from stages 0 to 1 and continued with gradual improvements from stages 1 to 2 and then 2 to 3. On the other hand, the conceptual success rate improved almost by triple the value from stages 0 to 1 and continued with gradual improvement from stages 1 to 2 and 2 to 3. This means that students started the course with weaker mathematics understanding but
showed a major improvement from stages 0 to 1 especially in their conceptual understanding. They also showed improvements from stages 1 to the end of course conceptually and procedurally. This means students improved their mathematics understanding during the course. More information to support this will be discussed in Chapter 6.

Studying similar questions between the level quiz and Test 4, three questions only were found. Tables 5.22 and g compare the success rate for the three similar questions. The aim of using this comparison is to determine whether students improved their procedural and/or conceptual understanding from the Level quiz to Test 4.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Style</th>
<th>Number of Students at Success Rate /130</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Simplify Using Exponential Properties</td>
<td>Procedural</td>
<td>12</td>
<td>9.2</td>
</tr>
<tr>
<td>3-Solve Linear Equation with One Variable.</td>
<td>Procedural</td>
<td>65</td>
<td>50.0</td>
</tr>
<tr>
<td>4-Find the Profit. Word Problem (%)</td>
<td>Conceptual</td>
<td>15</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Table 5. 22: The percentage at success rate in the Level quiz

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Style</th>
<th>Number of Students at Success Rate/130</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divide and simplify rational and exponential expressions</td>
<td>Procedural</td>
<td>106</td>
<td>84.8</td>
</tr>
<tr>
<td>1) Solve linear equation with one variable</td>
<td>Procedural</td>
<td>124</td>
<td>99.2</td>
</tr>
<tr>
<td>12) Find the profit</td>
<td>Conceptual</td>
<td>102</td>
<td>81.6</td>
</tr>
</tbody>
</table>

Table 5. 23: The percentage of students at success rate in Test 4.
Tables 5.22 and 5.23 show that these students’ abilities to solve procedural problems in these topic areas improved from stages 0 to 3. Similarly, the tables show that the students’ abilities to solve conceptual questions improved from stages 0 to 3.

The procedural-conceptual understanding was also studied from another perspective. Figure 5.25 gives two similar conceptual examples of the same student whose ability improved to solve a conceptual word problem during the course from the Level Quiz to Test 4.

Figure 5.25: Two examples for the same student whose ability to solve a certain conceptual question in the Level quiz (left) and later in Test 4 (right).

Figure 5.25 demonstrates an example for one student who could not solve one conceptual question (*Find the meaning of equilibrium by using Revenue = Cost*) in the Level quiz. He tried to use a rational expression which was an inappropriate method to solve the question. He tried to simplify $150x^2$ without realizing that he could not simplify when the expression was connected to addition or subtraction. The student was unable to select the appropriate
technique in order to solve the problem. In Test 4 (Find the meaning of break-even by using Revenue = Cost), not only could the same student solve the question correctly, but he used new techniques such as ‘solving quadratic equations using factoring’ to solve the question. He showed completed algebraic steps when combining like terms and factoring quadratic equation before solving the equation. This means, the student had developed his ability to select the suitable mathematics technique in order to solve this type of conceptual word problem compared to his mistakes made in the Level quiz. This means, according to (tables 5.21, 5.22 and 5.23) the students made some improvement in their mathematical understanding during the course.

The students in the study started the course with procedural understanding more than conceptual understanding. They started the course with weaker conceptual and procedural understanding but showed a major improvement during the course especially in their conceptual understanding at the first stage. Also, they showed major improvement in their abilities solving similar (procedural and conceptual) questions from the Level quiz and Test 4. These results were major indicators that the students improved their mathematics understanding during the course.

5.8 Concept Maps

The participating students were asked to draw concept maps and connect the topics (students’ learning outcomes) that they had encountered in the Math 095 and the Math 096 courses. They completed these concept maps at stages 0, 2 and 3. The use of concept maps gives an indicator of the level of the students’ level of connectivity which might be an indicator of their conceptual understanding at a particular point during the course. When analysing these concept maps, two basic approaches were used: quantitative and qualitative. In this chapter,
concept maps will be analysed quantitatively. Individual concept maps will be analysed qualitatively in Chapter 6.

The quantitative approach included the use of different scoring methods such as counting the number of valid links and invalid links (if any) according to Kinchin, Hay & Adams (2000). Table 5.24 shows the codes and the description of the criteria used when analysing the concept maps for all students participating in the study.

Also, SPSS was used to analyse the data collected. This study is different with its curriculum and mathematical level contents than research studies done by Kinchin, Hay & Adams (2000) or McGowen and Tall (2001). This led the researcher to design a coding system that assumed that High connectivity is an indicator of a more conceptual understanding. The score was calculated for each concept map using this formula: Score = Number of valid links - Number of invalid links.

<table>
<thead>
<tr>
<th>Name of Code</th>
<th>Code Number</th>
<th>Score (valid links)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Connectivity</td>
<td>1</td>
<td>0-15</td>
</tr>
<tr>
<td>Medium Connectivity</td>
<td>2</td>
<td>16-20</td>
</tr>
<tr>
<td>High Connectivity</td>
<td>3</td>
<td>More than 20</td>
</tr>
</tbody>
</table>

Table 5.24: Concept map connectivity codes and descriptions.

An example of ‘Low Connectivity’ is shown in Figure 5.27, ‘Medium Connectivity’ is shown in Figure 5.28 and ‘High Connectivity’ is shown in Figure 5.29.
Figure 5.26: Example of a drawn concept map with “Low Connectivity” = 1.

Figure 5.26 shows an example of a ‘Low Connectivity’ concept map for a (mid-range self-efficacy achieving) student. He created five different clumped groups of topics. For example, he connected all topics related to polynomials together but not to other topics. He left ‘laws of exponents’ without any connection to any other topic. He had three invalid links (adding/subtracting polynomials to multiplying polynomials, adding/subtracting rational expressions to multiplying/dividing rational expressions, and solving equations with one variable was repeated). He sees individual distinct areas. This showed a total of 12 valid links – 3 invalid links = 9 links. This also showed that the student was lost connecting topics
together and might have connected them procedurally more than conceptually following their topic titles (common words) only.

Studying Figure 5.27, the same student connected topics conceptually more than procedurally at stage 2, achieving ‘Medium Connectivity’. For example, he created a net of topics and not clumps of groups as done in stage 0. He created a central topic where all other topics lead to it (Solving algebraic equations). It is noticeable that he combined some topics without clear ideas or reasons to combine them (multiplying or dividing expressions/equations) or (multiplying or dividing polynomials, expressions + factor). He is not seeing the very clear
links between certain topics, still he sees more links than he did in stage 0. He showed a total of \(22 - 2 = 20\) links. This presented better students’ connectivity and conceptual understanding than his level of understanding at stage 0.

Figure 5.28: Example of a drawn concept map with “high connectivity” level = 3.

Figure 5.28, shows a different student who demonstrated a higher level of connectivity ‘High Connectivity’ between the topics. For example, he created a central important objective ‘solving algebraic equations’ and connected many other topics to it. He connected all kinds of operations on polynomials to ‘solving algebraic equations’, operations on rational expressions to ‘solving algebraic equations’, and many other topics to ‘solving algebraic equations’. He also showed more organised thoughts when he used ‘combining like terms’ and/or ‘GCF’ more than one time as needed. He showed a total of 34 valid links. This means he showed a higher level of connectivity and conceptual understanding.

Table 5.25 shows the median for the level of connectivity for all students at each stage.
<table>
<thead>
<tr>
<th>Stage Number</th>
<th>Mean using connectivity codes</th>
<th>Median using connectivity codes</th>
<th>Name of code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>10 valid links = 1.0</td>
<td>1.0</td>
<td>Low Connectivity</td>
</tr>
<tr>
<td>Stage 1</td>
<td>16 = 2.0</td>
<td>2.0</td>
<td>Medium Connectivity</td>
</tr>
<tr>
<td>Stage 2</td>
<td>19 = 2.0</td>
<td>2.0</td>
<td>Medium Connectivity</td>
</tr>
</tbody>
</table>

Table 5.25: Median of level of connectivity for all students at each stage.

Table 5.25 shows that the students’ connectivity codes started at ‘Low Connectivity’ in stage 0. It improved to ‘Medium Connectivity’ at stage 2 and 3. The data also shows that 19 out of 130 students had ‘High Connectivity’ and 8 out of 130 students with ‘Low Connectivity’ at stage 3. This is a possible indicator of the increase in students’ conceptual understanding as students started to see proper links between topics at stages 2 and 3. This might be an indicator that the students in the study improved their mathematics understanding during the course. More related information related to this will be discussed in Chapter 6.

### 5.9 Attendance

This section discusses students’ attendance records at the end of each semester out of 75 teaching days as shown in Table 5.26 and Figure 5.8.a and b.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Mean in Percentage</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>73.6</td>
<td>98.1</td>
<td>74</td>
</tr>
<tr>
<td>G2</td>
<td>70.3</td>
<td>93.7</td>
<td>70.5</td>
</tr>
<tr>
<td>G3</td>
<td>70.8</td>
<td>94.4</td>
<td>71</td>
</tr>
<tr>
<td>G4</td>
<td>70.6</td>
<td>94.1</td>
<td>71</td>
</tr>
<tr>
<td>G5</td>
<td>70.6</td>
<td>94.1</td>
<td>71</td>
</tr>
<tr>
<td>G6</td>
<td>70.4</td>
<td>93.9</td>
<td>71.5</td>
</tr>
<tr>
<td>G7</td>
<td>71.2</td>
<td>94.9</td>
<td>73</td>
</tr>
<tr>
<td>G8</td>
<td>69.8</td>
<td>93.1</td>
<td>72.5</td>
</tr>
</tbody>
</table>

Table 5.26: The mean, mean in percentage, and median of total attended days for each group at the end of the semester out of 75 days.

Figure 5.30 shows the Boxplot for total students’ attendance records out of 75 days.
Table 5.26, Figure 5.29 and Figure 5.30, showed that all groups had high attendance rates. This means that most students were attending classes regularly. This contradicts the general
attendance history at GUST where students have had low attendance rates. This might be an indicator that they had high motivation during the course.

The students who were considered outliers in Figure 5.1 and 5.4 were further examined. These low attending students’ outliers were found to be the same students’ outliers discussed in section 5.4. This means, they had lower self-efficacy, lower motivation, lower test scores and lower attendance records than other students in the study.

Table 5.27, compares the attendance percentage for all students in MFU and for the students in the study.

<table>
<thead>
<tr>
<th></th>
<th>MFU (%)</th>
<th>Students in the study (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2018</td>
<td>82.1</td>
<td>95.5</td>
</tr>
<tr>
<td>Fall 2017</td>
<td>79.8</td>
<td>96</td>
</tr>
</tbody>
</table>

Table 5.27: Percentage of attendance for MFU-Math 096 students compared to the students in the study

This table shows that the attendance rate for the participating students in the study is higher than the attendance rate for other Math 096 students at MFU. This also could be a possible indicator of higher motivation levels for the students in the study.

5.10 Success Rate

This section discusses the success rate in this study and compares it with the success rate of MFU in Math 096. Table 5.28 shows the pass-fail rates for each participating group included in the study. The codes used in the table were P = Pass, NP = Not Pass, and W = Withdrawn. Figure 5.31 presents the pass-fail rates for each participating group included in the study. Also, Table 5.29 shows the pass-fail percentages in MFU for Spring 2017 and Fall 2017. Table 5.30 compares the pass-fail rates between MFU and the participating students in the
Lastly, Figure 5.32, compares pass-fail rates for Math 096 for the students participating in the study and students in MFU.

<table>
<thead>
<tr>
<th>Group #</th>
<th>Number of P</th>
<th>Number of NP</th>
<th>P (%)</th>
<th>NP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>0</td>
<td>100</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>3</td>
<td>84.2</td>
<td>15.8</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>2</td>
<td>88.2</td>
<td>11.8</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>2</td>
<td>90.0</td>
<td>10.0</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>2</td>
<td>85.7</td>
<td>14.3</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
<td>2</td>
<td>88.9</td>
<td>11.1</td>
</tr>
<tr>
<td>7</td>
<td>17</td>
<td>2</td>
<td>89.5</td>
<td>10.5</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
<td>2</td>
<td>84.6</td>
<td>15.4</td>
</tr>
<tr>
<td><strong>Average of All Groups</strong></td>
<td><strong>14.4</strong></td>
<td><strong>1.9</strong></td>
<td><strong>88.9</strong></td>
<td><strong>11.1</strong></td>
</tr>
</tbody>
</table>

Table 5.28: Pass-Fail rates for each participating group in the study.

Figure 5.31: Pass-Fail rates for each participating group in the study.

Table 5.29 shows the pass-fail percentages for Math 096 in MFU for Spring 2017 and Fall 2017.
### Table 5. 29: Pass-Fail percentages for Math 096 in MFU for Spring 2017 and Fall 2017.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Student Grade</th>
<th>Student Headcount</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Semester 2017-18</td>
<td>NP</td>
<td>51</td>
<td>37.8</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>78</td>
<td>57.8</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>6</td>
<td>4.4</td>
</tr>
<tr>
<td>Spring Semester 2016-17</td>
<td>NP</td>
<td>74</td>
<td>19.5</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>306.0</td>
<td>80.5</td>
</tr>
</tbody>
</table>

Table 5. 30: Pass-Fail rates for Math 096 for the students participating in the study and students in MFU.

<table>
<thead>
<tr>
<th>Academic Status</th>
<th>Number of Students in The Study</th>
<th>Number of Students in MFU</th>
<th>Pass-Fail Rate for The Students in The Study</th>
<th>Pass-Fail Rate for The Students in MFU</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>115</td>
<td>384</td>
<td>88.5</td>
<td>75.4</td>
</tr>
<tr>
<td>NP</td>
<td>15</td>
<td>125</td>
<td>11.5</td>
<td>24.6</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>509</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 5.32: Pass-Fail rates for Math 096 between students participating in the study and MFU.
The above tables and figures show that the pass rate for students participating in the course is higher than the pass rate of other Math 096 students at MFU.

5.11 Summary

This section lists the key findings of this chapter and the bridging points connecting the numeric and concept maps data analysis to qualitative data analysis that will be discussed in Chapter 6. Also, this section lists the added interview questions to the original interview questions applied in the study.

5.11.1 Key Findings

This section lists the key findings in this chapter that will be supported through the qualitative data analysis in the interview chapter:

1) The data analysis showed that almost 70% of the students participating in the study had higher than Algebra I mathematics course at school but could not pass the Accuplacer examination.

2) All eight groups of students participated in the study developed higher self-efficacy towards learning mathematics during the course compared to their low self-efficacy at stage 0.

3) Most of the students improved their motivation levels towards learning the course materials during the course compared to their low motivation levels at stage 0.

4) Students showed a major improvement in their test scores from stages 0 to 1, then gradual improvements from stage 1 to the end of the course. Test scores also improved by 111% percent increase from stages 0 to 3.

5) There is a positive correlation between students’ self-efficacy and their test scores in this study.
6) There is a positive correlation between students’ motivation and their test scores in this study.

7) The tests were also analysed procedurally and conceptually. Students showed improvement in their mathematical understanding (procedurally and conceptually) during the course with a high increase from stages 0 to 1 in the conceptual understanding.

8) Through concept map analysis, students showed a noticeable improvement in their connectivity as they improved from ‘Low Connectivity’ at the start of the course, to ‘Medium Connectivity’ at the end of the course. This might be an indicator of an improvement in their mathematics understanding especially in their conceptual understanding.

9) The attendance rate for the participating students in the study is higher than the attendance rate for other Math 096 students at MFU. This might be related to their motivation increase during the course.

10) The students participating in the study showed a higher pass rate compared to other Math 096 students’ pass rate at MFU.

5.11.2 Bridging points

This section lists important points that require further discussion and support in Chapter 6 through students’ interviews and qualitative data analysis:

1) Although most low self-efficacy students did not pass the course, they showed a noticeable improvement in their self-efficacy levels at the end of the course.

2) According to the data collected from the self-efficacy and motivation questionnaires, most students graduated from high school with low self-efficacy and motivation levels.
3) Most students who joined Math 096 with direct entry had high self-efficacy at stage 0.

4) Most students indicated that they did not enjoy using different computing programs when solving algebraic problems.

5) Most students who answered that mathematics was not their favourite subject taken in high school had lower self-efficacy than the rest of the students in the study. In contrast, students whose mathematics was their favourite subject taken in high school had had higher self-efficacy than the rest of the students.

6) Most students participating in the study indicated that they were calculator dependent and had lower self-efficacy levels than the rest of the students. In contrast, students who indicated that they were calculator independent had higher self-efficacy.

7) Many students with high self-efficacy indicated that it was not important to take a foundation mathematics course(s) before joining the college level courses. In contrast, students with low self-efficacy indicated that it is important to take a mathematics foundation course(s) before joining the college level courses.

5.11.3 Added Interview Questions

The numeric data analysis showed a clearer view of the study and the need for questions to be added in order to show a better connection between the qualitative and quantitative data analysis in this study. This section lists the added interview questions for different self-efficacy students’ levels.

Low and Middle Self-efficacy Students:

1) Data collected showed that although you did not pass the course, you improved your capability to solve mathematical problems and your test scores. Why?
2) Data collected at the start of the course showed that you had lower capability towards taking any mathematics course. Why?

3) Were you offered the chance to use different computing programs when solving mathematical algebraic problems in the past? If yes, how did you feel about it?

4) Why did you prefer to use the calculator when solving any mathematics problems at the start of the course?

**High Self-efficacy Students:**

1) Data showed that you had high capability towards studying mathematics when you joined Math 096. Why?

2) The data collected during the course showed that you (agreed/disagreed) that it is important for you to take a foundation mathematics course before joining college level courses. Why?

3) Were you offered the chance to use different computing programs when solving mathematical algebraic problems in the past? If yes, how did you feel about it?

4) Why did you answer with (Y/N) for the question “I cannot solve any mathematics problem without the help of a calculator”?

This chapter summarises the numeric and concept maps data analysis in this study. Chapter 6 will discuss the qualitative data analysis from the students’ interviews and individual cases studies which could support Chapter 5 key findings in this study.
Chapter Six: Qualitative Data Analysis

6.0 Introduction

This chapter discusses the qualitative data collected from the 25 semi-structured interviews and the individual students’ case studies. The students were selected based on their self-efficacy level at stage 0 and their willingness to be interviewed. The 25 students who volunteered were divided into three self-efficacy categories; high, middle, and low. More details will be provided in section 6-3. The same interview questions were used with all the selected students. Also, additional interview questions were used in a second interview phase which were included after the analysis of the quantitative data. The results produced by the analysis in this chapter will be discussed with the statistical results reported in Chapter 6.

6.1 Emerging Themes in the Study

Three major emerging themes were identified during an initial review of the data: Self-efficacy, Motivation, and Mathematical Understanding. The transcribed interviews were examined thoroughly to identify where the students made comments related to each major theme with the second supervisor (Dr. Annette Taylor). The data for each student was then grouped in a table with the three major themes as headings.

English is the second language used in Kuwait. This means that the students used basic language in order to answer each question in the interview. Table 6.1.a shows some of the key word examples used to identify each major theme:
### Major theme

<table>
<thead>
<tr>
<th>Key words</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-efficacy</td>
<td>adequacy, competence, effectiveness, potency, ability, capability, can, capableness capacity, effect, efficaciousness, energy, force, influence, very, easy, power, strength, success, sufficiency, use, weight, deal with challenges</td>
</tr>
<tr>
<td>Motivation</td>
<td>Good, great, excellent, the way you teach, exciting, fun, interesting, brought us together, know each other, ….mentioning or appreciating an act</td>
</tr>
<tr>
<td>Mathematical Understanding</td>
<td>Understanding, to understand, think, learn…</td>
</tr>
</tbody>
</table>

Table 6. 1: the number of times each student commented on each major.

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Self-efficacy</th>
<th>Motivation</th>
<th>Mathematical Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shamar</td>
<td>12</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Muhamad</td>
<td>14</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Shamlan</td>
<td>19</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>Amina</td>
<td>11</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Dina</td>
<td>13</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Hanif</td>
<td>16</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Bojbara</td>
<td>15</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Qoloob</td>
<td>14</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>Said</td>
<td>17</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Ahmad</td>
<td>16</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Anin</td>
<td>14</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Duwailah</td>
<td>13</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Bader</td>
<td>13</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Fares</td>
<td>11</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Hamad</td>
<td>11</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>Hassan</td>
<td>15</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Jana</td>
<td>10</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Fadil</td>
<td>14</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Rodhan</td>
<td>18</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Mariam</td>
<td>23</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Omar</td>
<td>18</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Saada</td>
<td>18</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>Salwa</td>
<td>15</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>Johna</td>
<td>18</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Yasmine</td>
<td>12</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td><strong>370</strong></td>
<td><strong>407</strong></td>
<td><strong>352</strong></td>
</tr>
</tbody>
</table>

Table 6. 2: The number of times each student commented on each major emerging theme.
The table shows that all these students made extensive comments related to their capability (self-efficacy) to learn the course materials, motivation and mathematics understanding to work hard, and pass the course. The table also shows that most students’ comments referred to their motivation levels during the course, secondly to their self-efficacy, and lastly to their mathematical understanding of the course materials. This means, students were mostly motivated during the course. How and why were they motivated, had high or low self-efficacy level, or mathematical understanding, will be discussed in the found sub-themes and individual student’s case studies.

6.2 Emerging Sub-themes in the Study

This section explains the emerging sub-themes within each major theme. The data collected from each interview was examined again to identify where students made similar comments in order to find emerging sub-themes. Different colours were used to identify each emerging sub-theme as follows:

- Group Work
- Teacher’s Teaching Methodology
- Tutor’s Attitude
- Social media (WhatsApp) Group
- Gamification (Kahoot) and puzzle sheets
- Revision Notes
- Bonus marks
- Small boards
- Online Homework
- Correcting Own Students’ Errors
- Change in Student’s Attitudes
- Attendance

Table 6.3 shows an example of one student’s interview data and emerging sub-themes.
<table>
<thead>
<tr>
<th>Self-efficacy</th>
<th>Motivation</th>
<th>Mathematics Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>• This (your care) made me feel capable to understand not only to pass this course but any math other maths course in the future.</td>
<td>• I loved revision notes. You provided us with excellent variety of questions. They were tricky and forced us to think. They were short and summarizing the chapter.</td>
<td>• that we helped each other to reach the same level of understanding (Group work).</td>
</tr>
<tr>
<td>• The more I attended, the more I felt that I was capable to prepare for college algebra and any future course.</td>
<td>• All this encouraged us to attend the whole time so that we don’t miss any review you offered. They were only 5 or 6 questions in the revision notes, but were very rich to review for any quiz or test. (revision notes)</td>
<td>• you were around us the whole time checking that we all understand and you gave us hints in case we needed it.</td>
</tr>
<tr>
<td>• I feel that I have enough knowledge to pass any math course. I have the basics and I am capable to do it. (attendance)</td>
<td>• This is from group work as you used to divide us in class into groups of 4 students and you used to switch us around from one group to another. All this was very helpful</td>
<td>• All this was very helpful and improved our understanding of the course materials. (group work, bonus marks, your teaching)</td>
</tr>
<tr>
<td>• This (changed your view) changed my mind about math to feel that I can take any math course in the future.</td>
<td>• Group work brought us together to the same level ... All this was very helpful</td>
<td>• Also, one students could ask to solve a certain question and one of the group members will answer by sending a picture and a voice notes sometimes which improved our understanding. (WhatsApp)</td>
</tr>
<tr>
<td>• (teaching for understanding) Seriously there are so many differences in the way all my life teachers taught me and you. I wish they all learn from you. I can easily do it.</td>
<td>• Add to this, you were around us the whole time checking that we all understand ... All this was very helpful</td>
<td>• so we had to learn our lesson properly, pay attention, focus, understand, solve quickly, and receive the bonus mark (kahoot)</td>
</tr>
<tr>
<td>• Taking the course with you and everything you offered made it easy to learn and improved my capability to learn and understand maths.</td>
<td>• You didn’t keep us in the same groups, you kept rotating us so that different students are with different group members each time... All this was very helpful</td>
<td>• I felt that the questions were too strong (higher in level) that forced us to think and improve our understanding (revision notes)</td>
</tr>
<tr>
<td>• After the first month, I felt that I am capable to take any maths course in the future.</td>
<td>• One of your conditions in order to receive the bonus marks that you had to hear us helping each other. ... All this was very helpful</td>
<td>• Another new changing technique you used and I appreciated is called reverse learning technique. Instead</td>
</tr>
<tr>
<td>• I never computed anything without using the calculator. I did improve when I took Math 095 but</td>
<td>• Group work lead us to create WhatsApp group so that we could socialize and work together in the classroom and outside the classroom. I never did any of this at any maths course in the past. It’s great.</td>
<td>•</td>
</tr>
</tbody>
</table>

190
- **definitely became stronger in computing**
- **I was surprised that we actually could do math using technology (online HW)**
- **I used to hate it, but now I feel I can easily do it and other computing.**
- **Sometimes you were firm and other times you were very funny. You cared about us a lot. This made me feel capable to understand not only to pass this course but any math other maths course in the future.**
- **Also, we exchanged notes in class one student was absent, he would request class notes and we would send the picture to the group. Also, the program made it easy for us to meet at cafés in evenings (WhatsApp)**
- **Also, you started motivating us by offering us bonus marks when doing different activities in class**
- **Also, you started motivating us by... and playing different games like Kahoot and the puzzle sheets in the classroom.**
- **One fun games was Kahoot. It was so much fun and motivating for us to attend class on regular basis with something new almost each time we meet.**
- **Plus, we received marks which did help us raise our grades. It was such a good game. (kahoot+puzzle sheets)**
- **But what you brought to the course has been major and life changing which I feel the most we needed at any foundation course**
- **Also, you did remind us everyday about our upcoming quizzes, tests, or HW. You were always supporting us.**
- **One important thing to add was the way you care and teach us in class. You treated us like a caring sister. You laugh, joke, smile and talk to us.**
- **I knew that it’s a harder course but it became very easy with time because of everything you were offering.**
- **of only learning how to solve, you taught us how to create an example. This was very important for our understanding and motivated us towards passing the course.**
- **I felt that the more I attended, the more I could understand.**
- **Attendance might be the main reason behind my understanding and success.**
- **You were very fair with us all. You reflected care about us all and equally. You kept asking us many times if why did we solve the problem this way or that way.**
- **You repeated many times and refused to go to the next question if any of us did not understand.**
- **At early course, I used to avoid going on the board to solve. Now, I ask you to pick me so that I share my answer and understanding with my classmates.**
- **You also used similar questions when we used the individual small boards. I liked that you gave us once a word problem and asked us to translate it into an equation. This used to be very difficult for me to solve but it’s important to us to learn how to translate the problem from a word problem to an equation and solve it... This was very important for our understanding and motivated us towards passing the course.**
I feel very motivated when I think about how I used to feel when I was in math 095 and where I am now in math 096. This was very challenging for me. It also provided similar examples which I liked a lot. It was great and motivating practice at home. (online hw)

Also, we received grades for it (online HW) which was great to raise our overall grades.

It was the most fun mathematics course I have ever taken.

You also used similar questions when we used the individual small boards. I liked that you gave us once a word problem and asked us to translate it into an equation. This used to be very difficult for me to solve but it’s important to us to learn how to translate the problem from a word problem to an equation and solve it ... This was very important for our understanding and motivated us towards passing the course.

Table 6. 3: An example of one student’s interview data and emerging sub-themes

Table 6.4 shows the number count of each emerging sub-theme in Self-efficacy, Motivation and Mathematical Understanding for all semi-structure interview students.
<table>
<thead>
<tr>
<th>Group work</th>
<th>SE</th>
<th>M</th>
<th>U</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shewri</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mohammedi</td>
<td>1</td>
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Table 6.4: The number count of each emerging sub-theme in self-efficacy, motivation and mathematical understanding.

193
6.2.1 Emerging Sub-Themes in Self-Efficacy

Table 6.4 shows that teachers teaching methodology and the change in students’ attitudes were the greatest influences in improving students’ self-efficacy, motivation, and mathematical understanding during the study. Group work was involved in using the puzzle sheets, bonus marks, correcting own students’ errors, revision notes, and small boards. The use of such a variety of activities in the classroom positively influenced students’ self-efficacy during the course. Of these, the small plastic boards had the least influence on students’ self-efficacy. The positive changes in students’ attitudes also produced creative use of technology programs such as the social media (WhatsApp) group. The influence of each sub theme will be discussed in more detail section 6.3.

6.2.2 Emerging Sub-Themes in Motivation

Table 6.4 shows that students’ motivation was noticeably influenced by the teacher’s teaching methodology in the classroom. The teacher’s approach improved students’ motivation during the study and there was a noticeable difference in the number of mentions in comparison to the other elements.

Group work was secondly most mentioned by the students. Considering that playing games (such as the puzzle sheets), bonus marks, correcting own students’ errors, Revision Notes, and the small boards involved the use of group work, the use of such a variety of group work activities in the classroom positively influenced students’ motivation during the course. It is also noticeable that students’ improved motivation produced a positive change in students’ attitude towards learning the course materials. It also produced a creative use of technology programs such as social media (WhatsApp) group as an online group work communicating tool. Revision notes, small boards and reviewing own errors were the least
mentioned motivational elements. Section 6.3 discusses how each sub-theme influenced students’ motivation according to their interview comments.

6.2.3 Emerging Sub-Themes in Mathematics Understanding

Table 6.4 shows that students’ mathematics understanding was noticeably influenced by the teacher’s teaching methodology in the classroom. The teacher’s approach improved students’ understanding and it was mentioned three times more frequently than the next highest element. Group work was the second most mentioned element. Considering that playing games such as Kahoot and the puzzle sheets, bonus marks, correcting own students’ errors, revision notes, and the small boards involved the use of group work, the use of such a variety of group work activities in the classroom positively influenced students’ mathematics understanding during the course. Small boards and WhatsApp were mentioned the least of the elements for mathematical understanding.

6.3 Sub-Emerging Themes and Students’ Self-efficacy, Motivation, and Mathematical Understanding

The following sections discuss how each sub-theme influenced students’ self-efficacy, motivation and mathematics understanding according to their interview comments.

6.3.1 Group Work

Group work introduced a new teaching methodology for college students at GUST according to the students’ interviews. It changed the student’s learning experience, Dina said that “I loved using group work which I never experienced in the past .... I used to find maths very difficult to understand. I used to hate it but now it’s becoming easier and I can do it”. Group work assisted the students to socialise together, which created a comfortable learning
environment that improved their understanding and capability to learn. Hanif who mentioned that “This (group work) improved personally my understanding in a foundation math course and made me feel more capable to understand it and pass the course”. These students clearly felt that group work could improve their capability to learn and this impacted on their self-efficacy.

Group work motivated the students to compare their individual experiences, create cooperative relationships with each other, and continue working hard towards success. Shamlan mentioned “I love group work. It made us closer to each other”. Also, Bojbarah mentioned that “Group work was amazing. Sometimes I don’t understand anything through any problem you explained, my group members will explain it to me. You usually solve one example with us and then ask us to work on the second one, that’s when I ask my friends around if I don’t know how to solve a problem”.

Group work changed students’ attitudes towards learning mathematics. It improved students’ self-confidence, relationships among each other, and motivated them to understand mathematics during the course. Mariam mentioned “I used to hate group work in school because I used to be the only one who does not understand, but now I love it because everyone is so loving and cooperating so that we all work hard and understand ...I understand much better and feel more confident that I can pass the course easily”. Also, students realised the relations from using group work, to improving their understanding, receiving the bonus marks, and achieving success. Khaled added “You used to ask us to work in groups. This was good so that we could help each other and communicate and get to know each other ... Our goal as a group was to help each other in order to solve all assigned
questions, as fast as possible in order to receive the bonus mark ... This helped us to improve our understanding a lot and helped us to pass the course”.

### 6.3.2 Teacher’s Teaching Methodology

Participating students expressed their feelings differently towards the way they were taught in the course. They realised that the teacher’s teaching methodology was one key element for their understanding in the course. Shamar mentioned that “I can easily do it. Seriously there are so many differences in the way all my life teachers taught me and you. I wish they all learn from you”. The approach used in the classes is changing his view of mathematics. Also, the teacher created a high expectancy level for the students with clear suggestion that they would pass the course which supported students’ feelings about their capability to understand mathematics during the course. Saed indicated that “in your class, I understood better and you wanted us to be the best. you told us many times ‘you can do it’ and now I see that I really can do maths”. This means that students learned about how to learn, regulate their studying time, and focus on what to learn. Also, Rhodhan mentioned that “You Ms. Sali, would assign us a question, then would wait for a minute or two so that we try on our own and we discuss it with our friends around. You come around each one of us to check how much do we know about the question and if we could solve it or help other students around to solve it. You wouldn’t show us how to answer the question unless you checked that we tried to solve it within our groups. This has forced me to think carefully before answering any question, understand better and feel better about myself and capability to learn maths now and in the future”. This improved students’ self-efficacy towards learning the course materials, as they took more responsibility for their own learning.
The teacher used the SMIC framework in lessons to motivate the students to continue attending class and work hard in the course. Shamar said “The way you taught us and with everything you offered in the course was amazing ... You were always supporting us. You encouraged us to respect attending class”. Also, not only did the teacher cover the assigned materials, but she also assisted the students to organise their study time, when and how to do their online homework, and taught them how to learn mathematics more effectively. Bojbarah mentioned that “You reminded us every day to work on our HW. You were going around each one of us telling us what to do and when. I feel everything I am doing (from practice, to online hw, to Kahoot) is just excellent and is building my knowledge in mathematics and improving my understanding”.

6.3.3 Tutor’s Attitude

The teacher created a family relationship between the students and between the teacher and the students. This created a supportive and safe learning environment for the students to receive assistance when needed which improved students’ self-efficacy during the course. Qoloob indicated that “She used to care about us so much to understand and actually improved studying the subject ... she is as close to us as a sister or a mother. She is always available to answer any question or need in the office or in class... It made me feel that the subject is very easy to understand... I feel that I can pass this course easily”. Also, the teacher shaped up the students’ attitudes to learn mathematics. She taught them how to organise their time, and to regulate their daily assigned work. This influenced positively their self-efficacy to learn the subject and pass the course. Bojbarah mentioned that “It’s amazing the influence of “do this “, “follow this”, “pay attention”, “don’t forget to do your hw on daily basis”. All this seriously affected me and led me to learn how to learn properly, how to organize my time. It showed me that I can do it, I can learn math and can pass. This makes
me feel I am ready to take any course in the future such as college algebra, calculus, statistics and any other course”. This improved their self-efficacy in mathematics during the course and prepared them for other future courses.

The teacher created a family environment that showed a supporting system that motivated the students to work hard and learn the course materials. This has had a great influence on the students’ motivation in their classes Shamar added that “One important thing to add was the way you care and teach us in class. You treated us like a caring sister. You laugh, joke, smile and talk to us. Sometimes you were firm and other times you were very funny. You cared about us a lot”. Also, the teacher’s attitude in the classroom improved student’s confidence, motivation, and capability to learn mathematics during the course. Mariam explained that “the teachers in the past did not care if I understood because most students in class understood except me but you Ms. Sali care and make sure that we all understand and are following you. I feel very motivated, confident and capable that I can solve the problem more than 70% correct and feel motivated to solve it”.

Also the teacher monitored student’s individual academic and understanding progress, which prepared them for taking college level courses. Fares explained that “I have never had a teacher in high school or in Math 095 asked me why were you absent? ‘Make sure you take the notes from your class members’, or ‘Come see me if you need help’. You know each one of us. You cared to check in class if each one of us understood what you taught us. Other teachers would not care because we could receive an FA, but you are different and you didn’t want any of us to receive it … When you feel that any of us is in risk to fail, you call us individually and you give us a plan to work hard, study and how possible would it be to pass the course”.

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6.3.4 Gamification (Kahoot) and Puzzle Sheets

Anin could see that the consolidation work in applying the practice in class using games and puzzles, helped improved their understanding and feelings about it. This improved students’ self-efficacy to study the course materials. Anin stated that “After playing games and puzzles or after playing Kahoot. It definitely helped me to understand because we got to practice what we learned over and over again not just theoretically where the teacher teaches on the board, but we also feel that we can do it ourselves in different ways and its excellent, strong, and very useful way that made learning easier”.

Kahoot provided the students with “fast thinking” questions and tasks that motivated them to find the easiest and most appropriate methods to solve these problems. Rodhan indicated that “You made us play Kahoot once a week. You motivate us to solve correctly and you give the top 10 the bonus mark. This was very motivating for us to solve carefully and quickly so that we receive the bonus marks and it improved our understanding as well”. Also, Shamar added that “you started motivating us by offering us bonus marks and playing different games like Kahoot and the puzzle sheets in the classroom”,

The students created a connection between playing the puzzle sheets or Kahoot, attending class time, improving their understanding, and gaining the bonus grades in order to pass the course. Saada explained that “playing the puzzle game where Ms. Sali used to ask us to solve certain questions in a puzzle sheet and the first three groups who completed solving it would receive bonus marks added to their quiz grades. This was very motivating for us to attend class more and understand more. Kahoot was another motivating thing the teacher used in class. It was fun and easy where we could use our mobile phones and the top 10 scoring students received the bonus mark. I liked it a lot because it helped us to improve our quiz
grades. Plus, it helped us to focus and learn to solve each question faster. This helped to improve our understanding”.

6.3.5 Online HW

Saada realized the importance of the use of challenging questions in PEARSON MyMathLab and its influence on improving his attitude towards working hard to study the course materials. This improved his self-efficacy to study the course materials. He mentioned that “MyMathLab we might solve about 10 problems which helped us to know the topic more and be familiar with it and understand it better. The more correct answers I get, the more I feel that I can do the following question. This makes me feel better that I can learn maths and do much better in completing the HW”. Also, students could also see the similarities between the questions taught in class and the questions used in the online homework (PEARSON MyMathLab) which was the best practice needed at home. Bojbarah mentioned that “I was not too careful to do them on time at the early stages in the course. But afterwards, I didn’t accept less than 100% in each section. ... I write each question down and compare it to your questions in class, find the solution and enter it. It’s a very good practice. For the HW, it says “well done”, “fantastic”, “Keep going” which made me feel that I can always do the next question and can improve learning the course contents”. The more questions the students were solving, the more they were encouraged to continue and move on to the following question, which increased the students’ self-efficacy with a desire to practice at home and continue learning mathematics.

Other features of PEARSON MyMathLab are that it provided an e-text and videos that explained all the materials taught in the course. This provided accessible online assistance for the students especially when they missed attending classes. Mariam explained that “I like to
use multi-media e-text very much as it shows the text with all available examples I can highlight, I can circle any important note I like using. Also, it shows videos for teaching different concepts which is helpful as it shows a certain way to teach the topic. I recommend using it because using PEARSON MyMathLab, it’s like revision for me at home after taking the lesson in class”.

Also, the online program offers a variety of questions with different levels of difficulty which motivated the students to use them as a review to prepare for quizzes and tests. This improved students’ understanding. Hanif also clarified that the online HW is “very useful. It makes me think and prepares me for all quizzes and tests ... with all the great tools you offered (group work, different revision notes, online HW, reviewing after the test, games ...), this made me feel that I understand math really well’.

6.3.6 Correcting Own Students’ Errors

Reviewing their own test mistakes in groups allowed the students to explore their major and minor mistakes in each test. Hassan also mentioned that “reviewing our tests, make us understand our mistakes and the knowledge stays in our head really well. All this make me feel taking mathematics is easy and I can pass the course”. This improved their self-efficacy to continue and complete the course successfully and learn more mathematics in the future.

Correcting their own mistakes allowed the students to realise their mistakes, understand why they solved them this way, and how to correct them appropriately. This motivated the students to improve their grades. Hassan said “reviewing our tests, make us understand our mistakes and the knowledge stays in our head really well. All this make me feel taking mathematics is easy and I can pass the course”. Also, Test correction was a new learning experience that students were never exposed to in the past, which changed the teaching
environment for the students and motivated them to continue studying the course materials.

Bader explained that “I also liked reviewing our mistakes after the test. This helped us understand our mistakes and how to correct them so that we do not do those mistakes again. I have never done this in high school nor at college. I like what you are doing in this course a lot”.

Test corrections showed the students how they understood the question during the test and after being graded. They realised their learning and understanding progress and how important it is to avoid making those mistakes in future tests and receive higher grades in the next test and pass the course. Amina also indicated that ‘When I looked at some of my mistakes, when I see how small and silly they were, I realize how important it is to understand them so that I don’t do this mistake any more’. Omar added that ‘One very important thing you always do is revising our test after you grade it. I don’t remember any teacher who has ever done it before. This helped us to realize our mistakes and learn how to avoid them in the future especially that we did this through group work. This improved my understanding a lot’.

6.3.7 Revision Notes

The revision notes summarised the chapter in a few questions for the students. The questions used the reverse thinking methodology which taught the students learning how to learn. It also showed them how easy it is to learn mathematics. This improved students’ self-efficacy during the course. Fares mentioned that “You used revision notes at the end of each chapter. This was a great review for each chapter. It was hard at the beginning. But we learned how to study and think about it, through group work and then through your teaching. This made learning mathematics so much possible, doable, and easier than before”. Bader also added that “Revision notes were excellent, and a summary of the chapter. They helped
me to understand the most important concepts covered in the chapter also using creating examples more than just solving examples. This also made me feel that I am capable to learn easily”.

The question variety motivated the students to review the taught materials and understand. Also, the use of revision notes was a new approach for these students. The students were asked to solve each question in a group, which allowed the students to think, understand, and find their own methods to solve them together. Mariam explained that “In regards to revision notes, we never had it before ... I like it a lot that you write the question on the board, you give us time to think about it before answering them. The prof in the previous course used to write the question and actually answer it for us or ask us to answer it at home as an exit question. You now give us 2 minutes to think about as many ways as possible to answer the assigned question”.

6.3.8 Social media (WhatsApp) groups
The WhatsApp application provided an electronic support of group work methodology that was available both in class and outside the classroom as well at all times. Muhamad also indicated that “It was such a support system available the whole time”. The WhatsApp group was a creative - idea by the students. It brought thoughts, ideas, members, and knowledge together to the same level of understanding. Fares indicated that “I think the group work encouraged Salam to create a WhatsApp group ... WhatsApp group improved this connection more. For example, if Salam was absent, then I will send him the class notes on WhatsApp, and any class member would do that ... Things brought us together to the same level of thinking, understanding of maths and feeling good about our own knowledge and capability
to do maths”. WhatsApp is one element that changed students’ attitude and self-efficacy to learn mathematics or take any mathematics course in the future.

The WhatsApp group continued providing the supporting system, started by the group work in class, for the students as it enabled them to communicate and socialise every day. This improved students’ motivation during the course. Also, the WhatsApp group created a family-style relationship among the students as Mariam said that “we can talk to each other in class and then we talk on WhatsApp group as well. We have been discussing many things on WhatsApp, not only math, it’s also giving a family feel to it and I legitimately love this”. The students realised that help was always available all the time through the use of WhatsApp group which assisted improving their understanding of the course materials. Omar added that ‘Another way of looking at group work was WhatsApp group. It was a way to communicate while we were at home. If I was absent and missed any class materials, I would send the request on the WhatsApp group, and one of the guys would send me the materials and someone else might explain to me any question that I could not understand. It helped bringing us together to the same level of understanding’.

6.3.9 Bonus Marks

MFU teachers noticed that students at GUST are grades-driven. They felt that the more grades they were gaining, the better they felt about their understanding and capability to learn mathematics. Rodhan mentioned that “my overall has come up from everything you offer in class, the understanding, the bonuses. I feel I know maths better than before and can do it”. Bonus grades were given to the top 10 students answering the puzzle sheet or Kahoot questions correctly. Some students had to study on a daily basis in order to answer the questions properly and gain the bonus marks. This increased their self-efficacy to learn
mathematics. Hassan mentioned that “The bonus marks encourage us to study more. When I receive the bonus mark, I understood how to solve the problem which means I can do math and can do the next problem”. Also, Bader added that “The more bonus marks I gained, the better I felt about myself which made me feel that I could solve more maths problems in the future”.

The bonus marks were one source of motivation to attract the students to attend, learn, understand, and achieve in mathematics. The students are grade-driven and the bonus marks motivated the students to improve their mathematics understanding and grades. Also, Rodhan explained that “you made us play Kahoot once a week. You motivate us to solve correctly and you give the top 10 the bonus mark. This was very motivating for us to solve carefully and quickly so that we receive the bonus marks and it improved our understanding as well”.

Offering the bonus marks, motivated the students to seek understanding in order to pass the course. John explained that “I like that the games in this course. Games motivate me to solve more math problems in order to receive the bonus mark. The more I solve, the more I understand maths ... When you used to tell us that we will play Kahoot after a day or two, I used to review at home so that I score high and gain the bonus mark. It was very motivated to study, understand what you taught us, and play the game in class with other students. Which improved my understanding”.

6.3.10 Small Boards

Using the small boards motivated the students to learn mathematics. The questions used were short, often demanding and summarised the previous lesson which also helped create a connection to the current lesson. Dina added that “I feel really good that I can really learn and improve in learning maths”. Fares also mentioned that “Using the small board, it was
such a good daily review for yesterday’s lesson. The questions reminded us of the basic information of the lesson, which built our confidence and knowledge well enough so that we can solve any other maths problem”. This improved students’ self-efficacy to learn mathematics in the future.

The use of the small plastic boards was a new teaching tool used in the study. Saed mentioned that “I liked using the individual plastic boards because it took me back to high school. One teacher, used to ask us to use them to write vocabulary words in a quiz or test. In the class, it was so exciting”. Also, using the small boards changed the traditional teaching method and provided the students with high confidence, and high self-efficacy to solve each assigned problem. This motivated the students to seek better understanding of the taught materials. Rodhan indicated “I have never seen the small individual boards before. It’s so much fun. It’s so boring to keep working with the same way of teaching. It broke the usual class routine. It made us feel older and wiser that we used our own boards and shared answers with our friends. It was very interesting and motivating to think differently and try our best to understand and answer”.

6.3.11 Change in Student’s Attitude

The teacher used different education approaches while teaching the course which created a whole new learning experience for the students according to their interview comments. This changed the students’ attitudes towards learning mathematics as it showed them it is always possible to learn and pass the course. Also, the students realised the importance of taking this course before joining college level courses. This improved students’ self-efficacy during the course. Shamar explained that “But what you brought to the course has been major and life changing which I feel the most we needed at any foundation course … changed my mind
about math to feel that I can take any math course in the future”. Also, taking this course changed the students’ attitudes from hating and rejecting learning mathematics to accepting learning mathematics. Dina indicated that “I used to find math very difficult to understand. I used to hate it but now it’s becoming easier and I can do it”.

The teacher helped the students develop new learning techniques in order to understand mathematics and achieve higher grades according to their interview comments. These techniques influenced the students’ attitudes to seek understanding, socialise, and to regulate their time to study mathematics, which motivated the students to study mathematics easily. Hassan explained that “I hated math in the past. But this course changed my mind about the way I think about studying math. Now it seems easier to study math. The course taught us new ways to study math like MyMathLab, revision notes and many ways that I never learned before. This makes me feel I can study any math course at any time and it will be easy”.

Also, the course provided the students with new skills and techniques in order to assist them finding their own paths into learning mathematics. This changed students’ attitudes to learn mathematics and motivated them to work hard to pass the course. Mariam also indicated that “till taking this course I used to think that it’s either you are born to be good at math or you would be born not good at math. This course showed me that I could grow into it. I feel so motivated to take college algebra which I used to think that it will be a difficult course, I feel its going to be an easy course”. Also, John added that “I used to hate math since I was a little boy. Since taking this course, it changed my idea completely towards studying mathematics. Now, I feel smart and I can solve math problems. I can take any math course in the future”.
6.3.12 Attendance

The students recognised the importance of regular attendance for this course. They connected attendance to missing the taught materials, the in-class activities, their understanding and to improving their self-efficacy towards learning mathematics. Shamar explained that “The more I attended, the more I felt that I was capable to prepare for college algebra and any future course ... Attending this course was the main reason behind having all my high grades. Dina agreed that “I feel that all the students are encouraged to attend. I feel that the more I attend class, the more I can understand and learn the materials taught”.

The teacher motivated the students to attend class by changing the traditional teaching methodology and use of creative approaches to improve their understanding and achievement. Hassan added that “I could not miss anything you offered in class because I would feel guilty to miss anything. Because the way you deliver materials in class is excellent and motivated me to improve in mathematics a lot”. Also, Mariam indicated that “If I don’t attend, I will not understand. Its 100% important to attend the course in order to pass”.

Students also realised that improving their attendance is related to improving their conceptual understanding during the course. Anin also added that “Attendance leads to high marks because through group work, you will attend and discuss the difficult concepts and the more challenging ideas in the course, and understand well. You have to be there in class to know it”. Salwa explained that “I felt that I had to attend in order to learn and understand properly and you will be more motivated to continue the course and pass it.”
6.4 Students’ Case Studies

This section discusses six individual students’ case studies. The volunteered 25 total students were selected based on their self-efficacy at stage 0 and their willingness to take part in the interview. The students were divided into three categories; high, middle, and low self-efficacy. The researcher selected the best two students from each category based on their best explanations and answers for each of the interview questions. Each of the students’ profiles includes background information collected from their background, self-efficacy, and motivation questionnaires at stage 0, and at other stages in the course. Also, it includes information collected from their semi-structured interviews and concept maps analysis at different stages of the course. These case studies are used in order to explore the factors and reasons for each student’s success or failure in the course.

6.4.1 Muhamad (Student #16 Gr.4, High self-efficacy)

Stage 0

Table 6.5 shows a summary of Muhamad’s background information at stage 0. It includes data collected from his background, self-efficacy, and motivation questionnaires at stage 0.

<table>
<thead>
<tr>
<th>High School Major Type (Science/Liberal Arts)</th>
<th>Highest Math Taken</th>
<th>Number of Times Taken Math 095</th>
<th>Number of Times Taken Math 096</th>
<th>Maths Was My Favourite Subject in High School</th>
<th>Cannot Solve Any Maths Problems Without The Calculator</th>
<th>Enjoyed Using Computing Programs While Solving Algebra Problems</th>
<th>Pass/Not Pass</th>
<th>Important to Take Foundation Maths Course</th>
<th>Attendance /75</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.A.</td>
<td>Alg. II</td>
<td>0</td>
<td>1</td>
<td>Y</td>
<td>N</td>
<td>P</td>
<td>N</td>
<td>P</td>
<td>75</td>
</tr>
<tr>
<td>S.E. at stage 0</td>
<td>Mt. stage 0</td>
<td>Level Quiz %</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>95.7%</td>
<td>98%</td>
<td>78</td>
<td></td>
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</tr>
</tbody>
</table>

Table 6.5: Muhamad’s background data at stage 0.
During the interview, Muhamad explained that he had been good at maths at school, which was probably the reason for his high self-efficacy level at stage 0. He realised that there was a difference between the traditional teaching approach that he had encountered at school and the new teaching approach that he experienced in this course, which he recognised had improved his understanding and maintained his high levels of self-efficacy and motivation during the course. He said that “I received traditional teaching when I was younger, but I was good in maths. I knew that I was going to pass the course, but did not expect to get such high grades and feel this good about my understanding and capability to learn maths in the future”.

**Change in Student’s Attitudes**

Although Muhamad did not pass the Accuplacer examination, he did feel that he had enough mathematical knowledge to go straight to a college course and that it was not important for him to take a foundation mathematics course. However, by the end of the course he had realised that he had gained a great deal of confidence in mathematics and was prepared for future study in this subject. He said that “I knew that I didn’t actually need to take any foundation course before joining college course. Still, I was worried before starting the course that I was not ready to join college courses. After taking the course, I feel that I can take any mathematics course in the future”.

Muhamad explained that he was never exposed to any technological tools at school except for a calculator. He said that “I have never seen any computer programs to solve mathematics problems before. We were only allowed to use the calculator at school”. Muhamad explained that he had enough arithmetic skills to carry out basic numeric operations during the course.
He stated that “I didn’t need to use the calculator during the course. I have been good in mathematics since my school days. I know that I can manage and do all major operations in maths. But, during the course, you asked many questions involving operations on decimals and I improved a lot doing this”.

Figure 6.1 shows Muhamad’s concept map at stage 0.

![Muhamad’s concept map at stage 0](image)

Figure 6.1: Muhamad’s concept map at stage 0

A very clear feature of this concept map is that it contains five distinct clumps. It is noticeable that Muhamad had a simple approach for linking some topics together mainly by selecting similar words. For example, he linked all topics related to percent together in one clump. He also clumped all operations related to polynomials together. He applied the same approach to rational expressions. In these three cases, the key words used such as ‘rational expressions’ seems to be the key to creating the clump, although there may have been some mathematical association.
In the other two clumps, there were no common words that could have been used to create the clumps. This means that Muhamad probably had some sense of the mathematical connections between these topics. For example, he connected ‘solving linear equations’ with two other sensible related topics. Also, all the topics in the other clump had a connection with indices which might explain why they were grouped together.

Muhamad’s concept map analysis at stage 0, shows that he seems to have a disjointed view of mathematics at this stage and only links together topics with very strong connections. This might be an indicator of a procedural approach to mathematics. In his interview, Muhamad confirmed this conclusion when he stated that “The first one, I can see now that topics were not very much related. I didn’t know or understand the concepts yet. My ideas were scattered’.

Muhamad’s background information shows that he started the course with high self-efficacy and motivation levels, and low level quiz score. Also, the data shows that he did not have a clear view of conceptual mathematics, his view was more procedural, as shown in his concept maps analysis at stage 0.

**Muhamad’s progress from stages 1 to 3:**

The graphs in figure 6.2 show that Muhamad maintained high levels of motivation and self-efficacy throughout the course and that his test scores improved.
Muhamad explained how worried he was about taking the course at stage 0, but felt that he could overcome his worry gradually during the course. He improved his test scores during the course, which continued supporting his high self-efficacy level to take any mathematics course in the future. He explained that “there were some students in my English class last course who told me that Math 096 is very hard. On day one of the course, you started telling us about the syllabus of the course. I felt that I am familiar with some topics and after the first week of the course, I started realizing that it’s easy to understand and pass the course especially with everything you offer in the course. Then, after the first test and receiving my grade, I felt more motivated to study harder every day and felt more capable to get a 100% in the next quiz or test. I believe that I am capable to pass any math course in the future”.

Muhamad discussed the different features he encountered during the course and their influence (if any) on his self-efficacy, motivation, mathematics understanding and test scores.

Figure 6. 2: Muhamad’s self-efficacy, motivation, and test scores during the course in percentages.

**Change in Student’s Attitudes**

Muhamad explained how worried he was about taking the course at stage 0, but felt that he could overcome his worry gradually during the course. He improved his test scores during the course, which continued supporting his high self-efficacy level to take any mathematics course in the future. He explained that “there were some students in my English class last course who told me that Math 096 is very hard. On day one of the course, you started telling us about the syllabus of the course. I felt that I am familiar with some topics and after the first week of the course, I started realizing that it’s easy to understand and pass the course especially with everything you offer in the course. Then, after the first test and receiving my grade, I felt more motivated to study harder every day and felt more capable to get a 100% in the next quiz or test. I believe that I am capable to pass any math course in the future”.

Muhamad discussed the different features he encountered during the course and their influence (if any) on his self-efficacy, motivation, mathematics understanding and test scores.
• **Group Work**
Muhamad described how he was exposed to new educational approaches such as group work during the course. He indicated that the group work provided the students with a support system that brought their knowledge together, which made learning easier and improved his mathematical understanding. He expressed that students created some positive reputation encouraging each other to take this course because of the use of the group work approach. To Muhamad, the use of group work seemed to be a key feature that contributed to his success in the course. He explained that “*I never had group work done in my high school courses and this was why my cousin recommended that I take the course with you. It was a new way for us to learn. When I am involved in group work, if I don’t understand any topic, someone else will understand it and will explain it to me. They might even explain it to me in another way that might turn to become easier for me and I might understand it better*”.

• **Social Media Group**
WhatsApp is a social media application that the students decided to use during the course to replicate, to some extent, the benefits of the group work that they had experienced in the classes. This application continued to provide the social and learning support that group work provided in class, and at any time outside of classes they could seek assistance from each other. This contributed to the maintenance of Muhamad’s high levels of intrinsic motivation and mathematical self-efficacy levels. Muhamad explained that “*Group work led us to create WhatsApp application ... The WhatsApp group is a good way for students to communicate in class and outside the classroom. We explain things to each other using WhatsApp program, show pictures of different solutions, share notes if anyone was absent, and update him with any notes that he missed or review so that he catches up with the rest of his classmates. It is a great way to communicate with each other outside the classroom. Also, if one student did not*
understand how to solve a certain problem, then any student from the WhatsApp group would explain how to solve the problem either through a voice note or using a picture. This helps us improve our understanding among each other. I remember that I did not understand a concept in Chapter 2 applications, so I sent my question on WhatsApp. Ahmed called me and explained it to me in details. It was such a support system available the whole time…. which was very motivating and made me feel that I can always do it”.

- **Gamification**

Playing the puzzle sheet and Kahoot was another new educational approach that Muhamad was exposed to during this course. He realised that he was engaged and socially competing with his classmates through playing the games in class. This intrinsically motivated him to relate learning and understanding to having fun. Also, he understood that playing the games improved his level of understanding as it reviewed previous topics. The bonus points improved his grades and extrinsic motivation at the same time. Muhamad explained that “I don’t remember any teacher or course instructor who played any game with us. Using the games and puzzle sheet was very interesting. It was very helpful because it motivated me to study well and have fun in class and get better understanding. While we play, we were reviewing the materials were taking which makes me feel that I understand the topic really well. Kahoot was so much fun. It forced me to review the materials from the previous day so that I gain the points in Kahoot. It forced me to study harder and solve faster in order to receive the bonus point. It was so much fun and funny to compete between each other in class. Sometimes we get easy questions and it was easy to solve them. For harder questions that needed more time, we had to think faster in order to solve them. All this built my understanding and made us feel that I am capable to do all kind of questions easy and hard”. 
• **Small Boards**
Muhamad thought that using the plastic boards was a different approach but also realised that the way that they were used helped to connect the previous lesson to the new one, which contributed to his high self-efficacy level and improved his understanding level of mathematics. He explained that “The weird plastic board that we used was so new to me. I liked it because it reviewed the previous lesson you taught the previous day. Which was a good way to connect between the previous lesson and the new lesson. You used to ask us what did you learn in the previous day? This approved my concepts and made me feel that I am capable to understand everything in this course easily”.

• **Revision Notes**
Muhamad indicated that revision notes included questions with different levels of difficulty, which improved his conceptual understanding and contributed to his self-efficacy level during the course. He explained that “I want to mention the revision notes, it made the lesson seem shorter because they covered a summary of everything covered in the chapter. Few days before the test, I would review all revision notes you gave us which was excellent review. The way you wrote the question “create an example” you are showing us what are we capable to solve. When we try to answer it, it will improve our concepts and we would see what we need to work on and what we don’t need to work on. If you say “write a binomial” and some students do not know how to write a binomial, here they need to work how to write a binomial not a trinomial for example”.

• **Bonus Marks**
Using the bonus marks was one extrinsic motivating key for Muhamad to improve his understanding level and grades. Muhamad mentioned that “the bonus marks were good and
useful because they motivated me improving my grades and understanding to study well”.

- **Teacher’s Teaching Methodology**

  With regard to the teacher’s teaching methodology, Muhamad expressed his appreciation of the way the teacher monitored how he students interact with each other while solving different problems. Also, he realised that she taught them how to learn which improved his mathematics understanding level. He explained that “The way you teach was excellent. It is so different. You explain more, repeat the information over and over, you check everyone’s’ answer within the groups, and you allow us to figure out the answer so you don’t actually solve the questions for us. You basically teach us how to learn in our way which is very special. It’s good because it helped me to understand better in a good way”.

  Muhamad also explained that taking this course, including the use of the different educational approaches, improved his motivation level and gave him the confidence to take any mathematics course in the future. He said that “I love taking math with you. I love solving every problem in every lesson you teach us with everything you offered in the course. This made me feel very motivated and felt the ego to attend every math class. I hope that I will have the same feeling next course because sure I feel that I can pass any math course easily now. I can study any math course in the future, it’s so much fun”. He explained that his grades had improved during the course and how this has influenced his confidence to take any college course in the future. He mentioned that “Test 1: 92%, Test 2: 98%, overall in quizzes mostly 100, overall average is 96%. I am eager to take any math course in the future. I am 100% ready to take any math course in the future especially that I still need to so another 3 credit courses in my accounting course”.
This concept map shows that Muhamad used a different approach to link the topics at stage 2. He showed no single clumps, by using common words, as done at the previous stage. Also, there are no isolated topics that were unconnected. Muhamad created a ‘net’ of links where each topic was connected to one or more other topics regardless of the use of common words, which shows that he had more sense of the relationships between different mathematics topics at this stage.

Also, he created a central topic ‘solving algebraic equations’ where many other key topics were connected directly to it. Muhamad knew that ‘finding different solutions’ is a result of ‘solving algebraic equations’ and did not link it to any other topic. He did not only focus on the major topics but used simpler topics such as ‘combining similar terms’ or ‘find GCF’ as
links between other topics. In fact, he included ‘combining similar terms twice’ for this purpose.

In conclusion for Muhamad’s concept maps analysis at stage 2, he seems to have a better connected view of mathematics at this stage. This might be an indicator of a more conceptual approach to understanding mathematics. In his interview, Muhamad confirmed this conclusion when he indicated that ‘the more topics we were taking in depth, the more I realized that most topics were connected and related to each other and lead to solving algebraic equations.

- **Attendance**
Muhamad talked about the important of connecting between attendance, improved mathematical understanding level, and gaining better grades. He explained that “attending class is very important for students so that we get better understanding, focus on lessons, more fun and receiving more grades. On the other hand, not attending, would lead to lower grades because I would not understand the lesson well. I would even miss class time and the fun time and would lose the bonus marks”.

- **Online Homework**
Muhamad explained how the online homework program was available as a practice and support system for the taught lessons, and could be used every day and at any time. He added that the level of difficulty used in the questions was motivating and challenging, which helped him to develop a better understanding. Also, he realised that the online homework was another motivating factor that contributed towards improving his grades. He explained that “the online HW was very good for me. It was a great way to practice and review at home to
study for quizzes. When I understood any concept in class, the online HW helped me to practice it and understand it better. It is a good tool to improve our understanding and this leads us to improve our grades in quizzes and tests. I liked the style and difficulty levels they offered us, some were easy and other ones were harder which was challenging and interesting for me. I also liked the ‘similar problem’ option because it was very helpful because it taught me how to solve a question if I didn’t know how to solve it. I like it a lot”.

Figure 6.4 shows Muhamad’s concept map at stage 3.

This concept map shows that Muhamad used a similar approach to that used in the map at stage 2. He continued to show no single clumps. He also used a ‘net’ of links where each topic was connected to one or more other topics. Muhamad shows more sense of the relationships between different mathematics topics at this stage.
Also, the central topic ‘solving algebraic equations’ seems more obvious where many other key topics were connected directly to it. Muhamad knew that ‘combining like terms’ is related to operations on polynomials, rational expressions, and translate and solve as he created a smaller central topic between them. He included it twice for this purpose. He linked ‘finding different solutions’ is a result of ‘solving algebraic equations’ and did not link it to any other topic.

Muhamad’s concept map analysis at stage 3 indicates a more conceptual and connected understanding of mathematics at this stage. In his interview, Muhamad confirmed this conclusion when he indicated that “through the course, we understood more concepts and relations between the different topics”. He seems to understand that the end product of many mathematical problems requires the solution of some sort of equation.

Figure 6.5 relates similar questions from Muhamad’s level quiz at stage 0 and Test 4 at stage 3.
Considering figure 6.5, Muhamad did not know how to solve question 5 in the level quiz (left). He didn’t seem to know what equilibrium means. He didn’t even try to show any mathematics steps. Considering figure 6.5 (right), not only did Muhamad know what equilibrium means, he also used new techniques such as solving quadratic equations using factoring in order to find the solution(s) for this question. This shows an improvement in Muhamad’s conceptual understanding during the course and his ability to use a range of ideas to solve a problem.

In conclusion, the data collected from the questionnaires, test scores, the semi-structured interviews, and concept maps analysis show that not only did Muhamad improve his test
scores and mathematical understanding during the course, he also maintained high levels of self-efficacy and motivation levels. Each of the main educational approaches used in the course had some positive influence on Muhamad’s self-efficacy, motivation, and mathematics understanding levels, and test scores, and he recognised that they assisted him to pass the course with high grades.

6.4.2 Shamar (17 Gr.3, High Self-efficacy)

Stage 0
Shamar is a 27 years old married student with a child. He was employed at the military-government company before joining this course. His wife supported him so that he could continue his education in order to improve his position at his company. Table 6.6 shows a summary of Shamar’s background information at stage 0. It includes data collected from his background, self-efficacy, and motivation questionnaires at stage 0.

<table>
<thead>
<tr>
<th>High School Major Type (Science/Liberal Arts)</th>
<th>Highest Math Taken</th>
<th>Number of Times Taken Math 095</th>
<th>Number of Times Taken Math 096</th>
<th>Maths Was My Favourite Subject in High School</th>
<th>Cannot Solve Any Maths Problems Without The Calculator</th>
<th>Enjoyed Using Computing Programs While Solving Algebra Problems</th>
<th>Pass/Not Pass</th>
<th>Important to Take Foundation Maths Course</th>
<th>Attendance /75</th>
</tr>
</thead>
<tbody>
<tr>
<td>S Calc.</td>
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<td>1</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>P</td>
<td>N</td>
<td>Y</td>
<td>75</td>
</tr>
</tbody>
</table>

Table 6.6: Shamar’s background data at stage 0.

Shamar explained the reason for his high self-efficacy level at stage 0. He seemed to believe that he had enough mathematics knowledge to pass the course although he did not pass the
Accuplacer exam. However, he had a low level of motivation at the start of the course. Shamar said that “I know that I am good in math since I was in elementary school and I could pass it, but I never had a good teacher who attracted me to like math. I just felt that I was not motivated to take the course at the start of the course”.

Shamar explained that he was never exposed to any technological tools in mathematics lessons before joining GUST. He explained that “I graduated from a public school system in Kuwait. We never used any computer programs to solve any mathematics problem. I am only familiar with basic computer programs like word, and other simple programs”.

Shamar knew that he had low motivation level at stage 0 and he believed that he needed to take a foundation mathematics course before joining college level courses at GUST. He said that “I did agree that it is important to take the foundation course. I felt that my low motivation did not encourage me to take any college mathematics course and the foundation course might prepare me to take college level courses”.

Shamar had used a calculator since his early middle school years until his final high school years. He knew that he had weak arithmetic skills at stage 0 and that he could not solve any mathematics problem without the use of the calculator. He explained that “I know that I struggled when I took Math 095 because we started using the calculator at school since grade 5 or 6 I think. I never computed anything without using the calculator. I did improve when I took Math 095 but definitely became stronger in computing in Math 096 because you forced us to use long division when dividing decimal numbers. I used to hate it, but now I feel I can easily do it and other computing”.

Figure 6.6 shows Shamar’s concept map at stage 0.
This concept map shows that it contains five distinct clumps. It is noticeable that Shamar had a simple approach for linking some topics together mainly by selecting similar words. For example, he linked all topics related to percentages together in one clump. He also clumped all operations related to polynomials together. He applied the same approach to rational expressions and solving linear equations. In these four cases, the key word used was ‘rational expressions’, ‘solve’, and ‘polynomials’. These four cases seem to be the key to creating the clump, although there may have been some mathematical association.

In the top left clump, there are no common words that could have been used to create the clumps. This means that Shamar probably had some sense of the mathematical connections between these topics. For example, he connected ‘order of operations’ with ‘laws of..."
exponents’, and ‘find prime factors’. Also, on the bottom left, Shamar used some kind of a chain mapping approach for connecting indices. For example, he linked convert ‘percent to decimal’ to ‘decimal to percent’ to ‘percent to fraction’. These may not present accurate mathematics associations according to the order shown.

In conclusion for his concept maps analysis at stage 0, Shamar seems to have an unclear view of mathematics at this stage and only links together topics with very strong connections. This might be an indicator of a procedural approach to mathematics. In his interview, Shamar confirmed this conclusion when he stated that “At the start of course, I only grouped similar topics together. I have never done this before”.

In summary, Shammar’s background information shows that he started the course with high self-efficacy and low motivation levels, and low level quiz score. Also, the data shows that he did not have a clear view of conceptual mathematics and showed more of a procedural approach as confirmed by his concept maps analysis at stage 0.

**Shamar’s progress from stages 1 to 3:**

The graphs in figure 6.7 show that Shamar maintained high levels of self- efficacy throughout the course and that his motivation and test scores improved.
Figure 6.7: Shamar’s self-efficacy, motivation, and test scores during the course.

The figure shows that Shamar showed a noticeable improvement in his self-efficacy and motivation levels, and his test scores from stages 0 to 1. It also shows that he continued with his high self-efficacy and motivation levels, and test scores as well for the rest of the stages of the course. Shamar discussed different features that he encountered during the course and their influence (if any) on his level of self-efficacy and motivation, and his mathematical understanding as demonstrated by his test scores, and passing the course.

**Teacher’s Teaching Methodology**

Shamar explained his belief that the teacher’s role and the approach that he/she uses in the classroom is very important for the students’ understanding and success levels. Also, he explained that he had low motivation level to study mathematics at the start of the course and how hard it was for him to take any mathematics course. He appreciated the teacher’s approaches used in this course. Shamar said “the past mathematics courses I took at school or here Math 095, I used to feel that they were hard. I know that Math 095 should have been an easy course, but the way I received it from the teacher in class made it hard. I honestly think
that teacher has an important role in making the course easy or difficult to understand for the student. The way you taught us and with everything you offered in the course was a whole new method that I was never exposed to in the past”.

Shamar discussed different features he encountered during the course and their influence (if any) to his self-efficacy, motivation, and mathematics understanding levels, or test scores.

- **Group Work**

Shamar explained that he was never exposed to the teaching approaches used in this course before taking it. These approaches were all new to him. He clarified that group work was a great communication, social, and teaching support system to the students in the classroom. The students could rely on each other to answer and explain questions among their groups without the constant need to ask the teacher how to solve those questions. Also, group work allowed the students with different levels of understanding to explore their own solving strategies and share them with their group members. This helped improved his levels of mathematical understanding, social, and communication during the course. Shamar said “these new teaching methods you did in class, I never had before. For example, for four months in 095, I never knew more than one student. In your course, we became all one team knowing and working together in groups. This is from group work as you used to divide us in class into groups of 4 students and you used to switch us around from one group to another. This created some kind of communication among us. I know now all my classmates, all because of group work. I noticed that each one of us in class has a different way of thinking and understanding in maths. Group work brought us together to the same level so that we
helped each other to reach the same level of understanding. Also, we taught each other new
different ways to solve different problems”.

• **Tutor’s Attitude and Bonus Marks**
Shamar also discussed the influence of the teacher’s teaching approach in the course. He explained that the teacher monitored the students while working together, and motivated them with bonus marks if they could explore their own learning strategies among their groups. This had a positive influence to his understanding level in the course. Shamar said that “you were around us the whole time checking that we all understand and you gave us hints in case we needed it. It was great that you were around us checking on us the whole time. You didn’t keep us in the same groups, you kept rotating us so that different students are with different group members each time. If I did not understand anything from you, Fahad might explain it in an easier way. Fahad or any other students might make it look simpler to me. One of your conditions in order to receive the bonus marks that we had to hear and see us helping each other, and if we don’t help each other then we lose the mark. Plus, everyone has to solve everything in his note book. …. You kept asking us many times if why did we solve the problem this way or that way … All this was very helpful and improved our understanding of the course materials”.

• **Social Media Group**
Shamar explained that WhatsApp group is a social media application that provided social and learning online support for the students at any time needed. The students decided to create the WhatsApp group so that they could continue assisting each other any time needed by explaining class notes, or providing answers for any question needed. This contributed to an improvement in his mathematical intrinsic motivation to work together. This also assisted
Shamar to improve his understanding level in order to prepare for quizzes and tests with his friends. Shamar said “Group work lead us to create WhatsApp group so that we could socialize and work together in the classroom and outside the classroom. I never did any of this at any maths course in the past. We used WhatsApp to inform each other about many things like quiz or test dates. Also, we exchanged notes in class when one student was absent, he would request class notes and we would send the picture to the group. Also, one student could ask to solve a certain question and one of the group members will answer by sending a picture and a voice notes sometimes. This has been very useful to all of us. Also, the program made it easy for us to meet at cafes in evenings to study together to prepare for quizzes and tests”.

- **Gamification and Attendance**

Shamar realised the connection between learning mathematics, having fun through playing games, reviewing the taught materials, understanding mathematics, gaining grades, and passing the course. This positively influenced Shamar’s intrinsic motivation level and other students to attend class regularly. Also, Shamar was extrinsically motivated by the bonus grades offered when winning the games. This motivated him to focus in class while learning, understand the taught materials, and improve his grades. Shamar said “you started motivating us by offering us bonus marks and playing different games like Kahoot and the puzzle sheets in the classroom. One fun game was Kahoot. It was so much fun and motivating for us to attend class on regular basis with something new almost each time we meet. Plus, we received marks which did help us raise our grades. It was such a good game. It was a good and challenging practice after teaching us each lesson. Each one of us challenged himself against time so we had to learn our lesson properly, pay attention, focus, understand, solve quickly, and receive the bonus mark”.
• **Teacher’s Teaching Methodology and Change in Student’s Attitudes**

Also, Shamar could distinguish between the old and new teachers’ teaching approaches between different courses. He appreciated the new teacher’s teaching approach and how this contributed and positively changed his attitude towards attending class time, working hard to learn the course materials, and pass the course. This teaching approach of high expectations supported Shamar’s self-efficacy level and improved his mathematical understanding level to pass the course, unlike his previous teachers’ approaches. Shamar said that “In previous courses, I felt that teachers took their teaching duty as just a paid job that had to be done regardless if they were doing it properly or not. No teacher I remember used your new teaching techniques to teach their courses. They didn’t care unfortunately. They used to come to class, teach, and leave. But what you brought to the course has been major and life changing which I feel the most we needed at any foundation course. Also, you did remind us every day about our upcoming quizzes, tests, or HW. You were always supporting us. You encouraged us to respect attending class because the class time was becoming more valuable and so we wanted to attend and we had to attend class. This improved my capability to work hard to understand mathematics and pass the course”.

• **Revision notes and Attendance**

Also, another new educational approach that Shamar appreciated was the revision notes. The questions’ used in the revision notes included different levels of difficulty and techniques that allowed the students to use those questions to prepare for quizzes and tests. Shamar also realised that the teacher’s teaching approach allowed the students to explore their own strategies when solving algebraic problems using the questions from the revision notes. This improved his mathematical understanding level and motivated him to work hard to pass the course. Shamar said “I loved revision notes. You provided us with excellent variety of
questions. They were tricky and forced us to think. They were short and summarizing the chapter. I felt that the questions were too strong (higher in level) that forced us to think and improve our understanding. All this encouraged us to attend the whole time so that we don’t miss any review you offered. They were only 5 or 6 questions in the revision notes, but were very rich to review for any quiz or test. ... I liked that you gave us once a word problem and asked us to translate it into an equation. This used to be very difficult for me to solve but it’s important to us to learn how to translate the problem from a word problem to an equation and solve it. Another technique you used and I appreciated is called reverse learning technique. Instead of only learning how to solve, you taught us how to create an example. This was very important for our understanding and motivated us towards passing the course.

- **Tutor’s Attitude and Change in Student’s Attitude**

Shamar also discussed the teacher’s attitude and its positive influence on students’ self-efficacy and mathematical understanding levels to pass the course. He compared his experience with his past teachers’ attitudes and the attitude for the teacher of this course. Shamar explained that “One important thing to add was the way you care and teach us in class. You treated us like a caring sister. You laugh, joke, smile and talk to us. Sometimes you were firm and other times you were very funny. You cared about us a lot. Other teachers used to live high on a cloud and did not care to look down to us and our needs but you did. You were so down to earth and real. This made me feel capable to understand not only to pass this course but any math other maths courses in the future.... You repeated the lesson many times and refused to go to the next question if any of us did not understand. This changed my mind about math to feel that I can take any math course in the future”.

Figure 6.8 shows Shamar’s concept map at stage 2.
This concept map shows that Shamar used a different approach to link the topics at stage 2. He continued using some links with common words in one case. For example, he linked ‘multiplying and dividing rational expressions’ to ‘adding and subtracting rational expressions’ but ended it showing some mathematics connection to ‘solving algebraic equations’. Shamar created a ‘net’ of links where each topic was connected to one or more other topics regardless of the use of common words, which shows that he had more sense of the relationships between different mathematics topics at this stage. Also, he continued using the chain map approach on the left side but ended up connecting it to the central topic.

Also, he created a central topic ‘solving algebraic equations’ where many other key topics were connected directly to it. He did not only focus on the major topics but used simpler topics such as ‘combining similar terms’ to link between other topics.
In conclusion for Shamar’s stage 2 concept maps analysis, he seems to have a better connected view of mathematics at this stage. This might be an indicator of a more conceptual approach to understanding mathematics. In his interview, Shamar confirmed this conclusion when he indicated that ‘at mid and end of course, I could see more connections as simplifying rational expressions lead to solving algebraic equations. Simplifying polynomials also lead to solving them’.

- **Attendance**

Shamar talked about his regular attendance during the course. He realized a positive relation between his attendance, mathematical understanding and self-efficacy levels, and passing the course with high grades. *I was committed during the whole course. I felt that the more I attended, the more I could understand. The more I attended, the more I felt that I was capable to prepare for college algebra and any future course. Taking college algebra as the first credited course is a major thing in my life and I want to prepare to take an A in it. Attending this course was the main reason behind having all my high grades. I remember that you brought a different question in test 3 last week. I solved it but felt that I was not comfortable with the answer. I scratched it in the last few minutes and remembered another method you taught us in class and it really worked. Attendance might be the main reason behind my understanding and success. I feel that I have enough knowledge to pass any math course. I have the basics and I am capable to do it.*

- **Online Homework**

Shamar expressed his feelings when he started using PEARSON MyMathLab at the start of the course. He explained how hard and challenging this was when he joined GUST. He realised later that the questions’ quality was a key factor in improving his extrinsic
motivation level during the course as the software was available for practice at home. Shamar also was motivated by the different features offered by the program. Shamar used those features to prepare for quizzes and tests. He explained that “I remember when we first started the course, it was not easy because I was used to use pencil and paper. I felt that the program keeps offering new questions with different levels, this was very challenging for me. It also provided similar examples which I liked a lot. It was great and motivating practice at home. It’s a very good program. Time is a big challenge because there is a due date so that we gain the grade. The program offered 3 chances to solve the problem while I gave myself only one option which is to solve it correctly from the first time and I did in most cases. It’s such an excellent practice every day, for each quiz or test. Also, we received grades for it which was great to raise our overall grades”.

- **Change in Student’s Attitudes**

Also, Shamar expressed how he felt about gaining high scores in his tests. He explained that taking this course not only motivated him to take future mathematics courses, but also improved his confidence level to share his knowledge with his classmates on the board. He said that “I had in Test 1 = 85%, Test 2 = 92%, Test 3 = 89%. I feel proud of every single grade I gained in this course. I feel very motivated when I think about how I used to feel when I was in math 095 and where I am now in math 096. I had 50s and 60s in math 095, look now I have no less than 89% in my tests and feel very motivated to get another 80 or 90% in the final exam. At early course, I used to avoid going on the board to solve. Now, I ask you to pick me so that I share my answer and understanding with my classmates. I even explain the steps. I can easily do it. Seriously there are so many differences in the way all my life teachers taught me and you. I wish they all learn from you”.
Figure 6.9 shows Shamar’s concept map at stage 3.

This concept map shows that Shamar used a similar approach used in the map at stage 2. He continued to use a ‘net’ of links where each topic was linked to one or more other topics. Also, he continued to use the central topic ‘solving algebraic equations’ to which many other key topics were connected directly. Also, Shamar knew that ‘combining like terms’ can be used to link major topics. For example, he used it to link between ‘translate and solve’ and ‘solving algebraic equations’. He also showed that ‘finding different solutions’ is a result of ‘solving algebraic equations’ and did not link it to any other topic.

In conclusion for Shamar’s concept maps analysis at stage 3, Shamar seems to have a more conceptual understanding of mathematics at this stage. In his interview, he confirmed this
conclusion when he indicated that “I did not understand any connection at early course stages but during the course, I learned the relations between them and feel that I can connect them again without looking. The more we learned in the course, the more I understood the connections between topics”.

Figure 6.10 shows similar questions from Shamar’s level quiz (left) at stage 0 and Test 4 (right) at stage 3.

![Figure 6.10: Similar questions from Shamar’s level quiz (left) at stage 0 and Test 4 (right) at stage 3.](image)

Considering figure 6.10, although Shamar showed that he knew what equilibrium means in question 5 in the level quiz (left), he didn’t seem to know how to continue solving the problem using basic algebraic steps. Considering figure 6.10 (right), he used new techniques such as solving quadratic equations using factoring in order to find the solution(s) for this question. This means, Shamar showed some improvement in his conceptual understanding during the course.
In conclusion, Shamar joined MFU with a Science high school background. He started the course with a high level of self-efficacy, but with a low level of motivation and low level quiz score. Shamar maintained his high self-efficacy level and improved his test scores, and motivation level after stage 1. Each of the new educational approaches used in the course had some positive influence to Shamar’s self-efficacy, motivation, mathematical understanding levels, and test scores. This assisted him to pass the course with high grades. Shamar confirmed his progress when he explained that “I did not expect to pass this course. Before taking this course, I was very scared of taking Math 096 ... I am very glad that I took the course with you ... I remember when I took math 095, I had to put double the effort in order to understand and pass the course. I passed it hardly. As soon I started the course here, I knew that it’s a harder course but it became very easy with time because of everything you were offering ... I feel that I can take any math course in the future”.

6.4.3 Hanif (Student #7 Gr.4, Middle Self-efficacy)

Stage 0

Table 6.7 shows Hanif’s background information at stage 0.

<table>
<thead>
<tr>
<th>High School Major Type (Science/Liberal Arts)</th>
<th>Highest Math Taken</th>
<th>Number of Times Taken Math 095</th>
<th>Number of Times Taken Math 096</th>
<th>Maths Was My Favourite Subject in High School</th>
<th>Cannot Solve Any Maths Problems Without The Calculator</th>
<th>Enjoyed Using Computing Programs While Solving Algebra Problems</th>
<th>Pass/Not Pass</th>
<th>Important to Take Foundation Maths Course</th>
<th>Attendance /75</th>
</tr>
</thead>
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<td>Y</td>
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<td>NP Y</td>
<td>Y</td>
<td>Y</td>
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<td>Mt. stage 0 /50</td>
<td>Level Quiz %</td>
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</tbody>
</table>

Table 6.7: Hanif’s background at stage 0.
Hanif explained that the reason for his low self-efficacy level at stage 0, was that he hated taking any mathematics course. He explained that “*I registered telling myself even if I fail maths, I had to go through it. I hated the idea that I was going to take any math course since I was in high school. This is how I felt at the start of the course*”.

Hanif knew that he had weak mathematics knowledge when joining GUST and that he needed to take a foundation course before taking college level courses. Hanif said that “*I used to hate thinking to take any maths course but I knew that I needed it and every student needs to take foundation maths courses especially if they are weak in maths.*”

Hanif clarified that he was not exposed to any use of technology in mathematics classes before joining GUST. He said that “*The only technology tool that we used at school related to maths was the calculator. They allowed us to use it at middle school*. Hanif realised that he had weak arithmetic skills and that he relied on the use of the calculator before joining MFU. He explained that “*I started using the calculator in middle school and got used to it. My computation skills were very weak when I joined GUST as I could not solve any problem without the use of the calculator. But they improved a lot*”.

Figure 6.11 shows Hanif’s concept map at stage 0.
Figure 6.11: Hanif’s concept map at stage 0.

An unclear feature of this concept map is that it contains three distinct clumps. Hanif had a simple approach for linking some topics together mainly by selecting similar words. For example, he linked all topics related to percentage, decimals and fractions together in one clump. He also clumped all operations related to factors, order of operations, and laws of exponents together without showing clear sense of the relation between them.

For the major clump, he showed a confused view as he combined all operations related to ‘polynomials’ to operations on ‘rational expressions’, and ended it at solving linear equations although there may have been some mathematical association. Also, he connected ‘solving linear equations’ with two other sensible related topics such as ‘combining like terms’ and ‘adding or subtracting rational expressions’.
In conclusion for Hanif’s concept maps analysis at stage 0, he seems to have a disjointed and unclear view of mathematics at this stage. This reinforces that he had weak knowledge and understanding of mathematics. In his interview, Hanif confirmed this conclusion when he stated that “When I look at all concept maps now, I see the mess in the first one. It’s terrible. It shows that I never did it before and never learned how to connect topics together”.

In summary, Hanif’s background information shows that he started the course with lower self-efficacy and low motivation levels, and low level quiz score. Also, the data shows that he had an unclear view of conceptual mathematics and had weak mathematics understanding as shown in his concept maps analysis at stage 0.

**Hanif’s Progress From Stages 1 to 3:**

Figure 6.12 shows Hanif’s self-efficacy and motivation levels, and test scores during the course.

![Figure 6.12: Hanif’s self-efficacy and motivation levels, and test scores during the course.](image)
The figure shows that Hanif showed a noticeable improvement in his self-efficacy and motivation levels, and his test scores from stages 0 to 1. It also shows that he continued progressing with his high self-efficacy and motivation levels, and test scores as well for the rest of the stages of the course. He ended the course with high self-efficacy and motivation levels, and test score at stage 3. Hanif discussed different features that he encountered during the course and their influence (if any) on his level of self-efficacy and motivation, and his mathematical understanding as demonstrated by his test scores, and passing the course.

- **Group Work**

Hanif could differentiate between the traditional teaching approach experienced in Math 095 and at school and his new teaching approach that he encountered in the course. He realised that group work provided a continuous social, support for learning which helped improve his mathematical understanding and self-efficacy. It also made him feel that he could take any mathematics course in the future. He explained that “I took math 095 here at GUST. I had a very normal boring course where the teacher teaches and leaves. I never had a teacher who liked fun and used it in the classroom. I was surprised at the start of the course when you asked us to solve the puzzle sheet using group work. It was fun and beneficial because if I don’t understand any point from the problem you assigned, any group member would explain it to me and I might explain to any of them the problem that they don’t understand well. This improved personally my understanding in a foundation math course and made me feel more capable to understand it and pass the course”.

- **Tutor’s Attitude and Teacher’s Teaching Approach**

Hanif appreciated the teacher’s attitude and its positive influence on his mathematical understanding. He explained how the teacher monitored each student’s progress and tried to
create communication among them through the use of different educational approaches in the classroom. Also, she monitored the students’ understanding and provided assistance for them when needed. Hanif said that “I never had a teacher in my life who reflected this much care towards improving her students’ understanding as you did. While working in groups, you go around each group and each member to check that we were all working, communicating, solving, we understand how to work properly. If you feel that any one of us needs help, you would help him. If one was absent, you would ask him to make sure to catch up with us either by coming to your office or reaching the teaching assistant. If any us receives lower grade on the test, you set with us individually and discuss the grades, then you plan for us how to make up our grades and improve them in order to pass the course”. He added that the teacher’s teaching approach also improved his mathematical understanding level during the course through the use of different teaching methods to solve each assigned problem. He explained that “while you teach, I feel you offered us as many easy methods as possible so that we find the easiest method for us and use it while solving. Again, this made solving so much easier”.

- **Correcting Own Students’ Errors**

Hanif appreciated the value of reviewing his mistakes after each test, which has helped improve his mathematical understanding and developed a skill to use in future college courses. He added that “you bring the graded test and ask us to go over our mistakes within our groups so that we understand our mistakes and do not do them in the future. Going over my mistakes made me understand math better than before. It made understanding math seem so much easier than what I expected in order to prepare for our major credited math courses”. 

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• **Revision Notes**

When using the revision notes, Hanif explained that the questions used in them were rich in mathematics knowledge to prepare him for future quizzes and tests. He explained that “I like reviewing from the revision notes because they were the best revision we could use in order to prepare for all quizzes and tests. This improved our understanding a lot. This forced us indirectly to think, study and realize how can we easily understand math and pass the course”.

• **Small Boards**

Another new educational approach that Hanif discussed was the use of the individual plastic board. He explained that the questions used involved problem solving which provided a connection between the previous and the current lessons as well as improving his mathematical understanding. He said that “another new thing that I was exposed to was the use of individual plastic boards. It was different because the questions were required that we think carefully how to create and solve certain problems. It made us all think, understand, and at the same time revise the previous lesson”.

• **Gamification and Bonus Marks**

Hanif also related playing different games in class such as the puzzle sheets and Kahoot to enjoying class time, improving his intrinsic motivation level, improving his mathematical understanding, gaining bonus marks, and passing the course. Gaining the bonus grades extrinsically motivated Hanif to work hard studying the course materials and gain the grades. He said that “the puzzle sheets were a good way for us to motivate us to think, solve in group and gain the bonus mark in case we were on the top three teams answering the assigned questions. We all work together at the same time explaining to each other. The bonus marks assist us to improve our grades which is very important to us to pass the course ... Kahoot is
amazing. It motivates us to think fast in order to receive the bonus mark. Its taught us to realize our mistakes as well. I wish we can always play it even in future courses. It’s such a motivating thing in the course. We are always excited to play it”.

- **Social Media Group**

Hanif valued the use of the WhatsApp group as a social media communication tool. It provided the social and learning support he needed outside the class room. He expressed his intrinsic motivation from using the WhatsApp group as he could study and review the mathematics together with his friends. This improved his mathematical understanding and self-efficacy levels, which encouraged him to learn more mathematics and eventually to pass the course. Hanif said “WhatsApp group helps the students in different aspects. We socialize on the personal level, we became as close as brothers, we go out and have fun. This helped us to meet and discuss taught materials and prepare together for the next quiz or test. And, we use the group to send each other class notes or any missing note. We also remind each other of the contents included in the coming quiz or test. Sometimes one student would need help explaining one problem, another student would explain it and send it as a picture. This made me feel that helps is there in class and outside class, which made me feel more capable to understand maths and motivated me to work harder in the course to pass”.

Figure 6.13 shows Hanif’s concept map at stage 2.
This concept map shows that Hanif used a ‘net’ of links where each topic was connected to one or more other topics. Except “convert percent to decimal”, there are no other single clumps despite showing all topics related to ‘rational expressions’ linked on the right side of the net. This shows a simple approach for linking some topics together mainly by selecting similar words together which had more sense of the relationships between different mathematics topics. Still, he linked ‘operations on rational expressions’ to ‘adding and subtracting polynomials’ which was linked to ‘solving algebraic equations’ which shows no clear mathematics understanding. Also, he used ‘solving inequality” twice linked to each other without showing any clear meaning to it. He also linked ‘find GCF’ to ‘find GCF’.
Hanif started by creating a central topic ‘solving algebraic equations’ where three other key topics were connected directly to it. Hanif knew that ‘finding different solutions’ is a result of ‘solving algebraic equations’ and did not link it to any other topic.

In conclusion, Hanif’s concept maps at stage 2, seem to have a slightly more connected view of mathematics. In his interview, Hanif confirmed this conclusion when he indicated that “through the course period, the teacher explained the relations between topics and they started to make sense to me”.

- **Attendance**

Hanif related student’s attendance to their motivation and mathematical understanding, and passing or failing the course. He explained that “I believe that the more the student attends, the better understanding he gets. I am certain that those students not attending the course regularly will fail the course. Missing more than one or two classes (course materials) may cause the student to be lost because it’s all accumulative. I believe that missing only group work is a big loss for the students because group work motivates us to work harder, understand, feel better and pass”.

- **Online Homework**

Hanif expressed his motivation to the use PEARSON MyMathLab during the course. He used the questions provided in the program as a review source to prepare for quizzes and tests which improved his self-efficacy level. He said that “very useful. It makes me think and prepares me for all quizzes and tests. They have all level of students, easy and hard. I feel that being able to solve MyMathLab questions, makes me feel that I can solve any question
coming on the test or quiz because they can’t be harder than the higher level questions in MyMathLab”.

Figure 6.14 shows Hanif’s concept map at stage 3.

![Concept Map](image)

Figure 6.14: Hanif’s concept map at stage 3.

This concept map shows that Hanif used a similar approach to that at stage 2. He continued to use a ‘net’ of links where each topic was connected to one or more other topics.

Also, the central topic ‘solving algebraic equations’ seems more obvious as there are many other key topics that were connected directly to it. Hanif knew that ‘collecting like terms’ is related to operations on polynomials. Also, he used ‘convert decimal to percent’ twice to link topics together. He showed ‘finding different solutions’ as a result of ‘solving algebraic
equations’ but did not link it to any other topic. Hanif also used ‘solving inequality’ twice linked to each other and applied the same to ‘find GCF’ without showing clear meaning to it.

- **Change in Student’s Attitudes**

In conclusion for Hanif’s concept maps analysis at stage 3, he seems to have improved his conceptual understanding in mathematics at this stage. Hanif shows more sense of the relationships between different mathematics topics such as rational expressions or polynomials and their relation to the centre topic. In his interview, Hanif confirmed this conclusion when he indicated that “when the teacher tested us in the middle and end of the course, I could relate them in much better way because I understand them now. I know now that translate and solve is related to solving rational equations which is connected to solving equations with inequalities and to solving algebraic equations. I know that GCF is there with all kind of simplifying of algebraic equations as well. It all makes sense now because my understanding has improved a lot along the course and feel really good about it”.

Figure 6.15: Similar questions from Hanif’s level quiz (left) at stage 0 and Test 4 (right) at stage 3.
Considering figure 6.15, although Hanif showed that he knew what equilibrium means in question 5 in the level quiz (left), he didn’t seem to know how to continue solving the problem using basic algebraic steps. Considering figure 6.15 (right), Hanif tried to use algebraic techniques such as solving quadratic equations using factoring but he seemed to miscalculate the factors of 2400 which led him to the wrong solutions for this question. Despite his calculation mistake, Hanif showed an improvement in his conceptual understanding when answering this type of question.

- **Change in Student’s Attitudes**

In conclusion, Hanif’s background data shows that he started with low self-efficacy and motivation levels at stage 0, despite the fact that he was a science major student at high school. Also, Hanif hated mathematics before starting the course and hesitated to take it. Not only did he improve his test scores during the course, he also improved his self-efficacy and
motivation levels. This helped him to pass the course. He explained this when he said that “I hated math in the past. Since I started this course, I started to understand the basic concepts needed to pass this course and other courses in the future. I am enjoying my time in class. I aim to score for above 80% in the final exam and Math 111 ...I scored in 75% in Test 1, 77% in Test 2, and an overall of 76.6%. I never expected to get these high grades. It’s such an awesome feeling that I actually earned them. I am very motivated to work harder to prepare for the final exam and take any future math courses easily. I think that I can”.

6.4.4 Amina (Student # 8 Gr.1, Middle Self-efficacy)

Stage 0

Table 6.8 shows Amina’s background information at stage 0.

<table>
<thead>
<tr>
<th>High School Major Type (Science/Liberal Arts)</th>
<th>Highest Math Taken</th>
<th>Number of Times Taken Math 095</th>
<th>Number of Times Taken Math 097</th>
<th>Maths Was My Favourite Subject in High School</th>
<th>Cannot Solve Any Maths Problems Without The Calculator</th>
<th>Enjoyed Using Computing Programs While Solving Algebra Problems</th>
<th>Pass/Not Pass</th>
<th>Important to Take Foundation Maths Course</th>
<th>Attendance /75</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.A.</td>
<td>Alg.II</td>
<td>1</td>
<td>1</td>
<td>Y</td>
<td>N</td>
<td>P</td>
<td>Y</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>S.E. at stage 0 /70</td>
<td>Mt. stage 0 /50</td>
<td>Level Quiz %</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 6.8: Amina’s background data in stage 0.

Amina explained the reason for her low self-efficacy level at stage 0. She didn’t like to study mathematics and was worried to take any mathematics course. She had always been exposed to traditional teaching approaches and was more used to memorising steps and her mathematical understanding seemed to be very procedural ... She said “I am a Liberal Arts major and I never liked maths before. We had to do maths in school as the teacher tells us how to do it. It was a never fun class. I was worried at the start of the course to fail the course”.
Amina was never exposed to any technology in mathematics lessons at school. She said “I was never exposed to any technology in any of my high school maths. We only used the calculator”. Amina recognised that she had weak arithmetic and calculation skills. She was calculator dependent before joining GUST. She explained “I loved using the calculator. I never learned my multiplication table properly till I joined GUST.

Amina did realise that her mathematical background was weak and believed that it was important to take a foundation course to improve her mathematical skills, especially as the course grade does not count towards the students’ Grade Point Average. Amina said “I have always known that I was weaker in maths and needed help. I believe that it’s great to have a foundation maths course because it’s a P/NP course so we get to improve our maths skills while it’s not counted from our GPA.”

Figure 6.16 shows Amina’s concept map at stage 0.

![Amina’s concept map at stage 0](image-url)
This concept map contains three clear distinct clumps and one chain map. For three clumps, Amina used a simple approach for linking some topics together mainly by selecting similar words. For example, she linked all topics related to percent together in one clump where the word ‘percent’ was the centre of the clump. She also clumped all operations related to ‘rational expressions’ together where ‘rational expressions’ were the centre of the clump. Also, she linked ‘laws of exponents’ to ‘prime factors’, ‘order of operations’, and ‘dividing polynomials’ which seem to show no clear mathematics relationships between those topics. This does not represent strong mathematic understanding.

In the top clump, she linked operations on ‘polynomials’ to ‘collecting like terms’, and ‘solving algebraic problems’ which showed some sense of the mathematical connections between these topics.

In conclusion for Amina’s concept maps analysis at stage 0, she seems to have a disjointed view of mathematics at this stage and only links together topics with very strong connections of similar words. This might be an indicator of a procedural approach to mathematics. In her interview, Amina confirmed this conclusion when she stated that “The first concept map was a big failure because I was connecting topics that did not make sense to me at all. When we took Math 095 course, no one told us about the connections between topics. My map did not make any sense to me”.

In summary, Amina’s background information shows that she started the course with lower self-efficacy and motivation levels, and low level quiz score. Also, the data shows that she did not have a conceptual view of mathematics. She did have a more procedural view, as shown in her concept maps analysis at stage 0.
**Amina’s Progress From Stages 1 to 3:**

Figure 6.17: Amina’s self-efficacy, motivation, and test scores during the course in percentages.

The figure shows that Amina noticeably and gradually improved her self-efficacy and motivation levels, and her test scores from stages 0 to 2. It also shows that she settled at high self-efficacy and motivation levels, and test scores from stages 2 to 3. She ended the course with high self-efficacy and motivation levels, and a strong test score at stage 3. Amina discussed the different features that she encountered during the course and their influence (if any) on her level of self-efficacy and motivation, and her mathematical understanding as demonstrated by her test scores, and passing the course.

- **Revision Notes**

Amina appreciated the questions’ used in the revision notes as they were deep enough to provide Amina with proper preparation for quizzes and tests. This improved her
mathematical understanding during the course. Amina said “The revision notes you gave to us, I feel that they were very helpful, they made my studying for the tests much easier which made it easier for me to solve questions on any test. This has lead me to understand more the taught topics really well”.

- **Teacher’s Teaching Methodology**

Amina realised the benefits of the teacher’s approach; using different strategies to solve the same problem, monitoring students’ levels of understanding, repeating information if needed, and encouraging the students to understand conceptually rather than procedurally. Developing this conceptual approach gave her the confidence to feel that she would be able to understand the mathematics that she will encounter in her future studies. She said “the way you teach is so perfect, I feel I receive the taught info easily and smoothly and it makes so much sense. Even if we don’t understand a point, you go over it again in an easier way so that we understand it without the need to memorize the steps. I think this is the perfect way to understand math, not just to memorize it. This made me feel that I can understand math in the future”.

- **Group Work**

Using group work in class motivated Amina to learn how to learn mathematics, think carefully, explore her own strategies to solve problems, and improve her level of mathematical understanding. The group work involved using games such as the puzzle sheet or Kahoot. This motivated her to improve her attendance during the course and as a consequence her level of self-efficacy increased to a level where she felt that she would be able to take any mathematics course in the future. She explained “working in groups in the classroom, I feel that it forced us to think and find ways to solve each assigned question including the puzzle sheet or any other question. If one of us was stuck solving a problem,
her group member will assist her to understand it and solve it. Having group work offered in the class has motivated us to attend more cause the class time is not boring anymore, its more interesting, more fun to attend. It’s not the usual and traditional course to attend, there is much more to expect from attending the class every day. We didn’t feel that we wanted to get this class time over with and leave as I used to feel in previous courses. This has made me feel that I am able to take and learn the next math course and that it will be easy for me cause taking this course will make it easier for me to take the next course. I used to feel that the more correct answers I could answer in the classroom, the more motivated I was to solve the next question”.

- **Social Media Group**

The students in Amina’s class decided to extend group work by creating a WhatsApp group online-social media application. The WhatsApp group brought the students together to socialise, communicate, teach each other when needed, and prepare for quizzes and tests together. It was an online supporting system between the students. This intrinsically motivated Amina to work together with her classmates, understand the materials, and pass the course. She said that “another point I liked in this class that we created a group in the WhatsApp, which helped us to stay connected with each other and other students in the class. We used it for sending class notes in case one of us missed a class, sometimes if I have a question that I did not know how to answer, I would send it on the WhatsApp group and then the students would help me to answer it. Also, we used it to remind each other of date of a certain quiz or test. There were many benefits of using this program, one was that it made us to get to know each other (everyone in the class). Before using it, I didn’t even know my classmates’ names and the group helped me to get to know their names, personalities sometimes as well”.
• **Bonus Marks**

Amina is grade driven similar to many students at GUST. She was extrinsically motivated, by the bonus points offered, to prepare well for quizzes and tests so that she could, gain the bonus points and be more likely to pass the course. She explained that “another point I liked a lot in the course was the bonus points we could receive, maybe it was the most motivated thing that encouraged me to study and take any quiz you offered. I wanted to work as hard as I could in order to receive the bonus point. It helped to pass the course”.

• **Attendance**

Enjoying class time through the use of playing different games such as the puzzle sheets and Kahoot, intrinsically motivated Amina to attend class regularly, learn the taught materials, improve her mathematical understanding level, gain the bonus marks, and pass the course. She was also extrinsically motivated by the bonus grades to work hard to gain them and improve her grades. She explained that “It motivated me to attend class, it kind of forced me to pay more attention in class to understand the lesson so that I know how to answer each assigned question in the puzzle sheet and in Kahoot. Kahoot is so much fun game because we were competing who will answer quickly and correctly and receive the bonus mark ... I like Kahoot a lot as it motivates me to work hard and fast but sometimes it stressed me out as it made me feel that I had to solve the questions very fast in order to receive the bonus mark. We need to break the teaching routine and allow some excitement”.

• **Correcting Own Students’ Errors**

Amina realised the connection between correcting her own mistakes in tests, improving her mathematical understanding, and passing the course. Not only had Amina improved her
mathematical understanding and level of self-efficacy, but had also demonstrated her extrinsic motivation due to the bonus marks which could improve her overall grades. Also, correcting her own mistakes allowed Amina to see how minimal her mistakes were and how to avoid doing them in the future. She explained that “I liked the idea that you gave us back the test after grading it and asked us to go over our mistakes and solve them within our groups. If we correct them properly, we gained a bonus mark. Which is so good and made us understand more the taught materials. Also, it made me feel that I can solve math problems. When I looked at some of my mistakes, when I see how small and silly they were, I realize how important it is to understand them so that I don’t do this mistake any more. All this motivates me to study harder and understand more and feel how easy it is to pass the course”.

- **Teacher’s Teaching Methodology**

Also, Amina appreciated the teacher’s teaching approach. She explained that the teacher’s teaching approach was suitable for Amina’s level of understanding and needs. She also appreciated all the new teaching approaches used in the course. Amina explained that this improved her level of self-efficacy and her ability to learn mathematics in the future. Amina said that “I will add that the way you teach helped us to understand really well. At other classes, the way they teach was either too fast, or was not well explained. I like to take my time receiving the knowledge and going over it as you do is very important for my understanding. The way you teach prevent me from asking special tutors to be re-taught. No one used group work or Kahoot in any previous course which improved my ability to learn and understand mathematics in the future”.

Figure 6.18 shows Amina’s concept map at stage 2.
This concept map shows that Amina used two clumps where each topic was connected to one or more other topics. For example, she linked all operations related to ‘rational expressions’ by using common words such as ‘rational expressions’ in one clump. Still, she showed some understanding when she used ‘collecting like terms’ and ‘convert between decimals and percent’.

For the ‘net’ of topics, she showed that she had more sense of the relationships between different mathematics topics at this stage. For example, she created a central topic ‘solving algebraic equations’ where many other key topics were connected directly to it. Amina knew that operations on ‘polynomials’ led to ‘solving algebraic equations’. Similarly, she showed that ‘translate and solve’, and ‘solving inequalities’ lead to ‘solving algebraic equations’. Amina did not only focus on the major topics but also used simpler topics such as ‘combining similar terms’ or ‘find GCF’ as links between other topics.
In conclusion for Amina’s concept maps analysis at stage 2 she seems to have a more connected view of mathematics at this stage. This might be an indicator of a more conceptual approach to understanding mathematics.

Taking this course, not only motivated Amina to attend regularly, but also allowed her to enjoy her time while learning, and improved her mathematical understanding. She explained that “I am very carefully to attend class every day. But, when the class is boring, I may not be as careful to attend class every day. In this course, because of the understanding, the games, the fun tools the instructor offers on daily basis, this made me feel more keen to attend class so that I understand more”.

**Online Homework**

Although Amina appreciated all the features offered in PEARSON MyMathLab, she had some complications that may have discouraged her from using it. She realised that it was an available online for practice at home and that she could raise her grades by using it. This extrinsically motivated Amina to use the program for her practice and improve her grades in the course. She explained “I don’t prefer it much. If I write a small letter than a capital letter, it will count it as a mistake. You have to be careful solving the problems. I like the practice online because it did raise our grades if done correctly ... it helps raising grades but I hope they can make it easier to enter the answers in the future ... If I didn’t know how to answer a certain question, I would try to look at ‘similar question’ so that its gives me an idea on how to solve my question in a similar way”.

Figure 6.19 shows Amina’s concept map at stage 3.
Figure 6. 19: Amina’s concept map at stage 3.

This concept map shows that Amina used a similar approach to that used in the map at stage 2. She connected all the topics using a ‘net’ of links where each topic was connected to one or more other topics. Amina shows more sense of the relationships between different mathematics topics at this stage.

Also, the central topic ‘solving algebraic equations’ seems more obvious with many other key topics connected directly to it. Amina showed some understanding when she used ‘combining like terms’, ‘convert decimals to percent’, and ‘find GCF’ to link between major topics. For example, she connected ‘collecting like terms’ to ‘adding or subtracting rational expressions’ to ‘solving rational equations’. She showed that ‘finding different solutions’ is a result of ‘solving algebraic equations’.
In conclusion for Amina’s concept maps analysis at stage 3, she seems to have improved her conceptual understanding of mathematics at this stage. She seems to understand that the end product of many mathematical problems requires the solution of some sort of equation. In her interview, she confirmed this conclusion when she indicated that “through taking the course topics and learning relations between them, I could connect them properly. For example, adding and subtracting polynomials will lead to solving them. Multiplying and dividing rational expressions will lead to solving them at the end. I understood the relation between topics along the course”.

- **Change in Student’s Attitudes**
Amina started the course with low self-efficacy and motivation levels, and a low score in her level quiz. She realized the positive influence of the use of the new educational approaches to improve her understanding and self-efficacy level and pass the course. She believes in the teacher’s role in her success. She explained “I started the course feeling and thinking that I am not able to understand or solve mathematics problems. The more I attended, the more I felt that I understand the course materials and that I can pass the course. Its everything you offer us and all the tools you use to help us understand. Now, studying math is easy and passing the course is easy as well. I know that I will do better and better and pass the course. I am not even worried about taking the next course, but we need a good teacher to teach it as good”.

Figure 6.20 shows similar questions from Amina’s level quiz (left) at stage 0 and Test 4 (right) at stage 3.
Considering figure 6.20 (left), Amina showed that she did not seem to understand the meaning of equilibrium in question 5 in the level quiz. For example, she did not make any attempt to solve the problem. Considering figure 6.20 (right), not only did Amina know the meaning of equilibrium, she also used new algebraic techniques such as solving quadratic equations using factoring and found the right solution(s) for this problem. This indicates that, Amina improved her conceptual understanding during the course.

- **Change in Student’s Attitudes**

In conclusion, Amina’s background data shows that she started the course with low self-efficacy and motivation levels, and a low level quiz score at stage 0. The data also shows a gradual improvement in her test scores, self-efficacy and motivation levels from stages 0 to 2. She stayed at high self-efficacy and motivation levels, and high test scores from stages 2 to 3.
She passed the course with a high overall grade. She explained “I didn’t expect to reach where I am at the moment. I expected to fail the course to be honest. The more we went in depth in the course, the more I understood maths and the more I felt that I am more capable to pass the course. This made me feel that I can take any math course in the future and pass it ... Nothing is impossible, if you have the confidence and belief in your capability, nothing will stop you. I got this feeling after taking the course with you. Everything will be easy. I have never seen a 93% as a test score in math before”.

6.4.5 Shamlan (Student # 13 Gr.2, Low Self-Efficacy Student)

Stage 0

Table 6.9 shows Shamlan’s background information.

<table>
<thead>
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<th>High School Major Type (Science/Liberal Arts)</th>
<th>Highest Math Taken</th>
<th>Number of Times Taken Math 095</th>
<th>Number of Times Taken Math 096</th>
<th>Maths Was My Favourite Subject in High School</th>
<th>Cannot Solve Any Maths Problems Without The Calculator</th>
<th>Enjoyed Using Computing Programs While Solving Algebra Problems</th>
<th>Pass/Not Pass</th>
<th>Important to Take Foundation Maths Course</th>
<th>Attendance /75</th>
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<td>Y</td>
<td>75</td>
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</table>

S.E. at stage 0 /70

| Mt. stage 0 /50
| Level Quiz %
| 19                                   | 13               | 8
| 27%                                   | 26%              | 8%

Table 6.9: Shamlan’s background information at stage 0.

Shamlan explained that his schoolteachers had always exposed him to traditional teaching approaches, but that he had graduated from high school hating mathematics. He had low self-efficacy and motivation levels, and his score on the level quiz at stage 0 was very poor. He said, “I learned maths at school when the teacher would write things on the white board, and we copy and he leaves. I hated maths and hated to learn it. I never thought I could learn it as
I do now … Taking math at high school was a disaster. It was all in Arabic and the teacher didn’t care about us at all”.

He explained that he was never exposed to any technology in mathematics lessons before joining GUST. Shamlan said, “I never used any tool to solve mathematics except the calculator at school”. Shamlan added that he graduated from school with weak arithmetic and calculating skills. He was calculator dependent and said that he could not do the simplest computations when he joined GUST. He said that “I could not do the simplest computation when I joined GUST.

Figure 6.21 shows Shamlan’s concept map at stage 0

Figure 6. 21: Shamlan’s concept map at stage 0. (first time taking the course)
A clear feature of this concept map is that it contains three distinct clumps. It is noticeable that Shamlan used a simple approach for linking some topics together, mainly by selecting similar words in one certain clump. For example, he linked all topics related to ‘percent’ together at the bottom clump. He also clumped all operations related to ‘translate and solve’ and ‘solving linear equations’ together. He used ‘solving equations two times. In these two cases, the key word ‘solve’ seems to be the key to creating the clump, although there may have been some mathematical association.

Considering the major clump at the top of his diagram, it is noticeable that the centre and right-hand topics were somehow linked mathematically to each other, while the topics on the left side did not show any connections to the remainder of the topics in the clump. For example, he linked ‘multiplying polynomials’, ‘multiplying rational expressions’ and ‘adding and subtracting rational expressions’ together. This indicates that Shamlan probably did not have a clear sense of the mathematical connections between some of these topics.

The conclusion derived from Shamlan’s concept maps analysis is that he seems to have a disjointed view of mathematics at this stage, which may be an indicator of a very weak understanding of mathematical connections. In his interview, Shamlan confirmed this conclusion when he stated that “The first one (concept map) does not look too good”.

In summary, Shamlan’s background information shows that he started the course with low levels of self-efficacy and motivation, and a poor level quiz score. Additionally, his concept maps data shows that he had a weak conceptual understanding of mathematics at stage 0.
**Shamlan’s Progress at From Stages 1 to 3:**

Figure 6.22 shows Shamlan’s self-efficacy and motivation levels, and test scores during the course as percentages.

![Graph showing Shamlan's progress](image)

The figure shows that Shamlan made noticeable improvement in his self-efficacy and motivation levels, as well as his test scores from stage 0 to 1. It also shows that these levels did not change much from stage 1 to 2. From stage 2 to 3, Shamlan’s self-efficacy and motivation levels, and test scores increased again. Shamlan discussed different features that he encountered during the course and their influence on his level of self-efficacy and motivation. His test scores demonstrate how his mathematical understanding improved through the duration of the course.

- **Tutor’s Attitude**

Shamlan expressed that he knew that he had weak mathematics basic skills. His learning was not previously monitored, as was done in this course. His teacher’s attitude during the course
positively influenced his self-efficacy level, which was very motivating for him and encouraged him to attend classes regularly, work hard and improve his grades. “I felt always motivated to come to your class in this course. You cared so much about teaching us to extend that we have always felt that you were like a mother to us because you give us so much during class. Even that I am very bad in math and have had low grades in this course, I still look forwards to attend every day. Many of my friends in other classes don’t care to attend much of their math classes and wonder why do I attend every day. You did so much in class which made me feel that next test I will do better. I am getting better and better in math despite my low grades”.

- **Teacher’s Teaching Methodology**
Shamlan appreciated the teacher’s teaching approach, as he compared his previous and current experiences classes. For example, he explained that his previous teachers provided questions and answers to the students, compared to his current teacher who allowed students to explore their own learning strategies. He liked the fact that she offered different methods to solve the same problem, and he appreciated her monitoring of the students’ progress and mathematical understanding. This helped improve his conceptual understanding and self-efficacy levels, and motivated him to work hard during the course. He explained that “at school I remember that they didn’t actually teach, they used to give us the answer and didn’t allow us find out the answer as you do. In the last two high school years, the teacher used to write on the board, look at us in the eye and asked us to copy from the board and left. Didn’t care if we understood. Exactly the opposite of you, you were always around us. You checked the way we solved each problem. You checked how did we understand things. When you feel that we may not understand anything, you would repeat things and tried to find easier methods that we could understand ... All this taught us the main concepts of the course,
motivated us to continue and made us feel better and better about the way we understood things and how can we learn math in the future”.

- **Group Work**

Shamlan liked the use of group work in class as it provided him with support and made him feel relaxed in class, which also improved his relationships with his peers. He changed from a student who used to sit alone in his previous course, to one with increased self-confidence, who played a key role in his group. He clearly attributed the group work to his improved mathematical understanding, linking this to the discussions that took place between himself and his peers. This changed his attitude towards learning mathematics and motivated him to attend regularly. Shamlan said that “In math 095, we didn’t do anything that you offered in our course now. I love group work. It made us closer to each other. If I didn’t understand any step from you, one of my friends and group members would explain it to me. I used to sit alone in math 095, now I am the one who start asking my group members how to solve problems and recommend my methods to solve them as well. This helped us to understand things really well. We come to class relaxed and feeling good to attend. Actually, I feel that I want to attend and this is why I didn’t miss many classes during the course”.

- **Small Boards**

Using the individual plastic boards was a new experience for Shamlan. These helped him to connect the content of the previous and current lessons. In addition, he appreciated the questions used as they involved the use of new learning techniques. For example, some questions challenged Shamlan to create examples and improved his mathematical understanding when exploring the ‘reverse thinking’ approach. This also improved Shamlan’s motivation and mathematical understanding levels. He explained that “you motivated us using the individual plastic boards. It was a good way to review and understand
the previous lesson you taught us. The questions you used were hard but easy at the same
time. They were hard because we never created examples before but became easy when we
understood how to think in reverse thinking”. Similarly, Shamlan appreciated the variety of
questions, different levels of difficulties, and the summarised concepts used in the revision
notes. He felt that the questions provided summarised knowledge for each chapter used that
he could use them to prepare for quizzes and tests. This improved his self-efficacy and
mathematical understanding levels. He added that “I liked the revision notes as you
summarized a chapter in few questions. This improved my understanding and made me
double sure that I could solve different problems in different ways ... The review notes, you
minimize everything (the chapter contents) into one lesson that contains the most important
contents of the chapter. I used the revision notes to review for our major tests”.

•  **Gamification (Kahoot) and Puzzle Sheets**

Playing games such as Kahoot and puzzle sheets was another new approach that Shamlan
was exposed to while taking this course. He realised that the questions used in Kahoot and
the puzzle sheets were challenging, which forced him to think fast, and work hard to gain the
bonus grades. He connected the benefits of enjoying learning through the use of the puzzle
sheets and Kahoot He claimed that these improved his intrinsic motivation level, his self-
efficacy and mathematical understanding levels, which enabled him to gain bonus marks in
order to pass the course. He explained that “I never tried the puzzle sheet, and Kahoot before
taking this course. They were so much fun and beneficial. All this taught us the main
concepts of the course, motivated us to continue and made us feel better and better about the
way we understood things and how can we learn math in the future ... I loved Kahoot and the
puzzle s as they were challenging for us and forced us to think. I have low grades, and
Kahoot and the puzzle sheets helped me to raise my grades with the bonus marks. No teacher offered this before. They motivated and made me to think faster. I like Kahoot more because its fast and we could use our mobile phones”.

Similar to many other students, Shamlan is grade-driven. He was keen, and extrinsically motivated to apply all the requested activities used in class in order to receive the bonus marks, raise his grades, and pass the course. “The bonus marks are helpful so that they improve my grades in quizzes when I mess things up”.

Figure 6.23 shows Shamlan’s concept map at stage 2.

Figure 6.23: Shamlan’s concept map at stage 2.

This concept map shows that Shamlan used a different approach to link the topics at stage 2. He showed no single clusters as applied at the previous stage. Also, there are no isolated topics that were unconnected. Shamlan created a ‘net’ of links, where each topic was
connected to one or more other topics. This shows that he had more sense of the relationships between different mathematics topics at this stage.

He also created a central topic ‘solving algebraic equations’, where many other key topics were connected directly to it. Shamlan knew that ‘finding different solutions’ is a result of ‘solving algebraic equations’ and did not link it to any other topic. Not only did he focus on the major topics, but also linked simpler topics such as ‘combining similar terms’ or ‘find GCF’ as links between other topics. In fact, he included ‘combining similar terms’ and ‘GCF’ twice for this purpose. Shamlan separated ‘solving rational equations’ from ‘solving algebraic equations’, possibly indicating his uncertainty in the relationship between the two concepts.

In conclusion, for Shamlan’s concept maps analysis at stage 1, he seems to have a slightly improved view of mathematics at this stage, but this view is not complete. This might be an indicator of a more conceptual approach to understanding mathematics.

Despite the fact that Shamlan’s grades did not qualify him to pass the course at stage 3 of his first time taking the course, he ended the course with improved self-efficacy and motivation levels compared to those at earlier stages of the course. He explained that “But nothing was like taking this course with everything covered in it. I was a liberal Arts major so we never took serious math or algebra. I expected to do worse in this course because I knew that I joined with a very weak math background but seriously what you offered, made me feel that I am capable to continue the course and pass it at the end”.

- **Change in Student’s Attitudes**

Taking this course changed Shamlan’s attitude when considering taking any other mathematics courses in the future. This is despite the fact that he considered changing his college major from Finance to Public Relations (PR). The Finance college major requires
Taking more mathematics pre-requisite courses than the public relations major. Taking the course improved Shamlan’s self-efficacy level and gave him the confidence to take any mathematics course in the future and continue in his Finance major. Shamlan explained that “taking the course changed my view to take any mathematics course. At the beginning of the course, I thought to change my major from finance to PR because of math. Regardless if I pass this course or not, I feel it’s possible for me to understand the course materials and then pass in the future. I want to continue taking maths courses and take other courses in the future. I can do it and will continue in my finance major. I feel this. I just need to focus more and I know that I can pass”.

Figure 6.24 shows Shamlan’s concept map at stage 3.

![Shamlan’s concept map at stage 3](image)

This concept map shows a similar approach to that used by Shamlan in the map at stage 2. He continued to use a ‘net’ of links where each topic was connected to one or more other topics.
Also, the central topic ‘solving algebraic equations’ seems more obvious where many other key topics were connected directly to it.

Shamlan did show some conceptual understanding as he used ‘GCF’ to link between topics twice. Also, he showed that ‘finding different solutions’ is a result of ‘solving algebraic equations’ and did not link it to any other topic. Shamlan also showed an incomplete view of mathematics, as he did not link ‘combining like terms’ to other topics. Furthermore, he did not include topics related to operations (+, -, ×, ÷) on ‘rational expressions’, which were included in the assigned list by the teacher. He also used ‘solving inequalities’ twice without showing sufficient justification for doing so. Finally, he separated ‘solving rational equations’ from ‘solving algebraic equations’.

In conclusion, for Shamlan’s concept maps analysis at stage 3, he seems to have briefly improved his conceptual understanding in mathematics at this stage. He still does not show a complete view of conceptual understanding. In his interview, he confirmed this conclusion when he indicated that “In phase one, I put adding and subtracting polynomials together while in phase 3 you can see I have ‘order of operations’ connected to ‘combining like terms’ to ‘adding and subtracting polynomials’, and all to ‘solving’. There are much more topics and I think that I have a better idea combining the topics together. I understand better by now”.

- **Online Homework**

Shamlan was extrinsically motivated to use PEARSON MyMathLab despite the fact that he was never exposed to technology during his school years. He used the program for online practice of the material taught in the lessons. He appreciated the different features offered by the program, such as giving three chances to solve each problem, and used the ‘view similar
problem’ feature. This improved his mathematical understanding. Shamlan explained that “I like using MyMathLab because I do it on my own time. I look at similar examples so that I remember how you taught us the problem and then try to solve it. It helped me to understand after you taught us. It’s such a great variety of problems and very good practice at home that is always available for us. Plus, we get marks for it which is great. It gave me 3 chances to try solving each problem. It helps me to apply what you teach us in class at home which improved my understanding”.

- **Attendance**

According to Shamlan, using the new educational approaches in classes motivated him to commit to attending class time regularly during the course. He positively related attendance to improving his mathematical understanding and motivation levels, and grades in the course. He explained that “I believe that if I miss a class, I will miss a lesson which is very hard to understand on my own. Attending class makes me feel better about the way I understand. Especially that I understand a lot from the way you teach. I attended class every day and my results was all my fault as I should have studied the course seriously at early stages. I am very motivated to attend every day. You could not have done any better to help us understand. You provided us with the best ways to understand during the course period. You kept us motivated the whole time with everything you offered … The less I attend, I will miss a lesson which could lead to less learning, less understanding and low grades in tests and quizzes I would get”.

Figure 6.25 shows similar questions from Shamlan’s level quiz (left) at stage 0 and Test 4 (right) at stage 3.
Figure 6. 25: Similar questions from Shamlan’s level quiz (left) at stage 0 and Test 4 (right) at stage 3.

Considering figure 6.25, Shamlan showed that he did not know the meaning of equilibrium in question 5 in the level quiz (left), and that he did not do any basic algebraic steps in order to solve the question. Considering figure 6.25 (right), Shamlan exhibits an understanding of what equilibrium means. However, he did not seem to know how to apply ‘combining like terms’ properly, nor he could solve the quadratic equation using the quadratic formula or by factoring. Shamlan showed a slight improvement for his conceptual understanding during the course.

In conclusion for this course, Shamlan started the course with low self-efficacy and motivation levels, and level quiz at stage 0. Not only did he improve his self-efficacy and motivation levels during the course, but also he improved his test scores from stages 0 to 1. He showed some stability in his motivation and self-efficacy levels, and test scores from
stages 1 to 2. Additionally, Shamlan showed improvement in his self-efficacy and motivation levels, and test scores from stages 2 to 3. Shamlan explained in his interview “even that I was very bad in math and have had some low grades in this course, I still look forwards to attend every day ... You did so much in class which made me feel that next test, I will do better, I am getting better and better in maths despite my low grades”. Despite the improvement in Shamlan’s self-efficacy and motivation levels, his grades, did not qualify him to pass the course. He received an NP grade.

Shamlan registered for the Math 096 course at the next opportunity and chose the same tutor with the same educational and teaching approaches. Shamlan agreed to have a second semi-structured interview at the end of stage 3 of his repeated course in order to find out the reasons for taking the course with the same instructor and educational approaches.

- **Change in Student’s Attitudes**

Shamlan explained how the educational approaches used in the course positively influenced his self-efficacy, motivation, and mathematical understanding levels at the end of the previous course. The teaching approach, the activities and fun games encouraged him to take the course again with the same teacher as previously, in order to pass the course. Shamlan explained that he was ill during the previous course, which caused his failure. He added that taking the previous course changed his attitude to work harder and pass the course. Shamlan explained that “I think that you have the previous recording. I took the course again because seriously I have always felt the courage to come to class, attend, and have the way you teach which is excellent. I used to receive the taught information in your class fast especially with everything fun you offer in class. The reason I failed last time was all because of my fault. I should have taken the course seriously last time at the first month or so, especially that I was
not well and was hospitalized a couple of times during the course, but everything changed this time. Shamlan discussed the reasons for re-taking this course with the same teacher, instead of taking it with other teachers in the department. He also explained how each activity used in class encouraged him to attend, work hard, gain the bonus marks, and pass the course. He said “I felt good about my understanding and ability to pass in your class last time and I didn’t want to lose it. You encouraged and motivated us to attend, and to work hard. You created games and puzzles, then offered bonus marks and motivated us to continue working hard. You were always around us offering help. You offered different games and bonuses. You were always prompt and responsible. You teach from your heart and give us everything you got”.

Figure 6.26 shows a conceptual question from Shamlan’s Test 4 at his repeated course.

Figure 6. 26: A conceptual question from Shamlan’s Test 4 at his repeated course.
Considering figure 6.26, Shamlan made a good attempt to try to solve question 19 in Test 4 of his repeated course. For example, he tried to solve the quadratic equation using the quadratic formula. His miscalculation when combining like terms, led him to the wrong solutions. It seems that Shamlan was double-checking his answer by using the factoring method and ended up with the correct solutions. Not only did Shamlan solve the question correctly, but also showed the use of new techniques to solve the question. This means Shamlan showed an improvement in his conceptual understanding while taking the repeated course.

Figure 6.27 shows the Shamlan’s self-efficacy and motivation levels, and test scores in percentage in his repeated course.

![Shamlan- Repeated course](image)

Figure 6. 27: Shamlan’s self-efficacy, motivation, and test scores in percentage in his repeated course.

- **Teacher’s Teaching Methodology**

Shamlan was very motivated to take the next mathematics college course. He explained the benefits of using each of the educational approaches in the course and how this motivated
him to work hard, understand the course materials, and pass the course. He improved his self-efficacy to take college mathematics courses in the future. He said that “I just followed your instructions carefully and studied. I had to give it all what I got. I studied your chapter revision notes, class notes, I used WhatsApp group to communicate with my classmates outside the classroom, I focused when using group work in class, I also focused when Kahoot and the puzzle sheets and everything you provided played to us. I knew I could pass from the first period I attended this course. Having previous notes also helped. It feels that I should never stop trying ... I am honestly very excited. I feel that I understand the subject even more than before and I can do well in the next course easily. I can’t wait to take College Algebra. I feel capable to pass it easily”.

In conclusion, failing the course for the first time changed Shamlan’s attitude to work hard and seek proper learning of mathematics when he decided to take the second course. He started the second course with high self-efficacy and motivation levels from stages 0 to 1. His high self-efficacy- and motivation levels stayed stable from stages 1 to 3. For his test scores, he made a 95% percent increase in Test 1 from the first to the second course. He also made a 112 % percent increase in Test 2 from the first to the second course, and a 66% percent increase in Test 4 from the first to the second course. He passed the course with high overall average. Shamlan related his experience when taking maths in the past to his experience when taking Math 096. He explained that his confidence and self-efficacy were high when he started his second Math 096 course. He appreciated all the educational tools used in the course and how this assisted him to pass the course easily. He explained that “I took math 095 with another instructor and he was very different than you. I felt very relaxed with you last course even that I failed the course. I was very confident that I was going to pass easily this course when taking it with you and experiencing everything you offer us. I have loved always
the way you teach and your care about how you help us understand. Look where I am and how happy I am now ... I knew you were the best”.

6.4.6 Dina (Student # 3, Gr.2, Low Self-efficacy Student)

Dina is an older student employed in the government sector. She was encouraged by her parents to gain a college degree and improve her status at the ministry. She took Math 095 and Math 096 both on two occasions. She was considered a repeater with weak mathematics background at stage 0.

Stage 0

Table 6.10 shows Dina’s background information at stage 0.

<table>
<thead>
<tr>
<th>High School Major Type (Science/Liberal Arts)</th>
<th>Highest Math Taken</th>
<th>Number of Times Taken Math 095</th>
<th>Number of Times Taken Math 096</th>
<th>Maths Was My Favourite Subject in High School</th>
<th>Cannot Solve Any Maths Problems Without The Calculator</th>
<th>Enjoyed Using Computing Programs While Solving Algebra Problems</th>
<th>Pass/Not Pass</th>
<th>Important to Take Foundation Maths Course</th>
<th>Attendance /75</th>
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</thead>
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<tr>
<td>L.A</td>
<td>Alg. II</td>
<td>2</td>
<td>2</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>P</td>
<td>Y</td>
<td>73</td>
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<tr>
<td>S.E. at stage 0 /70</td>
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<td>Mt. stage 0 /50</td>
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<td>Level Quiz %</td>
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<td></td>
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</tbody>
</table>

Dina explained that she hated mathematics during school and believed that she could never learn it. This was the reason for her low self-efficacy level at stage 0. Dina explained that “when I joined Math 096, I used to hate math. I used to feel math is hard and difficult. I can never learn math”.
Dina explained that she was never exposed to any technology in mathematics lessons before joining GUST. She said that “at public schools, we used the computer to write essays and other things but not to do maths.”. She realised how weak basic mathematical skills were before joining GUST. This was the reason for her indication of being a calculator dependent in her background questionnaire. She said that “I was terrible in adding, subtracting, multiplying or dividing before joining GUST”.

Figure 6.28 shows Dina’s concept map at stage 0.

![Dina’s concept map at stage 0](image)

Figure 6. 28: Dina’s concept map at stage 0

Dina’s concept map contains three distinct clumps. It is noticeable that Dina used a simple approach for linking some topics together, mainly by selecting similar words. For example, she linked all topics related to ‘polynomials’ together in one clump. Similarly, she clumped all operations related to ‘exponents’ together. Also, she linked two clumps with one link. One
clump showed all related topics to ‘solving algebraic equations’ and another clump with all topics related to ‘percent’. In these three cases, the key words were used such as ‘polynomials’ or ‘exponents’ seems to be the key to creating the clump, although there may have been some mathematical association.

In the top right clump, the word ‘solving’ was the common word. Also, she connected ‘solving linear equations’ to the ‘percent’ without showing sensible relations between them. This suggests that Dina showed a limited sense of the mathematical relationship between some, but not for all of the topics.

In conclusion, for Dina’s concept map analysis at stage 0, she seems to have a weak view of mathematics at this stage, and only links together topics with very strong connection words. This might be an indicator of a procedural approach to mathematics. In her interview, Dina clarified this conclusion when she stated that “The first one looks messy. I am looking at it and it does not make any sense to me ... I know how to connect the topics with each other now so when I look at the first map, it looks embarrassing. I can see now that the topics were not properly chained to each other. The topics were scattered”.

In summary, Dina’s background information shows that she started the course with low self-efficacy and low motivation levels, and very low level quiz score. Also, the data shows that she did not seem to have a view of conceptual mathematics and weak mathematical understanding as shown in her concept maps analysis at stage 0.

**Dina’s Progress From Stages 1 to 3**
Figure 6.29 shows Dina’s self-efficacy, motivation, and test scores in percentage during the course.

![Dina's self-efficacy, motivation, and test scores](image_url)

Figure 6.29: Dina’s self-efficacy, motivation, and test scores in percentage during the course.

The figure shows that Dina showed a noticeable improvement in her self-efficacy and motivation levels, and her test scores from stages 0 to 2. Also, she was stable at her high self-efficacy and motivation levels, and test scores from stages 2 to 3. She ended the course with high self-efficacy and motivation levels, and a good test score at stage 3. Dina discussed different features that she encountered during and the course and their influence on her level of self-efficacy and motivation, and her mathematical understanding as demonstrated by her test scores, and passing the course.

- **Group Work**

Dina explained that she was never exposed to group work during her school years. Group work provided her with the social and learning support system that she had needed in the past, but that had not been available for her. This learning support allowed Dina to get to
know her class mates, interact with them, and learn new techniques needed for her understanding improvement. Dina explained that “I loved using group work which I never experienced in the past. I felt the difference when using it as I felt that it increased the motivation among the students. I felt that I understood the materials more. While setting in the group, if I don’t understand a point, one of my group members would help me to understand it. I also helped students with things I knew and they didn’t. I never had group work done in my class before, I never knew my classmates. I know them all by name because of group work”.

- **Social Media (WhatsApp) Group**

Dina did enjoy group work and using a WhatsApp group as a social media online application as an extension support provided by group work. This provided some positive and intrinsic motivation to Dina to seek better understanding and continue learning mathematics in the course. For example, the program provided her with an online support for her questions at home from her classmates. She said that “Group work was extended in the WhatsApp where we were connected in the classroom and outside the classroom as well. When I go home, I have been feeling that I can always ask the girls about any question I need, about any missing hw any other missing work”.

- **Gamification (Kahoot) and Puzzle Sheets**

Dina also was intrinsically motivated by the new educational approaches used in the course, such as playing the puzzle sheets and Kahoot. She felt that using the puzzle sheets and Kahoot positively changed the traditional teaching approach. For example, creating the competition while playing the games improved her motivation and mathematical understanding levels. Dina said that “Another thing I liked in this course was using the puzzle
sheet, I liked it a lot. It was a new change for the course, it makes math easier for me to understand. I used to find math very difficult to understand. I used to hate it but now it’s becoming easier and I can do it. The way math used to be taught was too traditional, it was boring since we were children and it never changed till taking this course. The puzzle was different, it created some kind of a competition between the girls. It also created motivation among us. Another thing to mention, is the use of Kahoot. Again, it broke the traditional routine, it’s something new that I never experienced, very beneficial. It was very good game that improved our understanding”.

- **Bonus Marks**

Dina liked to gain bonus marks in order to improve her overall grades. She realised the connection between learning mathematics, enjoying learning mathematics, completing the puzzle sheets or playing Kahoot, and gaining bonus grades to pass the course. This improved Dina’s extrinsic motivation level to work hard, understand the course materials, and gain the bonus grades. She explained that “we felt motivated who will answer first, who will win the bonus mark. I used to feel not happy if I don’t win the bonus mark. This forced me to study carefully and understand the taught topic really well”.

- **Correcting Own Students’ Errors**

Dina appreciated reviewing her own tests and correcting her mistakes among her group members. This not only assisted Dina to realise her mistakes, but also provided her with better motivation and the mathematical understanding to solve similar questions in future tests. She especially enjoyed the support received when discussing her mistakes with her group members. She explained that “Another positive difference was the review after the test, it showed me my mistake and how to understand how to solve them appropriately. It motivated me to keep trying to realize my mistakes. This was very beneficial for my
understanding during the course especially that we helped each other in groups while correcting our individual mistakes. The student with the right answer helped the student with the wrong answer”.

- **Teacher’s Teaching Methodology and Tutor’s Attitude**

Dina appreciated the teacher’s teaching approach and attitude used during the course. She explained how the teacher monitored students’ interaction with each other while working in groups, and students’ understanding levels of the taught topics during the course. The teacher also created group discussions which helped improved Dina’s mathematical understanding. Also, the teacher’s attitude provided a certain learning support system that was always available to assist Dina and other students when needed. Dina explained that “Another thing to mention, is the teaching style used. She did show care about our understanding. She wondered around each one of us to check if we understood everything she taught, she created discussion groups among us, she was ready to repeat anything that we did not understand. She created a better relationship with us more than a usual teacher-student relationship. She was very nice and easy to reach when needed”.

Figure 6.30 shows Dina’s concept map at stage 2.
This concept map shows that Dina used a different approach to link the topics at stage 2. She did not create any single clusters by using common words, as at the previous stage. Dina created a ‘net’ of links where each topic was connected to one or more other topics regardless of the use of common words, which shows that she had more of a sense of the relationships between different mathematics topics at this stage.

She also had a central topic ‘solving algebraic equations’ with many other key topics were connected directly to it. Dina knew that ‘finding different solutions’ is a result of ‘solving algebraic equations’. She did use simpler topics such as ‘combining similar terms’ or ‘find GCF’ and linked them to the central topic, which showed that she had no sense of how she recognised the connections between them.

In conclusion, for Dina’s concept maps analysis at stage 2, she seems to have slightly more connected view of mathematics at this stage. This might be an indicator of a gradually
developing conceptual approach to understanding mathematics. She explained that “The second one was better than the first one but the last one shows more of my understanding of connecting the topics of each other. It even shows more understanding of the course in general”.

- **Teacher’s Teaching Methodology and Attendance**

  Dina explained that using the new educational approaches not only motivated her to attend regularly, but also changed her attitude positively to learn mathematics. She started to value the benefit for attending class regularly. This improved her motivation and mathematics understanding levels, and grades during the course. Dina said that “In the past, I never cared about attendance and felt that the other students were not attending properly. Since taking this course, because of the group work, games, offered bonus marks, we started feeling that it is important not to miss any activity or bonus mark. The course is becoming easier and easier. Attending has been more fun and encouraging it’s all because of your teaching and everything you offered in class. I feel that all the students are encouraged to attend. I feel that the more I attend class, the more I understand the materials taught. If I don’t attend, I wouldn’t know how to solve any question”.

- **Online Homework**

  Dina appreciated the use of PEARSON MyMathLab during the course. She said that the program provided online practice and support any time she needed. Also, she liked the fact that the program included materials that were connected to the taught materials in class. She explained that “It was very useful cause it was excellent practice at home so that I get familiar with the taught materials. The more I practice do and see the problems, the more I will know to do solve them”. Figure 6.31 shows Dina’s concept map at stage 3.
This concept map shows that Dina used a similar approach used in the map at stage 2. She continued to use a ‘net’ of links where each topic was connected to one or more other topics. Dina shows more of a sense of the relationships between different mathematics topics at this stage.

The central topic is ‘solving algebraic equations’ with many other key topics connected directly to it. She showed some understanding that the end product of many mathematical problems requires the solution of some sort of equation. Dina showed that ‘combining like terms’, ‘converting decimals to %’, and ‘order of operations’ as linking tools between topics. She used ‘combining like terms’ twice for this purpose. She also linked ‘finding different solutions’ is a result of ‘solving algebraic equations’ and did not link it to any other topic.

In conclusion for Dina’s concept maps analysis at stage 3, she seems to improve her conceptual mathematics understanding at this stage. In her interview, Dina confirmed this.
conclusion when she indicated that “The last one is the best as it is all organized and all topics are connected properly. Adding and subtracting polynomials lead to solving it. Also multiplying and dividing rational expressions will lead to solving rational equations. Translate and solve leads to solving equations with one variable ... I feel I understand the topics more now and know how to relate them to each other. This has reflected that my understanding of the course materials improved during the course”.

Figure 6.32 shows similar questions from Dina’s level quiz at stage 0 and Test 4 at stage 3.

Figure 6. 32: Similar questions from Dina’s level quiz (left) at stage 0 and Test 4 (right) at stage 3.
Considering figure 6.32, Dina showed that she did not seem to understand the meaning of equilibrium in question 5 in the level quiz (left) and she did not apply the correct algebraic simplifying steps to the expression that she obtained. Considering figure 6.32 (right), not only did Dina know the meaning of equilibrium, but she also used correct algebraic techniques, such as solving quadratic equations using factoring and found the right solution(s) for this problem. It is noticeable that Dina tried to solve the question twice on the sides of the page to double check and find the appropriate method to solve it. She did not want to quit easily before solving the question. This suggests that Dina improved her learning skills and mathematical understanding during the course.

- **Change in Student’s Attitudes**

In conclusion, Dina was a Math096 repeater. She started the course with a very low level quiz score, and self-efficacy and motivation levels at stage 0. She showed a noticeable improvement in her self-efficacy and motivation levels, and test score from stages 0 to 2. She worked hard and stayed stable with high self-efficacy and motivation levels, and test scores from stages 2 to 3. She indicated that she realised that she was able to pass after the mid-term exam. She passed the course with high self-efficacy and motivation levels, and a high test score at the end of the course. Dina said to confirm this that “I started the course feeling that I could never pass the course, especially that I took Math 095 twice. I started feeling better gradually. I scored low in test 1, improved a bit in test 2, but improved a lot after mid-course and knew that I was going to pass the course. I started with very low capability then ended up feeling happy up in the sky and can take any math course in the future … I learned from everything we do in class between group work, puzzle sheet, kahoot and reviewing after the test. It all helped me to improve my understanding and improve my grade in test 2. All this made it easier for me to understand the taught materials and made me feel that I am capable
to understand, improve and take the next course. I feel really good that I can really learn and improve in learning math”.

6.5 Summary

This chapter explored the qualitative data analysis in the students’ semi-structured interviews. The interviews were coded and tallied. The major themes explored are:

- Self-efficacy
- Motivation
- Mathematics Understanding

The interviews were also coded and tallied in order to explore the sub-emerging themes. They are:

- Group Work
- Teacher’s Teaching Methodology
- Tutor’s Attitude
- Social media (WhatsApp) Group
- Gamification such as Kahoot and Puzzle Sheets
- Revision Notes
- Bonus marks
- Small boards
- Online Homework
- Correcting Own Students’ Errors
- Change in Student’s Attitudes
- Attendance

In their interviews, the students expressed their different feelings and attitudes towards each of the major themes and sub-themes explored in this study. They also explained how each sub-theme (often linked to the educational approach) influenced their self-efficacy and motivation levels, and/or mathematics understanding levels. The interviewed students were divided into three self-efficacy levels: High, middle, and low according to their self-efficacy levels at stage 0, and their willingness to take part in the interview.
Students with different levels of self-efficacy discussed their feelings and attitudes when they started the course. They also expressed their feelings and attitudes towards experiencing each of the educational approaches used in the course, and whether or not they influenced their self-efficacy, motivation, or mathematical understanding at different stages in the course. Not only did students with different self-efficacy levels explain that they improved their mathematical self-efficacy, motivation, and understanding during the course, but they also ended the course with high levels of achievement in the course. Chapter 7 will discuss the answers to the research questions for this study.
Chapter Seven: Research Questions and Answers

7.0 Introduction

This chapter addresses the research questions of this study. The research questions will be discussed in the light of the results explored from the numeric and concept maps analyses in Chapter 6 and the qualitative data results from Chapter 7.

7.1 What mathematical backgrounds do students have when they join an MFU course and what is the relationship between their backgrounds and their self-efficacy?

GUST statistics from Fall 2013 to Fall 2018 showed that 25.8% of students joining GUST passed the Accuplacer examination while 74.2% failed and had to be enrolled in a mathematics foundation course. The statistics also revealed that the average percentage of students joining MFU with the Liberal Arts major has been 52.79%, while the average for the Science major students this has been 47.21%. This indicates that students who have studied mathematics, some as high as grade 12, have been joining MFU with a low level of mathematical knowledge that is below the Accuplacer standard mathematical level, suggesting that students could not effectively apply and use the mathematics that they have studied at school.

For the students participating in this study, the background data showed that almost half of the students had a Liberal Arts major while the other half had a Science major as discussed in Chapter 6. At stage 0, the majority of the Science major students had low self-efficacy levels but these levels were higher than for the Liberal Arts major students. The data also showed that 33% of students participating in this study had taken at least the Algebra I level of mathematics at school and 35% had taken the Calculus level mathematics. The Algebra I
group had the lowest self-efficacy level and the Calculus group had the highest self-efficacy level compared to the rest of the students. The data showed that 67% of the participants had studied at a level higher than Algebra I and should have been expected to use their mathematical knowledge to progress from the Accuplacer examination directly to college courses. In their semi-structured interviews, all of the students indicated that they experienced traditional teaching methods at school, where the teacher walks to the classroom, lectures, asks the students to copy the materials from the board and leaves. This could be related to the GUST statistics that revealed that 75.2% of students joining GUST could not pass the Arithmetic section of the Accuplacer examination and had to be enrolled in Math 095, which is a course that revises very basic mathematical skills. This supports the finding that students participating in the study graduated from school with weak mathematical knowledge.

In contrast, the data showed that the students who passed the Arithmetic section in the Accuplacer examination and joined Math 096 directly (24%) had higher self-efficacy levels than the other students in the study. This suggests that they had a better learning experience in mathematics during their school years than the other students in the study. Also, the students who had repeated either Math 095 or Math 096 had lower self-efficacy than the other students in the study. This suggests that, they had a poor experience learning mathematics during their first attempt at taking these courses.

The data collected from their background questionnaires shows that 72% of the students in the study indicated that mathematics was not their favourite subject at high school and that these students had lower self-efficacy levels at stage 0. This also agrees with the results discussed in the literature review by Bong and Skaalvik (2003), Diseth, Danielson, and
Samdal (2012), Phan (2012), and Stankov, Lee, Luo & Hogan (2012) who indicated that students’ self-efficacy influences their achievement.

In contrast, the 28% of students who said that mathematics was their favourite subject at school had higher self-efficacy levels than the rest of the students. This also agrees with the results discussed in the literature review by Pajares and Miller (1994), Richardson, Abraham, and Bond (2012), and Fan & Wolters (2014) that those students had higher self-efficacy had better performance in the Accuplacer examination and liked to study mathematics. In their interviews, most students with high self-efficacy at stage 0 indicated that they felt that it was unnecessary to take a foundation course. This means, they did not feel that they needed to improve their mathematics knowledge, although they failed the admissions test. Also, most of the students with middle and low self-efficacy levels indicated that they realised that they had mathematical weaknesses and needed to improve their mathematical knowledge by taking a foundation course before joining any college level courses. This agrees with the results discussed in the literature review by Hackett (1985), Pajares and Miller (1994), and Siegle and McCoach (2007) that explained that there is a positive relationship between mathematical self-efficacy and students’ academic achievement. This means that the majority of the students participating in the study recognised that they were not prepared to join mathematics college courses.

The questionnaire at stage 0 asked the students about their computational skills. Most of the students indicated that they were calculator dependent and had low self-efficacy levels. In contrast, the students with better computation skills had higher self-efficacy levels. In their interviews, all of the students indicated that they were allowed to use the calculator during their early and middle school years. This means that many of the students participating in the
study graduated from the school system with high levels of calculator dependency and poor mental arithmetic skills. This could have been a contributing factor for the high failure rate on the Arithmetic section of the Accuplacer examination where calculators are not permitted.

Lastly, most students participating in the study indicated that they did not enjoy using different computing programs in mathematics. In their interviews, all of the students explained that they were never exposed to technology when learning mathematics at school, except for the use of the calculator. This means that the students were never exposed to new technological tools and were more used to traditional procedural teaching methods, which could have contributed to their mathematics weaknesses when they joined MFU.

7.1.1 Self-efficacy

The data analysed at stage 0 showed that most of the students participating in the study graduated from the school with low self-efficacy, which is not a good preparation for joining college level courses with even small amounts of mathematical content. This agrees with the results discussed by Hackett (1985), Pajares and Miller (1994), Siegle and McCoach (2007), Pietsch, Walker and Chapman (2003), and Chemers, Hu, and Garcia (2001) as they agree that improving students’ self-efficacy can positively influence students’ mathematical achievement.

It is noticeable that the students with better arithmetic skills in the Accuplacer examination had higher self-efficacy levels at stage 0. In their interviews, these high self-efficacy students were asked about the reason for their high self-efficacy at the start of the course. The students explained that they knew that they had reasonable mathematical skills that did not require them to join a mathematics foundation course.
Despite the fact that all of the students participating in the study had failed the Accuplacer examination, the students with higher mathematical knowledge had higher levels of self-efficacy. The students with direct entry to Math 096, had higher self-efficacy levels which had slightly influenced their Accuplacer examination scores to join Math 096 directly without the need to join Math 095. This agrees with the results discussed in the literature review by Pietsch, Walker and Chapman (2003).

7.1.2 Motivation

The data analysed at stage 0 showed that the median on the motivation questionnaire for all the students participating in the study was very low. This means that the majority of the students participating in the study graduated from the school systems with low motivation levels towards the study of mathematics, which is not a good preparation for joining college level courses.

Researchers such Fan & Wolters (2014), and Areepattamannil (2014) explained that motivational beliefs are very important elements in students’ academic success. This can be clearly supported by the results found in this study as many students had low level quiz scores at stage zero, low Accuplacer examination scores, and very low motivation levels. The students’ low performance correlated to their low motivation levels at stage 0. This supports the results discussed in the literature review by Kim & Keller (2010).

7.1.3 Level Quiz

The data analysed at stage 0 showed that the mean level quiz score for all 130 students participating in the study was 38%, which was very low. Also, all the students participating in the study had failed the Accuplacer examination. This means that most of the students
participating in the study joined the course with weak mathematical knowledge. When these students graduated from the school system they were not equipped with the appropriate mathematics knowledge and skills required to join college level mathematics courses.

7.1.4 Concept Maps

The concept maps analysis discussed in Chapter 6 showed that the students’ connectivity codes started at ‘Low Connectivity’ in stage 0. The participating students graduated from school with a weak conceptual view of mathematical topics which suggests that they had weak conceptual understanding.

The success rates for students on the conceptual questions in the level quiz were very low at the start of the course. This provides further evidence that the students participating in the study graduated from school with more procedural rather than conceptual understanding. This agrees with Skemp’s (1976) definition of conceptual understanding as it is related to what to do and why. This also agrees with the results discussed by Tall et al. (2001) in the literature review who found that low achieving students were unable to develop mastery skills and could not develop any degree of proficiency with material they had already seen previously in the mathematics course. The students in this study could not build concepts or find the proper routes toward connecting their concept maps at stage 0 in agreement with Skemp (1976).

Considering the results discussed in the students’ semi-structured interviews, all of the students participating in the study indicated that they had experienced traditional teaching methods at school, which were more procedural rather than conceptual and passed the school examinations as a consequence of learning specific techniques rather than having a deep understanding of mathematics. These results support the students’ low Accuplacer and level
quiz scores when joining MFU. This agrees with results discussed by Byers and Herscovics (1977) who defined procedural as the ability to apply an appropriate remembered rule when solving a problem without questioning or knowing why the rule was applied.

In summary, it seems clear that most of the students participating in the study joined the course with 1) low self-efficacy levels, 2) low motivation levels, 3) weaker mathematical knowledge, and 4) a procedural rather than conceptual view and understanding of mathematics. These students were not mathematically prepared to join mathematics college level courses.

7.2 What was the relationship found (if any) between the use of the SMIC framework in MFU classrooms and students’ mathematics achievement?

This section discusses the relationship between every major theme or sub-theme of the SMIC framework and the students’ mathematical achievement based on the results reported in Chapters 6 and 7.

7.2.1 Self-efficacy

The teacher implemented the educational approaches contained in the SMIC framework during the course in order to improve students’ motivation, self-efficacy and mathematical understanding levels. Most of the students who participated in the study indicated that they had never been exposed to those educational approaches during their school education. Furthermore, in their interviews, the students described how the use of each of those approaches helped improving their self-efficacy levels and their achievement in the course.

The data analysis discussed in Chapter 6, shows that the self-efficacy levels for the vast majority of the participating students improved from stages 0 to 3 and most noticeably from
stage 0 to 1. Also, the data analysis discussed in Chapter 7 shows that the test scores also increased from stage 0 to 3 and noticeably from stages 0 to 1. This strongly suggests that the students’ self-efficacy was positively correlated to the students’ performances in tests and final course achievements. This agrees with results shown by Williams and Williams (2010); Hackett (1985); Pajares and Miller (1994); Pajares (1996); Pietsch, Walker, and Chapman (2003) who explained that self-efficacy can influence students’ performance. Most of those researchers referred to students’ mathematics self-efficacy at school levels and for different western cultures. The results found in this study support the results discussed by these researchers with further evidence obtained in a Middle Eastern culture, and at the freshmen rather than school mathematics level.

The few students who started the course with high self-efficacy levels were able to maintain their high self-efficacy during the course and improved their test scores throughout the course. This further supports the argument that there is a positive correlation in this study between the students’ self-efficacy and their test scores. This supports the research discussed by Williams and Williams (2010) who explained that high self-efficacy students challenge themselves and maintain their commitment in order to achieve their goals. The high self-efficacy students in this study challenged their own knowledge and worked hard during the course, continued to put their best efforts into studying the mathematics in the course and improved their knowledge in order to pass the course.

For the low self-efficacy student outliers, the data shows that these students were able to improve their self-efficacy, and test scores during the course by more than 50%. This also shows the positive correlation between students’ self-efficacy during the course and their test scores. Researchers such as Stevens, Olivarez, Lan, and Tallent-Runnels (2004) discussed the influence of self-efficacy on students’ academic achievement, final-year grades, student...
class work, homework, and student examinations. This means, those low self-efficacy student outliers did improve their self-efficacy and then their mathematical achievement.

7.2.2 Motivation

The teacher implemented the use of educational approaches as part of the SMIC framework during the course in order to improve students’ motivation, self-efficacy and mathematical understanding levels. Most students who participated in the study indicated that they had never been exposed to these educational approaches during their school education. The approaches included working in groups, playing a variety of mathematical games, using revision notes and small boards for reviewing, and offering bonus marks. Also, the teacher played an important role as she offered a positive attitude to the students, which they did not seem to have experienced before. Furthermore, in their interviews, the students described how the use of each of those approaches helped to improve their motivation levels. Considering the data analysis discussed in Chapter 6, motivation levels for all participating groups gradually improved from stage 0 to 3 and mostly significantly from stage 0 to 1 in a similar way to their test scores. According to the results found in this study, there was a correlation between students’ motivation levels during the course and their test scores. These findings add support to the results discussed by researchers such as Fan & Wolters (2014) added that students’ ability intrinsic values positively predict their mathematical achievement. Also, other researchers such as Murayama, Pekrun, Lichtenfeld, and Hofe (2013) explained that

“learning strategies are described as planned sets of coordinated study tactics that are directed by a learning goal and aim to acquire a new skill or gain understanding (Alexander & Murphy, 1998). According to these views, motivation and learning strategies should, by their nature, facilitate long-term
learning processes, … , these variables are indeed important for students’ academic growth over the school years” (2013, p. 1487).

Furthermore, the results discussed in the students’ interviews supported these findings. The students explained that the used educational approaches contributed to their improved motivation levels during the course, which positively correlated to the improvements in their level of achievement. This is also supported by other results discussed in the literature review, such as Kim & Keller (2010) who claimed that beliefs about gaining knowledge can positively affect students’ motivation and achievement. The evidence added in this study is that there is a positive correlation between college students’ motivation levels and their mathematics achievement, especially in a Middle Eastern culture like Kuwait.

7.2.3 Mathematical Understanding

This section discusses the relationship between each sub-element of ‘Mathematical Understanding’ of the SMIC framework and students’ achievement.

7.2.3.1 Cooperative Classroom Environment

A) Group Work

In their interviews, group work was identified as one major sub-theme that was mentioned by almost all of the students. The students indicated that group work encouraged them to socialise together and created a comfortable learning environment that helped to improve their mathematical understanding and capability to learn. This supports Francisco (2013) who indicated that group work is is based on discussions and students’ communicating mathematically, involving their mathematical arguments, and constructing a deeper understanding of concepts. Group work provided the students with a support system that brought students together to the same level of thinking and understanding. In this way, group
work assisted the students to explore their own mathematical strategies, challenge themselves to solve different questions with different levels of difficulty, and improve their mathematical understanding. This is supported the results discussed by other researchers in the literature review such as Sahlberg & Berry (2003), Chambers & Timlin (2013), Steinberg & Vinjamuri (2014), Sofroniou and Poutos (2016), and Burke (2011) that group work assist the students to improve their mathematical understanding. In contrast other researchers such as Martin and Towers (2015), Wegerif et al. (2017), and Fransisco (2013) indicated that teachers cannot assume that all group work is effective and good group work. Also, Burke (2011) discussed some disadvantages for using group work in the classroom. The researcher tried to overcome the disadvantages listed by Wegerif et al. (2017) and Burke (2011) as follows:

1) One policy for using group work in the classroom in this study that one group member was asked to represent the answer on the board. The students were asked to rotate every time representing the answer on the board. This means, in case a student avoided the interaction with his/her group members, he/she would have to explain their answer on the board. This enforced the student to interact with other members and improve his/her participation and understanding in order to answer the question. The maximum number of students in each class did not exceed 22 students. This assisted the teacher to know all class members in less than a month period, watch them, and assist them individually in each of their 5 groups.

2) When the teacher noticed any domination from any group member, she would interfere in order to make sure that all group members agreed or disagreed with their presented final answer. Also, using rotation in representing the group on the board assured that all group members had to understand and agree with their presented
solutions. This also improved students’ self-efficacy, motivation and understanding in the course.

3) The researcher/teacher in this study involved her pedagogic knowledge in organising the class time. She realised that using different activities such as group work involved most of class time and based her teacher’s and students’ interaction in groups in order to improve their self-efficacy, motivation and understanding in the course.

Group work is considered one key approach used in this study as all of the students indicated that it was a new teaching approach that they were exposed to at the college level in Kuwait, and which assisted them to improve their motivation levels during the course.

Group work was very different to the traditional teaching approach used at MFU and this fresh approach helped motivate the students. Also, group work assisted the students to exchange ideas with other members of their group, maintain their curiosity, and develop their understanding. Also, the students added in their interviews that group work had improved most of their self-confidence levels, their relationships with each other, and motivated them to explore their own learning techniques during the course which resulted by effective group work as recommended by researchers such as Wegerif et al. (2017) and Ryve, A., Nilsson, P., & Pettersson, K. (2013). Lastly, group work changed the students’ attitudes towards learning mathematics and improved their levels of self-efficacy, motivation, and mathematical understanding. This resulted in improved student’s test scores and mathematical achievement in the course.
B) Gamification such as Kahoot and Puzzle Sheets

The puzzle sheets and Kahoot are considered new challenging and creative activities used in the course according to the students’ interviews. The puzzle sheets were one of group work resources that were used in the classroom to improve students’ learning experience and motivation. The puzzle sheets encouraged the students in this study to interact with the other group members when solving mathematical problems and explore their own learning strategies. The students created some social and supporting bonds and encouraged each other to work hard and solve the problems. The students also indicated that playing games such as Kahoot, which is a very interesting and motivating game, created competition between them. Kahoot provided the students with a “fast thinking” challenge that motivated them to find the easiest and most appropriate methods to solve the problems, which improved their mathematical understanding during the course. The students added that solving the Kahoot questions correctly in class, encouraged them to put more effort into studying at home. This assisted them to do well in the game and gain the bonus marks available from it. In their interviews, most students distinguished between learning mathematics through a traditional teaching approach and using a variety of different interesting approaches in class, which helped to improve their mathematical understanding, and motivation levels. Using those approaches has been key in this study as the students indicated that they were never exposed to gaming at their school or college years, which could have contributed to their achievement in this course.

Also, offering new teaching approaches from the relevant literature during the course like gaming, created a fun and exciting learning environment that motivated them to work harder during the course to achieve a pass at the end because they were enjoying the experience. Also, the students created a connection between playing games such as Kahoot or the puzzle
sheets, and improving their motivation, capability, and understanding levels, gaining bonus marks, and passing the course. This supports the results found in the data analysis where students’ motivation is positively correlated to their achievement. Also, playing the games improved the students’ engagement in the classroom, which encouraged their attendance as well, as they enjoyed these activities. This boosted their enthusiasm to complete tasks at home, improve their learning skills, think fast, and improve their grades when gaining the bonus grades. Not only did this improve the students’ mathematical understanding, but also their self-efficacy and motivation levels. Those results agree with other results discussed by other researchers such as Lazarides, Buchholz, and Rubach (2018) and Topîrceanu’s (2017) in the literature review, that mastery goal orientation activities can positively influence students’ mathematical understanding.

In contrast, Cruickshank and Telfer (1980) listed some disadvantages for using games in the classroom. The teacher tried to overcome those disadvantages as follows:

1) The teacher in this study used her pedagogic knowledge in order to practice using the game Kahoot and the puzzle sheets several times till she managed to spend half class time (30 minutes) to use those games only to practice the taught topics, 2) The teacher noticed that the more time she spends preparing those games at home, the less time she will need to used them. Also, she created a template in Kahoot for each section, then used them in every course for each taught section. This means, she didn’t have to create them from scratch every time she used them, 3) playing games can be critical to what will be learned when used as a practice for the last 20 to 30 minutes of class time, 4) Searching through the internet search engines provided a variety of online game options for different grade levels. Also, attending different professional development sessions at your work place or webinars can provide information on new activities that can be used in the classroom, 5) Kahoot is free of charge.
and the puzzle sheets are as well. There are many available free online games these days, 6) Although using some games such as Kahoot might be noisy, the teacher can manage the students’ excitement and noise by asking them to not to be too noisy or they could lose the bonus mark as a consequence, 7) when the teacher decides to use a game, he/she should inform the students about the games rules and directions before they start playing. This can save class time and students’ frustrations, and 8) offering bonus marks when playing the games and puzzle sheets motivated every student in this study to participate playing. Many students explained that the more fun the class time, the more they wanted to attend. This could have been an important contributor to their high attendance rate during the course, which could have positively influenced their achievement in the course.

C) Revision Notes

Creating revision notes was another group work resource. The questions used in the revision notes included some that summarised Chapter content and involved different levels of difficulties. Also, they involved the reverse thinking approach which helped the students understand how to learn rather than just applying standard mathematical techniques. Using revision notes in class not only improved the students’ conceptual understanding levels, but also enabled them to increase their motivation and understanding levels. Also, using these kinds of questions encouraged the students to use them while preparing for future tests and quizzes. For these students, the use of this type of revision notes was a new and positive educational experience. This supports the results discussed in the literature review by Lupu (2013) that keeping a record of the students’ own work can improve their skills, knowledge, and learning strategies. This could positively influence students’ mathematical understanding, motivation, and self-efficacy in this study.
Furthermore, when using the revision notes, the students were given the opportunity to think, understand, and find their own learning approaches to solve different mathematical problems. Also, the revision notes did not only contribute to improved students’ understanding, but also to improved levels of self-efficacy and motivation. This was another ‘new’ teaching approach, which according to the students’ interviews, they considered motivating and effective at the freshmen mathematics level in Kuwait.

**D) Small Boards**

Using the individual small boards was another group work activity used in this study. Their use provided higher confidence and self-efficacy levels for some of the students which they mentioned in their interviews. The students realized that they were making connections between the previous and current lessons when they used the small boards. The questions involved different levels of difficulties. Also, they involved the reverse thinking approach which required the students to think more deeply rather than just applying procedural mathematical techniques. Not only did this improve the students’ mathematical understanding, but also enabled them to increase their motivation level as using this approach was another ‘new’ teaching approach for college level students in Kuwait. This agrees with the results discussed in the literature review by Hagger et al. (2016) that providing engagement through the use of in class activities can improve students’ understanding and motivation.

The use of these boards created engagement between group members which motivated the students to attend, work hard, and hence pass the course. Changing the teaching routine could have contributed to their high attendance rate during the course. Using the boards helped improving not only the students’ self-efficacy and mathematics understanding levels, but also
their motivation levels, students’ engagement abilities in the classroom, and mathematical achievement in a college level course.

E) Correcting The Students’ Own Errors

Students’ correcting their own errors is another group work strategy that was used in this study. Reviewing their own test errors in groups allowed the students to explore both their major and minor mistakes in each test and to develop new strategies to avoid making these mistakes in the future. In their interviews the students explained that understanding why or how they made these mistakes improved their mathematics understanding, and their self-efficacy levels. This also allowed the students to avoid making similar mistakes in the future, which assisted them to prepare for future tests. As the students were provided with bonus marks when correcting their mistakes in each major test, this motivated the students to improve their grades and mathematical knowledge as well. This created a new learning environment for the students and positioned them to feel more able to solve different mathematics problems in the future. When the students understood their mistakes, they kept a record in their note books which helped developed better learning skills. This agrees with the results discussed in the literature review by Kazemi and Stipek (2001), Askew et al. (1997), Swan (2005), Kasmer and Kim (2011), Hiebert et al. (1997), Linchevski (1995), and Bush and Karp (2013) who indicated that students studying their own misconceptions can improve their learning and understanding skills.

The students mentioned in their interviews that this approach was unique to them especially as they were used to traditional teaching approaches at school, and in Math 095.
7.2.3.2 Teacher’s Teaching Methodology

The results discussed in the students’ interviews showed that the teacher assisted the students to organise their study time more effectively, particularly in relation to their online homework, and helped them to develop better study skills in the context of mathematics. Also, the teacher taught the students how to think and explore their own learning strategies to solve the same problem or different problems, which made learning easier for the students. The teacher’s approach motivated the students to improve their mathematics understanding during the course. In this study, the teacher assisted these college students to think, learn, and reflect on their insights into their learning, which improved their mathematical achievement in the course. This agrees with the results discussed in the literature review by Barnes (2005) who indicated that collecting and connecting different mathematical ideas can improve students’ mathematical understanding and achievement.

The teacher used her pedagogic knowledge as recommended by Askew et al. (1997), Barnes (2005), Swan (2005), Kleickmann et al. (2015), Shulman (1987), Ayvazo and Ward (2011), Krauss et al. (2008), Hill, Rowan, and Ball (2005), and Bush and Karp (2013). For example, she created discussion groups through the use of group work, and was always available to answer any question for the students. Similarly, the teacher created fun games, offered bonus marks, and motivated the students to work hard during the course to improve their mathematical understanding. This agrees with the results discussed in the literature review by Hiebert et al. (1997), Peled and Segalis (2005). When using revision notes and the small boards, the teacher used creative and informative questions that involved ‘reverse thinking’ which enabled to improve their conceptual thinking as recommended by Mason (2010), Hiebert and Lefevre (1986), and Wigley (1992), and Falk (2011).
In contrast, researchers such as Sokol, Gozdeka, Figurska (2015) indicated that “currently gained knowledge and experience does not guarantee success in the workplace for leaders. First of all important are the ability to use them in practice management” (2015, p. 1981).

The teacher in this study did not only use her pedagogic knowledge while teaching the course and offering different approaches, but also tried to use her creativity, practice, and knowledge. She organised the class time, practiced each approach several times, and analysed the students’ abilities in order to assist the students to overcome obstacles towards their mathematical achievement. Other researchers such as Garfield (1993) expressed some concerns regarding using activities in the class to promote students’ learning. The teacher in this study tried to overcome Garfield’s concerns. For example, 1) the teacher did not lose her position as a centre of attention and knowledge provider because she was monitoring every group and student while working on different activities, and 2) the teacher motivated all the students to participate in their discussions and group work. Some students tried to resist being involved into their groups but she used rotating group leaders and students presenting each group on the board, to ensure that all group members participated. By the end of the course, the weaker students were asking to present their solutions on the board which showed that they could improve their self-efficacy, motivation, and mathematical understanding during the course.

Also, the researcher in this study had to use her teaching methodology and approaches in order to deal with the students’ poor attendance issue. This will be discussed in details in section 8.2 (c).

Lastly, it is important to discuss what was discussed in the literate review by Skemp (1976) who explained that it is quite difficult to teach students whose goal is to understand
instrumentally, taught by a teacher who wants them to understand relationally. This was achieved in this study as the researcher/teacher could show that it is possible to improve students’ procedural knowledge to understand mathematics conceptually. The use of the researcher’s pedagogic knowledge influenced her to use those approaches to transfer the students’ procedural knowledge into conceptual knowledge as recommended by Byers and Herscovics (1977). This improved students’ mathematical understanding during the course.

7.2.3.3 Tutor’s attitude

The interviews showed that the students felt that the teacher had created a family relationship among the students, and between the teacher and the students. This created a learning environment in which the students’ felt supported and free to ask for and receive assistance when needed. The teacher also set high expectations for the students and encouraged them to be responsible of their own learning. This agrees with the results discussed in the literature review by Fan & Wolters (2014), Siegle and McCoach (2007) who emphasised that teacher’s talk and feedback can have a significant effect on students’ perceptions of their own effort and ability. Also, Pietsch, Walker and Chapman (2003) explained that it is important to enhance self-efficacy in students’ beliefs in order to achieve fundamental mathematical outcomes. The teacher in this study, had a unique personality that combined family and social relationships with the students and tried to bond the students together in order to improve their mathematical self-efficacy, motivation, and understanding.

Furthermore, the teacher helped the students to organise their time and plan how to complete their assigned work. Also, the students realised that the teacher’s attitude could positively influence their motivation and understanding levels. The teacher’s attitude in the classroom
helped to improve the student’s motivation, capability, and understanding. These results are supported by similar results discussed by Lazarides, Buchholz, and Rubach (2018). The students participating in this study expressed that the teacher’s attitude positively influenced their motivation, self-efficacy and mathematical understanding levels at this college level course.

The teacher created discussion and engagement activities through the use of group work, and was always available to answer any question for the students. Also, she provided the sense of emotional support through monitoring their work and positively advising them on how to improve their mathematical understanding and overall grades. They expressed their appreciation and positive motivation for the teacher’s attitude in their interviews. They also explained that this positively influenced their attendance during the course. This agrees with the results discussed by Klem & Connell (2004), and Sokol, Gozdek, and Figurska (2015).

7.2.3.4 Bonus marks

Students at GUST are generally grade-driven. Some students expressed this view in their interviews, saying that the more grades they were gaining, the more they were motivated to study on a daily basis in order to answer the assessment questions correctly. In particular, they talked about the bonus grades given to the top 10 students answering the puzzle sheet questions or Kahoot questions correctly. Also, the more bonus grades they were gaining, the higher their self-efficacy. During the course, the students were motivated to work hard in the course, understand, receive the bonus marks, and improve their achievement. This agrees with results discussed in the literature review by Miendlarzewska, Bavelier, and Schwartz (2016) and Wigfield & Eccles (2000) who explained that certain expectancies and values
may have a direct influence on achievement choices such as performance, effort and persistence.

In this study, the reward system clearly improved the students’ motivation, mathematical understanding, and self-efficacy.

7.2.3.5 The Use of Technology: Online Homework (PEARSON MyMathLab)

The student interviews revealed that the students realised the importance of practicing the mathematical techniques developed in the lessons in an online environment through the use of the questions provided by PEARSON MyMathLab, and how this positively influenced their motivation and mathematical understanding level. PEARSON MyMathLab provides very similar features and results, as discussed by Handal & Herrington (2003), which improved the students’ mathematical motivation and understanding during the course. Also, the students explained that practicing the course materials through the variety of questions provided in the program, enabled the students to prepare for quizzes and tests. Also, PEARSON MyMathLab provided features such as e-text and videos, which explain all the mathematical ideas taught in the course. This provided an online assistant for the students, which they could access at any time and was particularly useful if they missed attending any classes. This agrees with the results discussed in the literature review by Hiebert and Lefevre (1986), Swan (2005) and Hiebert et al. (1997), Handal & Herrington (2003), Hargreaves, Shorrocks-Taylor, Swinnerton, Tait, & Threlfall (2004), Soliman and Hilal (2016), and Banerjee and Subramaniam (2012) as this online practice could have helped the students to fill any gaps in their knowledge and positively influenced their students’ mathematical understanding.
In contrast, researchers such as Monson and Judd (2001) discussed some disadvantages for using CalMaeth in the classroom. The teacher in this study, tried to overcome those disadvantages similar to the disadvantages in PEARSON MyMathLab. For example, 1) the teacher believes that using PEARSON MyMathLab can assist students to practice the learned knowledge in the classroom but can never replace the teacher and the methodologies that can be used to deliver the knowledge to the students, 2) MyMathLab can diagnose students’ misconceptions in routine skills and can improve their mathematical understanding, motivation and self–efficacy. This was shown as the software provided different features such as ‘similar example’, several chances before counting the students’ mistakes, and offering motivating words such as ‘good job’, ‘well done’ and ‘excellent’, 3) the software allowed the students to enter algebraic expressions and symbols, and 4) MyMathlab is a well established software that did not accept ‘bugs’ except when receiving weak internet connections.

Lastly, the course syllabus assigned 5% of the overall grading scheme of the course to the online homework, which motivated the students to practice more when solving the homework problems and improve their overall grades.

7.3 What features within the SMIC framework promoted improving students’ self-efficacy in this study?

Researchers in mathematics education have discussed different factors that could correlate with students’ self-efficacy, but they have not identified factors that could influence self-efficacy especially in mathematics. For example, Bandura (1981) discussed the correlation between students’ self-efficacy and motivation. The interview results also revealed a correlation between the students’ motivation and their self-efficacy in the course. Not only did students’ motivation improve, but also their test scores and overall achievement levels
improved. The students’ motivation correlated with their achievement, which also correlated to their mathematical self-efficacy during the course.

Other researchers such as (Ahn, Usher, Butz and Bong, 2016; Britner & Pajares, 2006; Joët, Usher, & Bressoux, 2011; Usher, 2009) explained that mastery experience and students’ achievement could predict students’ self-efficacy. Also, other researchers such as Wang, Liang, Lin, and Tsai (2017) explained that students’ understanding correlate with their self-efficacy as well. They indicated that “students who have a higher agreement with the learning conception as understanding tend to be equipped with better ability to construct integrated knowledge structures” (2017, p. 94). Furthermore, the concept maps analysis used in the study showed noticeable improvements in the students’ conceptual understanding during the course. The interview results showed a correlation between students’ mathematical understanding and their self-efficacy during the course. In this study, not only did students’ mathematical understanding improve, but also their test scores and overall achievement levels. This also correlated to their mathematical self-efficacy during the course. This suggests that the improvements in the students’ mathematical understanding assisted promoting their self-efficacy. Wang, Liang, Lin & Tsai (2017) added in this regards that “Past research has revealed that students’ conceptions of learning, academic self-efficacy, and academic performance are closely related (Ferla, Valcke, & Schuyten, 2008; Chiou & Liang, 2012; Lin & Tsai, 2013a, 2013b)” (2017, p. 94).

This study is unique as it explores the mathematical self-efficacy in the context of a college level course in Kuwait. In their interviews, many students explained how the use of each educational approach (group work, playing games such as Kahoot and puzzle sheets, revision notes, small boards, and correcting the students’ own errors, online homework,
social media (WhatsApp) group application, teacher’s teaching methodology, tutor’s attitude, and bonus marks) positively correlated with students’ mathematical self-efficacy, motivation, understanding and their test scores. In their interviews, many students clarified that group work did promote students’ self-efficacy in this study. When using group work, the students encouraged each other to work hard, support each other to the same level of thinking, and encouraged each other to study together both outside and in the classroom. This promoted their mathematical self-efficacy during the course. These results agree with other results discussed by researchers such as Ahn, Usher, Butz and Bong (2016), who explained that when students improve their engagement in the classroom, this can improve their self-efficacy. They added that positive or negative feedback through the use of social persuasion can affect students’ self-efficacy. Other approaches such as the use of the puzzle sheets, revision notes, social media (WhatsApp) group application, and correcting their own student errors were other approaches that involved group work and which positively influenced students’ self-efficacy in this study. Also, the students indicated that the teacher’s teaching methodology, the online homework, and teacher’s attitude improved their motivation and mathematical understanding, which positively promoted their self-efficacy according to (Bandura, 1981; Ahn, Usher, Butz and Bong, 2015; Britner & Pajares, 2006; Joët, Usher, & Bressoux, 2011; Usher, 2009; Usher & Pajares, 2008; Wang, Liang, Lin, and Tsai (2017)).

This means, the researcher used those ‘new’ educational approaches in order to improve students’ mathematical motivation and understanding, which promoted their self-efficacy and mathematical achievement as a result.
7.4 Summary

Students joined GUST for the past five years with low levels of self-efficacy, motivation, and mathematical understanding. During this study, students were exposed to some educational approaches (SMIC framework elements and sub-elements) that they were not exposed to in their past according to the data collected from their semi-structured interviews. The data showed positive correlations between students’ test scores and their self-efficacy, motivation, and mathematical understanding levels. Also, the students explained in their interviews the positive influence they felt from being exposed to the SMIC framework elements used in the study and how this influenced their mathematical self-efficacy, motivation, and mathematical understanding, with special focus on promoting students’ self-efficacy during the course.
Chapter Eight: Conclusions

8.0 Introduction

The researcher in this study aims to improve the students’ achievement through improving their self-efficacy, and motivation levels through implementing the SMIC framework. She also aims to engage the conceptual and procedural methods in order to improve the student’s mathematical understanding through implementing the SMIC framework. Kuwaiti academic research provides very limited work on educational approaches that would improve students’ mathematical self-efficacy, motivation, and understanding.

This chapter discusses the limitations of the study, the study’s contribution to knowledge, and the recommendations can be made for mathematics teachers to improve students’ mathematical achievement, self-efficacy and motivation in this type of context. Also, this chapter refines the SMIC framework elements and sub-elements in order to improve students’ mathematical achievement.

8.1 Limitations of The Study

a) The sample size for the students participating in this study was 130 students. Studying a larger number of students at MFU with other teachers with different commitments or involvements with the use of the SMIC framework other than the researcher could have enriched the study through a wider data analysis and produced more generalisable results. This could encourage other school departments or colleges to adopt the SMIC framework.

b) The GUST assigned grade system for MFU courses is to award a Pass or Not Pass grade on completion of their courses. This means that the course grade does not count towards the students’ overall Grade Point Average. This also means that some students aim to pass the course by reaching 70% in their overall course grade, which is the minimum
requirement to pass. This was mentioned by some students’ in their interviews. When the
students realise this at the start of the course, this could discourage and/or demotivate
some students from putting their best effort into studying the course. If the course was
counted towards the students’ grade point average, the students could have provided more
serious means to pass it. The researcher could overcome this issue by offering many
approaches in the study that improved students’ motivation, self-efficacy, and
mathematical understanding.

c) The attendance policy implemented at MFU can discourage students from attending class
regularly. The students receive an email count and email reminders for each of their
absences. The email policy states that students will receive automated warning emails for
each number of absences as shown in table 8.1. This means that some students realise at
the start of the course that they are allowed to miss up to 20 hours of classes during the
course. This could discourage and demotivate students from attending regularly as a
consequence the students may not engage seriously with the educational approaches
offered during the course, which could negatively influence their mathematical
achievement.

<table>
<thead>
<tr>
<th>Warning</th>
<th>Number of Absences(MFU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>5 Hours</td>
</tr>
<tr>
<td>Second</td>
<td>10 Hours</td>
</tr>
<tr>
<td>Third (Last)</td>
<td>15 Hours</td>
</tr>
<tr>
<td>NP</td>
<td>20 Hours</td>
</tr>
</tbody>
</table>

Table 8. 1: GUST attendance policy for MFU courses.

The researcher will discuss how could she overcome the weak attendance issue in section 8.2 (c).
d) The role of the researcher-teacher is considered a limitation in the study and a potential for bias. In contrast, the researcher observed the participants as an active researcher in order to gain an insider's perspective on what is going on in the study without losing the credibility of the study. Also, in order to avoid biases in this study, the study framework involved exploring the themes in the study, reasons for finding them, and how they could influence students’ mathematical achievement. This included avoiding interpreting any inappropriate feature that might mislead the data analysis. Also, using the pilot study approach provided some in-depth features which assisted the researcher to clarify the strengths and weaknesses of the study, and avoid biases that could have occurred in the study. Moreover, The researcher kept a research journal of the pilot study as suggested by researchers such as Watt (2007). She shared this research journal comments and designed plan for the main study with her director of studies and other supervisors in order to make sure that her designed plan may not influence the routine of the course. The researcher considered studying the legitimacy and reliability of the study; 1) She received approvals from GUST and Plymouth university administrations, and MFU supervisors, 2) She was not involved when assigning any of the MFU courses, 3) She was not involved when designing the syllabus and the grading scheme of the course, 4) She was not in control of students’ attendance records as this was done by GUST automated registration system, 5) She was involved in a testing committee that designed standarised tests for MFU and did not design her own tests, and 5) She designed the educational approaches in the main study based on her research journal comments and refinements explored during the pilot study. For example, she noticed the change in students’ motivation from the start to the end of the pilot study and how could this enrich the study. This assisted her to add motivation as a major element of the study and study the theoretical and educational approaches that might assist improving it. Also, the researcher wrote detailed notes in her
research journal that supported the fact that the pilot study did not provide enough information about students’ conceptual understanding in the study. This assisted her to design the use and analysis of concept maps, and apply them in the main study. Other refined elements were discussed in details in Chapter three.

Examining the journal research of the pilot study assisted the researcher to make meaningful connections between theory and practice, avoid biases, and understand reflexivity and all aspects of research methodology in the study as recommended by Watt (2007).

In this section, the researcher explains how could she overcome the disadvantages listed by Unluer (2012) for being a researcher-insider in this study and avoid bias:

1) **Duality Rule:** The researcher was assigned all 8 participating groups in the study randomly by GUST’s registration office and the MFU director. After introducing the study to the students, they could have perceived her as their mathematics teacher and researcher for the course according to Unluer (2012). Since the researcher in this study received approval by Plymouth University and GUST administrators’, she did not have difficulties in expressing her role as a teacher and a researcher to other faculty members or administrators. Also, she provided the students and MFU administration with the study information and established cooperation between the participants. The Math 096 committee not only was established to design standarised tests for all Math 096 classes, but also involved double grading methodology after grading each test. This assured that all Math 096 teachers teaching the course were using the same answer key for the tests and were applying the same credits and partial credits while grading each test. Furthermore, the researcher did not discuss or share
any data or observations in this study except with her director of studies, and other supervisors of the study. This assured confidentiality of the students’ and GUST’s information, and that the researcher did not lose any quantitative or qualitative data during the study.

2) **Overlooking certain routine behaviours**: While collecting the data for the pilot and main studies, the director of studies (Dr. Ted Graham) visited GUST and supervised the process applied during the study. Also, the MFU director (Dr. Ilene Winokur) was aware of all the details applied in the study to assure that this was done for the benefits of the department and the students in MFU. Also, Dr. Winokur has been making annual observations of all mathematics teachers in the department including the researcher. She awarded the researcher an evaluation score of (4.6/5 to 5/5) in the past four years during the period of the study. She explained in her annual evaluation, her appreciation of the teacher’s knowledge into the implication of the study, and their influence on the students’ mathematical achievement. This encouraged the researcher to continue using her pedagogic knowledge and research into her classroom in the future as recommended by Unluer (2012).

3) **The participants may tend to assume you already know what they know**: Using the pilot study was an important key for the researchers in order to find the needed refinements and what is best for the study. For example, the researcher could collect more data from two different cohorts, add find more approaches for the study, study students’ motivation, adjust the way to use each approach, and conduct more interviews. Also, the researcher used the pilot study to learn more about conducting interviews which allowed the students to have more opportunity to reflect on their perspectives and clarify the answers for each question freely. This enriched the study.
with respect to the choice of data required for the analysis as recommended by Unluer (2012).

8.2 Contributions to Knowledge

There are very few and very limited current Kuwaiti research studies in the field of mathematics education. Also, the few available studies that discuss very limited topics, mostly related to the use of computer technology into teaching mathematics. This study is unique as there has been no research study that discusses 1) improving mathematical self-efficacy in Kuwait at any level, 2) a framework that contributes to improving mathematical self-efficacy, motivation, and understanding levels at college level courses in Kuwait, and 3) Exploring positive correlation between students’ self-efficacy and their mathematical understanding, and students’ motivation and their mathematical understanding.

Also, this study contains some elements that were explored as ‘not planned outcomes’ and will be discussed in details as follows:

1) Social Media (WhatsApp) Group

The WhatsApp group application is a mobile application that “allows the sending of text messages and voice calls, as well as video calls, images and other media, documents, and user location. The application runs from a mobile device but is also accessible from desktop computers. … Originally, users could only communicate with others individually or in groups of individual users” (WhatsApp, 2018). The WhatsApp group was a creative idea used by the students as a result of the improved socialisation among the students after using group work in class as they explained in their interviews. The WhatsApp group application provided a
social electronic form of support that was available online and at all times for the students. It brought the students’ communication and social skills together. The WhatsApp group application allowed the continued use of group work by the students in an electronic format.

In their interviews, the students indicated that they were creatively helping each other by using voice notes and attaching pictures to explain steps to solve different problems via the WhatsApp group. Also, the students used the WhatsApp group application to remind each other of quiz or test dates and content. This created a positive influence for the students’ and helped create a positive attitude towards learning mathematics. Using the WhatsApp group motivated the students to communicate at any time outside class time, answer questions, understand mathematics, and assist each other to pass the course. This means that using the WhatsApp group application positively contributed to students’ mathematical motivation and understanding in this course.

2) The Use of ‘New’ Educational Approaches at College Courses and The Change in Student’s Attitudes

Several students explained in their interviews, that the teaching approaches used in this course were new to them. It is important to consider that one major feature of this study was that it used educational approaches that are not normally found in Kuwaiti school or college level mathematics courses. The most common college teaching approach involves ‘lecturing’ rather than ‘teaching’. Using the approaches from the relevant literature in the SMIC framework positively influenced the students’ attitude towards learning mathematics and improved attendance. The students started to seek understanding, socialise, and increased the time that they spent studying mathematics after ‘hating studying it’ for many years. This also positively influenced most students’ self-efficacy and as a consequence some decided to
maintain their college majors instead of changing to college majors with less mathematical requirements. The students realised, during the course, that they were able learn mathematics and pass both this and future courses.

Furthermore, the teacher encouraged the students to explore new learning techniques in order to understand mathematics and achieve higher grades. This positively influenced students’ self-efficacy levels during the course. Yu and Singh (2018) added in this matter that “when students believe teachers care and are willing to help them, they are more likely to internalize teachers’ values and beliefs; therefore, they are more likely to experience gains in self-efficacy when teachers tell them they are capable” (2018, p.83). The course not only influenced the low self-efficacy students’ attitudes towards mathematics, but also influenced the high self-efficacy students’ attitudes who maintained their self-efficacy levels during the course and continued learning mathematics. This improved students’ motivation, self-efficacy, and understanding levels to achieve a pass grade at the end of the course.

3) Attendance

Attendance has always been a major element influencing students’ achievement in education and poor attendance has been a feature of this type of course. The students, in their interviews, recognised the importance of attendance to their success in the course. They related attendance to enjoying the in-class activities, improving their understanding and self-efficacy levels during the course. Also, the students correlated their attendance with improved motivation and mathematical achievement. This agrees with the results discussed by researchers such as Parke and Kanyongo (2012) who indicated that

“missed educational time in school may lead to poor grades and further absenteeism, leading to a vicious cycle that is a major concern of all educators (Phillips, 1997). Along with high school and college grade point average
(GPA), attendance is considered important for adaptive functioning in the cognitive and behavioral realms (Roby, 2004)” (2012, p. 161).

The students recognised that good attendance is a very important way to enable them to participate in the exploration of the mathematics content of the course. Some of the students related good attendance to improving their conceptual understanding through exchanging ideas among their group members. Also, the students realised that the more they attend, the more they will engage with mathematics in an interesting way in class and that the higher their intrinsic motivation will become. They also linked good attendance to improved understanding and higher grades particularly due to the bonus marks. The students participating in the study had higher attendance rates and higher pass rates compared to other Math 096 groups at MFU. This validates the positive correlation between students’ attendance at the freshmen level courses, their exposure to the SMIC framework, and achievement in the course. Parke and Kanyongo (2012) added in this matter that

“large-scale, school-level analyses conducted in Maryland and Ohio established relationships between attendance and achievement … Roby (2004) studied Grades 4, 6, 9, and 12 in all Ohio schools. Attendance rates ranged from 85% to 99%. Strong correlations were found between schools’ attendance rates and student achievement on the Ohio Proficiency Tests.” (2012, p. 163).

8.3 Further Recommendations to Increase The Levels of Students’ Mathematical Self-efficacy and Achievement

a) Many students join foundation programmes in Kuwait with weak mathematical backgrounds, poor self-efficacy, motivation, and mathematical understanding levels. Researchers in mathematics education in Kuwait are recommended to apply further research in different fields of mathematics education, especially related to mathematical self-efficacy. For example, it is important to study the best approaches that can be used in
order to improve students’ mathematical self-efficacy in Kuwait. Also, it is important to consider studying it at both school and college levels. It is important to study larger sized samples, including different ages, and genders. This can provide an opportunity to use a wider variety of data analysis and obtain results that can be generalised for each academic level in order to improve students’ mathematical self-efficacy in Kuwait. Tackling students’ mathematics self-efficacy can be a major element to improve students’ achievement in mathematics in Kuwait.

b) It is important for mathematics educators at this level is to use frameworks such as the SMIC framework that have been shown to improve students’ mathematical self-efficacy, motivation, and understanding levels. It is important to allow students to explore the best ways to learn mathematics and change their attitudes to the study of mathematics in their school or college years. This can have a major positive influence on the students’ choices when selecting college majors which have mathematical content. Also, this can change the nature of students’ beliefs towards studying any mathematics course in the future and can improve students’ mathematics achievement. Further research in this aspect would be beneficial for all aspects of mathematical education in Kuwait.

School and college mathematics educators are recommended to encourage their students to use the WhatsApp group application, or similar, when communicating with each other in order to provide social and mathematical support when their students are learning mathematics. This has the potential to improve their motivation to learn mathematics during the course.

c) It is recommended that GUST educators, or educators at any other educational institution, assign a course grade of ‘numerical and letter grades’ instead of using only the P/NP
system for foundation courses. Also, it is recommended that the course grade partially counts to students’ GPA. This can initiate responsibility among students to consider taking the foundation course in a serious manner similar to those taking a college level course. This could motivate the students to work hard, understand the course content, and improve their achievement levels. Further research in this aspect would be beneficial in the mathematical education field in Kuwait.

d) It is recommended that GUST educators or educators at any other educational institute to consider changing the attendance policy from 20 to 5 allowed absences during a course. Attendance is a key element for students to explore the course materials and educational approaches used in order to allow students to improve their mathematical self-efficacy, motivation and understanding levels. This can change the students’ attitude so that they feel responsible for attending regularly and motivate them to work hard and pass the course. Further research in this aspect can be beneficial in the mathematical education field. Lastly, mathematics school and college educators are recommended to monitor their students’ attendance in order to improve their achievement in the course.

e) It is important to consider the teacher’s role in this study, especially with her pedagogic knowledge (MSc in mathematics and MEd in mathematics education), 17 years of teaching experience in both the school and college systems, her teaching experiences in both Canada and Kuwait, and her attitude with the students in this study. This could have enriched her overall experience and assisted in finding the new teaching approaches in this study. Further research is recommended to study implementing the SMIC framework with teachers with different pedagogic backgrounds and/or teaching years of experience in mathematics.
f) This study lists sub-elements of the SMIC framework that contributed to improving students’ achievement. The study’s major elements included students’ self-efficacy, motivation, and mathematical understanding. Further research is recommended in order to find how could each major element (if any), influence other major elements. For example, would improving students’ motivation influence self-efficacy? Would the mathematical understanding influence self-efficacy? Separate studies would be interesting to explore and to be applied in the classroom.

8.4 Why Use The SMIC Framework?

Kuwait’s educational history includes a great deal of support from the Kuwait government to improve the education system for all subjects taught at schools. The same history has shown that for mathematics, Kuwait is ranked at the bottom of the TIMSS list in 2015.

The researcher of this study has taught mathematics at the MFU at GUST for the past 9 years. She noticed through her experience that most students have joined MFU with low self-efficacy and the motivation to study mathematics. She also noticed that these students had very weak basic mathematical skills required to join college level mathematics courses. She started exploring a framework that could improve the mathematical achievement of these students through improving their self-efficacy, motivation, and mathematical understanding levels.

The researcher used educational approaches during the course of the study. The educational approaches included group work, playing games such as Kahoot and puzzle sheets, revision notes, small boards, and correcting the students’ own errors, online homework, social media (WhatsApp) group application, teacher’s teaching methodology, tutor’s attitude, and bonus marks. The results in the study showed positive corrections between students’ test scores and
their self-efficacy, motivation, and mathematical understanding levels. In their interviews, most students indicated that the use of those approaches positively influenced their self-efficacy, motivation, and mathematical understanding levels. This increased the level of mathematical achievement during the course.

It is known about GUST students’ attendance culture that the attendance rate at GUST has been weak since it was established, which was the reason for implementing the student’s swipe card recording system. When the students were exposed to the sub-elements of the framework (group work, playing games such as Kahoot and puzzle sheets, revision notes, small boards, and correcting the students’ own errors, online homework, WhatsApp group application, teacher’s teaching methodology, tutor’s attitude, and bonus marks), participating students not only improved their attendance rates, but also explained how motivated and interested they were to attend. The participating students were coming from a very standard ‘boring’ procedural teaching environment at the school system. This shows that not only were the students exposed to dramatic changes when exposed to those educational approaches, but they also adjusted in a three months course and showed willingness to learn mathematics differently at a freshmen level course.

Being involved with the sub-elements of the SMIC framework, not only motivated the students to work hard together in groups, but also lead them to socialise inside the classroom and outside by meeting in coffee places as they mentioned in their interviews. This also broke down the different social and cultural barriers between them.

The researcher tried to sell them partial bonus grades added to their quiz grades if they showed the extra effort to attend, to work in groups through the puzzle sheet days, to correct
their own errors in groups, and to play Kahoot. The students bought the idea and felt motivated to attend. They expressed that those approaches were new and encouraging, and they were getting a reward that assisted them to improve their grades and pass the course.

Furthermore, most students’ backgrounds showed little experience of using technology when learning mathematics. The students explained in their interviews how interested they were to use the PEARSON system when solving their online homework and how they could easily adjust to using it. Also, the students showed their motivation to work hard in the course as they tried to implement technology together with group work when they decided to create the WhatsApp group application. They used the program to assist each other explaining different questions and to remind each other of different examination dates. This contributed to students’ mathematical understanding and success in the course. Other students explained that using Kahoot in the classroom encouraged them to ‘jump around’ and motivated them to use fast thinking in order to solve the questions and gain the bonus grades. This means, using technology was a major element in the framework that contributed to the students’ mathematical achievement.

Mohammad participated in the Spring 2017 cohort of the study. He emailed the teacher one year after taking the course to thank her for the improvement when taking other advanced mathematics course. He appreciated the teacher’s teaching methodology and he had used the same techniques when taking his College Algebra, Calculus, Accounting and Chemistry courses. Mohammad expressed his appreciation not only for the understanding he received during the course, but also his motivation to improve his mathematics knowledge and successfully graduate with his Accounting degree major. This means, using the SMIC framework, not only improved the student’s mathematical knowledge, but also improved
their skills to take higher level courses and succeed in their preferred selected major courses.

This can be seen in figure 8.1

Figure 8. 1: Mohammad’s email to the teacher in this study

The quantitative and qualitative data results were joined together in order to create a framework that could positively influence students’ mathematical self-efficacy, motivation, and understanding levels for school and freshmen college students in Kuwait. This study is considered unique in the Kuwait education system as research education in Kuwait is very limited in the field of mathematics education generally, and especially with regard to the approaches that could improve students’ mathematical self-efficacy at school and college system courses.
References


Gerring, J. (2004). What is a case study and what is it good for?. American political science review, 98(2), 341-354.


Mason, L. (2010). Beliefs about knowledge and revision of knowledge: On the importance of epistemic beliefs for intentional conceptual change in elementary and middle school students.


Appendix A: Plymouth University Approval for The Pilot and Main Studies
Appendix B: IRB Approvals for Pilot and Main Studies

Dear Hammad, Thank you for submitting your paper "Factors Behind Mathematics Achievement for Freshmen students at a Foundation Mathematics Program in Kuwait". The IRB Admin made a decision concerning that paper: *

Your paper is accepted. Please upload the full paper in your submission * In reviewing once again the above proposal the committee is unanimously agreed that the changes from the previous submission raise no ethical concerns, nor are they in contraindication to the IRB guidelines. The proposal is well-written and shows convincingly that there is no risk to participants. The proposal is therefore approved by the Committee.

--- E-IRB Submission System team
Dear hammad.s, Thank you for submitting your paper “Factors Behind Mathematics Achievement for Freshmen students at a Foundation Mathematics Program in Kuwait”. The IRB Admin made a decision concerning that paper: “Your paper is accepted. Please upload the full paper in your submission.” In reviewing the above proposal, the Committee concurs that this is an interesting project and the modifications made to the previous submission now satisfy the IRB ethical requirements. The Committee therefore concludes that there are no risk factors of harm to participants and no contraindications to IRB guidelines and so approve this proposal. Below are some suggestions regarding the overall structure of the research that may be some help to the author.

Suggestions on structural amendments (please note that given these do not impact IRB guidelines, these are mere suggestions for a more polished submission of the research for academic purposes).

The information in the appendices look good, however, the manuscript itself could use major reorganization for coherence and clarity. The ideas appear to be scattered, which makes following your argument pretty challenging. I would suggest the following, which might be helpful. Introduction - You can outline what the problems are, that is, the issues you are attempting to address in your research. - Discuss how previous research has attempted to examine the issue in question and how your research is different from extant research and what it will contribute. - If there are any theoretical positions you are using, be explicit and indicate how it helps to address questions you have. - Also, try to link the studies you are citing, as they stand now, they are just stand alone ideas are not critically examined. - Lastly, there are several structural (grammatical) issues with the manuscript that could use some straightening out. --- E-IRB Submission System team
Appendix C: MFU Approvals for Pilot and Main Studies

RE: Research study approval

IW
Thu 4/28
Sali Hammad, Wassim I. Daher

Inbox

Action Items

Dear Sali,
Thank you for revising the proposal and making it clearer about the relationship between your study and the benefit to the MFU and its students. Dr. Wassim and I just met and reviewed your request and we both approve that you pilot the study in your MATH 096 class during Summer 1. Please set up a meeting with me before I leave on May 12th so we can discuss your plan to implement the study. I want to be sure that Dr. Wassim and I are clear about it.
Regards,

Dr. Ilene Winokur
Director
Foundation Program Unit
Gulf University for Science & Technology (GUST)
Office: W1-265
Phone: +965 2530 7196
Email: alzaid.i@gust.edu.kw
RE: Spring Case Study Approval

Ilene K. Winokur

Tue 10/18/2016 1:13 PM

To: Sali Hammad <Hammad.S@gust.edu.kw>
Cc: Wassim I. Daher <Daher.W@gust.edu.kw>

Dear Sali,

Thank you for presenting your pilot study results to the MFU yesterday. It was very informative and I look forward to hearing more once the full study is completed.

I have read through the proposal and see the list of modification you made based on our discussions during your presentation today. Dr. Wassim and I approve the study to be undertaken next semester. I look forward to meeting your Dr. team in the spring.

Regards,

Dr. Ilene Winokur
Director
Foundation Program Unit
Gulf University for Science & Technology (GUST)
Office: W1-265
Phone: +965 2530 7196
Email: alaneil6@gust.edu.kw

---

RE: Data collection (second phase)

Ilene K. Winokur

Thu 9/14/2017 2:54 PM

To: Sali Hammad <Hammad.S@gust.edu.kw>; Wassim I. Daher <Daher.W@gust.edu.kw>

Dear Sali,

As per our discussion yesterday, you have approval for the final phase of your study this semester.

Regards,

Dr. Ilene Winokur
Director
Foundation Program Unit
Gulf University for Science & Technology (GUST)
Office: W1-265
Phone: +965 2530 7196
Email: alaneil6@gust.edu.kw
Appendix D: Math 096 Syllabus

Gulf University of Science and Technology

Course Number and Section  MATH 096
Instructor
Office
Telephone
Email
Office Hours

READ THIS INFORMATION CAREFULLY AND RETAIN IT FOR FUTURE REFERENCE. FAMILIARITY WITH THE INFORMATION CONTAINED IN THE SYLLABUS IS THE PERSONAL RESPONSIBILITY OF EACH STUDENT.

University Mission:

- To enrich the cultural, intellectual, academic and technological movement in Kuwait.
- To meet the needs of the labor market for professionals and technicians by providing manpower whose qualifications are consistent with the expectations.
- To participate in the continuous development of the community undertaking academic research and field studies, and providing advice and experience to private and government bodies through participation in setting up technology parks.
- To contribute to the development of manpower capabilities through continuous education programs and rehabilitation.
- To cooperate with similar institutions at national, regional and international levels

Foundation Program Mission:

The mission of the Foundation Program is to help students gain access to one of the baccalaureate and/or graduate programs and to equip students with the knowledge, the skills, and the resources necessary to successfully earn a degree.

Math Foundation Program Mission:

The mission of the Math Foundation Unit (MFU) is to provide quality mathematics instruction to students with an emphasis on the mathematic skills necessary for academic success.

Program Goals
• Provide quality mathematic instruction for students who require remediation of mathematic skills.
• Prepare students for further academic study in the Gulf University for Science and Technology.
• Provide mathematic instruction based on education theories and the latest research in the field.
• Provide students with the advising they need to successfully reach their academic or professional goals.
• Provide learner-centered instruction.
• Provide services relating to admission, counselling, academic life, and the general success of students attending GUST.
• Provide an environment of intercultural understanding and cooperation.

Student Goals

Students of the MFU program will be actively involved in their own learning and will:

• Develop math knowledge and skills that involve:
  ➢ employing mathematical information symbolically, visually, and numerically;
  ➢ applying arithmetic, algebraic, and geometric models to solve problems;
  ➢ formulating mathematical models, such as formulas, graphs, and tables; and
  ➢ applying mathematical skills to estimate and check answers to mathematical problems, determining reasonableness; alternatives; and correctness and completeness of solutions.
• Develop critical thinking skills and transfer their knowledge to other learning environments.
• Develop and apply the necessary skills for the use of technology to enhance their learning, communication and collaboration
• Follow ethical standards of conduct and maintain academic integrity including in the use of technology
• Demonstrate ability to communicate and collaborate with diverse groups of people
• Develop self-efficacy.

Program Credo:

At the the Math Foundation Unit (MFU) we strongly believe that:

1. Everyone can learn math to the highest level.
2. Mistakes are valuable.
3. Questions are really important.
4. Math is about creativity and making sense.
5. Math is about connections and communicating.
6. Math class is about learning not performing.
7. Depth is more important than speed.

Gender Segregation:

All instructors, coordinators, and staff will conduct university activities in compliance with applicable laws, regulations, and university policies and procedures. GUST accreditation by the Ministry of Higher Education (Council for Private Universities) depends on compliance with Article 6 of the Law on the Establishment of Private Universities (Law No. 34 for the year 2000). The Article says:

Private universities/collages and branches of foreign universities shall abide by the following:

1. Operate its buildings to ensure gender segregation in all departments, disciplines and student activities.
2. Observe Islamic values and time-honored traditions in relation to students’ costumes and activities.

All faculty and staff must comply with Article 6 of the Law on the Establishment of Private Universities.

Required Textbook:

**Textbook:** Introductory and Intermediate Algebra – 5th Online Edition

**Author:** Marvin L. Bittinger, Judith A Beecher
**Publisher:** Pearson

The book contains “My Math Lab Student Access Kit” that is essential to register for the online homework and lab. Registration in MyMathLab is mandatory.

Every student is required to have a textbook or e-book for the course. Bringing the textbook or e-book to class is mandatory.

Course Description:

MATH 096 Intermediate Algebra.

Prerequisite(s): ACCUPLACER (Arithmetic ≥72 ) and (Algebra <82) or MATH 095. This course is a review of algebraic concepts and applications through the use of a variety of factoring techniques, graphing linear equations and inequalities, systems of equations, and an introduction of the main concepts of polynomial, rational and radical functions. Emphasis is placed on algebraic techniques in order to successfully complete Math 111 College Algebra. Non-matriculating; the credits do not count towards graduation.

Course Objectives:

Students are to acquire the basic algebra skills that will enable them to learn and remember the fundamentals of mathematics. Including:

1. Identifying, simplifying and evaluating algebraic expressions, using arithmetic operations
2. Solving linear equations in one variable, using addition and multiplication principles.
3. Solving and graphing linear equations and inequalities using algebraic operations and properties.
5. Engaging in substantial practice of Polynomial operations with applications
6. Simplifying rational expressions and equations, using algebraic properties.

**Student learning outcomes:**

The student will be able to apply algebraic literacy for subsequent math courses according to standard American Mathematics in which he/she:

1. Solve linear equations and linear inequalities.
2. Solve Real life applications.
3. Perform basic operations on Polynomials such as Add, Subtract, Multiply and Divide.
4. Factor polynomials of different types.
5. Solve Quadratic equations using factoring and quadratic formula.
6. Perform arithmetic operations on rational expressions and complex fractions including simplification
7. Solve rational equations.
8. Find domain and range of functions.
9. Graph linear, quadratic, rational, radical, and absolute value functions (by point plotting method).
10. Graph solutions of linear inequalities.

**Course/Classroom Rules & Policies:**

1. **Punctuality:** Classes begin on time. You must be in the classroom when the class is scheduled to begin. If you find the door closed, do not knock or try to gain entry. If you do try to enter, an incident report will be filed.
2. **Communication:** The official means of communication at Gulf University of Science and Technology is GUST email. You should read your emails every day so that you do not miss important messages. You should also clean your email account weekly. This includes emptying the Deleted Items.
3. **Language:** The official language of instruction at GUST is English. Continually improving your English language skills is important for your success at GUST and with future employers. You must use English and not Arabic in the classrooms at all times and anytime you speak with your instructor.
4. **Absences:** You are absent each time
   a. You do not come to class
   b. You do not bring your ID card to class
   c. You do not swipe your student ID card before attendance is closed
   d. You arrive after the door or attendance system closes
   e. You leave a classroom without permission
5. **Student Work:**
   a. You will receive a zero for any missed quiz, test, or exam (refer to Student Handbook for Attendance Policy).
   b. You are responsible for all homework and assignments missed AND for making sure that they are caught up and ready to participate in class when they return.
   c. You receive a zero for any assignment not submitted by the deadline including homework and other graded course work.
6. **Unexpected University Closings:** You will be expected to submit any assignments and/or be prepared to exams, quizzes etc., and the next day your class meets following unscheduled cancellations.
7. **Academic Integrity:**
   a. Cheating will not be tolerated.
   b. Plagiarism will not be tolerated. (Plagiarism is grounds for dismissal from the University. Students are referred to the GUST Bulletin for details regarding Academic Honesty.)
8. **Classroom Behavior:** The instructor reserves the right to manage a positive learning environment and thus will not tolerate any kind of inappropriate conduct during the course. Rules of classroom behavior include but are not limited to the following:
   a. You must put your telephone on silent and out of sight during class.
   b. You may use classroom computers for class activities only.
   c. You may not eat, drink, or smoke in the classroom.
   d. You may not be disruptive or disrespectful.

**Attendance Policy:**

Attending classes is a crucial element for student success in university courses and in particular mathematics courses; consequently you are advised to attend each class session on time and always bring and swipe your student card at the beginning of each class. Each student is responsible for swiping his own card and is not allowed to swipe the card for any other student. If a student is caught swiping a card for any other student who is not attending the class, an academic dishonesty report will be filed for both students and may lead to subsequent action by the university. It is the sole responsibility of the student to be present for each class on time. You will automatically receive attendance warning via GUST email according to following schedule.

<table>
<thead>
<tr>
<th>Warning</th>
<th>Number of Absences(MFU)</th>
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<tbody>
<tr>
<td>First</td>
<td>5 Hours</td>
</tr>
<tr>
<td>Second</td>
<td>10 Hours</td>
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<tr>
<td>Third (Last)</td>
<td>15 Hours</td>
</tr>
<tr>
<td>NP</td>
<td>20 Hours</td>
</tr>
</tbody>
</table>

**Understanding sick days and personal days:**

You should try not to miss *any* classes. The university has a policy on attendance. There are **no excused absences**; therefore, all absences are unexcused.

**Homework and Online Practice Policy:**

The online homework for this course is an important component of the course and is the active student learning platform. Each student is encouraged to complete the homework sets on his/her own without the use of calculator in order to maximize learning. The homework and the online practice is worth 10% of your total course grade. Students can access the homework assignments through “My Math Lab” at [www.coursecompass.com](http://www.coursecompass.com) after creating a student account for their particular section. Each Assignment will be uploaded chapter/section on My Math Lab website and Due Dates are assigned giving consideration to the fact that the student will have the skills required to complete them successfully. Any homework or Online Practice set that is completed after the deadline will be assigned a grade of 50% of the original grade. So it is important to complete the homework on daily basis according to the course calendar attached below and avoid any difficulty that might arise during the last days before an assignment is due.
Lectures and Guided Practices:

For Math 096, classes are from Sunday through Thursday. Each session is 50 minutes long. Students are advised to bring textbook, workbook, a notebook, and a pen/pencil to take careful notes. Remember that you can receive extra help from your instructor during his/her office hours.

Calculators are not allowed in this course. Therefore, you are discouraged from bringing any type of calculator to class.

Math TA’s Office Services:

Math TA’s Office is located in W3-203. They provide the following services:

- ✔ Student subject tutoring
- ✔ Help with how to use and register for “My Math Lab”
- ✔ General help on how to manage your course and be an active student
- ✔ Review Sheets and review exams.

Students with Disability

I wish to fully include persons with Special Needs in this course. Please let me know if you need any special accommodations in the curriculum, instruction, or assessments of this course to enable you to fully participate. I will maintain confidentiality of the information you share with me. If you have a disability that impacts your classroom performance and wish to request an accommodation, contact the Student Success Center Services (SSC) for Special Needs at N3-101. They require documentation regarding your disability to enable them to comply with your request. Admission of SSC is voluntary and will be handled in a confidential manner. GUST does not discriminate against individuals with Special Needs.

Grading Scheme:

The grading scheme is as follows:

<table>
<thead>
<tr>
<th>Quiz/ Test/ Exam</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>15%</td>
</tr>
<tr>
<td>Test 2</td>
<td>20%</td>
</tr>
<tr>
<td>Test 3</td>
<td>10%</td>
</tr>
<tr>
<td>Quizzes: A minimum of one quiz per chapter</td>
<td>15%</td>
</tr>
<tr>
<td>Homework and Online Practice</td>
<td>10%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>30%</td>
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</tbody>
</table>
The final grade for this course is either “Pass” (Course Average $\geq 70$) or “Not Pass” (Course Average $< 70$). A student must maintain an average of 70% on all his/her cumulative semester work in order to pass the course.

**Use of Email:**

It is very important for every student to familiarize him/herself with the use of Email. Dates for exams, important announcements, posting of Chapter Review Sheets will be done through email and My-Math lab. Regular cleaning of your email inbox is highly recommended.

<table>
<thead>
<tr>
<th>WEEK 1</th>
<th>Date</th>
<th>Activity</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>15-Jan</td>
<td>Course Introduction /Syllabus</td>
<td></td>
</tr>
<tr>
<td>Mon</td>
<td>16-Jan</td>
<td>TAs My Math Lab Registration</td>
<td></td>
</tr>
<tr>
<td>Tues</td>
<td>17-Jan</td>
<td>Sec 2.1 and Sec 2.2 Page 110: 14,38,44,50 &amp; Page 116: 6,24,38</td>
<td>B, A</td>
</tr>
<tr>
<td>Wed</td>
<td>18-Jan</td>
<td>T.A. Practice section 2.2 Page 117: 36,40,44,47,52</td>
<td></td>
</tr>
<tr>
<td>Thurs</td>
<td>19-Jan</td>
<td>Sec 2.3 Page 128: 84,85,90128</td>
<td>A</td>
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<table>
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<th>Date</th>
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<th>Objectives</th>
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</thead>
<tbody>
<tr>
<td>Sun</td>
<td>22-Jan</td>
<td>Sec 2.4 Page 134: 16,32,35,40</td>
<td>B</td>
</tr>
<tr>
<td>Mon</td>
<td>23-Jan</td>
<td>T.A. Practice section 2.3 &amp; 2.4 Page 138: 39, 40,45,46,45</td>
<td></td>
</tr>
<tr>
<td>Tues</td>
<td>24-Jan</td>
<td>Sec 2.5 Page 143: 2,8,18,22</td>
<td>A</td>
</tr>
<tr>
<td>Wed</td>
<td>25-Jan</td>
<td>T.A. My Math Lab online practice section 2.4 &amp; 2.5</td>
<td></td>
</tr>
<tr>
<td>Thurs</td>
<td>26-Jan</td>
<td>Chapter 2 Applications Page.1451Complete Exercises #41 &amp; 44 + Handout</td>
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</tbody>
</table>

<table>
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<th>Date</th>
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<tr>
<td>Sun</td>
<td>29-Jan</td>
<td>Sec 9.1 Page 658-660: 12,16,28,56</td>
<td>C</td>
</tr>
<tr>
<td>Mon</td>
<td>30-Jan</td>
<td>T.A. Practice section 9.1 Page658-660: 22,34,38,4460</td>
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</tr>
<tr>
<td>Tues</td>
<td>31-Jan</td>
<td>Sec 9.2 Page 672 - 673: 18,21,30,45,47,50,53age</td>
<td>A, B</td>
</tr>
<tr>
<td>Wed</td>
<td>1-Feb</td>
<td>TA: Practice Sec 9.1&amp;9.2 Page 672-673: 22,34,44</td>
<td></td>
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<tr>
<td>Thurs</td>
<td>2-Feb</td>
<td>Chapter 9 Applications + Handout</td>
<td></td>
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</table>

<table>
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<th>Objectives</th>
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<tr>
<td>Sun</td>
<td>5-Feb</td>
<td>T.A. Online practice section 9.1&amp; 9.2n</td>
<td></td>
</tr>
<tr>
<td>Mon</td>
<td>6-Feb</td>
<td>Chapter 9 word problems</td>
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</tr>
<tr>
<td>Tues</td>
<td>7-Feb</td>
<td>Sec 4.1 Page 255: 64, 72, 76, 82, 84, 94, 96</td>
<td>D, E, F</td>
</tr>
<tr>
<td>Wed</td>
<td>8-Feb</td>
<td>T.A. My Math Lab On Line Practice section 4.1</td>
<td></td>
</tr>
<tr>
<td>Thurs</td>
<td>9-Feb</td>
<td>Sec 4.2 Page 265: 24, 32, 40, 50, 52age</td>
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</table>

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<th>Date</th>
<th>Activity</th>
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<td>Sun</td>
<td>12-Feb</td>
<td>Sec 4.3 Page 277-281: 4, 54, 69, 84, 86,92,</td>
<td>B, D</td>
</tr>
<tr>
<td>Mon</td>
<td>13-Feb</td>
<td>TA Practice section 4.1 &amp; 4.2 Learning Catalytics</td>
<td></td>
</tr>
<tr>
<td>Tues</td>
<td>14-Feb</td>
<td>4.4: Page 287: 8, 36, 39</td>
<td>A, B</td>
</tr>
<tr>
<td>Wed</td>
<td>15-Feb</td>
<td>MyMathLab 4.3 &amp; 4.4</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Week</td>
<td>Section</td>
<td>Pages</td>
</tr>
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<tr>
<td>16-Feb</td>
<td>6</td>
<td>Sec 4.5</td>
<td>297: 22, 34, 40, 42</td>
</tr>
<tr>
<td>19-Feb</td>
<td>Sun</td>
<td></td>
<td></td>
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<tr>
<td>20-Feb</td>
<td>Mon</td>
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<tr>
<td>21-Feb</td>
<td>Tues</td>
<td></td>
<td>308: 49, 62, 66, 69, 70</td>
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<tr>
<td>22-Feb</td>
<td>Wed</td>
<td></td>
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<tr>
<td>23-Feb</td>
<td>Thurs</td>
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<td>316: 21, 26, 29, 32, 36</td>
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<tr>
<td>26-Feb</td>
<td>Sun</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27-Feb</td>
<td>Mon</td>
<td></td>
<td></td>
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<tr>
<td>28-Feb</td>
<td>Tues</td>
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<tr>
<td>1 Mar</td>
<td>Wed</td>
<td></td>
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<tr>
<td>2 Mar</td>
<td>Thurs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-Mar</td>
<td>Sun</td>
<td></td>
<td>325: 12, 18, 24</td>
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<tr>
<td>6-Mar</td>
<td>Mon</td>
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<tr>
<td>7-Mar</td>
<td>Tues</td>
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<tr>
<td>8-Mar</td>
<td>Wed</td>
<td></td>
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</tr>
<tr>
<td>9-Mar</td>
<td>Thurs</td>
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<tr>
<td>12-Mar</td>
<td>Sun</td>
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<td>737-738: 11, 16, 30, 52</td>
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<tr>
<td>13-Mar</td>
<td>Mon</td>
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<td></td>
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<tr>
<td>14-Mar</td>
<td>Tues</td>
<td></td>
<td>344: 20, 22, 27, 32</td>
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<td>15-Mar</td>
<td>Wed</td>
<td></td>
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<tr>
<td>16-Mar</td>
<td>Thurs</td>
<td></td>
<td>352: 4, 12, 20, 22, 26</td>
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<td>19-Mar</td>
<td>Sun</td>
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<td>378: 2, 14, 17, 20, 26378</td>
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<tr>
<td>20-Mar</td>
<td>Mon</td>
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<tr>
<td>21-Mar</td>
<td>Tues</td>
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<td>379: 45, 56, 61, 67</td>
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<tr>
<td>22-Mar</td>
<td>Wed</td>
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<tr>
<td>23-Mar</td>
<td>Thurs</td>
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<td>400: 12, 23, 26, 38</td>
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<tr>
<td>26-Mar</td>
<td>Sun</td>
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<td>434: 58, 60, 62, 66</td>
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<tr>
<td>27-Mar</td>
<td>Mon</td>
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<td>28-Mar</td>
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<td>29-Mar</td>
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<td>30-Mar</td>
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<td>2 Apr</td>
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<td>434: 58, 60, 62, 66</td>
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<tr>
<td>3 Apr</td>
<td>Mon</td>
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<tr>
<td>4 Apr</td>
<td>Tues</td>
<td></td>
<td>439: 18, 28, 31</td>
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<tr>
<td>5 Apr</td>
<td>Wed</td>
<td></td>
<td>Online Practice Sec 6.1, 6.2</td>
</tr>
<tr>
<td>6 Apr</td>
<td>Thurs</td>
<td></td>
<td>449: 18, 22, 30, 43</td>
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<td>9 Apr</td>
<td>Sun</td>
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<td>458: 6, 18, 22, 36</td>
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<tr>
<td>10 Apr</td>
<td>Mon</td>
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<td>Date</td>
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<tr>
<td>Tues 11-Apr</td>
<td>14</td>
<td>Sec 6.6 Page 467: 2, 10, 15, 17</td>
<td>A</td>
</tr>
<tr>
<td>Wed 12-Apr</td>
<td>14</td>
<td>Online Practice Sec 6.4, 6.5</td>
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</tr>
<tr>
<td>Thurs 13-Apr</td>
<td>14</td>
<td>Sec 6.7 Page 473 1, 5, 9, 15, 19, 23, 37</td>
<td>A</td>
</tr>
<tr>
<td>Sun 16-Apr</td>
<td>14</td>
<td>Applications Chapter 6 Handout will be given</td>
<td></td>
</tr>
<tr>
<td>Mon 17-Apr</td>
<td>14</td>
<td>Practice section 6.5 Page 458: 13, 35 &amp; Practice section 6.6 Page 467: 4, 8</td>
<td></td>
</tr>
<tr>
<td>Tues 18-Apr</td>
<td>14</td>
<td>Sec 7.1 Page 525: 1, 17, 54</td>
<td>A, B, D</td>
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<tr>
<td>Wed 19-Apr</td>
<td>14</td>
<td>Test -3</td>
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<tr>
<td>Thurs 20-Apr</td>
<td>14</td>
<td>Sec 7.2 Page 531: 9, 14 ge</td>
<td>A</td>
</tr>
<tr>
<td>Sun 23-Apr</td>
<td>15</td>
<td>University Holiday</td>
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<tr>
<td>Mon 24-Apr</td>
<td>15</td>
<td>Practice Sec 7.1, 7.2</td>
<td></td>
</tr>
<tr>
<td>Tues 25-Apr</td>
<td>15</td>
<td>Sec 7.3 A Page 544: 2, 4, 22</td>
<td>A, B</td>
</tr>
<tr>
<td>Wed 26-Apr</td>
<td>15</td>
<td>Online Practice Sec 7.1, 7.2, 7.3</td>
<td></td>
</tr>
<tr>
<td>Thurs 27-Apr</td>
<td>15</td>
<td>Sec 7.3 Page 544: 17, 19, 21, 25</td>
<td>C</td>
</tr>
<tr>
<td>Sun 30-Apr</td>
<td>16</td>
<td>Practice Sec 7.1, 7.2, 7.3</td>
<td></td>
</tr>
<tr>
<td>Mon 1-May</td>
<td>16</td>
<td>Final Exam Review</td>
<td></td>
</tr>
<tr>
<td>Tues 2-May</td>
<td>16</td>
<td>Final Exam Review</td>
<td></td>
</tr>
<tr>
<td>Wed 3-May</td>
<td>16</td>
<td>Final Exam Review</td>
<td></td>
</tr>
<tr>
<td>Thurs 4-May</td>
<td>16</td>
<td>Final Exam</td>
<td></td>
</tr>
<tr>
<td>Sun 7-May</td>
<td>17</td>
<td>Office hours</td>
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</tr>
<tr>
<td>Mon 8-May</td>
<td>17</td>
<td>Office hours</td>
<td></td>
</tr>
<tr>
<td>Tues 9-May</td>
<td>17</td>
<td>Office hours</td>
<td></td>
</tr>
</tbody>
</table>
Name of Principal Investigator

Ms. Sali Hammad

Title of Research

Factors Behind Mathematics Achievement for Freshmen Students at a Foundation Mathematics Program in Kuwait.

Aim of research

This study aims to improve students’ achievement in mathematics (algebra) by combining the conceptual, procedural algebraic understanding with the assistance use of technology and the effect of students’ self-efficacy through the SMIC (Successful Mathematics Implementing Classroom) framework.

Description of procedure:

a) **Beginning of the course:** Students will be will complete a Self-efficacy questionnaire, a Background questionnaire and Motivation questionnaire. The students will take a level quiz to assess their algebraic and mathematics level at this course. Also, students will be asked to draw their own individual concept maps.

b) **Mid-course:** The students will complete the Self-efficacy and Motivation questionnaires, a course level quiz and test. Also, students will be asked to draw their own individual concept maps.

c) **End of the course:** The students will complete the Self-efficacy and Motivation questionnaire, all quizzes and test scores will be collected. Also, a group of selected students will be interviewed. In addition, the students' MyMathLab scores will be collected. Also, students will be asked to draw their own individual concept maps. The semi-structured interviews will be voice-recorded in order to assist me in recalling students’ answers easily accurately. This may assist me finding research results. The semi-structured interviews will be voice-recorded in order to assist me in recalling students’ answers easily accurately. This may assist me finding research results.

Description of risks: There are no risks involved if you decide to participate in this research study.

Benefits of proposed research: There are no direct benefits to you for participating in this research study. The study may help educators to improve student’s mathematics understanding and self-efficacy through the use of Successful Mathematics Implementing Classroom (SMIC) framework in order to improve students’ achievement in mathematics.
**Right to withdraw:** Your participation is voluntarily. There is no pressure for you to answer the questionnaire, to take interview or write the quiz. If you wish to take part, you will need to sign a consent letter which will be given to you later. If you do not wish to participate in the study, or if you do not feel comfortable while using any of the study instruments mentioned above, you are free to leave the classroom while other students are filling up the forms. Your lack of participation in the study will not affect your enrolment in the course, your professional relation with the instructor, nor your scores (grades) received through the assigned assessments during the course.

**Participating in the study:** If you agree in taking part in this study by filling up the questionnaires, answering the quizzes and tests, participating in the classroom and the interview, all will be conducted at times and places suitable for you. This interview will last around no more than 20 to 25 minutes, and you may feel free to submit the questionnaire, quiz or test when feeling finished answering any of them.

**Recorded media sessions:**
Interviews will be voice-recorded which will assist the researcher to recall different interview answers accurately to know what students say easily. If you do not wish me to record your interview, please say – I will then make notes instead. All of voice recorded sessions will be stored until the completion of the research study (PhD) and then will be destroyed. All recordings will be shared between the researcher and the supervisor of the study only.

**The ethical approval of the study:** This research study was approved by the Institutional Review Board (IRB) committee at Gulf University for Science and Technology in Kuwait, and the Faculty of Science and Engineering Research Ethics Committee at University of Plymouth.

**Confidentiality:** All data/names of the participants will be treated confidentially. All data will be de-identified prior to analysis. The researcher will share the data with the supervisor of the study only. Also, the researcher will keep all the data collected and will store them till the completion of the research study (PhD) and then will destroy them.

**Questions/concerns:** Please contact the researcher Ms. Sali Hammad at (Hammd.s@gust.edu.kw, 25307485, W1-272, GUST campus, Kuwait) with any questions or concerns about the research. If you feel the problem has not been resolved please contact the secretary to the Faculty of Science and Engineering Human Ethics Committee: Mrs Paula Simson 01752 584503.
Appendix F: Consent to Participate in Research Project/Practical Study
PLYMOUTH UNIVERSITY
FACULTY OF SCIENCE AND ENGINEERING
Human Ethics Committee Consent Form
School of Computing, Electronics and Mathematics

Name of Principal Investigator
Ms. Sali Hammad

Title of Research
Factors Behind Mathematics Achievement for Freshmen Students at a Foundation Mathematics Program in Kuwait

Brief statement of purpose of work
This study aims to improve students’ achievement in mathematics (algebra) by combining the conceptual, procedural algebraic understanding with the assistance use of technology and the effect of students’ self-efficacy through the SMIC (Successful Mathematics Implementing Classroom) framework.

The objectives of this research have been explained to me.
I received the Research Information Sheet. I understand that I am free to withdraw from the research at any stage, and ask for my data to be destroyed if I wish. I understand that my anonymity is guaranteed, unless I expressly state otherwise. I understand that the Principal Investigator of this work will have attempted, as far as possible, to avoid any risks, and that safety and health risks will have been separately assessed by appropriate authorities (e.g. under COSHH regulations)

Under these circumstances, I agree to participate in the research.

Name: …………………………………….. ID: ……………………………..

Signature: …………………………………….. Date: ……………………………..
Appendix G: Student’s Background, Self-efficacy and Motivation questionnaires Towards Studying Mathematics at MFU, at GUST.

A: Student’s Mathematics Background

Please read the questions carefully before you decide to participate in the study. Respond to each statement using the scale provided below:

Choose Yes or No for the questions 1 to 11:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I graduated with an Arts major high school diploma.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2. I graduated with a Science major high school diploma.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>If other diploma program, please list below:</td>
<td></td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>3. Below is the highest mathematics course I received in my high school diploma, (choose one):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra I (Grade 8 mathematics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra II (Grade 9 or 10 mathematics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Calculus (Grade 11 mathematics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculus (Grade 12 mathematics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I took the course Math 095 here at GUST.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5. If yes, how many time?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I am taking Math 096 for the first time.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>7. I am taking Math 096 for the second time or more.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>8. Mathematics was my favourite subject taken during my high school diploma.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>9. I cannot solve any mathematics problem without the help of a calculator.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10. I believe it is important for me to take a foundation mathematics course before joining the academic program at GUST.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>11. I enjoy using different computing programs when solving an algebraic problem.</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
**B: Self-efficacy belief towards studying mathematics at MFU?**

Please respond to each statement using the scale provided below:

SD: I strongly disagree
D: I disagree
N: I neither agree nor disagree
A: I agree
SA: I strongly agree

<table>
<thead>
<tr>
<th>Statement</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am confident that I can understand the basic algebraic concepts presented by the instructor in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>2. I am confident that I can understand the most complicated algebraic concepts presented by the instructor in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>3. I am confident that I can do a great job in my mathematics and algebraic assignments</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>4. I am confident I can perform well in the quizzes and tests offered in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>5. I am certain that I can read and solve the hardest word problems and applications taught in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>6. I am certain that I can master the skills being taught in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>7. I am confident I can solve any type of mathematical or algebraic question in this course without the use of the calculator.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>8. Considering the difficulty of this course, the instructor, and my skills, I think I will improve my mathematics understanding in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>9. I am confident that receiving a high grade on my Algebraic test will encourage me to study harder for the following quiz or test.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>10. The harder the mathematics problem is, the more confident and challenged I am to solve it.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>11. I am confident that I am capable of learning mathematics and Algebra in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>12. I am certain that I will pass this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>13. I am confident that I will pass the next mathematics or algebraic course needed for my college major.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>14. I am certain I have the talent to successfully complete mathematics course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>
C. Motivation towards studying mathematics at MFU?

Please respond to each statement using the scale provided below:

SD: I strongly disagree  
D: I disagree  
N: I neither agree nor disagree  
A: I agree  
SA: I strongly agree

<table>
<thead>
<tr>
<th>Statement</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel that I will be able to use what I learn in this course in other courses.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>2. Getting a good grade in this course motivates me to work harder and practice more.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>3. I feel that if I try hard enough, then I will understand the course materials.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>4. I want to do well in this course because it is important to show my ability to my family, friends, employer, or others.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>5. I expect to do well in this course.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>6. I feel that mathematics is becoming an easier subject to learn.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>7. I feel that something I learn in mathematics makes me think about things.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>8. In this course, I feel that I learn something interesting</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>9. Learning mathematics gives me opportunities for personal advancement.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>10. I expect to be able to solve mathematical problems anywhere I come across them if they are of my level of education.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>
Appendix H: Math 096-Level Quiz1
Gulf University for Science and Technology
Mathematics Foundation Unit

Student name: ____________________  ID#_____________________________  Section#____

1) Simplify:

a) \(30 - 4\left(9 \div (5 - 2^3)\right) + (9 - 7)^2\)  

b) \(\frac{21a^4b\ c}{7a^2b^3c^{-2}}\)

[4 marks]

2. Evaluate each of the following expression according to each given value of \(x\):

[4 marks]

a) \(\frac{4}{x-1}\) (when \(x = 1\))

b) \(\frac{0}{x+3}\) (when \(x = 5\))

3) Solve the equation below for \(x\)  

\[3(4x - 2) - 1 = 2(3x - 1) + 7\]  

[5 marks]

4) The Smith family paid a total of $4000 as a down payment on a new luxury recreational boat. If this represent 20% of the total price, calculate the price of the new boat.  

[4 marks]

5) A computer company uses the polynomials \(R = 150x^2 + 50x - 10\) and \(C = 150x^2 + 20\) to estimate its monthly revenue \(R\) and cost \(C\) in dollars for producing \(x\) cell phones per month. Find the number of cell phones produced when the revenue and cost reach equilibrium. Explain your final answer.  

[4 marks]
Appendix I: Semi-structured Interview to check student’s Mathematics Experience and Satisfaction

7) How does this course compare to your previous study of mathematics, have you noticed any differences? (if they mention group work or puzzles ask why?)

8) Have you done better in this course than you expected? Why?

9) Let’s discuss your attendance and absences and their affect to your overall understanding and overall achievement in this course.

10) How has this course changed your view towards mathematics? Why?

11) Explain the differences between your concept maps across the course.

12) How do you feel about your overall grade so far? How do you feel about studying more mathematics courses in the future?

13) How useful (or not) was using the online HW (PEARSON MYMATHLAB)? Why?

14) What recommendations would you recommend to teachers to improve the course in the future?
Appendix J: Math 096- Test 1

Math-096 – Intermediate Algebra – Test 1

Student’s Name: ----------------------------------- GUST ID: ----------------------

Section: ----------------------------------------------- Instructor: ----------------------

Instructions:

1. Exam time is **50 minutes**.
2. **Calculators** and any smart devices including smart watches are **not allowed** during the exam.
3. Mobiles are not allowed during the exam.
4. Show your detailed work to each question for proper credit.
5. This test contains **10 questions** worth a total of **50 points** and a bonus question.
Course Learning Outcomes

The student will be able to apply algebraic literacy for subsequent math courses according to standard American Mathematics in which he/she:

1. Solve linear equations and linear inequalities.
2. Solve Real life applications.
3. Perform basic operations on Polynomials such as Add, Subtract, Multiply and Divide.
4. Factor polynomials of different types.
5. Solve Quadratic equations using factoring and quadratic formula.
6. Perform arithmetic operations on rational expressions and complex fractions including simplification
7. Solve rational equations.
8. Apply properties of rational expressions to simplify radical expressions.
9. Simplify and perform operations with numerical radicals.
10. Find domain and range of functions.
11. Graph linear, quadratic, rational, radical, and absolute value functions (by point plotting method).
12. Graph solutions of linear inequalities.
Question 1:

(a) Solve, graph, and write answer in interval notation.

\[-2y + 1 < 5\]

(b) Solve, graph, and write answer in set-builder notation form.

\[-19 \leq -2x - 7 \quad \text{and} \quad -2x - 7 < -20\]

Question 2: The depreciation for the price of a newly purchased car over the years is given by the formula \( P = -4,000t + 32,000 \).

a) What will the price of car be after 4 years?

b) Solve the formula for \( t \).
**Question 3:** Solve, graph, and write answer in interval notation.

\[ 9x - 6 < 3x \text{ or } -4x \leq 12 \]

**Question 4:** Solve

a) What is 7% percent of 325? Round your answer to the nearest tenth.

b) The Smith family paid a total of $4000 as a down payment on a new luxury recreational boat. If this represent 10% of the total price, calculate the price of the new boat.
Question 5: Ali left a 1.5 KD tip for a meal that cost 50 KD.

a) What percent of the cost of the meal was the tip?

b) What was the cost of the meal including the tip?

Question 6: Solve

Jalal claims that it costs him at least 6 KD every time he calls his business clients. If his typical call costs 1.5KD plus 450 fills for each minute. How long do his calls typically last? (Hint: 450 fills = 0.450KD)

Question 7: Solve

a) \( \frac{1}{3} + x = 11 \)

b) \( 5 - 2(x + 6) = 10 - 7(x + 1) \)

Question 8: Decide if the value \( x = 7 \) is a solution of the equation \( 6x + 4x - 2 = 68 \).
Question 9: Simplify write answers with positive exponents

a) \((\frac{xy^4}{w^6z})^{-6}\)

b) \((-4x^3y)^2\)

Question 10: Evaluate \(\frac{1}{x^2} - 2\), when \(x = -10\)

Bonus

Layla has 848 points in her math class. She must have 80% of the total number of 1300 points by the end of the term to pass the class. What is the least number of extra points she must earn by the end of the term to pass the class?
Appendix K: Math 096- Test 2

Math-096 – Intermediate Algebra – Midterm V1

Name: ----------------------------------  GUST ID: ------------------------------

Section: ----------------------------------  Instructor: ------------------------------

Instructions:
6. Exam time is 50 minutes.
7. Calculators and any smart devices are not allowed during the exam.
8. Mobiles are not allowed during the exam.
9. Show your detailed work to each question for proper credit.
10. This test contains 9 questions worth a total of 50 points.
Course Learning Outcomes

1. Solve linear equations and linear inequalities.

2. Solve Real life applications.

3. Perform basic operations on Polynomials such as Add, Subtract, Multiply and Divide.

4. Factor polynomials of different types.

5. Solve Quadratic equations using factoring and quadratic formula.

6. Perform arithmetic operations on rational expressions and complex fractions including simplification.

7. Solve rational equations.

8. Apply properties of rational expressions to simplify radical expressions.

9. Simplify and perform operations with numerical radicals.

10. Find domain and range of functions.

11. Graph linear, quadratic, rational, radical, and absolute value functions (by point plotting method).

12. Graph solutions of linear inequalities.

Question 1: Multiply.

a) \((t + 1)(-2t + 1)\)  

b) \((3p - 2)^2\)

c) \((x + 2)(x + 3)(x - 3)\)

Question 2: Divide.  

\[
\frac{-35x^7 + 15x^6 - 30x^5}{-5x^3}
\]

Question 3: Perform the indicated operation.  

\[(2x^2 + 2xy) - (-2x^2 - 10y^2 + 5xy) + (-3y^2 - 5xy)\]

Question 4: $100 is deposited into an account with interest rate \(r\) (in Decimal form), compounded annually. The amount in the account after 2 years is given by \(100(1+r)^2\). Calculate the amount of money if the interest rate is 10%. Round your answer to the nearest cent.

Question 5: Simplify. Assume that all variables represent positive real numbers.

a) \[\left(\frac{a^{-2}}{2b^{-3}}\right)^{-2}\]

b) \[\sqrt[2]{\frac{32x^{-4}z^6}{2x^5z^{-6}}}\]
**Question 6:** Factor.

a) \(6x^5y^3 - 9x^7y^4 + 3x^4y^5\) 

b) \(x^3 + 8x^2 + 16x\)

c) \(m^2 + 4m - 21\)

**Question 7:** A computer manufacturing company uses the polynomials \(R = 200x^2 + 180x + 500\) and \(C = 170x + 100\) to estimate its monthly revenue \(R\) and cost \(C\) in dollars for producing \(x\) computers per month? Profit = Revenue – Cost

(a) Write a polynomial \(P\) for the company monthly profit.
(b) Find the profit for \(x = 30\)

**Question 8:** Sylvia traveled \((5x + 3)\) kilometers in the morning then she traveled 2 kilometers less in the afternoon. Write a polynomial \(K\) that represent the difference between the distance traveled in the morning and the distance traveled in the afternoon.

**Question 9:** \$150 is deposited into an account with interest rate \(r\), compounded annually. The amount in the account after 2 years is given by \(150(1 + r)^2\). Write a polynomial that represents 3 times the amount in the account after 2 years without parenthesis.
Appendix L: Math 096- Test 4

Math-096 – Intermediate Algebra – Final Exam Standardised Answer Key

Student’s Name: ------------------------------- GUST ID:----------------------

Section: -------------------------------------- Instructor: ----------------------

Instructions:

11. Exam time is 120 minutes.

12. Questions are not allowed during the exam.

13. Calculators and Mobiles are not allowed during the exam.

14. In any rational expression, the denominator does not equal zero.

15. Show your detailed work to each question for proper credit.

16. This test contains 19 questions worth a total of 100 points.
**Course Learning Outcomes**

The student will be able to apply algebraic literacy for subsequent math courses according to standard American Mathematics in which he/she:

1. Solve linear equations and linear inequalities.
2. Solve Real life applications.
3. Perform basic operations on Polynomials such as Add, Subtract, Multiply and Divide.
4. Factor polynomials of different types.
5. Solve Quadratic equations using factoring and quadratic formula.
6. Perform arithmetic operations on rational expressions and complex fractions including simplification
7. Solve rational equations.
8. Apply properties of rational expressions to simplify radical expressions.
9. Simplify and perform operations with numerical radicals.
10. Find domain and range of functions.
11. Graph linear, quadratic, rational, radical, and absolute value functions (by point plotting method).
12. Graph solutions of linear inequalities.
**Question 1** Solve and check answer:  

\[
10 - 4(x + 6) - 5 = 3x - 5
\]

\[
(2 + 4(x - 3)) = 3x - 4 \quad \text{and} \quad 2 + 4x - 12 = 3x - 4 + x \quad \Rightarrow \quad 4x - 10 = 4x - 4 \quad \Rightarrow
\]

**Question 2** For the graph given below

a) Does the graph represent a function?

\[\text{Yes}\]

b) The Domain;

\[\{-56, -5, -4, -3, -2, -1, 0\}\]

c) All x-values such that \(f(x) = 1\)

\[x = -1 \text{ and } x = -5\]

d) The range

\[\{4, 5, 6, 7\}\]

e) \(f(0) = 6\)

**Question 3** Solve:

The Parkinson’s family paid a total of $7000 as a down payment on a new luxury recreational car. If this represent 10\% of the total price, calculate the price of the new car.
**Question 4** Solve, Graph, and write answer in interval notation.  

\[ x - 8 > -5 \text{ or } -x - 1 > 1 \]

\[
\begin{align*}
0.5 \text{ m} & \quad x > -\frac{5}{4} \\
4.0 & \quad \text{ or } \quad -3.0 \text{ or } -2x > \\
\end{align*}
\]

\[
\Rightarrow x > 1 \quad \text{or} \quad x < -2
\]

Choose the correct line and \( \frac{1}{2} \) a mark for each correct point.

**Question 5** Multiply:  

\( [6 \text{ marks}] \)

a) \( k \cdot (k + 5)^2 \)

b) \( (2x + 7)(2x - 7) = \frac{(3x - 7)(x^2 + 2x + 4)}{0.5} + \frac{(3x - 7)(x^2 - 2x + (3x - 7)(4))}{1} \)

c) \( (a + 3 - b)(a - 3) = \frac{-(y)^2 + (x + 1)^2}{1} = \frac{x^2 + 2x + 1 - y^2}{1} \)

**Question 6** Subtract: \( (8m^3 - 7m + 3) - (-7m^3 - 5m + 3) \)  

\( [4 \text{ marks}] \)

**Question 7** Divide: \( (-25w^4 - 15w^3 + 5w^2) \div (-5w) \)  

\( [2 \text{ marks}] \)

**Question 8** Factor:  

\( [6 \text{ marks}] \)

a) \( x^4 - 2x^3 - 48x^2 = \frac{0.5}{2} x^2 (x^2 - 4x - 32) = \frac{1}{2} (x - 8)(x + 4) \)
b) \(c^4 - 81\)

**Question 9** Solve \(\text{[8 marks]}\)

(a) \(x^2 = 4x + 45 = \frac{0.5 m}{x^2 - 5x - 24} = 0 \Rightarrow (x - 8)(x + 3) = 0 \Rightarrow x - 8 = 0 \text{ or } x + 3 = 0\)

(b) \(x(x + 5) = 40 + 2x\)

**Question 10** Perform the indicated operations and Simplify: \(\text{[8 marks]}\)

a) \(\left(\frac{5}{a - 2} - \frac{1}{2 - a}\right) = \frac{0.5 m}{x - 3} \cdot \frac{x + 4}{x + 4}\)

b) \(\left(\frac{1}{k + 3} \div \frac{k + 3}{2k + 6}\right) \cdot \frac{k^2 + 6k + 9}{6} = \left(\frac{1}{t + 2} \cdot \frac{1.5 m}{2(t + 2)}\right) \cdot \left(\frac{0.5 m}{(t - 2)(t + 2)}\right) = \frac{0.5 m}{t - 2}\)

**Question 11** Solve \(\text{[5 marks]}\)

\[
\frac{8}{x + 6} + 3 = \frac{8}{x} \\
\text{Lcd} = \frac{0.5 m}{x(x + 6)} \Rightarrow -8(x) + 8(x + 6) + 3(x)(x + 6) = 0 \Rightarrow -
\]

**Question 12**

For producing a certain type of mobile cover, the total cost is given by the formula \(C = 2100 + 1500x\) and the total revenue is represented by the formula \(R = 1600x - x^2.\) Find the break-even point(s)? \(\text{[6 marks]}\)

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b) Simplify: \[ \frac{36}{d^2} - \frac{6}{d} \left( \frac{x}{y} \right)^2 \left( \frac{1 - \frac{9}{y}}{y^2 - 3y} \right) = \frac{1}{m} \left( \frac{y^2 - 9}{y^2 - 3y} \right) - \frac{1}{m} \left( \frac{y + 3}{y(y - 3)} \right) = \frac{1}{m} \left( \frac{y + 3}{y} \right) \]

[4 marks]

**Question 13**  
The profit (in thousands of dollars) from selling \( x \) luxury motor jet-skies produced by a local company is given by \( P(x) = x^2 - 4x - 60 \).  

(a) Find the profit when 11 jet-skies are sold.  
\[ P(60) = \frac{1}{m} \left( 60^2 - 20(60) - 800 \right) = (3600 - 1200 - 800) = 1600,000 \]

(b) Find the number of jet-skies that must be sold so that there is no profit \( (P = 0) \)  
\[ x^2 - 20x - 800 = 0 \Rightarrow (x - 40)(x + 20) = 0 \Rightarrow x = 40 \text{ Jet Skies} \]

**Question 14**  
A parking lot charges 0.700 KD for the first hour, and 0.100 KD for each additional hour or part thereof. Determine, how many hours, Salah was parked if he paid a total of 3.200 KD for parking fees.  
\[ 269 + x \geq 360 \Rightarrow x \geq 360 - 269 \Rightarrow x \geq 91 \]

**Question 15** Simplify:  
\[ \frac{32a^6c^2}{18a^{-2}c^3} + \frac{4a}{b^2} \Rightarrow \left( \frac{2m}{3a^2c^5} \right)^2 = \left( \frac{1m}{9a^4c^{10}b^4} \right)^{0.5m} \frac{1m}{9a^2} = \frac{1.5m}{a^2c^{10}}b^2 \]

[4 marks]

**Question 16** Simplify:  
(a) \[ \left( \sqrt{16x^6y^8z^7} \right)^6 = \left( \frac{1}{16x^7y^8z^7} \right)^{1} \left( \frac{1}{x^2z} \right)^2 = \frac{1}{16x^7y^8z^7} \frac{1}{x^4z^2} = 16x^3y^8z^5 \]

[6 marks]
(b) \((\sqrt[3]{2a^7b^7})^{-15}\) = \(\left(\frac{1}{3a^9b^7}\right)^{\frac{1}{3}}\) = \(\left(\frac{1m}{3a^9b^7}\right)^{-2}\) = \(\left(\frac{1}{3a^9b^7}\right)^{2}\) = \(\frac{1}{9a^{18}b^{14}}\)

**Question 17:** Consider the linear function 

\[7x - 10y = 5x + 4 - 8y\]

(a) Find the slope. 
\[-5y = -2x + 10 \Rightarrow y = \frac{2}{5}x - 2 \Rightarrow m = \frac{2}{5}\]

(b) Find the coordinates of the y-intercept. 
\[if \ x = 0, \ then \ y = -2 \Rightarrow (0, -2)\]

(c) Find all x values when \(f(x) = 0\). 
\[if \ y = 0, \ then \ y = \frac{10}{2} = 5 \Rightarrow (5, 0)\]

(d) Graph

(1 m for each correct point)

**Question 18:** Use the quadratic formula to solve: 
\[x^2 - 2x - 1 = 0\]

[2 marks]

**Question 19:**

If the width of a rectangular office is given as \((x + 2)\) meters and the length is 3 times the width, find the length and the width of the office given that the area is 48 \(m^2\).

[2 marks]