Integrated Technologies Instructional Method to Enhance Bilingual Undergraduate Engineering Students' Achievements in the First Year Mathematics

A thesis submitted for the degree of Doctor of Philosophy

by

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Thesis Abstract

Mathematics permeates almost every aspect of human life and it is a skill much needed by the increasingly complex technological world. It is necessary that this essential skill must be properly developed among students to prepare them for future academic and professional careers. An assessment of the research-based instructional strategies blending with old traditional methods with the modern technological development is a must. Due to the complexity of mathematics learning and the varied learning styles of learners, an integration of appropriate multiple instructional strategies into mathematics education will positively impact mathematical achievement of students.

The purpose of this research was to examine the effects of the use of Integrated Technologies Instructional Method (ITIM) as a supplement to the traditional lecture method on mathematics achievement of the Integral Calculus students at the College of Engineering, University of Ha'il, Saudi Arabia. The ITIM includes the four instructional strategies such as the use of the Computer-Supported Collaborative Learning, the collaborative learning, the bilingual support and the study support. Different types of academic supports have been used to examine their effects on students achievement in mathematics.

Mathematics, the bedrock of science and engineering, is considered a very important indicator of a student's academic success in professional higher education. Undergraduate engineering students' low achievement in the first year mathematics is an issue demands much attention. The study was undertaken to address students' weak background in mathematics and particularly their high failure rates in this particular course. A total of 218 undergraduate engineering students, comprising of both the experimental and the control groups, were involved in this experimental design study. The control group was taught by the traditional lecture method whereas the experimental group was exposed to the ITIM as a supplement to the traditional lecture method. Apart from the effects of the use of ITIM, students' performance in the previous courses (covariates) such as mathematics, computer, and the English language were compared with their final grades of the Integral Calculus course. The final grades of students were taken as the dependent variable and the ITIM and students' scores in the previous courses as the independent variables. It has been noticed from the literature review that the application of only one instructional strategy does not address the needs of the diverse learning styles of students.

A mixed mode method, quantitative and qualitative, was used to collect and analyse data. The quantitative data instruments included students' final exam grades and the student questionnaires. Interviews with students were used as qualitative tools of data collection. An independent t-test, ANOVA, univariate analysis and the stepwise multiple regression analysis were performed to determine the overall statistical significance.

The study concluded that there was a statistically significant difference in the performance of the experimental group of students' in terms of their end-of-course grades compared to that of the control group. The regression model revealed significance of covariates on the dependent variable. However, no significant relationship was found between the mathematics achievement and attitudes towards the use of ITIM. The study was an attempt to demonstrate the suitability of the instructional strategies on the bilingual Arab undergraduate engineering students; however, they can probably be applicable to other bilingual students.

Acknowledgements

In the name of Allah the Most Gracious the Most Merciful

I am thankful to Almighty Allah for making this academic endeavour possible.

I sincerely pray for the good health of my parents who have always remembered me in their prayers for a smooth and successful completion of my PhD.

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Author's Declaration

I declare that this thesis I hereby submit for the degree of PhD at Brunel University, UK, is my own work, supervised by Professor Wamadeva Balachandran and Dr. Zayed Ali Huneiti. I have not previously submitted the work at any university or for any other publication.

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Regression equations models equations.

1. Y(DV)= -0.286+Experimental Group (Pre_study_math)(0.977);
2. Y(DV)= -1.137+Experimental Group (Pre-study_math)(0.837)+ Experimental Group (Pre-study_computer)(0.414)
3. Y(DV)= -1.318+Experimental Group (Pre-study_math)(0.753)+ Experimental Group (Pre-study_computer)(0.300)+Experimental Group (Pre_study_English) (0.280)
4. Sample mean

$$\bar{x} = \frac{\sum x}{n}$$

n = sample size

5. t-test for independent samples

$$t = \frac{M_X - M_Y}{\sqrt{\left[\frac{\left(\sum X^2 - \frac{(\sum X)^2}{N_X}\right) + \left(\sum Y^2 - \frac{(\sum Y)^2}{N_Y}\right)}{N_X + N_Y - 2}\right] \cdot \left[\frac{1}{N_X} + \frac{1}{N_Y}\right]}}$$

$\sum$= sum the following scores
M_X= mean for Group A
M_Y= mean for Group B
X = score in Group 1
Y = score in Group 2
N_X= number of scores in Group 1
N_Y= number of scores in Group 2

6. Standard deviation

$\sigma = \sqrt{\frac{\sum(x-\bar{x})^2}{n}}$

$\sigma = the\ standard\ deviation$

x= *each value in the population*

$\bar{x} = the\ mean\ of\ the\ values$

$n = the\ number\ of\ values\ (the\ population)$

7. **Sample standard deviation**

$s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$

$s = \sqrt{\frac{SS_x}{n-1}}$ $\qquad SS_x = \sum x^2 - \frac{(\sum x)^2}{n}$

8. Regression and correlation

$$SS_x = \sum x^2 - \frac{(\sum x)^2}{n}$$

$$SS_y = \sum y^2 - \frac{(\sum y)^2}{n}$$

$$SS_{xy} = \sum xy - \frac{(\sum x)(\sum y)}{n}$$

9. Pearson product-moment correlation coefficient

$$r = \frac{SS_{xy}}{\sqrt{SS_x SS_y}}$$

LIST OF ABBREVIATIONS

UOH:	University of Ha'il
ITIM:	Integrated Technologies Instruction Method
MSCL:	MATLAB-Supported Collaborative Learning
CS:	Collaborative support
BS:	Bilingual support
SS:	Study Support
CAS:	Computer Algebra System
GPA:	Grade Point Average

CHAPTER 1

Introduction

1.1 Background of the Study

Mathematics and mathematical models form the core of the disciplines of science and engineering. Mathematics is considered a very important indicator of a student's academic success in professional higher education. A thorough understanding with adequate competence in mathematics plays a crucial role in the success of engineering students. Engineering disciplines in general contain high mathematical content as Hawkes and Savage (2000) reported that about 75% of electronic engineering is mathematics. Mathematics teaches one of the most important skills required for engineering students and that is problem solving. Unfortunately a vast majority of student population lacks that, Adams *et al.* (2007). Enhancing problem solving skill is one of the important aspects of teaching mathematics to engineering students, Schoenfeld (1992). The focus of engineering mathematics must be on the development of mathematical thinking, Cardella (2008), more than on amassing unconnected mathematical facts as it is usually the case in a traditional mathematics classroom. A holistic approach to teaching and learning requires encompassing a strong theoretical basis of the subject with its relevant applications. The reality is that engineering disciplines have a strong base in mathematics and achievement in maths for students paves a long way for their success in academia. It is of great concern to educators that students are lacking adequate essential mathematical skills to successfully complete engineering programmes.

There is an ever growing concern with regard to the decline of mathematical knowledge and skills, inadequate preparedness and the lack of commitment to mathematics on entry to engineering disciplines.

The majority of engineering lecturers surveyed by the Engineering Council of the United Kingdom (1995) believe that the mathematical competence of first-year engineering students is significantly weaker today than it was ten years ago. Engineering educators are faced with a decline in the mathematical abilities of first year engineering students, the challenge of teaching large classes with inadequate resources and varying abilities of students. Morgan (2011) describes that scores of physics and engineering academics believe that undergraduate students entering universities are unprepared for their fields of major, and are not achieving their full potential, because of lack of essential mathematical skills. One of the causes of students' failure in mathematics is due to their declining basic mathematical skills, Hawkes and Savage (2000). The authors have further reported that “students don’t seem to have the basics!” and “some have top grades and are having difficulty with algebra and calculus!” A significant number is weak across the whole spectrum of basic maths topics. This is affecting students' progress, their overall success and even after their graduation. The students’ inadequate mathematical preparation and insufficient skills in mathematics will also affect their performance in engineering courses. Many of these students are entering the engineering studies with a weak background in the prerequisites to calculus such as algebra, geometry, and trigonometry.

One of the most important and fundamental courses taught to students in the disciplines of engineering, science and computer science worldwide is calculus. The saying goes that “well begun is half done”. If students are well-prepared in mathematics that is required for engineering then it will facilitate their learning of engineering subjects. Calculus forms the core of the material taught to engineering students, Mustoe and Lowson (2002). Budny *et al.* (1998) reported that the reaction of students in the first semester or year is crucial to their subsequent performance. Tall (1985b), (1986a), (1986b); Steen (1988); Barnes (1988); Li and Tall (1993e); Thompson (1994) have reported students' conceptual difficulties with key calculus concepts such as limits, differentiation and integration. Student difficulties related to integration problems in calculus have been highlighted by several researchers such as Orton (1983), Kiat (2005) and Cottrill (1999). Cipra (1988), White and Mitchelmore (1996) have expressed much concern with regard to students' failure to develop a conceptual understanding of calculus topics because of the rote and manipulative learning that is taking place in introductory courses. This is partly due to the fact that calculus is still being taught in the traditional instructor-led manner despite the ever changing influence of technology in all spheres of human life. There are far reaching consequences of students' low achievement in mathematics, consequently student show low motivation towards learning mathematics; they fail the course repeatedly; do not interact with the course content, become passive learners and a number of them switch majors. It has also been noticed that maths is a subject withdrawn by students frequently and sometimes even causes the withdrawal from the entire semester.

Improving mathematics instruction and thereby enhancing student learning has been a subject of great interest to mathematicians and mathematics educators for several decades now. Hawkes and Savage (2000) in a report commented that there is no simple solution-no panacea to what is rapidly becoming one of the most challenging problems in the universities. The report further stated a wide range of follow-up strategies and various ways of finding to deal with the mathematics teaching of first year undergraduates and these include computer assisted learning of mathematics, support centres, supplementary lectures and the provision of study support. With the rapid technological developments, the demand for mathematics is growing exponentially due to the complexity of various engineering systems. The use of modern techniques and methods for addressing the lack of achievement of engineering students in mathematics has been widely discussed in the literature. Lopez (2007) found an extensive research highlighting the need for educators of engineers to adapt to changing nature of both the engineering profession and the student population in the 21st Century. A more diversified student population requires more comprehensive learning support systems.

It is generally recognised that several problems relating to the teaching and learning of calculus need to be addressed with the appropriate use of technology. A number of innovative teaching and learning methods and the use of different technologies have been pursued by researchers around the world. Such innovations are important for engineering students who have a wide diversity of pre-requisite knowledge and skills. However, the design of the teaching tasks must be meaningful and well-structured to be understood by varying ability students. To address students' high rate of failure in maths, a number of approaches and methods were used such as students' support programs, visualisation techniques, and the use of mathematical computer programmes. The learning in the 21st century must provide exposure to appropriate laboratory-based mathematical computer programmes, Lopez (2007), active learning, Lopez (2007) and Nirmalakhandan *et al.* (2007), Interactive learning, Mason (2002), Gavalcova (2008), Robinson (2012), collaborative work, academic support, offline and online lecture notes to enhance the mathematical education of engineering undergraduates, Green *et al.* (2003). The classical lecture method is prevalent in today's classrooms and a total reliance is certainly questionable. Among the several reform movements, one of the major ones has been the use of computer algebra systems for improving the calculus instructions. It has been reported that the integration of advanced computing algebra systems in classroom teaching had positive impact on students' mathematics achievement, Tokpah (2008). The interactive and novel ways of presenting the material through the electronic medium are effective and efficient in the presentation as well as aesthetically appealing. The Engineering Council of the United Kingdom while recognising the importance of mathematics in engineering education has also proposed a thorough integration of modern mathematical technologies as tools, Mustoe (2002). The author mentioned two aspects of the computer technology in the mathematical education of engineering undergraduates - the use of teaching packages and the use of packages to carry out complicated mathematical analysis. However, it was further stated that the computer should be used for difficult analysis after the basics have been learned manually. Tall (1993) and Heid (1988) suggest that one of the approaches of using the computer could be presenting mathematics graphically, numerically and symbolically; with or without programming. A variety of ways have been offered by researchers such as Heid (1988), Palmiter (1991); Barnes (1994); Hubbard (1995) for the use of symbolic computer software for the enhancement of students understanding of the subject. Over the past few decades, computer technology has revolutionised the way teachers teach and students learn. The computers offer the flexibility to adapt to different learning and teaching styles, Underwood J. and Underwood G. (1990). The computer technology can positively influence student learning processes and outcome, Cradler *et al.* (2002). "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning", Qing (2000). However, as highlighted by Schneiderman (2004), "Education technology is neither inherently effective nor inherently ineffective; instead, its degree of effectiveness depends upon the congruence among the goals of instruction, characteristics of the learners, design of the software, and educator training and decision-making, among other factors." Engineering mathematics students in the 21st century are compelled to have access to an appropriate computer technology due to the perpetually increasing complexities of the engineering programmes. They need to learn specialised computer software as a tool for problem-solving and learning mathematics. Information and communication technology can play an effective role as a cognitive tool in the teaching and learning of mathematics. The use of such technologies can present mathematics in a more authentic and tangible manner. They support and enliven students in learning of the subject, which traditionally has been termed as 'mathphobia', Papert (1993). Students' learning can be enhanced through three stages, organising, reflecting and connecting knowledge, Burns (2004). It is also reported that weaker students often are better able to succeed with the help of technology, and thereby come to recognise that mathematics is not just for their more able classmates, Wimbish (1992).

1.2 Study Setting: University of Ha'il

This study was conducted to address the first year engineering students' high rate of failure in the Integral Calculus course. It was conducted at the University of Ha'il (UOH), Saudi Arabia. UOH started in the year 2005 and is currently the only regional public university with a student population over 35000. The medium of instruction of many of its disciplines such as engineering, sciences, computer science, medicine and it allied areas is English. However, the schools of education, arts, literature and community college are taught in the Arabic language. The overwhelmingly students' population is in the later schools. UOH started as a community college in 1998 under the auspices of King Fahd University of Petroleum & Minerals and in 2005 it was upgraded to a fully-fledged university directly supervised and monitored by the Ministry of Higher Education. In an effort to unify the education system, the former Ha'il Teachers' College run by the Ministry of Education was merged with the University of Ha'il. The aim of the university is to prepare students for careers required by both the public and private sectors. It is considered one of the fast emerging new universities in the country; therefore, many of its programmes are still at the undergraduate level with a few colleges offering the selected masters' programmes. There are separate colleges for male and female students.

The University of Ha'il currently has the following colleges:

1. College of Engineering consists of the departments of Electrical, Chemical, Civil, Mechanical, Industrial, and Architectural. Through its programmes, the college aims to provide to its students excellence in engineering education and research.

2. College of Sciences comprises of the departments of Mathematics, Physics, Chemistry and Biology.

3. Medicinal Sciences consists of College of Medicine, Applied Medical Sciences, Public Health and Health Informatics, Pharmacy, Nursing and Dentistry.

4. College of Computer Science and Software Engineering consists of the departments of Computer Science and Software Engineering.

5. College of Business Administration comprises of the departments of Accounting and Management Information System.

6. College of Education consists of several departments ranging from Islamic Culture, Special Education, Education, Kindergarten, Curricula and Teaching Methods, and Psychology etc.

7. College of Arts and Literature consists of the departments of Tourism and Archaeology, English Language, Arabic Language, Foreign Languages, Social Sciences, Information Sciences, Media Studies and Interior Design.

8. Preparatory Year Programme is a one year in-house designed programme consists of several sequential levels of the courses offered. It aims at bridging the gap between the secondary education and the university education through incorporating various important language skills and the skills required for a successful life at the university. It prepares students in basics sciences such as maths, physics, computer science, engineering, and personality development etc. All students of sciences, engineering and medicine are required to successfully pass this programme prior to embarking on their undergraduate studies.

In the first year, two levels of mathematics courses are taught to undergraduate engineering students at the university, Calculus I (Differential Calculus), and Calculus II (Integral Calculus). Along with the maths course, simultaneously the students are required to take courses such as English, Physics, and Introduction to Computer Programming. The first year maths courses are taught 4 contacts hours per week with 50 minutes class duration. Currently there is no tutorial session and no exposure to any computer algebra systems offered in the maths curriculum. The only assessment criterion is the standard paper-based examination system with the breakdown of marks; 20% marks for major 1 and major 2 examinations each, 50% final exam, 5% quizzes, 5% towards attendance, homework and other assignments, in-class participation, and the class preparedness. These courses generally have large multi-sections coordinated by a faculty member who would also be involved in the teaching of the course.

1.3 Statement of the Problem

The primary raison d'être of this study was to address the lack of mathematical achievement of engineering undergraduate students. The focus of study was the Integral Calculus course which is taught in the second semester of the first year engineering at this university. The course is chosen for this study due to a history of students' repeated failure, its importance in the rest of the maths courses as well as the core engineering subjects. The Integral Calculus course is considered a gateway to the other courses in mathematics.

The purpose of this research was to examine the effects of the use of Integrated Technologies Instructional Method (ITIM) as a supplement to the traditional lecture method on mathematics achievement of the Integral Calculus students at the College of Engineering, University of Ha'il. The study utilised instructional strategies for improving the teaching and learning effectiveness of the first year engineering course based on the use of computer technology and motivational instructional approaches. Students at this university possess a wide ranging ability and specific challenges with regard to their mathematical knowledge and skills needed for engineering disciplines. A comprehensive literature survey was undertaken to examine the appropriate instructional technologies for aiding students in their learning of mathematics. A model for the integration of technologies into a mathematics curriculum can be rooted in several established models of learning theories. Bagley and Hunter (1992) indicated that computer technology can be used as a primary instructional device, a supplement to another instructional strategy or as a tool for active learning.

1.4 Teaching and Learning of Calculus

The traditional lecture method still remains a predominant and the most widespread mode of mathematics teaching in universities around the world. Traditional calculus teaching focuses more on the rote memorisation of procedures with almost negligible regard to the relational aspect of the learning of concepts. It is considered a good delivery mode of introducing and familiarising students with certain mathematical concepts and procedures to large class sizes. Its importance to mathematics cannot be overemphasised due to its inherent undeniable merits. According to a report of the European Society for Engineering Education (2013), lecture can contribute to the acquisition of a number of mathematical competencies for engineering students such as mathematical thinking, mathematical reasoning and representing mathematical entities. However, as highlighted by Frid (1994) the traditional teaching and learning of calculus puts more emphasis on procedures, rote skills and symbolic manipulation without any focus on multiple representations of mathematical concepts. The author further states that this kind of education is instructor-centred in which students are passive learners. Instructors' total reliance on this type of instruction has been heavily debated because of the advancement in the computer technologies. The traditional calculus instruction has caused high rates of failure and has not prepared students well, White (1995). The traditional format of the course cannot fully address all issues relating to students lack of achievement in calculus because it gives an overemphasis on algebraic manipulations and procedures leaving many conceptual areas unexplored. Therefore, students in a traditional course rely more on memorising mathematical rules and formulae to pass the course rather than developing an understanding of both concepts and procedures. Engineering disciplines require a good competence in mathematics to be able to understand and explore concepts logically. The crux of the matter is that the teaching and learning communities have expressed much dissatisfaction with regard to the way the teaching and learning of university calculus is carried out. The instructors are facing many challenges of motivating, engaging and teaching the varying levels of engineering students. There are challenges of how maths should be taught in a fast-changing society and how the computer algebra systems could be introduced in the engineering maths education.

1.4.1 Teaching and learning of mathematics in the 21st Century

Engineering students studying maths courses as pre-requisite are usually seen to be adequately motivated and their main focus is on the applications of mathematics. For them, the traditional classroom instruction in the 21st century is changing where a greater emphasis is given to collaborative work and establishing team spirit among students. The literature is rich in the identification of issues related to the positive impact of the use of mathematical and computational software in classroom. Johnson *et al.* (2000) reported that learning in cooperative groups promotes high success for engineering students. The technology further enriches such learning. In an ever increasingly complexity of the world, students must be equipped with all the knowledge and skills which are necessary for their success.

With the rapid growth of industrialisation and infrastructure development in Saudi Arabia, the demand for the national workforce is increasing exponentially. To meet this challenge, there is a greater need for bringing appropriate changes in the teaching and learning of engineering mathematics. The development of mathematical skills of engineering students is closely linked with the scientific, economic, Mutoe (2003) and technological developments. With the rapid pace of technological innovations in the changing world, the importance of mathematics for engineering students has grown without any doubt. As a consequence of these rapidly evolving dynamics, what and how mathematics should be taught to undergraduate engineering students is a subject of quite considerable importance. Saudi Arabia has a plan to train and educate its citizens to take over the jobs currently occupied by the foreign workforce in the near future. It is believed that one of the reasons for outsourcing jobs is that people in the outsourced countries are better skilled.

1.5 Purpose of the Study

The purpose of this study was to examine the effects of the use of Integrated Technologies Instructional Method (ITIM) as a supplement to the traditional lecture method on mathematics achievement of the Integral Calculus students at the College of Engineering, University of Ha'il. The use of computer-supported collaborative environment as a teaching and learning tool for mathematics is gaining momentum. The use of the combination of these strategies particularly the bilingual support and the study support concepts have been relatively few. For effective implementation of computer supported collaborative instruction, a number of factors need to be taken into consideration. Some of the factors are students' attitudes, aptitudes toward computer and maths. This study focussed on potential strategies of maths achievement: the Integrated Technologies Instructional Method as a supplement as shown in Figure 1.1. The next section will deal with the research significance and theoretical framework used in this study.

1.6 Research Significance and Contribution to Knowledge

The Computer-Supported Collaborative Learning provides a rich environment to students and its popularity is growing very fast. Students use technology as a medium and a tool in solving mathematical problems as well as to reinforce concepts. This is particularly true for presenting a mathematical concept such as limit, integral as the limit of Riemann sums and in recognising patterns in integrals symbolically, geometrically and numerically. The software programme such as MATLAB has the potential to meet the educational and professional needs of a large and increasingly diverse student population. Mathematical developments lay at the heart of rapid advances in engineering, biomedical science, commerce, and information technology. According to Enelund *et al.* (2011), the development of computer technology has led to new possibilities for engineering work in which mathematically complex problems are solved through computer visualisation and simulation.

While there are many reported benefits of the introduction of computer technology in teaching mathematics, there are fewer studies where it has significantly enhanced students' mathematical achievement. Particularly this is true in a traditional calculus course, where the lecture method is still the norm and so are the assessment procedures. Moreover, as highlighted above students repeated failure in this particular course at this university is an indicator of their weakness in their pre-requisite mathematics and thus consequent lack of motivation and interest. Most of the studies carried out by researchers are mostly outside of Saudi Arabia and have utilised either a computer algebra system coupled with collaborative work but the literature review carried out by this research has not revealed any study which has combined these strategies which is ITIM.

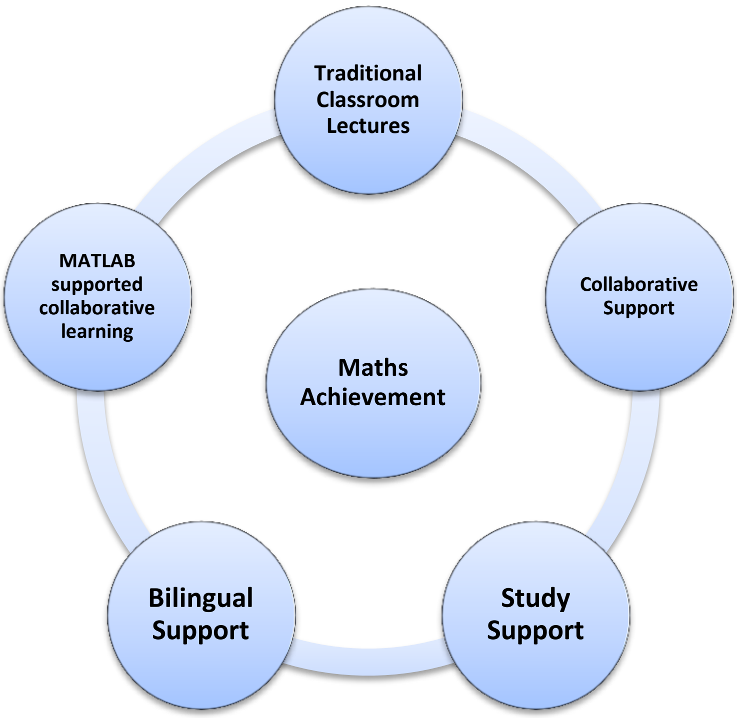

Figure 1.1: Integrated Technologies Instructional Method (ITIM) for mathematics

With the peculiar challenges with regard to the students, the findings have clearly demonstrated that the use of ITIM is a way forward in addressing the issue and might also be generalised for students of similar characteristics. Therefore, this study is an attempt to use mathematical software in conjunction with the relevant instructional strategies as supplement to the traditional instructor-led course. This was aimed at providing additional opportunities and supports for students to fill the mathematical achievement gap. This study contributes to an understanding of how the traditional teaching can be supplemented with the use of computer supported-collaborative learning, collaborative support, bilingual support and the study support. The literature review revealed no such study of its kind and particularly in the context of the University of Ha'il.

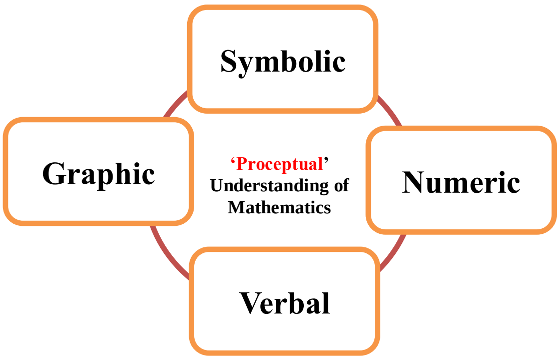

Figure 1.2: A theoretical framework for teaching and learning of mathematics with a CAS

1. In this research, the rule of three representations (symbolic, geometric and numeric) has been extended to the rule of four, as shown in Figure 1.2, in which students were asked to write the meanings of mathematical concepts after doing the MATLAB-based exercises.
2. The pattern recognition technique in evaluating indefinite integrals using computer algebra system has been mentioned in the literature, Heid (2001), Fey (1990) and Stewart (2003), however, the use has been restricted to a very few illustrations and the technique has been used for symbolic patterns only. In this work, the geometric patterns have also been used in addition to the symbolic ones as shown in Figures 4.22, 4.23, 4.24, 4.25, 4.26 and 4.27. The rule of three (symbolic, geometric and verbal) in terms of pattern recognition with the use of MATLAB is an innovative approach applied in this work.

3. The design, development, implementation and the evaluation of the Integrated Technologies Instructional Method for students with academic challenges as highlighted in the Introduction chapter, for enhancing the mathematical achievement of Arab bilingual undergraduate engineering students in the context of Saudi Arabia at this particular university is novel and fills the literature gap.
4. MATLAB-based activities conducted throughout the study in the computer lab have been described in detail and it has been noticed that such comprehensive description is missing in the literature.

The stakeholders who will benefit from the study are the classroom instructors, educators, researchers and the developers of computer algebra systems.

1.7 Theoretical Framework: Social Constructivism and Multiple Representations

Human learning is complex, Gredler (2005) and no single theory of learning is capable of explaining it, Philips and Soltis (2004). Generally, the theoretical framework will answer what the problem is and why the chosen approach is a feasible solution to the problem at hand. One of the characteristics which is appreciated in the mathematics education research is the heterogeneity or different theories, Arzarello *et al.* (2007) and the variety of frameworks is considered to be a rich resource that is absolutely necessary in order to handle the complexity of mathematics teaching and learning, Bikner-Ahsbahsand Prediger (2010). During 1990s, a number of reforms in mathematics education took place in the USA. The purpose of these reforms was to reflect on mathematics and pedagogy requisite for success in an increasingly complex and information-oriented society, NCTM (1989). The conclusions drawn were the changing world scenario in which new horizons of exploration and inquiry are the necessary ingredients of the modern education era. This has also brought about dramatic changes in learning theories and the thinking of mathematics and how it should be taught. The emphasis was given on how students construct knowledge actively in student-centered classrooms. Learning is believed to acquire through active involvement in the process. Current theories of learning mathematics suggest that students are not passive receivers of knowledge but actively construct knowledge consensual with social and cultural settings, von Glasersfeld (1991). Active learning was also highlighted by Ganter (2001). Students construct new knowledge based on their prior knowledge and this approach is called constructivism. Among several theories of learning, the theory which is considered quite popular to examine student learning in collaborative group settings is Social Constructivist Theory, Vygotsky (1978). The author further highlighted that student group work supports learning environment and human development. The phenomenon of learning can be studied effectively when students work collaboratively with peers as opposed to individual learning. Collaboration is a social situation and the student motivation can be maintained and enhanced as well as it helps in eliciting verbal communication in a natural setting, Roschelle *et al.* (1995). The authors defined collaboration as a coordinated, synchronous activity (face to face interactions) that is the result of a continued attempt to construct and maintain a shared conception of a problem. Social constructivism discusses the social dimension of mathematical learning because mathematics is a social endeavour. The dynamics of peer group socialisation can be studied from sociology. A number of social theories and cognitive theories are available in the literature and each theory helps a researcher in a particular dimension and sometimes multi-dimensional aspects. The influence of theories on mathematics achievement has been discussed extensively. Many practical research approaches have been utilised using practical frameworks, the framework for classifying the relationship between the success factors. Seminal work of Vygotsky in social constructivism is a milestone in understanding how students learn in a social setting and what could be done to optimise the learning outcome.

1.7.1 Computer Supported Collaborative Learning (CSCL)

With the advent of high speed computers, the collaboration developed into what popularly known as a computer supported collaborative learning. Computer technology is ubiquitous in all academic levels of mathematics education. Since maths learning is a human endeavour and the integration of computer technology in it led to the concept of computer-supported collaborative learning (CSCL). According to Stahl *et al.* (2006), CSCL is an emerging branch of the learning sciences concerned with studying how students can learn together with the help of computers. It is a pedagogical approach wherein learning takes place via social interaction using a computer. This kind of learning is characterised by the sharing and construction of knowledge among participants using technology as their primary means of communication or as a common resource. It is one of the fastest growing approaches in which learning occurs through human-computer interaction in a social collaborative setting. CSCL is still a relatively unexplored frontier in mathematics therefore it is important to identify its potential which may lead to student success and achievement. Students, in the mathematics classrooms, can use the technology as a medium and the tool in solving problems as well as to reinforce concepts which are sometimes impossible to do without it particularly for complex problems. The approach has transformed the process of learning within and outside the classroom. Humans learn through the interaction with the environment and the people around them. Learning is fundamentally a social activity. Thus collaboration is an essential ingredient of the complex processes of learning and the research in this area is immense. Collaboration, according to Roschelle and Teasley (1995), is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem. It is the learning which occurs socially in which the knowledge is constructed collaboratively. In this process, individuals solve problems meaningfully through negotiation and sharing. Individuals work and learn as a group with a common goal. The synchronous referred to here as a face-to-face interaction which is fundamental as it produces sound and authentic learning contrary to the traditional instructor-centred instruction. CSCL approaches, based on social constructivism, began during the mid-1990s to explore how computers could bring students together to learn collaboratively in small groups and in learning communities, Stahl *et al.* 2006. A number of quantitative techniques such as conversation analysis, Sacks (1992); ten Have (1999) or video analysis, Koschmann *et al.* (2006) based on ethno-methodology, Garfinkel (1976) are utilised for the measurement of learning in collaboration. It is believed that students actively work best when they know each other or have any common association or relationship. Active learning in small groups enhances student learning experience and the rate of retention of the material learned in the process is longer. Apart from these benefits of active learning, students see a sense of connection with the course content, get engaged and feel contented not only in the learning process but also in the real life experiences.

The collaborative learning strategy does support students learning of problems in small groups. For a traditional course which heavily relies on solving traditional problems, this kind of strategy plays an important role towards the success of students. Students will also learn to work with their peers which help them to be team learners. Team learning is one of the most important characteristics required to be successful for everyone in the work place and it is crucial for future engineers.

Steiner and Dana-Picard (2004) suggest that the concept of integration and its techniques in calculus should be taught in its classical way despite the availability of the computer algebra software programmes. This should be done by using selected examples which combine maximum possible techniques. The authors used some examples of computing indefinite integral and associated improper integral in their study and some of the misconceptions of students' regarding their nature are also explained. The study also touched upon the so called claim of some of the educators that 'an integral exists, if and only if, a CAS can compute it' and their proposing not to teach integration techniques or to teach minimal. They have also compared the answers of TI-92 CAS capability calculator with the exam true values. The authors concluded that the best way of teaching integration is teaching various techniques of integration through challenging problems which a CAS cannot do. CAS is a good tool for involving students in classroom learning or sometime self-learning but based on the classical way of teaching and learning.

The literature also revealed that the use of modern technologies such as Tablet PCs and Smart Phones improve motivation, communication (presentation of material), and promote curriculum access. Several authors have reported the positive effect of the use of Laptop computers on student learning, Shirley *et al.* (2002), University of Minnesota (2005) and Windschitl and Sahl (2002). The usefulness of the Tablet PC has also been reported by Weitz *et al.* (2006) in sketching complex mathematical formulae and as well as in class group work.

1.7.2 Multiple Representations

A cohesive and meaningful blending of various representations in the teaching and learning of mathematics is essential for students particularly for those who possess weak background in the subject. Each representation has its inherent merits and insights which facilitates in the construction of knowledge and their interconnection of mathematical concepts. According to the researchers Scanlon (1998), Tabachnek and Simon (1998) students oftentimes concentrate on the representation which presents the material in concrete terms and they do not use different representations. The authors further states that students choose them for understanding what representation is employed in solving a particular problem rather than using representations in multiple formats. Students therefore require support in the presentation of information coherently in order to maximise their learning. It is easy to emphasise and elaborate through the use of technology that algebraic, geometric and numeric representations are same in meaning but their forms of presentations differ.

Calculus concepts should be taught symbolically, numerically, and graphically, Ganter (2001), Tall (1993k) and Heid (1988). This can be achieved in a technology-enriched teaching and learning environment. The technology use provides a medium for explaining mathematical concepts through multiple representations which is virtually impossible to achieve without it. Duval (1993) advocated an absolute necessity of the use of different semiotic representations for a solid understanding of mathematical concepts. The theoretical framework shown in Figure 1.2 is based on the notion of 'procept' given by Gray and Tall (1994) and the semiotic representation of mathematical concepts by Duval (1993). This theoretical framework was used by Abdul Majid *et al.* (2012). In this study, MATLAB software has been used in collaboration to present the key concepts of the course such as integral, derivative and limits, in multiple representations. According to Seufert (2003) the deeper understanding of the material will occur with the help of multiple representations as each one provides opportunities to learners. The information in the long-term memory can be integrated by combining visual with verbal form and which would facilitate learners in enhancing their problem solving ability as well as the retention of knowledge, Mayer (2003).

Lowe (2003) while advocating the use of computer-based learning highlighted that the modern technology can present audio, video, animations with dynamically changing graphs and tables. Bigge and Shermis (1999) stated that various learning theories actually support the use of technology to enhance the learning and motivation of students.

1.8 Research hypotheses

The present study aimed to investigate the following hypotheses:

1. There is no significant difference between the achievement of the experimental and the control groups in the Integral Calculus course when the experimental group was taught by the traditional lecture method supplemented with the ITIM.
2. There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of MATLAB-supported collaborative learning as a supplement.
3. There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of collaborative learning as a supplement.
4. There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of bilingual support as a supplement.
5. There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of study support as a supplement.
6. There is no significant relationship between the achievement in Integral Calculus and the English aptitude of the experimental group.
7. There is no significant relationship between the achievement in Integral Calculus and the computer aptitude of the experimental group.

8. There is no significant relationship between the achievement in Integral Calculus and the mathematics aptitude of the experimental group.

9. There is no significant relationship between the achievement in Integral Calculus and the mathematics attitudes of the experimental group.

1.9 Assumptions

It was assumed that all participants of the study had clear understanding of the questionnaires as some of the questionnaires were translated into students' native language. The sample is randomly selected as the students registered in the intervention semester were assigned by chance not by choice to either the experimental group or the control group. The students, at the time of enrolment into the course, had the choice to decide through many sections of the course, however, they were not aware that they would be exposed to any intervention or change in the teaching and learning style. There were repeaters of the course and such students may have their choice of instructors not because of the variation in the style of instructions but possibly because of their familiarity with them or the convenience of the lecture time.

The traditional mode of instruction that is the chalk and talk method is the norm within the department. The Instructor-Researcher has some competence in the Arabic language therefore it is assumed that he could cope with students' inadequacy in the English language while collecting data through interviews and dialogues.

Students had completed some computer courses prior to registering for the Integral Calculus course. Hence it was expected that that they had necessary skills and competence for learning to use MATLAB for the course. Since the course is multi-section with a large number of sections and therefore all instructors must adhere to the departmental policies relating to the course.

1.10 Definitions of Terms and Abbreviations

UOH: University of Ha'il, Saudi Arabia, the institution where this research was carried out.

Integral Calculus – Calculus II-Math 102: This is a one semester (17 weeks) with four credit hour course offered to the undergraduate students who specialise in engineering, sciences, computer science and software engineering at the University of Ha'il. At the College of Engineering, currently this course is offered to students specialising in electrical, civil, mechanical, computer science, industrial, chemical and architectural engineering.

Achievement in Integral Calculus**:** This is the end-of-semester students' final grade in the course which is a sum of two major exams, a final exam, computer lab work, class work and the home work.

Traditional method: A teaching style in which blackboard/whiteboard, chalk or similar instruments are used and lectures are the primary teaching tools.

Integrated Technologies Instruction Method (ITIM) includes:
MSCL: MATLAB-Supported Collaborative Learning in which students' use of MATLAB in self-selected small groups in the computer lab

CS: Collaborative support in which students learning the maths problems in-class self-selected small groups.

BS: Bilingual support in which peers explain maths concepts to other students' in-class. The support also includes providing the English-Arabic mathematics glossary of key terms.

SS: Study Support in which the course related material such as semester planner, course formulae sheets, weekly home work sheets, and exams preparation tips are made available through the online webpage "World of Calculus" and offline.

CAS: The Computer Algebra System is referred to as an in-built capability of the MATLAB software.

1.11 Limitations of the Study

1. The study used the MATLAB software.
2. The sampled students computing skills could not be fully established. However they had undergone courses in computers and computer programming prior to this study and their GPA was calculated.
3. Some marks were allocated for the use of MATLAB and the learning of the course in collaboration.
4. The study was conducted at one university in Saudi Arabia. Hence it limits generalising its findings to other places.
5. The number of students in both the groups was not equal.

About one-fourth of the students in the experimental group belonged to electrical engineering. It is usually observed at the University of Ha'il that these students are found to be academically better in their level of mathematics, knowledge and skills. Some students belonged to the experimental group were repeating the course which raises questions to the internal validity such as attrition and carryover effects, Gliner *et al.* (2009).

The course is a multi-section course coordinated by a faculty member from the department and all policies relating to the course are maintained such as grading is done by instructors in a group for consistency. The instructors who were involved in teaching the course had at least 3 to 5 years of experience at this university. There are some issues or serious potential problems comparing groups. Instructors are different and thus different teaching styles and so is the case with students. The author Schoenfeld (2000) challenges the idea that the example of crop yield cannot be fully applicable in educational research. "Despite following the random selection of sample in the experimental design of the educational research, there would still be serious potential problems. If different teachers taught the two groups of students, any differences in outcome might be attributable to differences in teaching. But even with the same teacher, there can be myriad differences. There might a difference in energy or commitment: teaching the "same old stuff" is not the same as trying out new ideas. Or students in one group might know they are getting something new and experimental. This alone might result in significant differences. There is a large literature showing that if people feel that changes are made in their best interests, they will work harder and do better – no matter what the changes actually are. The effects of these changes fade with time. Or the students might resent being experimented upon."

1.12 Delimitations of the Study

1. The study focussed only on the ITIM strategies.
2. The study took place at a public university.

3. There are several related issues which cannot be controlled by the Researcher such as the instructors professional experience in teaching the course, the knowledge and training to use MATLAB software, the amount of time students studied on their own, class participation, students maths anxiety and their success in their past maths courses.
4. The study was delimited to students enrolled in Math 102 (Integral Calculus) at the UOH during the year 2012.

1.13 Outline of the thesis

Following the Introduction Chapter of the thesis, Chapter 2 reviewed the literature relating to the use of computer technologies which includes the Tablet PCs and Smart phones, Computer Algebra Systems (CAS) with a particular emphasis on MATLAB as a CAS in teaching and learning of mathematics to engineering students. The theories of teaching and learning related to mathematics are also included here.

Chapter 3 provides a detailed description of all the methods used in the study. It also includes the quantitative and qualitative methods of data collection.

Chapter 4 presents a detailed description of the use of Integrated Technologies Instructional Method which includes the use of MATLAB in collaboration, collaborative support, bilingual support and the study support.

Chapter 5 provides the results of the study both quantitatively and qualitatively. A detailed statistical analysis is provided signifying the results. An analysis of the data collected through individual and group interviews with students is given.

The results are presented in Chapter 6, discussion and conclusions are given in Chapter 7 followed by recommendations for future work is drawn.

References are provided at the end of Chapter 7. Related and necessary appendices are attached including some students sample work.

1.14 Publications

JOURNALS:

1 M. Abdul Majid, Z. Huneiti, W. Balachandran, Y. Balarabe (2013), "MATLAB as a teaching and learning tool for mathematics: A Literature Review", International Journal of Arts and Sciences-IJAS, Vol. 6, Iss.3, pp23–44, ISSN: 1944-6934, (Best research article award)

2 M. Abdul Majid, V. Sudhakar (2013), Use of an Interactive Algebra and Trigonometry Software Program: Students' Perceptions and Attitudes, International Journal of Systems Algorithms & Applications, Volume 3, ICRAET13, March 2013.

3 Wafaa Jawaada, M.S.M. Noorani, M. Mossa Al-Sawalha and M. Abdul Majid (2013), "Reduced-Order Antisychronization of chaotic systems via adaptive sliding mode control", Abstract and applied Analysis, Hindawi Publishing Corporation, Volume 2013, http://dx.doi.org/10.1155/2013/415652

4 M. Abdul Majid , Z. Huneiti, W. Balachandran, (2013), "Blended Approach in Teaching, Learning and Testing Mathematics", Journal of Engineering Education, January 2013, 103rd Quarterly Issue, Volume XXVI, No. 3, pp 37-45.

5 M. Abdul Majid , Z. Huneiti, W. Balachandran, (2013), "A study of the effects of using MATLAB as a pedagogical tool for engineering mathematics students", International Journal of Online Engineering, Austria, Volume 9,

Issue 2, pp 27-35.

6 M. Abdul Majid and V. Sudhakar (2013), "Use of an interactive algebra and trigonometry software program: students' perceptions and attitudes", International Journal of Systems Algorithms and Applications, March 2013, ISSN Online 2277-2677, Volume 3, Issue ICRAET 13, pp. 24-27.

7 M. Abdul Majid, Z. Huneiti, W. Balachandran, M. Al-Naafa (2012) “A study of the effects of using MATLAB as a pedagogical tool for engineering mathematic students”, IEEE xplore, E-ISBN 978-1-4673-2426-7, 978-1-4673-2425-0 (ICL selected paper).

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1 M. Abdul Majid, Z. Huneiti, W. Balachandran and Y. Balarabe (2013), "MATLAB as a teaching and learning tool for mathematics: A Literature Review", Mediterranean Conference on Academic Disciplines, March 3-7, 2013, Malta.

2 M. Abdul Majid and V. Sudhakar (2013), " Use of an interactive algebra and trigonometry software program: students' perceptions and attitudes", International Conference on Recent Advances in Engineering and Technology, February 27, 2013, Hyderabad, India.

3 M. Abdul Majid, Z. Huneiti, W. Balachandran, (2012) “MATLAB-aided teaching and learning of engineering mathematics”, 2nd International

Conference on Mathematical applications in Engineering (ICMAE'12), Kuala Lumpur, Malaysia· 3-5 July 2012. (ISBN : 978-983-43090-5-3).

4 M. Abdul Majid, Z. Huneiti, W. Balachandran(2012), A study of the effects of using MATLAB as a pedagogical tool for engineering mathematic students, 15th International Conference on Interactive Collaborative Learning, 41st IGIP International Conference on Engineering Pedagogy , September 26 – 28, 2012, Villach, Austria. E-ISBN : 978-1-4673-2426-7, Digital Object Identifier : 10.1109/ICL.2012.6402183

5 M. Abdul Majid (2012), "MATLAB for engineering mathematics students", PhD Students' Research Conference ResCon'12, Brunel University, July 2012, West London, UK.

Chapter 2

Literature Review

2.1 Introduction

This review is organised into a number of sections which includes the existing literature relating to student maths achievement in section one. The section on computer technology will review the use of computer including the tablet PC and smart phones as teaching and learning tools for mathematics with emphasis on computer algebra systems. A detailed discussion is provided on the use of MATLAB as a pedagogical tool for mathematics in small groups, collaborative-supported learning, bilingual support and the study support. Section three reviews the role of the variables such as maths aptitude, English aptitude and the computer aptitude in the overall performance of students' mathematics achievement. The chapter is concluded with the research findings relevant to the current study.

2.2 Student Mathematics Achievement

A combination of cognitive and affective factors contributes to students overall success in university courses particularly in courses like mathematics. The cognitive factors which are considered predictors of student mathematics achievement are the standardised maths aptitude tests, Benford and Gess-Newsome (2006). Success in maths courses can affect transfer and graduation rates, Ballard and Johnson (2004); Lagerlof and Seltzer (2009); Tai and Mintzes (2006). The most important contributor to students' success in any of the scientific disciplines (biology, chemistry, or physics) is their achievement in maths, Tai and Mintzes (2006). The students' success is correlated with their mastery of the basic maths skills. Many similar studies have been conducted to determine how best students can be helped and to overcome the underachievement in mathematical skills and knowledge.

A report by Mustoe (2003) stated that the appropriate education of engineers and scientists is an important element in the economic well-being of a country. Within that education, the mathematics component has a central role to play. With the sharp pace in economic growth and the increased technological development in Saudi Arabia, the lack of adequate achievement in basic sciences such as mathematics in higher education limits not only the career opportunities for graduates but also restricts taking up higher education programmes in mathematics-demanding disciplines such as engineering. According to KACGC Report (2013), Saudi students in 2012 have achieved 29th place over 101 countries and obtained 5 medals in the International Mathematics Olympiad. There has been a rapid growth in the number of Saudi students pursuing higher education in recent years. However, it has been noticed that in areas such as mathematics and engineering their number is still quite low and these areas are still unpopular compared to the disciplines of arts, literature and social sciences. Saudi Arabia is committed to providing higher education to its people through its international scholarship programmes. There are considerable differences in the performances of Saudi students in higher education and their counterparts in the Arab world and as well as with the Western countries. Students are continued to lag behind in academic achievement particularly in maths.

It has been always intriguing to know the factors that are more important to students’ success. Therefore, extensive research studies have been conducted to investigate the association between the success factors and the student maths achievement. The literature review revealed that there are several factors contributing to students' higher performance in mathematics and some of them are students' family backgrounds, availability of necessary learning resources, the amount of time spent on self-study of material, self-confidence, motivation to learn the subject, and their perceptions with regard to the usefulness of mathematics etc. The factors related to family backgrounds (level of parental education), Beaton *et al.* (1996); Cooper and Cohn (1997); Mullis *et al.* (2000); O'Connor *et al.* (1999) include the language used at home, availability of technological tools, study desk, books, and appropriate use of resources. Students' attitudes and perceptions of pursuing university education, their valuing maths, enjoying the subject, future career aspirations are also some important factors toward their achievement. Some studies on gender differences revealed that male students outperformed female students in mathematics at junior high and high school levels, Beaton *et al.* (1996); Fennema and Sherman (1977); Janson (1996); Mullis *et al.* (2000), as they differed in attitudes toward mathematics. However, a study by Zhang and Manon (2000) recognized that gender alone may not explain significant differences in performance. In addition, the role of intrinsic motivation is also very important in student learning as it often times has correlation with student performance in maths and other subject. Peer-instruction is another important area where student learn from their peers who assist them in studies. Students' mathematical achievement is also dependent upon their learning styles. Cronbach (1967), the notion of aptitude-treatment interactions (ATI) assumed that for an individual having a particular pattern of abilities certain techniques of instruction in a particular subject are more effective than others. Honey and Mumford (1982) described four types of learners, activist, theorist, pragmatist and reflector. Success is the result of interaction between various intellectual and non-intellectual variables, Kulik (1991). Research has shown that tutoring can have significant gains in students' mathematical achievement, Bennet *et al.* (1998), Ritter (2000). Tutoring, calculus workshop, projects, homework and writing in mathematics have been used as some of the intervention techniques.

The verbal ability in the language of instruction also impacts achievement in mathematics, Cottrell (1968). Language training is important to maths achievement as correlation was found between arithmetic achievement and reading achievement. Students given the translation of the words of mathematics can perform better than those who are not given. In addition, there are studies in which researchers have used maths homework as a factor for student achievement. High quality maths instruction is considered one of the important success factors in which reasoning and non-routine problems are used, computers are used for simulations and to demonstrate applications of mathematics. This requires qualified and committed instructors in the profession. The faculty committed to the learning of their students is the single most important factor for student success as they can make a big difference. The instructors who are out-of-field, exhibit less affirmation following correct responses from students, underprepared and less commitment to profession will negatively impact the quality of instruction in mathematics. In addition, variation in cut-off-point for final exam or declining standards of pass grades also badly affect students achievement in mathematics as well as the other subject.

Until the last few decades, traditional classroom instruction was the predominant method of teaching mathematics around the world. With the voice of concerns raised by educators due to the high failure rate of students in courses like university calculus and the lack of mathematical and analytical skills of graduates, various reform movements started in different parts of the world notably in the US and the UK. Educator almost unanimously felt the need to shift the prevalent traditional instruction to innovative approaches in teaching maths such as the use of computer technology and collaborative learning particularly for engineering maths students. This change in the shift partly resulted in the development of mathematical software such as Maple, Mathematica, MATLAB and many other computer algebra systems. The computer technology plays an important role in engineering maths education. The next section will provide the review of studies relating to student maths achievement and its use.

2.3 Computer Technology in teaching and learning of mathematics

This section gives an overview of the potential of technology in mathematics education and the related review of literature. One of the important factors in student success is the use of computer technology in the maths classroom. The technology includes the graphing calculators, tablet PCs, smart phones and the computer algebra systems. The review is followed with the impact of the use of MATLAB as a pedagogical tool, collaborative learning, bilingual support and the study support as supplementary instructional strategies to traditional lecture method on students' mathematical achievement. It is also discussed how these treatment variables impact the achievement of students in mathematics. The independent variables of the study are students' mathematics aptitude and attitudes, English aptitude, and computer aptitude apart from the instructional strategies utilised. A positive and statistical significance has been reported between the mathematics achievement and these variables. Standardised tests and measures are used to describe achievement of students in maths. This review of literature is directed to the lack of achievement in maths by engineering students worldwide with a particular reference to bilingual learners.

Technology in general and computer in particular have greatly influenced both teaching and learning of mathematics. Computers can present multimedia, graphs, text, and pictures much better than a traditional board. In many ways computers have been utilised to create a student-centred learning environment. Mathematical software can steer a student's learning at a pace that is suitable to their own level and speed with interactivity. Besides, assistive computer sessions can help weak students to improve their mathematical and problem-solving skills. This produces a truly authentic learning environment where students are actively engaged in the learning process. Tall (1988b) supported the idea of providing a rich computer environment which will allow students to carry out their mental ideas and which may give the opportunity to circumvent some of the trivialisation that may stunt future growth. It has been argued that complicated concepts cannot be made simpler for students but students can be given richer experiences that enable them to be seen in a wider and more powerful context.

Undoubtedly, technology has become ubiquitous in mathematics education. Does the use of computer tools or technologies per se enhance students learning? What factors influence classroom-based maths learning? The positive change in the teaching and learning lies in several factors. “Education technology is neither inherently effective nor inherently ineffective; instead, its degree of effectiveness depends upon the congruence among the goals of instruction, characteristics of the learners, design of the software, and educator training and decision-making, among other factors", Schneider (2000). However, for some, its use is still questionable.

Mathematical developments lay at the heart of rapid advances in engineering, biomedical science, commerce, and information technology. According to Enelund *et al.* (2011), the development of computer technology has led to new possibilities for engineering work in which mathematically complex problems solved in the computer visualisation and simulation plays a central role.

Blanco *et al.* (2009) conducted computer assisted quizzes developed using Moodle, an open source learning management system, for an undergraduate engineering calculus course. The study claimed to have contributed to the development of a new strategy that is an e-learning tool for assessment in mathematics. An analysis of the psychometric quality of the assessment was performed. This was done to check the appropriateness of the questions in relations to the given mathematical concepts, difficulty level and as well as checking whether questions discriminate between higher and lower mathematical abilities. The well-defined coefficients of the e-learning tool evaluated the effectiveness of quizzes in terms of the good and bad performing learners.

Li (2005) examined the effects of computer-assisted instruction (CAI) on adult at risk-learners in fundamental mathematics education. Splittgerber and Allen, (1996) defined at-risk learners are those who are seen with some type of learning barrier, such as learning disabilities, low literacy rates, language barriers, and/or life struggles. In particular, these students often fail academic courses factored by family socioeconomic conditions, family instability or tragedy, or having a sibling who drops out of school. At-risk students experience at least one of these factors, putting them at risk of not completing high school or attending college. Li (2005) in his study used technology as supplements in the form of tutorials and simulations activities to the teacher-directed instruction. The results showed gains in achievement tests, an increased student confidence and satisfaction with the mathematical learning of students who used CAI in comparison with those students who did not use CAI.

Kaput (1989) reported that computer environments impacted student attitudes and affective responses to instruction in algebra and geometry. In addition to changing the social context associated with traditional instruction, computer access provides a mechanism for students to discover their own errors, thereby removing the need for a teacher as an outside authority.

Bailey *et al.* (2001) examined the impact of nine web-based learning modules, designed to support fundamental concepts at university level finite mathematics courses. In this study, the learning was measured on both online module quizzes and in-class exams. Mathematical concepts were taught in class and they were reinforced by technology modules in an attempt to increase the learning process. The study reported positive contribution of technological based method to students' performance in the course. Also, the study suggested that web-based modules supported learning when it is used systematically by learners.

Ruthven *et al.* (2002) summarised the thematic components of the Information and Computer Technology (ICT) and resources based model for teaching and learning in mathematics. The teachers of a large number of schools and colleges were interviewed to examine how practicing teachers have incorporated technology in teaching of mathematics in the classrooms. The study provided an analysis around the central theme to suggest a pedagogical model. Ten operational themes emerged from the study were as follows:

1. **Ambience enhanced:** Technology was seen as a break from 'routine', as students like variety in their learning process.
2. **Restraint alleviated:** The drudgery of work was alleviated by access to technology such as drawing graphs.
3. **Tinkering assisted**: The immediate feedback provided by the technology supported self-correction by students themselves. The 'trial and improvement' strategies gave an experimental approach to learning tasks.
4. **Motivation improved:** ICT improved students' motivation towards learning as the lack of motivation towards learning is a great cause of concern for educators.

5. **Routine facilitated:** Routine classroom activities are facilitated making them to be carried out quickly and reliably.
6. **Activity effected:** The entire learning process was enhanced in terms of the pace and productivity of the classroom activities.
7. **Features accentuated:** Dynamic graphing capabilities of ICT provided visual presentation which helped students understanding, remembering and seeing.
8. **Attention raised:** ICT increased students focus on tasks by avoiding or overcoming obstacles.
9. **Ideas established:** ICT enhanced conceptualization.

The major trends analysis in co-incidence of operational themes was conducted in this study.

Technological tools have always been used in teaching mathematics to promote mathematical thinking (UK Engineering Council) and to solve complex problems and to link the subject to the real-world applications, NCTM (2000). The field of mathematics has greatly enhanced from the technological innovations throughout the history. Mathematical tools have gradually advanced and more rapidly over the past few decades from the four-function calculators to high-speed computers. The instructional uses of the computer technology applicable to mathematics at all levels are quite evident. Qing (2000) argued that with the use of computer, students can spend a significant amount of classroom time on computation; they can focus on higher level skills and useful applications of their newfound knowledge.

The positive impact of computer technology on student achievement has been widely reported in literature. The meta-analysis technique provides an overall picture of trends and patterns in the application of technology and its impact on student achievement. Glass (1982) through meta-analysis technique reported strong effect size of 0.35 for overall maths achievement when the computer was used as a supplement for instruction. This helped to highlight the idea that the effectiveness of computer technology may be closely linked to how the technology is used in the classroom and for what instructional purposes.

While discussing that many topics in mathematics which lend themselves to computer implementation, Dreyfus, and Halevi, (1990/91) stated that they have visual aspects which can well be represented on a computer screen; they have transformational aspects which necessitate a dynamic implementation; they have technical computational aspects which are not very relevant to the essence of the topic and are thus better taken care of by the computer; and they are intimately connected to the relationship between two different representations of the same concept; these two representations can be dealt with in parallel by the computer programme.

Anthony *et al.* (2000) consider technology as a motivating factor in enhancing the learning of mathematics and authors felt that the students should be prepared for necessary educational technological skills. Consequently, a new emphasis has been placed on undergraduate mathematics faculty to expand their knowledge base for the effective teaching and learning of mathematics. The need for engineering undergraduate mathematics students and their faculty to implement various advanced mathematics systems such as MATLAB and Maple etc., in today's classrooms has been increased significantly.

Undeniably technology has changed the nature of teaching and learning mathematics in general and more so for engineering disciplines. This dramatic transformation is due to the increased utilisation of technology and ever changing demands for highly skilled workforce in the 21st century. Therefore, the traditional methods of teaching and learning cannot fully equip engineering students with the ability to apply complex mathematical processes for finding feasible solutions to engineering problems of the modern world. Bigge and Shermis (1999) stated that various learning theories actually support the use of technology to enhance the learning and motivation of students. The technology not only opens the doors for innovative instructional practices but also motivates students towards learning. In a study, Devlin (1997) reported that in many cases the integration of technology into undergraduate teaching is seen as a way to revitalizing teaching and assist students in raising their level of mathematical skills and understanding.

Several investigations have shown that the utilisation of calculators/graphing calculators in the learning and teaching of calculus has produced positive results. It was reported that using "calculators" as an instructional technology for learning calculus has the following benefits on students' learning, Gimmestad, B. (1982):

1. Students sometimes change their solution approaches because of their access to calculators.
2. Students using calculators are more effective when exploring ideas or solution approaches within a problem context.
3. Students using calculators are much more likely to check their work by retracing steps.

Students' high motivation to learn and their feeling of success enhanced when they were given access to computer technology, Blanco *et al.* (2009) and Li (2005). "A teacher using technology to motivate students is more powerful and productive than one simply using lectures and textbooks." Splittgerber, F. L. and Allen, H. A. (1996).

In the following section, a review on the use of tablet PCs and smart phones in mathematics education is given:

2.3.1 Tablet PC and Smartphone

This section highlighted some of the key findings from a literature search and review of using Tablet PCs and Smart Phones for teaching and learning of mathematics. It also highlighted some of the benefits and capabilities of these smart devices arising from such as its portability, pen input, small size, shape and wireless networking etc. A modern Tablet PC is a wireless, portable and lightweight computer with a touch-screen interface that allows working with the gadget without a usual keyboard or a mouse using fingers or a stylus instead. It is typically smaller than a notebook computer but larger than a smart phone. It has built-in support for handwriting recognition. Another feature of the Tablet PCs is that it comes with Journal which works like a 'freehand notebook' as well as speech recognition. Students can use Tablet PCs to access classroom materials such as class lecture videos, websites links or worksheets. It allows mobility to students to move around in classrooms due to its wireless networking capability.

Weitz *et al.* (2006) regarding the use of Tablet PCs in teaching and learning in general have reported a number of uses among which was the ease of writing mathematical formulae and terminologies. They further reported the effectiveness in teaching online mathematics courses where communication among students and teachers play a vital role. The study also demonstrated the application of these devices for grading students' work online.

Miller (2004) in his study reported that Laptop computers have the capacity to put "ubiquitous computing" into the hands of users as well as supporting "mobility" allowing users to work anywhere at any time. Several authors have reported the positive effect of the use of Laptop computers on student learning, Shirley *et al.* (2002), University of Minnesota (2005) and Windschitl and Sahl (2002). The usefulness of the Tablet PC has also been reported by Cicchino and Mirliss (2004), Thomas *et al.* (2004) and Weitz *et al.* (2006) in sketching complex mathematical formulae and as well as in class group work.

Oliver (2005) reported that the new technology enhanced interactive learning in the classroom. Many constraints attached with traditional PC-PowerPoint types presentations in mathematics have been overcome with the Tablet PC.

A Smartphone is a mobile phone built on a mobile computing platform with more advanced computing ability and connectivity than a feature phone. The Smartphone-mediated learning provides one of the best practices and new approaches in mathematics education to address the needs of all stakeholders in the 21st century students, faculty members and universities.

It has been reported in the literature that the use of modern technologies such as Tablet PCs and Smart Phones improve motivation, communication (presentation of material), and promote curriculum access. However, there are some keys issues concerning their adoption in the classroom. The innovative practice can be supported when the appropriate infrastructure and technical support exist. In addition, a reliable and fast wireless access is vital in extending and enhancing learners’ experiences. Furthermore, the initial cost of the Tablet PC and auxiliary hardware remain key factors limiting uptake. Some of the hardware issues are the robustness of these devices, their short battery life of these devices, their low screen illumination and the chances of losing or misplacing digitiser pens. Furthermore the issues such as adherence to the limited class size, monitoring students’ activities, technology training as well as some of the ethical issues hinder into the adoption of these smart devices into teaching and learning.

Different terminologies have been used in the literature for modern technologies such as: Digital education, smart phones, Tablet PCs, educational tools, interactive white boards, projectors, virtualisation, podcasting, virtual labs, technologies that help define 21st-century classroom, probeware where students work as scientist, computer technologies, handheld technologies, world of rich media, rich software, and unique learning modalities etc.

The next section discusses on the use of computer algebra systems in mathematics education.

2.4 Computer Algebra Systems

Computer Algebra Systems were introduced in the early 1980s as a teaching and learning tool and muMath, now renamed as DERIVE, is considered to be the first CAS software. It was followed by the development of MATLAB in 1980s. The software development race in the area of artificial intelligence then continued with the introduction of Maple by Waterloo Maple and Mathematica by Wolfram during the same year followed by the creation of MathCAD in 1990s. Their uses were basically ranging from manipulation of symbolic equations to graphing equations and programming tedious algebraic tasks. Some of the popular CAS programmes such as MATLAB, MathCAD, Maple, Mathematica, Macsyma, MuPAD, Axion, Reduce and DERIVE have varying difficulty levels but their main purpose remained the same that is symbolic manipulation. Some of the CAS programs have their symbolic functionality integrated with others like Maple can be called in within the programmes such as MathCAD and MATLAB.

It is extensively reported in the literature that the demand for a thorough and deeper understanding of calculus is increasing in an ever increasingly technical and scientific world, but the teaching of it is unfortunately suffering. To address this issue, the literature is full of studies where the computer technology was introduced to the teaching and learning of mathematics and its one of the greatest innovations has been the Computer Algebra System. The proponents of Computer Algebra Systems such as Maple, Mathematica, and MATLAB etc., believe that these systems will allow instructors to focus more on the concepts of calculus rather than on computational techniques and can foster in students a more exploratory and experimental attitude toward mathematics. In addition to CAS, several other interventions were introduced.

The modern computer algebra systems are cognitive tools, Heid (2001). According to Pea (1987), a cognitive technology is “any medium that helps transcend the limitations of the mind in thinking, learning, and problem-solving activities”. Cognitive tools are both mental and computational devices that support, guide, and extend the thinking processes of their users, Derry (1990). They are used as a didactical tool to enhance students' mathematical learning and to provide them with essential career-related skills. Both advantages and disadvantages of using computer technology are reported in the literature. Those who oppose the didactical use of computer tools voice the declining mental and manual mathematical skills of students. However, those who support its use believe that these tools would not only enhance the presentation of mathematics but also could provide the necessary skills needed in the 21st century.

Lavicza (2010) investigated the use of CAS as well as the factors that influence their integration into university mathematics curricula. The author reported the findings on how lecturers’ conceptions interact with personal characteristics and external factors. It was observed that lecturers' system of conceptions plays the most influential factor with regard to CAS integration into the curriculum this is followed by their immediate environment such as the department and university, and then nationally-accepted/adopted teaching traditions. In addition to these three factors, the author analysed that personal characteristics factors such as lecturers' research area and age may also have an effect on the CAS integration. It was the following purposes of CAS use which were highlighted on the basis of the data collected from mathematicians from the UK, the US and Hungary:

1) encourage group work in classes;
2) visualise and project images;
3) assist experimentation, exploration, and discovery in classes;
4) offer realistic, complex, or real world problems for students;
5) to enable them to devote more time for conceptual problems;
6) motivate students in classes;
7) prepare and offer homework assignments; and,
8) for checking solutions of student assignments and worksheets.

The analysis of the data revealed that a greater frequency of the responses on CAS use was given to two most important areas; visualisation and experimentation. The author acknowledged the fact that certain frequencies are not the most precise indicators of the importance of particular themes, but these can imply what mathematicians find important with regard to CAS integration in mathematics teaching. The mathematicians' use of CAS in their research is the strongest predictor of their use of CAS in teaching.

The need for integrating computer algebra system technology into the teaching and learning of Integral Calculus is highlighted by Awang *et al.* (2011). The paper raised the issue due to the decline of the performance of students in mathematics exams and their insufficient basic mathematical skills and knowledge. The authors noticed a gap highlighting a mismatch between students learning styles with the teaching methods. The study concluded with the proposal of transforming teaching and learning of mathematics using CAS.

Stacey and Pierce (2002) explored the capabilities of CAS calculators (TI-92's) through teaching year 11 students introductory calculus for eight weeks aiming to primarily develop students' conceptual foundation for differentiation. The lessons were planned by a team of researchers and the teachers with the intention of developing students' understanding prior to their learning procedures. In addition to the above investigation, several feasibility studies, Heid (1988), Palmiter (1991) and Repo (1994) were conducted. With the use of CAS, students' mathematical potential was explored with less computational skill. Students became active learners in the whole process, and the CAS proved to be a powerful mathematical partner.

Heid (2001) used muMath, a symbolic manipulation software, for an introductory calculus course in 1984. At that time, the capability of generating graphs, tables or curves in muMath were not available. For illustrating the graphing, curve fitting and production of numerical tables of functions, the author used other computer programmes. The study was aimed at using the computer as a tool for drawing the attention of students to the more advanced level of understanding and the formulation and interpretation aspects of mathematics by diverting trivialising computations to the computer. Heid (2001) referring to the relationship of the impact of theories of mathematics pedagogy and the role of CAS in mathematics teaching and learning further pointed out that it is important to know what makes learning mathematics with access to a CAS different from the other environments.

The author outlined two important differences, that the access to a CAS does more than offer an alternative strategy for problem solving. The study referred to Pea (1987) who described the potential of the CAS being a “cognitive technology,” a media that helps “transcend the limitations of the mind … in thinking, learning, and problem-solving activities”.

Among the many popular CAS is Mathematica which has been extensively used in mathematics instructions. Crocker (1991) used Mathematica for teaching the concept of derivative. The author observed that the students who were considered as low or middle in terms of their abilities exhibited more probability of experimenting varied approaches to problems. In contrary, the students who perform well with the traditional methods found to be reluctant to trying new or different approaches to learning. The main conclusion of the study was that students who do not perform well in the traditional methods will benefit more when they are exposed to a different approach.

Alswaie *et al.* (2000) reported the effectiveness of “Calculus and Mathematica” (C&M). The study reported increased students’ mathematical understanding when the concept-based approach was used with the special features of their new method. Students gave high rating to features and capabilities such as graphing, computation, high speed and interactivity. It was observed that there was a shift from teacher-centred instruction to student-centred instruction as well as the procedural approach of the course to the conceptual understanding of the content. Each lesson in the C&M had three parts such as, Basics, Tutorials, and Give It a Try. Students start with the 'Basic' module first, then if they feel that they have understood the concepts well then they move to the 'Tutorial' where a gradual increase in the level of content is incorporated. The students then sequentially move to the last part of the course. The study concluded a positive change due to two reasons, firstly the strength of the Mathematica programme and secondly the organisation of the learning environment. The authors also reported the finding that exposure to C&M increased students' appreciation of integrating the technology in the teaching and learning process.

Meagher (2005) investigated the effectiveness of Mathematica on students learning of calculus. The main focus of the study was to examine students learning processes of calculus in a Computer Algebra System (CAS) environment. In this qualitative study, the author attempted to explore the mechanisms of day to day learning in a technology based instruction. The study aimed at understanding the appropriate balance between the integration of technology, by keeping in view the merits and demerits of CAS, into teaching without missing the advantages of the traditional methods. Two frameworks were used; one macro-framework which is Rotman Model of Mathematical Reasoning, and the other; micro-framework which is Pirie-Kieren Model of Mathematical Understanding. These frameworks were utilised in order to understand the place of technology in the learning of mathematics. The Pirie-Kieren Model was used as a lens through which to interpret and analyse specific learning episodes as they take place in the classroom. It was stated that the two frameworks combined together provided a vehicle for understanding learners' mathematical activity, mathematical reasoning and mathematical development in a CAS environment over a period of the study. The data for this study were collected through audio and video tapes supplemented by interviews as well as the students' performance in homework and tests. The study concluded that there is a need to fully understand the introduction of the technology on the conceptual development of student learning, pedagogical strategies, curriculum and assessment.

Bringslid and Norstein (2008) designed and evaluated Xmath and DMath online computer algebra modules called “Steplets” for undergraduate engineering students for teaching mathematics. The online mathematical content was used by both on-campus students and the distance learning students at different colleges. “Steplets” that used as computer algebra system were developed using webMathematica technology. The core of the technological concept was the step-by-step solution to mathematical problems. They were used to teach topics in calculus apart from other subjects such as algebra. The study also highlighted the mathematical procedures for certain problems. The data collected through questionnaires revealed that the step-by-step solution of the technology was preferred by all participated students. The technology such as “Steplets” was considered having a positive impact on the mathematical understanding of students. Regardless of how CAS is used, Tokpah (2008) pointed out that the CAS contributed to a significant increase in students’ mathematics achievement.

There is a wide spread literature on the use of technology in teaching calculus and its positive influence on attitudes and learning, particularly for its ease of computation and graphing. The Maple software is probably by far the most extensively used software in mathematics education. In a study, Noinang *et al.* (2010) developed a mathematics teaching-learning tool for multivariable integral calculus to enhance students’ self-motivation, self-planned learning and self-assessment. Interactive Maplets i.e., Microsoft PowerPoint with Maple-based animation integrated with Maple worksheets were used to reinforce students conceptual understanding of the course. The authors used computer visualisation and presentation techniques for aiding students’ understanding of mathematical concepts and methods. Their focus was on the key concepts of the course such as integration techniques for triple integrals. The students were provided with a step-by-step Maple based instruction for concepts such as displaying the graphs of the functions, defining and evaluating integrals and finally presenting the output symbolically. Some examples are given in the paper with the screens of the designed-Maplets along with the workbooks series. Two groups of students were formed, namely, the computer-aided group called IPM and the Traditional-Teaching Learning group (TTL). The mean, standard deviation and one-way ANOVA for pre-test scores and post-test scores on both groups were performed. An open-ended student survey was conducted on students' opinions on the IPM model. The study reported a positive result in which students who were taught by IPM method performed better than the TTL group in terms of the conceptual understanding of the course as well as superior knowledge of evaluating triple integrals with challenging domains of integration. The model's 3D feature supported the understanding as well as improved self-learning in students as the technology helped them draw difficult functions which are virtually not possible to achieve with the paper and pen.

References cited in the study by Murphy (1999) on Computer Algebra Systems in Calculus Reform provided several good examples of work on CAS. The author reported the ten featured projects to support calculus in which computers were considered essential in almost all of them. Out of ten projects, five projects were based on various CASs by researchers. Computer Algebra Systems such as MathCAD and Derive were used by Duke University, Smith and Moore (1990); University of Michigan-Dearborn used MicroCalc, Hoft and James (1990), Maple was used by Purdue University Schwingendorf and Dubinsky (1990); St. Olaf College used SMP, Ostebee and Zorn (1990); and University of Illinois at Urbana-Champaign used Mathematica, Brown *et al.* (1990b).

The researchers reported the following common features of the programmes:

1. The ability to explore more complicated mathematical problems because the students no longer have to do all of the manipulations by hand;
2. The use of the graphing capabilities of CAS to give students a geometric view of calculus concepts;
3. Students writing about their work;
4. Students exploring and creating meaning for themselves;
5. Some form of cooperative learning or group work

Small *et al.* (1986) presented their research work at the Tulane Conference on using CAS as a tool for teaching and learning of calculus to:

- improve conceptual understanding,
- Overcome limitations imposed by poor algebraic skills.

In light of the studies reviewed above, a summary of the features of the CAS are outlined below:

1. Students will be able to focus on more challenging problems as the technology will handle the tedious computation and algebraic manipulations.
2. The technological capability for graphing will provide students an opportunity to visualise graphs in a multidimensional environments as a result looking at calculus geometrically.
3. Students' higher level of understanding and the improvement in their technological skills are essentially required for future engineers.
4. An opportunity for rigorous experimentation with the technology.
5. Learning as group/cooperative/collaborative learning.
6. Calculus for the modern era, i.e., calculus for the 21st century future engineers.

An approach to the teaching and learning of mathematics gets richer when teachers provide their students with classrooms which have appropriate technological power, Heid and Edwards (2001b). CAS began a new era for symbolic representation and how its understanding can help students with the opportunity and motivation is further featured below by the proponents of calculus reforms as highlighted earlier:

1. To see that different symbolic expressions provide different transformation.
2. To outsource routine work to the CAS so that students can focus on more conceptual ideas, on the "bigger picture," or on more general ideas;
3. To reason with confidence about symbolic results (possibly reducing students' anxiety over "making mistakes")
4. To develop their own symbolic procedures;
5. To bridge the gap between concrete examples and abstract generalisation.
6. To interpret information gained through one representation in an equivalent one (to see the symbolic in the graphic, to see the graphic in the symbolic, to visualise a contextual situation symbolically)
7. To develop generalised rules for problems solving and to examine symbolic patterns (more concretely).

The instructors who used technology as an integral part of the teaching and learning of calculus in their courses perceived an increase in more active learning and increase in student motivation as reported by Rochowicz (1996). It also enhanced the overall learning experiences. The author further stated that "the perceived impact of using technology on specific topics of calculus appears to shift the focus of learning from symbol manipulation and skills to more interpretation, approximation, graphing and modelling". The study also highlighted that in a technology integrated environment on the significance of spending more time from the teacher and more creativity on his part is required.

Among several efforts to improve mathematics education, mathematics educators have used new and emerging technologies in the teaching and learning addressing the needs of the modern engineering disciplines. Many mathematicians and mathematics educators strongly advocate the use of CAS in mathematics education. Literature review reveals that CAS has been widely used for the teaching and learning of Calculus. The application of CAS is considered as one of the few important approaches for enhancing the teaching and learning of Calculus. The advocators of the use of technology are optimist that it can address all problems of teaching and learning. Many CAS programmes are fully interactive maths learning software which have certain in-built capabilities such as performing calculus & algebraic operations, plotting multi-dimensional graph and programming. These software tools also provide solutions to many complex and complicated numerical, symbolic and graphic mathematical problems.

As highlighted earlier that the Computer Algebra System, popularly known as CAS, is a modern computing technology which provides great learning and teaching opportunities to both students as well as instructors. MATLAB is one of the most popular CAS programmes which is widely used in mathematics classrooms especially at the university level. As more and more universities are adopting its use in education, the next section will study and analyse how the software has been used in teaching and learning of mathematics. Particularly focussing on how MATLAB has been used in problem solving, computation, and visualisation of mathematics through mathematical explorations etc. It has been used to be a technology that could be used for developing mathematical thinking, concepts and skills, and a source of motivating students for learning mathematics.

It is also a very useful tool in demonstrating connections in various underlying mathematical concepts in the teaching and learning processes.

A number of research studies published worldwide have categorically revealed positive learning in CAS integrated classroom instructions. They reported a significant increase in students' conceptual knowledge when CAS-based concept-oriented instructions were delivered in classrooms without deemphasising the importance of computation skills.

2.4.1 MATLAB for mathematics

MATLAB, the product of Mathworks Company, is the general purpose computing software. It contains a vast range of specialised toolboxes and also works as the computer algebra system through its symbolic maths toolbox. This toolbox performs symbolic algebraic/mathematical manipulative operations with a lot of built-in interactivity. MATLAB undoubtedly is popular among computer and multi-disciplinary scientists, engineers and particularly with experts in the area of computational mathematics. It integrates numerical, symbolic and the state-of-the-art graphic visualisation capabilities with quite intuitive computer programming environment.

The software has been used for teaching calculus, linear algebra, differential equations and many other mathematics courses. Liang *et al.* (2009) in their study used MATLAB, firstly, to facilitate students' learning of business-calculus course and, secondly, for finding solutions to real quantitative business problems through the applications of the principles of calculus. The study was conducted at the University of New Haven. The particular approach was used to address the inadequate skills of students in algebraic manipulations due to which the instructors were finding it difficult to teach the course within the time fixed for the course. The traditional method of teaching the course presented challenges to instructors and they found that the solution lies in the use of the modern technology in the form of the MATLAB for students learning. The topics such as introduction to limit, derivative, second derivative, optimisation, integration and its application in business, introduction to multivariate calculus, partial derivatives were presented step-by-step with the aid of MATLAB in the course. The study concluded that the software use has helped students to focus on key objectives of the course through the visualisation of the examples and quick numerical computation. Such application of technology will prepare students for more challenging career prospects.

The technology can also be used to demonstrate procedures of a concept in a sophisticated manner. Dunn *et al.* (2002) used MATLAB for teaching introductory algebra and calculus at the University of Southern Queensland, Australia. They argued that MATLAB can be incorporated into material learning in three ways, such as a numerical and graphical tool, as an aid to learning of ideas and concepts, as to show the procedure or concept in a more sophisticated way. In this work, the authors discussed five functions of MATLAB using the third approach.

Ocak (2006) in his study on the relationship between gender and students' attitudes and experience of using MATLAB found a positive correlation between students' attitudes and a prior experience on using the mathematical software programme. The study also explored if there were relationships between gender differences, attitude and the software program experience. Three calculus I classes comprising of 23 female and 37 male students from three different colleges were chosen for this study. All classes used MATLAB and classes chosen were of differing ability. Students' attitudes were assessed with an attitudes survey instrument and the prior experience with MATLAB was measured with a closed-ended response format questions. Students' familiarity with features of the software programme and their ease of use affect their enthusiasm and curiosity. Students' attitudes should be assessed prior to considering the use of MATLAB.

Brake (2007) used MATLAB as a tool in an attempt to increase the maths self-confidence and the maths ability of first year engineering technology students at the School of Engineering Technology, Eastern Michigan University. The software was aimed at improving students' learning. The author believed that self-confident students could be transformed from novice learners to expert learners and MATLAB would increase that self-confidence in them in analysing problems in mathematics. In this study, the researcher taught two sections of ET 100, Introduction to Engineering Technology, a first year engineering pre-requisite course for electronics engineering technology, mechanical engineering technology, and computer engineering technology. MATLAB was introduced into the curriculum, not just as a tool, but to be able to solve engineering problems. The number of students enrolled in this course was 38. A survey was carried out to obtain demographic information as well as data on students past mathematical training. It was included how confident students felt in solving two rather difficult problems relating to finding roots of numbers and applying the maths to the real world. A second survey was conducted at the end of the semester and a record of quiz, midterm and final grades on specific questions using MATLAB was kept. Since one of the goals was to turn the inexperienced students into expert learners, it was found that graphing helped many students learn to think more deeply about problems, however, further interpretation skills could not be enhanced due to insufficient time. Nevertheless, this study touched upon a very important issue of incorporating computational package into the learning of engineering technology course. There are some issues unaddressed relating to the low class size of students, improper brushing up of students skills in learning MATLAB, inadequate background of students in mathematics, and hence statistical insignificance in terms of its applicability to a wider audience and areas. There is a need for more research on the use of MATLAB as a tool to increase self confidence and maths ability in first year engineering students which the author also felt strongly about. The skills acquired through the use of MATLAB in the teaching and learning will prepare future engineers to meet the demands of the 21^{st} century.

Dunn *et al.* (2002) used MATLAB for teaching and learning of introductory calculus at the University of Southern Queensland, Australia. Five MATLAB based graphical interface programs were used to demonstrate the mathematical concepts such as Newton's Method, differentiation and integration. The programmes may present some unusual and important cases of the calculus concepts. The authors argued that MATLAB could be incorporated into learning of mathematics in three ways, namely, firstly as a numerical and graphical tool, secondly as an aid to learning of ideas and concepts and thirdly to show the procedure or concept in a more sophisticated way. In this work, the authors have used MATLAB using the third approach. The main focus of the use of these programmes was to demonstrate mathematical concepts rather than doing a particular task. The study also suggested that the computer technology should be used a supplement to the traditional teaching and learning.

Chaamwe (2010) provided a few illustrations for sketching mathematical graphs of functions using MATLAB. The study highlighted some general benefits of integrating the software. Student's motivation to learning can be enhanced and they can work collaboratively in teams. It could provide a problem-centred approach in teaching and learning. Their skills could be honed. The software can also be used for demonstrating a connection between the theory and the practice and as well as students actively participate in the learning process. The study also highlighted some relevant studies on the role of Information and Computer Technology.

Computer tools could also be used to overcome maths-phobia as termed by Papert (1993). Friedrich *et al.* (2008) described the cognitive role of computer technologies such as MATLAB in the development of students' mathematical reasoning, logic and problem solving skills. The graphing capabilities of various CAS programmes such as Maxima, Scilab, Micro Worlds, Dynamic and Interactive Geometry as well as MATLAB have been given. The study concluded that the issue of declining interest in maths and in its allied disciplines such as engineering is due to the lack of well-educated technical experts in cognitive technologies.

In a study by Dios *et al.* (2012), MATLAB and Learning Management System "Moodle" were introduced in the traditional teaching and learning of graduate engineering mathematics course. The aim was to give students a better understanding of the course contents. The paper discussed the mechanism of the new structure of the course including the web-based assessment. The Learning Management System "Moodle" was created as a virtual learning environment to work as a pedagogical model. The online quizzes were used using WIRIS, an editor to write symbols and formulae.

In a collaborative project between Swedish and British instructors (two mathematicians and one didactic expert), MATLAB was used to teach undergraduate engineering mathematics students, Burton *et al.* (2004). The aims of the project were to support students' visual and graphical understanding of mathematics and their access to the numerical computation of the course.

Individual interviews were conducted to get students feedback. Their overall feelings were mixed on their experience of using the software. To achieve effective software integration, the study has also provided suggestions such as ensuring clarity in learning goals, adequate number of MATLAB classes, and the preparation of a manual to support MATLAB programming by providing necessary reference material on the web. Students expressed their dissatisfaction with their experiences of using MATLAB as there was too much elapsed time between two MATLAB sessions consequently students had to learn the material over and over again. The study concluded that the integration of the software should be planned thoroughly with enough software documentation available.

In a study, Colgan (2000) described the integration of MATLAB to the teaching of traditional engineering mathematics course at the University of South Australia. The course included elementary linear algebra, the differential and the integral calculus. The need for the software integration was due to the decline in the mathematical skills of students entering into the engineering disciplines. MATLAB was chosen because of two reasons, firstly it was extensively used in some of the engineering programmes at the university and secondly it was believed to increase students' employability after graduation. A MATLAB guide specifically covering the course contents was prepared to incorporate the software into the teaching. This was considered a major component of integrating software into the syllabus. The software use was demonstrated in the classroom lectures. The graphing capability of the MATLAB was shown to students illustrating graphs of functions including features such as zoom on and multiple commands for plotting functions etc. It was used to improve students understanding of the mathematical concepts such as limits, continuity, differentiability, multiple representations of the Mean Value Theorem, Riemann Sums, and finding the volumes of solids of revolution etc. The methodologies of teaching the course were redesigned keeping in view of the qualities of the engineering programmes mentioned by the professional engineering body of Australia. The syllabus was rewritten outlining clearly the delivery and the assessment criteria. Weekly five contact hours were allocated for the course in which three hours of regular lecture, one hour of tutorial and one hour was dedicated for working with the software. Apart from the software guide, the syllabus also included the engineering applied examples relevant to the course. The emphasis throughout the process of technology integration was to enhance students' understanding of mathematics. The paper also provided some of the illustration of the engineering examples such as the classical problem of Snell's Law and the minimisation of the time in the refraction of light. To inculcate collaborative spirit among students, they worked in groups of four on MATLAB sessions and the engineering projects/assignments. A part of the group's work was performing the analysis of the engineering project and presenting that in the form of a report. The projects involved the knowledge of the engineering as well as the use of the mathematical formulae. The study concluded that the course was considered to be the most successful; however, no data have been provided. The author highlighted the need for striking a good balance between the amounts of time to be spent on MATLAB to the course requirement.

Schlatter (1999) described the visualisation benefits of using MATLAB in a multivariable calculus for various concepts such as three-dimensional surfaces, contours plots, gradient fields and parametric curves etc. The software, to some extent, was also used for symbolic integration and for setting up integrals. The author developed two- and three- dimensional interactive packages in MATLAB and they were used; firstly to help students in visualisation of mathematical objects and surfaces and; secondly to familiarise them with the use of MATLAB. The study concluded that the students could cover a more variety of integrals when the software would be used as a pedagogical tool. Apart from linear algebra and multivariable calculus courses, the software was also used for teaching concepts such as series convergence and numerical computation and visualisation of power series approximations. Moore (1988) used MATLAB to teach "Series and Differential Equations" at the Grinnell College. The goal was to provide graphic visualisation through the experimentation of various functions, and numeric computations for Taylor polynomials approximations, partial sums of power series, definite integrals and differential equations. Students' used MATLAB-based programmes. The study concluded that the software tools not only widen students' problem-solving ability, insight, flexibility but also their ability to use them. However, the study has not provided any students' feedback. In addition to the above studies, the software was also reported to be effective tool in the visualisation of mathematical concepts, Puhak (2011), Liang (2009), Henderson (2002), Smits (1992).

Another extremely powerful feature of MATLAB is its interactive numerical computation environment which is based on the matrix structure. Computational methods and skills of students in topics such as matrix computation, numerical differentiation and integration, and differential equations etc. can be enhanced with the use of the software. Particularly, engineering students need this skill to solve many engineering problems, Canfield (2012). Addabbo (2010) presented the approach that was used for teaching Introduction to MATLAB course for engineering students of Vaughn College who had completed calculus as one of the requirements. The course was divided into two parts; part 1 was related with programming techniques based on calculus problems, and the part 2 was the study of the numerical solutions of differential equations studied through linear and non-linear physical models. This approach was developed to demonstrate the relationship between the pre-requisite courses such as physics, statics, dynamics, writing and the vibration with that of calculus as well as to encourage higher order learning. Several projects such as matrix operations, summing series, Newton's Root Finding Method, weather data, and the numerical integration were given to students. Students were expected to do projects in groups of maximum three students. Upon completion, they were required to give a presentation and their performance was assessed on a set criterion. However, the study has not reported the effects of the approach and no conclusions were drawn.

The software had also been used to study some mathematical functions such as Weirstrass function and to study numerical approximation of π, Feng (2011). In this study, the author has also used the software for testing the convergence of an infinite series using the ratio test, root test and the integral test. Liang 2009, Burton (2004), Smits (1992), & Moore (1988) have also reported the benefits of using MATLAB as a computational tool. The positive impact of computer technology on students' learning and performance has also been examined and reported by Strayhorn (2006) as well as Kulik C. and Kulik J. (1991).

The integration of MATLAB has also been reportedly positive on students' performance in mathematics with "Moodle" an e-learning management system. The MATLAB package was integrated with Moodle as a supplement to the classroom lecture for teaching calculus to undergraduate students in Geodesy at the Vienna University of Technology, Judex *et al.* (2008). The blended teaching and learning approach was used to address the issue of students' lack of interest in mathematics and their weak background in the subject. To integrate MATLAB into the course, the software was used as an instructional tool and its basic course was included into the exercises of the mathematics courses. Specifically, the software was used for the large geometric mathematical drawings used in the Geo Science. Over 90 examples were developed and were made available via "Moodle" for students. The blended approach proved to be successful for the presentation of the heavy calculus course contents in a short time without sacrificing the true comprehension of the course. It enhanced the quality of lectures, improved students average grades as well as their programming skills.

The computer technology fosters positive attitudes towards mathematics, Lim *et al.* (2009), Yashau (2006), Ocak (2006), Gorev *et al.* (2004), Cretchley *et al.* (2000), increases students confidence in maths, Brake (2007), Kinney (2001) as well as it enhances their motivation towards learning maths , Puhak (2011) & Carol (2012).

Computers have also been used for motivating students toward mathematics and their use reportedly had positive impact. Puhak (2011) used MATLAB as a teaching tool to enhance students' motivation and understanding of applied mathematics. The method used for the implementation of the software included choosing one traditional calculus concept, using its application in related areas, performing related calculations for enhanced understanding, and dealing with associated questions to further students comprehension. This method was illustrated with the example 'Centre of Mass' with details of the role of MATLAB in the activity with the needed programming code and its visualisation. The study has not used the formal measurement techniques, but recommended, to assess the effects of the use of the approach on students' learning. However, routine course evaluations and volunteered feedback were received.

Cretchley *et al.* (2000) investigated the effects of the use of MATLAB on the attitudes and learning of undergraduate mathematics students at the University of Southern Queensland. The study also highlighted the relationships between attitudinal effects and performance. The student body had comprised of a diverse group, on-campus and distance learners, registered in the first semester Algebra and Calculus course. MATLAB was used in lectures, tutorial and assignments. In order to develop mathematical concepts and necessary skills, tasks were designed and a MATLAB manual was written. The use of the software was demonstrated in lectures and on-campus students attended weekly two-hour small group tutorials conducted by tutors and the distance learners used scheduled tutorial on telephones, emails and newsgroups. To encourage and motivate students, small prize money was announced. The data collection instruments used were a pre-study diagnostic test, two post-study examinations, questionnaires related to MATLAB-based assignments, interviews and group interviews, and a pre- and post-study survey questionnaire. The study reported that students' appreciation of the use of the software gradually increased over time and their ease of use developed as they overcome frustration and difficulty. The assessment of students' knowledge was based on an open book examination without the use of the computers to maintain equity. Students were not examined on their knowledge of the software. Pre- and post-study tests and assignments were conducted to evaluate students' mathematics learning experience, their opinions, skills and interviews were also conducted through group interviews and case studies. Students' opinions were sought on categories such as their learning of mathematics, their experience of using computer software in the learning of mathematics, and self-efficacy in math. MATLAB based tasks particularly explorations were reportedly successful and students reported their positive experiences such as visualizing and computing areas under curves, and the concept of definite integral by taking Riemann sums. The study also reported a wide acceptance, by both on-campus and external students, of the use of technology as an aid for learning and, in particular, of MATLAB as an appropriate software package. The authors reported a strong positive reaction to the experience of using MATLAB to support students learning of mathematics where inculcating motivation towards the study of mathematics many a times is a hardest job. Another motivating factor towards the use of the MATLAB was students' need and importance of its familiarity would help in their relevant engineering subjects. The software's graphical capacity, power and novelty were much appreciated by students. Other features students liked were MATLAB's speed in performing computation with ease, clarity in understanding through explorations, and use the software as a technology check for confirmation of their answers. MATLAB was favoured over graphing calculators due to the computer power with large screen and 3-D graphing capacity. Several others studies have also reported the benefits of using the software as a tool for increasing motivation, Pennell (2009), Ohrstrom (2005), Smits (1992).

Studies reviewed above describe varying statistical significance of the use of computer technology in fostering positive attitudes. The findings highlighted that the use of appropriate computer software developed positive mathematics achievement and a correlation between the aptitude and achievement together with the successful course completion.

Chapin *et al.* (2004) supplemented MATLAB with the standard calculus course for giving simple homework assignments to students at Ohio University. The authors outlined three categories, integrated use, project format and textbook add-on, of the uses of technology in the literature. They, however, implemented the use of the software for simple assignments for making its application easy and practical for both students and instructors. The study highlighted the incorporation of the technology through firstly, use of simple and basic calculations; secondly, giving very clear instructions on assignments; and thirdly, giving very clear and concise technical information. In conclusion, the authors proposed the use of software in undergraduate mathematics courses for simple homework and included a sample MATLAB assignment. The study has not discussed its effects on students learning.

Horwitz (2002) described collaborative engineering and science projects between mathematics and engineering departments for the purpose of enhancing the first year differential and integral calculus courses. Students used MATLAB in projects individually and in teams and some real data were used. The first semester projects were Hydraulic Engineering, designing a pipeline with minimum cost, optimization of irrigation channel and the second semester projects were Exponential Decay, Skydiver free fall, Wrecking ball, and the Automobile velocity data. A students survey was carried out and they were asked to rate the projects on the scale of 1 to 5. Students reported some complains on the difficulty level of the projects. Some variation was observed in the comments of students belonging to engineering disciplines compared with the students of science majors. In addition, some students did take part in the projects but did not fully understand the mathematics involved. The study concluded firstly that the students' motivation for doing projects did not seem to have increased at the end of the study, secondly, they were simply involved in the project without themselves understanding the process, and thirdly, in depth project understanding could not be achieved due to the pressure of covering the regular syllabus of the courses. The authors suggested offering one extra credit hour course which could enhance the calculus program. The positive feedback was received from students as they enjoyed doing the projects with MATLAB and they saw a connection of mathematics with the real world. A thorough understanding of mathematical concepts with their applications in engineering and science proved useful to students.

Szurley (2011) incorporated MATLAB within mathematics courses at the Francis Marion University. MATLAB was used for Calculus III projects involving numerical solutions and also for understanding the software's programming concepts. The projects involved L'Hopital Rule, improper integrals, sequences, power series, Taylor and Maclaurin series and as well as Linear Programming and

Linear Algebra. The study concluded that students' responses were not very positive about the use of MATLAB partly due to non-graphical interfaces provided to them but in the long run this exposure was believed to help them. The future plan was set up to develop interactive graphical interfaces. In another study, the author discussed the application of MATLAB for providing simulation to the projects involving solution of Differential Equations.

The study conducted by Liang *et al.* (2009) at the University of New Haven is an illustration and a summary of the use of MATLAB for teaching mathematics. The software use was aimed at helping students' learning of calculus-based business mathematics and to apply the calculus principles to find solutions to real quantitative business problems. The software was implemented to address students' varying levels of algebraic knowledge and skills and the challenge of completing the course in one semester. MATLAB was used to teach topics such as limits, derivatives, optimisation, integration and their applications in business as well as the introduction to multivariate calculus and partial derivatives. MATLAB-aided solutions to the mathematical problems were presented step-by-step. The researchers concluded that the software use had helped students in focusing on key objectives of the course through the visualisation of the examples and quick numerical computation. The study concluded with the statement that the application of computer technology would prepare students for modern day challenging careers in the workplace.

Talbert (2011) used MATLAB to teach problem-solving techniques to first-year Liberal Arts students who were enrolled in Calculus III at the Franklin College. Students spent most of the class time doing hands-on lab exercises, watching video lectures and completing online tutorial work. The inverted classroom model was used in this study. This model provided students the ability to learn on their own and to apply new concepts. Students took some time adjusting to the innovative learning model, however, their feedback was reportedly positive.

Legua *et al.* (2001) in their study provided a comparison of the use of DERIVE, Mathematica and MATLAB to solve the line integral, an engineering mathematical problem. The aim of the study was to harmonise the use of the software with the teaching of mathematics at the Escuela Universitaria de Ingeniera Tcnica Industrial. A comparison of how the line integral concept could be explained using DERIVE, Mathematica and MATLAB was given with screenshots. The study concluded the DERIVE software as the most efficient of the other programmes for evaluating line integrals. The study has not reported the effects of the use of this approach in the classroom teaching.

Linear Algebra course was among the most popular courses in which MATLAB was used as reinforcement to classrooms lecture, Szurley (2007), Palmer (2008) used MATLAB as a visualisation tool; Gunawardena and Jain (2002) used it for drill and practice in which a combination of text and visuals were presented in multiple format; Stewart *et al.* (2005) forms, visualisation, conceptualisation, and problem-solving; Hailan *et al.* (2012) for exploration and experimentation; Nyondo (1992) used MATLAB as a problem-solving tool; Naimark (2002) for connecting mathematics curriculum with the applications oriented engineering; Henderson (2002) and Han (2008) used as a supplement and Smits *et al.*(1992) described the impact of the use of MATLAB on mathematics achievement.

The software has also been used for a number of maths courses such as pre-calculus, Yushau (2006); applied mathematical modelling project using partial differential equation by Lim *et al.* (2009); Ohrstrom *et al.* (2005) for introduction of the 3d geometry of molecules and mathematics, differential equations and kinetics, systems of nonlinear equations and equilibrium analysis, Pennell *et al.* (2009) for Differential Equations course; Carol (2012) in the first year maths and Gorev *et al.* (2004) for solving maths problems. Brake (2007) used MATLAB with the aim to increase the maths self-confidence and the maths ability of freshmen engineering technology and Brown *et al.* (2012) used it as a complementary tool to the traditional lecture for exploring mathematical concepts for the 1st year electrical engineering students.

One of the benefits of computer technology is the accessibility of the mathematical concepts through visualisation. MATLAB is one of the best known software which contains mathematical data visualization capabilities, Palais (1999). The software has been used as a visualization tool in the courses like linear algebra, calculus and differential equations etc. With the help of computer technology, mathematical concepts can be represented numerically, symbolically, and graphically as well as it works as an effective communication tool as students work more in groups and in a collaborative environment. The graphics visualisation is an area where the interactive computer technology has had its great impact since it enhances students' comprehension. With computer technology such as CAS and software programs like Mathematica, Maple, MATLAB and others, graphs of many complex mathematical functions can easily be drawn giving a geometric approach to calculus which provides an intuitive approach to the course.

In a study by Stoynov (2008) the traditional method of teaching and learning was combined with DERIVE, a computer algebra system, for teaching mathematics to engineering students. The study aimed at firstly, familiarising students with DERIVE, secondly, using the CAS as an assimilation tool for mathematical concepts and thirdly filling the gaps created by the secondary education and pre-requisite course Mathematics 1 so that students can smoothly progress to

Mathematics 2 course. A detailed teaching activities plan and samples of some of the examples from the chosen topics were given. Those basic notions in mathematics 2 whose learning begins from high school and continues in mathematics-1 are taken as examples of activities in the study for example the concept of partial derivative begins with differentiation. Students were given a list of problems and the sequence of commands to be used in DERIVE. Some plotting related problems were also given to students in which students were asked to solve them by hand first and then to use the CAS to plot and shade domains of functions. The study concluded that mathematics 2 contents can be effectively taught when CAS DERIVE is integrated into teaching and learning. It also concluded the technology integration can also be a motivating factor for students towards the course.

As highlighted in the number of studied mentioned above that computer supported teaching and learning have reported some increase in mathematical achievement as well as foster positive effects on attitudes of students. However, the use of computer-supported instruction at the university level is still considered modest. A number of these calculus-based studies highlighted above are, however, been conducted outside of Saudi Arabia with relatively less work in this part of the world. In conjunction with the computer technology, the other instructional techniques such as collaborative learning, bilingual support and the study support are also necessary for students who have a history of difficulties in a course with a high rate of failure. In summary, the adoption and implementation of the appropriate instructional technologies is imperative to determine their synergy effects on the success of these students in the course. In sections to follow, this will be discussed in some detail.

2.5 Collaborative support for mathematics

Computer-supported collaborative learning (CSCL) is an emerging branch of the learning sciences concerned with studying how people can learn together with the help of computers, Stahl *et al* (2006). Students' learning can be enhanced when the opportunities are provided to them in which they can interact with each other in a variety of ways. Johnson *et al.* (2002) have identified five elements for effective cooperative groups and they are positive interdependence, individual accountability, promotes interaction, social skills, and group processing. Amita (2006) describes cooperative learning as collaborative learning in which students learn together in a small group of varying abilities and as a result achieves a common goal. The students combining peer tutoring with cooperative learning reduces maths anxiety and increases confidence in learning the subject. Peer-tutoring is an instructional technique in which some chosen students peers play the role of instructor in the classroom. Cohen (1994) introduced cooperative learning as the common work that has been in the form of small groups, through which students work with each other to ensure that each student participates sufficiently in the action or collective duty has been clearly identified. And Humphrey *et al.* (1992) introduced cooperative learning as the participation of students in the work to achieve the goals. Saydawi (1992) introduced cooperative learning as "the establishment of a micro-heterogeneous group of students, work in an effective cooperation to achieve goals, in the framework of the acquisition of any academic or social return to them as a group and as individuals, the benefits will be greater than their total individual ones". As defined by Al-Hashimi (1996), cooperative learning was "the type of classroom learning in which students learn together in small heterogeneous groups including students from various levels of performance (high, medium and low), but homogeneous in terms of the level of capabilities in the classroom as much as possible. And these groups work to achieve collective and unified goals".

A positive impact of peer interaction and achievement in small groups was consistently reported by Webb (1991). The study also showed the effectiveness of the group work when instruction and guidance was given on how to work in groups and collaborate with each other. An elaborated explanation was found to be more effective than merely giving answer to a question. A number of research studies reported positive impact on students learning when students are put into groups. In a study conducted by Davidson (1985), students' performance in mathematics achievement reported a significant increase than with traditional class instruction. Keller *et al.* (1997) reported a positive impact on the mathematical reasoning of students when they were exposed to CAS technology integrated in a group discussion technique. Anderson (2005) and Townsend *et al.* (1998) reported that the cooperative and collaborative work among students also inculcates positive attitude. In another study by Yusof and Tall (1992), small group problem solving was incorporated followed by a one hour lecture and discussion into their instruction. This innovation in teaching ultimately resulted in increased positive attitudes toward mathematics. High correlation between the collaborative learning and students' academic success was reported by Boaler *et al. (*2004). The students in this study have also developed positive dispositions towards mathematics and towards their peers. Collaboration has also improved significantly students' communication with each other. Johnson *et al.* (1995) formed a group consisting of 2 to 5 students for the completion of tasks. They reported that the group work carried out by students has been more fruitful than the individual work. Collaborative learning is one of the most important strategies of teaching maths as it seeks to promote cooperation, collaboration and social interaction among students. It supports teamwork, enhances creative thinking and raises the academic achievement level. However, this works best in most of the situations and cases where students know the other students very well. Almost all students at the University of Ha'il are the nationals of the country and their native language, culture, traditions and even the dialects are almost the same. Simple peer tutoring model was used in the class in which the instructor would teach a concept or a solution to a given problem followed by one of the students from the class to talk about the solution in Arabic which is students' native language then students would complete an assignment in groups. The need for making students learn in a collaborative environment is not only needed for a successful education but also an important personality trait the graduates need in today’s job market.

2.6 Bilingual support for mathematics

There is no definite definition to the word bilingual in the literature. "The bilingual is NOT the sum of two complete or incomplete monolinguals; rather, he or she has a unique and specific linguistic configuration", Grosjean (1989). It is believed that forcing bilingual speakers to function only in L2 (second language) leads to mental disadvantages such as slower processing speed and impaired decoding, rehearsal, and comprehension. On the other hand, recent experimental data suggest that using both languages can enhance learning, regardless of whether it is forced in a blind, nondeliberate format or done consciously, Figueroa (1991). This is because bilinguals may have stronger symbolic representation and abstract reasoning skills, Berguno and Bowler (2004), Macleay (2003) and this ability is developed through the experience of having two different words for most concepts which helps bilingual children's understanding the arbitrary relationship between words and their referents, Cummins (1976). They may also have enhanced problem-solving skills because of their ability to selectively attend to relevant information and disregard misleading information, Duncan (2005). Bilingual students acquire higher levels of academic achievement, De Avila and Duncan (1985). De Avila

(1985) defined a bilingual student to be the one who demonstrates proficiency in both the languages at a comparable level to that of an average monolingual student.

Researchers such as Yushau (2009), Setati and Adler, (2001) have reported benefits of providing a translation of key words into the students' first language. Furthermore, Secada and Cruz (1996) have recommended involving students who have comparatively stronger bilingual ability for translating the important key concepts into students' native language. The meta-analysis study conducted by Adesope *et al.* (2010) suggested that bilingualism, as well as the learning in the second language, is associated with a number of statistically significant cognitive benefits. More specifically, the study highlighted that the bilinguals outperformed monolinguals on many fronts including the abstract, symbolic representations and problem-solving as these abilities are essential for mastering mathematics. However, there are some conflicting studies in which the cognitive challenges of bilingual learners are reported. Cretchley *et al.* (2000) study reported that students whose mother tongue is not English preferred exploratory strategies. It is assumed that the appropriate use of technology such as MATLAB in small student group will benefit the students at the University of Ha'il as certain mathematical concepts become more accessible despite the challenges of learning maths in a second language.

2.7 Study support for mathematics

The apparent lack of willingness to work at studying is due to an absence of explicit knowledge of what is necessary to succeed in the academic arena, Boelkins *et al.* (1997). The causes of students' failure in studies, as highlighted earlier, was due to the absence of having a comprehensive strategy for learning and retaining the material, nor did they recognise the importance of working consistently and regularly. The authors suggested new approach had a “problem worksheet” for students for six days in a week. A daily schedule consisted of problems of varying difficulty such as routine homework problems from the most recent lecture, harder problems from the last few classes, and some review problems. The study also provided some directions to students' concerning creating note cards, breaking the material into bites and distributing new concepts over enough time periods. Students used 3 x 5 index cards for definitions, theorems, and key lecture points. The authors described their experience "an eye-opening semester" as students work improved as they enjoyed seeing their success in the course. A dramatic change in students' study habits was observed as they worked harder consequently their quality of work improved. Students’ performance in exams was reported to have increased by a 25 point rise in the class average and this was achieved by maintaining the academic standards.

The three conceptualisations of study support in higher education according to Hallet (2010) are the skills focussed support, learner focussed support and practices that focus upon the academic literacy of a pedagogic community. The study utilised Bernstein’s framework in the analysis of the power relations, discourses and pedagogic identities created by each type. Skills focussed model of study support, relatively more wide spread than the other two, Gamache (2002), is taken as the focus of this study and this model is designed to ameliorate skill deficit, Brasley (2008) described by Bernstein (2000) as the power relations between ‘categories’ which can be agencies, agents, discourses or practices. Skills focussed models of study support is by and large used for skill deficient students or students unequal to be in par academically with their peers. However, Hallet (2010) argued that the skills taught out of context does not work because students may not be able to see the complexity and purpose of what they are doing. The author further expressed a need of theorising the concept of study support in higher education and the fear of undemocratic and unjust pedagogic communication due to the marginalisation of those students who are given this support. Hawkes and Savage (2000) outlined the following as the learning support:

- detailed back-up and lecture notes
- providing help on techniques of maths
- advice and references to background material (pre-requisite)
- help classes in the various maths skill

2.8 Attitudes towards Mathematics

Over the past many decades, much emphasis has been given to study students' attitudes towards mathematics. Students' attitudes towards mathematics play an important role in students' success in academia. Several professional and education bodies have emphasised on the need of studying affective variables with cognitive variables which in several ways contribute to the overall success of student academic achievement. Mathematics education must have a blend of teaching of mathematical concepts and procedures with developing positive dispositions towards mathematics.

Attitude is a psychological construct, Mueller (1986), and a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object, Fishbein and Ajzen (1975). McLeod (1992) defined affect which involves beliefs, attitudes and emotions toward maths. Attitudes and beliefs gradually and slowly develop compared to naturalistically dynamically evolving emotions. Beliefs discuss the why part of maths and students success in the subject. Students learn either by punishment that is negative motivation due to reprisal to failure or reward that is positive motivation. Attitudes are defined as positive or negative emotional dispositions, McLeod (1992) and Aiken (2000).

They are the psychological tendency expressed by an individual in the evaluation of an entity through cognitive, affective and behavioural responses with some degree of favour or disfavour, Eagly and Chaiken (1993).

Students' attitudes towards mathematics are complex and a number of measurement tools and constructs are reported in the literature. According to McLeod (1988), students' ability to problem solving in maths is linked with their attitudes. In a subject like mathematics, having a right and balanced attitude is crucial for a student's success in the subject and its allied areas. Maths develops ability to strengthen logical thinking skills, Houghton and Dawson-Threat (1999) which is a must in the modern world today. Students self-perceived maths phobia is an issue much debated worldwide. Their struggles in coping with the demands of the subject are quite evident and extensively discussed in the literature. Students' perceptions about the applicability of maths to subject like engineering have also raised a number of issues. They possess negative and poor attitudes towards the subject. When students pass the course they develop positive attitudes and self-efficacy and the vice versa. Therefore the instructors' task is daunting in the sense of improving students standards in maths to an adequate level so that they can fulfil the demands of the course. Human learning is complex, Gredler (2005), and no single theory of learning is capable of explaining human learning, Philips and Soltis (2004).

"Human-computer interaction is a complex phenomenon and the attitudes and feelings involved with this relationship are difficult to identify, Willis (1995). The author further reported positive attitudes towards computer technology. This positive change in attitudes also reported to have motivated students in mastering the necessary computer skills quickly. Confidence in learning mathematics, mathematics anxiety, and perceived usefulness of mathematics as the most frequently studied and identified affective variables associated with student achievement in mathematics, Reyes (1984). One of the strategies indicated by Bretscher (1989) is the use of a mathematics lab with computer and tutors providing individual instruction and hands-on practice in concepts and skills. This strategy may help addressing the motivation and maths anxiety in students. A number of reasons have been highlighted in the literature with regard to the reasons for developing positive attitudes towards maths:

- person's self-efficacy toward maths, participation in maths-related activities, interest in pursuing careers in maths, O'Brien and Martinez-Pons (1999); Betz and Hackett (1983).
- teachers' and parents' attitudes toward maths, Beswick (2006), Schoenfeld (1985).
- applicability of maths to students lives and future careers, Malmivouri (2006), Elliott *et al.* (2001).

There are generally two methods of measuring students attitudes and they are:

- Indirect Method (Infer from responses and behaviour towards objects, e.g., performance of behaviour that appears relevant to an attitude, Petty and Cacioppo (1996).
- Direct Method (Use psychometric scales, e.g., Thurstone, Likert, and Semantic Differential Scales. Petty and Cacioppo (1996).

An understanding of the nature of students' attitudes toward mathematics and its relationship with their achievement in mathematics is an important area explored extensively in the literature. Exploring the relationship between the students weak achievement in mathematics to their attitudes toward mathematics plays a crucial role for mathematics and engineering educators. In this process of understanding, it is important to know how engineering mathematics students perceive mathematics and their attitudes toward computer technology and the other instructional strategies outlined in the following sections of this chapter. The student response to an evaluation is expressed through three domains cognitive, affective and behavioural, Eagly and Chaiken (1993). According to Petty and Cacioppo (1996), attitudes are measured through the direct method and indirect methods. The direct methods use psychometric scales such as Likert, Thurston and Semantic Differential Scales. The indirect methods are used in which the inferences are made from responses and behaviours toward objects. A self-designed questionnaire to measure students' attitudes toward mathematics and the instructional strategies has been used in this study.

According to William *et al.* (2005) and Koller (2001), achievement and affect influence each other. The success and failure cycle in maths is largely dependent upon student attitudes, Ernest (2003), the Figure 2.1 depicts a relationship and a connection between students' developing positive attitude with the success in maths and its vice versa.

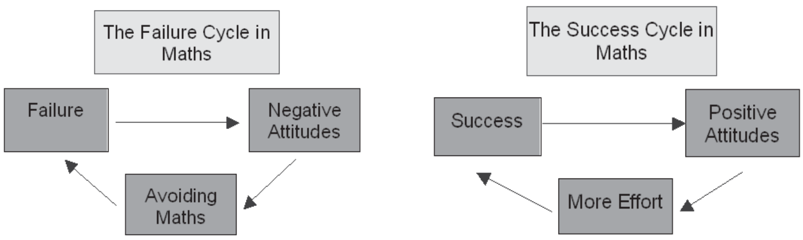


Figure 2.1: Failure and success cycles in mathematics, Ernest (2003).

The factors which can contribute to fostering positive attitudes reported in the literature are instructional styles, Harkness *et al.* (2007), Schweinle *et al.* (2006), Chesebro (2003), Stage (2000), Wanzer *et al.* (1998) and instructional techniques, Anderson (2005); Kinney (2001); Raymond and Leinenbach (2000).

- Increased use of application, modelling and interdisciplinary projects, multiple representations of key ideas, cooperative learning activities, writing about maths, Bookman and Friedman (1998), Yerushalmy and Schwartz (1998), Koehn and Ganter (1999)
- Integration of technology in calculus, Cipra (1988) and (1996)
- Applying calculus to their careers and life, Hurley *et al.* (1999), Cipra (1988), (1993), (1996)

Anderson (2005) and Townsend *et al.* (1998) reported that the cooperative and collaborative work among students also inculcates positive attitude. Reyes (1984) presented four affective variables which play an important role in mathematics education and they are confidence in learning mathematics, mathematics anxiety, attributions of success and failure in mathematics, and perceived usefulness of mathematics. These variables are related to the learning of mathematics in a number of ways. Fostering positive attitudes in students are important, however, the attitudes without a thorough mathematical understanding will be insufficient for succeeding in a technological world. A balanced combination of the subject knowledge with positive attitudes is essential and one without the other is insufficient.

Students' positive attitudes of learning in cooperative groups will give confidence to them not only in learning maths but also inculcate qualities of a team member or leader, a much sought after attribute for the job market, Popham (2005).

Royster *et al.* (1999) studied beliefs and attitudes of students studying a number of mathematics courses. The calculus sequence course was one of the main focuses of this study. The variables considered for the study were students' gender, mathematical background and their academic major. The Mathematics Disposition

Survey was administered to students at the start and at the end of the study to determine changes in beliefs and attitudes of individual students over the semester. The study indicated that students who started with a more positive disposition remained positive in their disposition towards the end and similarly those who started with a more negative disposition remained negative in their disposition. However, the study in general reported the development of positive attitudes over the semester particularly for pre-service elementary school teachers. The study concluded that confidence, perseverance and interest are all indicators of students' mathematical dispositions.

A large sample size meta-analysis survey studies carried out by Ma and Kishor (1997) on attitudes toward mathematics and their relationship with achievement reported stronger correlation on gender-based analysis.

Hannula (2002) developed a new framework for the analysis of attitudes with an illustration of a case study of one student. Cognition and emotion are considered two central concepts for the re-conceptualisation of attitude as one is neuron-based information processing and the other is the psychological reaction. These two concepts are taken as the two-sides of a coin. Interviews, observation and field notes were used for data collection to see changes in attitudes, beliefs and behaviours of 7 to 9^{th} grades students but the data were focused on the student. The student's attitude towards mathematics was reportedly changed dramatically over a short period.

An important factor of students' academic success or failure is their attitudes and what causes positive and negative attitudes toward mathematics. A number of research studies confirm a correlation between the attitude and the achievement in mathematics or its vice versa, Popham (2005), Royster and Schoeps (1999), Hannula (2002), Tapia and Marsh (2001), Lent and Gore (1997), Thorndike-Christ (1991), Gallagher and De List (1994), Shashaani (1995), Midley *et al.* (1989), Papanastasiou (2002), Higbee and Thomas (1999), Williams (2005); Koller *et al.* (2001). However, some researchers such as Cain-Caston (1993) reported no relationship between the attitudes and achievement.

Obviously, the assessment of attitudes toward mathematics would be of less concern if attitudes were not thought to affect performance in some way, Aiken (1970). It is believed that student mathematics achievement is linked to their overall academic success.

Motivation toward mathematics is the desire to learn intrinsically and extrinsically. Hannula (2006), Schweinle *et al.* (2006) described that cognition is related to the affective responses that learners make. Motivation has strong influence in developing positive attitudes which will result in how best students do the tasks. Instructors' survey at this university revealed that a majority of students lack motivation towards learning mathematics. Students spend very little time studying the subject on their own.

Research into finding the relationship between the bilingual engineering maths students with their maths achievement can contribute positively to the existing literature. There is a significant literature on student attitudes toward maths and the factors which impact them; however, there is still a dearth of research focusing on bilingual engineering mathematics students in the context of Saudi Arabia. There is more research on students' maths achievement but less on students' attitudes toward maths. This study investigates both quantitatively and qualitatively whether the intervention provided to students has developed positive attitudes among students at a university in Saudi Arabia.

2.9 Mathematics aptitude and mathematics achievement

Oxford dictionary defined aptitude as a natural ability to do something. In order to test this ability, several standardised and non-standardised tests are used globally in educational institutions and in corporate sectors. According to Aiken (1988) aptitude tests are used for predicting the cognitive behaviour of a learner. Reyes (1984) considered learning mathematics primarily a cognitive endeavour but affect can also play an important role in students' decisions about how they approach the mathematical content they study. However, Carr (2004) described that it may be physical or mental.

In an effort to identify the factors affecting student academic success in several disciplines including mathematics courses the extensive research studies have been undertaken all over the world. There are many research investigations carried out to determine aptitudes of students and the factors which influence them. Factors relating to student cognition are believed to be the most prevalent contributing predictor to student success in mathematics such as Scholastic Aptitude Test (SAT) in the context of American universities system. Although a majority of the researchers hold the opinion that the student good performance in high school and the standardised tests are success predictors at university mathematics courses while there are many contrary reports in the literature. Haase and Caffrey (1983a) (1983b) reported neither the high school grades nor the SAT/ACT predicted students' grades in introductory maths courses. Among a number of related variables, Meece *et al.* (1982) have identified that students' performance in previous maths courses to be a good predictor of their achievement in subsequent maths courses. These findings confirm the observations of Begle (1979) in which the author pointed out that students' best and strong indicator of success is the previous success history in the subject. Yushau (2004) has also considered student's success in the immediate pre-requisite maths course as a good predictor of achievement in the subsequent mathematics course.

In short, aptitude could be a good indicator of the present abilities and potentials of a learner and his ability to cope with new situations. A proper measurement of learners' aptitudes will certainly help in the appropriate allocation, utilisation and optimisation of human and non-human resources. This is truly the case with the process of enrolment of students in the universities and colleges around the world. This will also help educators and researchers in measuring and conjecturing students' performance in the related future courses and programmes. It is truism that one of the best predictors of an individual's future behaviour is what he has done in the past, which could be applied to mathematics achievement, Aiken (1971). Students' achievement in the integral calculus course is related to their past performance in pre-requisite course such as differential calculus. Therefore, in this study, students' achievement in the previous mathematics course as mathematics aptitude has been taken as a possible indicator of their success in the integral calculus course.

2.10 English Aptitude and mathematics achievement

Language is possibly the most important means of communication that humans use to communicate with each other. Its role in the teaching and learning process is undoubtedly crucial and particularly in mathematics education of engineering students. NCTM (2000) describes language as a means of communication of mathematics. According to Silby (2000), the language that a person uses in his daily life has an influence on his thought processes. In a globalised world, the issue has brought special attention to researchers as more and more students are getting an education in a language other than their own. This issue needs special attention because many students are taking mathematics instruction in their non-native languages, Ellerton and Clarkson (1996). The author further reported a relationship between the bilingualism and logical reasoning of students. Yushau (2004), while describing this shift in the trend, reasoned that the language of science, technology and Internet in the 21st century narrowed down a few influential languages. Undoubtedly English is one of the most widely spoken languages in today's world.

The study of the effects of bilingual instruction on students' cognition is an important area of research and the interest is growing as there are more and more bilingual students particularly for those whose native language is Arabic and their language of instruction is English. Studies such as Bernardo (2002) and Mestre (1988) have shown that students' perform poorly in solving mathematical problem not just because of poor cognition but it is mainly due to the difficulties they face in understanding the language. The issue gets more serious for students who are taking the mathematics courses in a second language. This is due to their inability to understand the language in which the subject is being taught. Aiken (1972) described a strong correlation between students' abilities in reading comprehension and in solving problems and the factor which highly influences the problem solving ability is the difficult vocabulary. According to Setati (2002) the students' tend not participate in the classroom discourse and develop a poor understanding if they are weak in the language of instruction.

2.11 Computer Aptitude and mathematics achievement

Another variable which has been investigated as a potential contributor to success in mathematics is computer-assisted instruction (CAI). In a study by Hearne and Lasley (2001) reported a strong relationship between the conceptual ability and computer aptitude for both males and females. Mevarech, Silber, and Fine (1991) investigated the use of computer-assisted instruction, for the purpose of drill and practice, in small groups and individually, with 149 junior high school math students. They found that compared to students who used computer-assisted instruction individually, CAI had a moderate positive impact on the achievement of small group participants, increasing their average student performance from the 50th percentile to the 73rd percentile. Mevarech *et al.* (1991) concluded that the small group instruction helped students to overcome some of the barriers to successfully learn mathematics with a computer. They also found that students in the small learning groups also reported improved attitudes about mathematics, and their ability in mathematics.

Wileman, Konvalina and Stephens (1983) discovered programming success to be highly related to measures of cognitive ability. Moreover, findings from this study indicated that an individual's propositional and deductive reasoning ability showed a much stronger relationship to computer aptitude than did school performance. In further support for a non-quantitative basis for computer aptitude, Steven (1983), using regression analysis, found computer literacy to be most a function of differing cognitive styles.

The students in the 21st century have a natural liking towards computers but there are still a few who still face a particular kind of phobia. There are mixed reports on students' use of computers in the classrooms. A student who develops a more positive feeling or attitude towards computer is more likely to benefit from the technology and it's vice versa. An anxious student may develop negative attitude towards its use and there exists a relationship between the attitudes toward computer and anxiety.

Anand *et al.* (2000) in their study on undergraduate and graduate students compared the impact of alternative methods of technology. The authors aimed at creating positive attitudes among students towards technology application making them learn and decide independently. In this study, two variables were identified as barriers of using technology, namely, computer illiteracy and lack of access to computer resources. The students were given orientation to the instructional material as well as some briefing on how to use them. There was minimal use of traditional lecture and the instructions were given in a collaborative environment. In addition, course hand-outs and video tapes were provided to students throughout their learning period. The course material and assignments were provided electronically to students through the email and the Internet and the students grades were provided online. Teachers and students used technology and students reported a positive feedback on the use of technology in the teaching and learning process. The authors recommended the need of conducting what was called the concept of Usability Testing during the stages of the design and implementation of technology. It was further concluded that in order for students to appreciate the use of computers, proper planning and student feedback in instructional designing and evaluation is vital for its success.

In a study conducted by Pitcher (1998) addressed the effectiveness of computer-enhanced learning for undergraduate mathematics. The study reported that students' computer skills are vital as they enable them to use the tools effectively and appropriately and reap the intended benefits. The course, as a university entrance test designed and developed by a group of educators, was used to help students in learning the pre-calculus material. In the post analysis of the data, the author argued that students study skills training and their learning experiences must be raised in order for computer assisted learning to work effectively. However, a negative association between computer-assisted instruction and student math achievement scores was found.

In this study, a range of instructional strategies using a mix of traditional and modem technologies have been utilised.

2.12 Summary

A comprehensive review of literature has been presented on the use of computer technologies and their impact on students' maths achievement. The main focus was given to the use of MATLAB in teaching and learning of mathematics. In addition, the review also included the importance of mathematics attitude, mathematics aptitude, computer aptitude and the aptitude in English language toward their contribution in mathematics achievement. Several benefits of the use of the computer supported teaching and learning and learning in small groups have been highlighted in the literature whereas the studies on bilingual instruction in mathematics as well as the use of study support are relatively less.

The research methods are discussed in the next chapter.

CHAPTER 3

Research Methods

3.1 Introduction

This chapter describes the research design and methodology, variables, the rationale behind selecting sample, instruments and their validity and reliability. A discussion on the justification for the use of mixed method design is also given. The research hypotheses have also been outlined.

The purpose of this research was to study the effects of the selected Integrated Technologies' Instructional Method (ITIM) on the mathematical achievement of the first year undergraduate engineering students at the University of Ha'il, Saudi Arabia. The study was conducted on students who were enrolled in the Integral Calculus during the year 2012, due to their history of repeated failure in the course, its importance in the rest of the mathematics courses as well as in the engineering disciplines. Students' inadequate mathematical knowledge and skills have led to their unsatisfactory performance in their engineering majors. The study assessed the effects of the variables such as MATLAB in a collaborative environment; collaborative support, bilingual (English-Arabic) support and the study support on students' mathematics achievement as a supplement to the traditional lecture method.

3.2 Research Design and Methodology

Research methods are a collection of procedures, schemes and algorithms. They help us collect samples, data and find a solution to a problem, Rajasekar *et al.* (2013). They are scientific methods of conducting research to systematically solve problems. Experimental method is adopted in this study and Table 3.1 provides an intuitive notation introduced by Campbell and Stanley (1963) to describe the cause-effect relationship between the independent variables and the dependent variable. In the table, R standards for randomisation, O for observations and X for treatment, the first row is for the experimental group and the second one is for the control group. Cook and Campbell (1979) argue that three conditions must be met for the existence of the cause-effect (causal) relationship and they are co-variation, temporal precedence and no plausible alternative explanations. Three conditions must be met in order to establish a cause-effect (causal) relationship in an experimental design study. They are temporal precedence, co-variation and no plausible explanations. The temporal precedence means that if there is a cause there would be an effect and in this case students' weakness in mathematics is basically the cause and their failure is the effect. The second condition is the co-variation of the cause and effect that means variation in the independent variables causing the effect in the dependent variable. However, this condition demands that you have to show a causal relationship such as if intervention then the outcome implies if no intervention then no outcome. Students have history of failures in this particular course and improvement in the overall results observed only in the intervention semester. The third criterion is that there must not be any plausible alternative explanations to the outcome other than the intervention meaning that you have to overcome/remove all extraneous and confounding variables (threats to validity) for establishing a firm causality. The threats to validity are the history, maturation, selection-testing, selection-instrumentation, mortality, and regression. Students had no history of this intervention. Since many repeat the course, therefore, some of them might have repeated the course with the same instructor. However, it might happen with both the instructors who were involved in the experimental semester. The factor of maturation may not apply for the mathematics therefore it is not a threat. The selection-testing, selection-instrumentation and regression are also not applicable as there was no pre-test conducted. It is argued that the study has a causal relationship and what usually causes the alternative explanations has been ruled-out. Furthermore the study had one control group to be compared with the experimental group and this design is considered a credible way forward to causality in conjunctions of the factors outline above. In the Table 3.1, R stands for randomisation, O for observations and X for treatment, the first row is for the experimental group and the second one is for the control group.

Table 3.1: Experimental Design notation, Campbell and Stanley (1963)

R	O	X	O
R	O		O

Cohen and Manion (2007) outlined the following key features of a true experimental design which according to Kerlinger (1970) is a good design:

1. One or more control groups
2. One or more experimental groups
3. random allocation to control and experimental groups
4. pretest of the groups to ensure parity
5. post-test of the groups to see the effects of independent variable
6. one or more interventions to the experimental group(s)
7. isolation, control and manipulation of the independent variables
8. non-contamination between the control and experimental groups

There are certain factors relating to extraneous variables such as participants, intervention and situation which cause an experimental error and the desired effect may not be attributed to the independent variable alone.

This study used an experimental covariance design in which one group was experimental and the other was control. The sample students were randomly selected and they had no prior information with regard to the method of instruction at the time of registration. There was no pre-test conducted, however, to ensure equity with regards to students' maths ability, their mathematical aptitude was measured through their GPA in their pre-requisite maths course. This criterion is considered as a reliable and a valid source of group equivalence, Yushau (2004), Meece *et al.* (1982), Begle (1979) and Aiken (1971). The average for the Differential Calculus course, a pre-requisite, taken by the sampled students was computed and it is given in Chapter 5, Table 5.1. The groups were equivalent or almost the same before the start of the study. However, often times it is not possible preventing or non-contamination of students of both groups from sharing their learning experiences from each other.

The intervention was given to the experimental group in which students were taught by traditional lecture method supplemented with the Integrated Technologies Instructional Method. The control group received only traditional lecture instruction. The post-study maths achievement was measured by the end-of-course grade.

This experimental design is appropriate for the study as it establishes cause and effect relationship between the variables. Statistics are used to determine whether or not the results are significant quantitatively. Cook and Campbell (1979) argue that three conditions must be met for the existence of the cause-effect (causal) relationship and they are co-variation, temporal precedence and no plausible alternative explanations. The temporal precedence means that if there is a cause then there would be an effect and in this case students' weakness in mathematics is basically the cause and their failure is the effect. The second condition is the co-variation of the cause and effect that means variation in the independent variables causing the effect in the dependent variable. However, this condition implies "if intervention then the outcome" meaning "if no intervention then no outcome". Students have a history of failures in this particular course and the mathematical improvement has been observed in the overall results in the intervention semester. The third criterion is that there must not be any other plausible alternative explanations to the outcome other than the intervention meaning that the study must overcome and remove all extraneous and confounding variables (threats to validity) for establishing a firm causality. The threats to validity are the history, maturation, selection-testing, selection-instrumentation, mortality, and regression. Students had no history of this intervention. Since many repeat the course, therefore, some of them might have repeated the course with the same instructor. However, it might happen with both the instructors who were involved in the experimental semester. The factor of maturation may not apply for the mathematics therefore it is not a threat. The selection-testing, selection-instrumentation and regression are also not applicable as there was no pre-test conducted. It is argued that the study has a causal relationship and what usually causes the alternative explanations has been ruled-out. Furthermore the study had one control group to be compared with the experimental group and this design is considered a credible way forward to causality in light of the factors outline above.

However, there is one aspect which has been much researched in the literature about the effects of teachers' knowledge, skills and competence and their relationship with the mathematical achievement of students. A number of studies have reported a positive correlation between the mathematical knowledge of teachers with that of the mathematical achievement of their students, Hill *et al* (2005), Hill, Schilling & Ball (2004). However, teachers' inadequate knowledge of the subject has been reported, Ball (1990), lack of conceptual understanding, Ma (1990), Therefore, attributing the improvement in the performance of the experimental group of students entirely due to the intervention is a much debatable task in the educational research studies. Since different instructors were involved in the teaching of experimental and control groups of students, this factor would lead to some degree of validity threat and consequently on the issue of generalisability of the research. Schoenfeld (2000) argued that testing students' performance for those who were taught by the traditional method and the ones exposed to the non-traditional method is as if comparing apples with oranges. The author further states that the use of statistics to determine whether the results are significant is a much more complex issue. The experimental research design which achieves greater internal validity is quite intrusive and difficult to carry out in the practical contexts due to its artificiality of the situation created in the experiment. Moreover, the results obtained are difficult to generalise due to the issues relating to its external validity. Despite these critical and negative comments, this design establishes a good causal relationship with high validity.

3.3 Variables of the Study

The method of instruction which is the ITIM as a supplement to the traditional lecture method was the main independent variable. The method involved four strategies, namely, the MATLAB-supported collaborative learning, collaborative support, bilingual support and the study support. The Attitudes Towards Mathematics was another independent variable along with the other covariates such as maths aptitude, English aptitude and computer aptitude. The students' maths achievement was identified as dependent variable as final letter grade which is considered to be an indicator of achievement in the course.

3.4 Research Hypotheses

The research hypotheses have been mentioned in section 1.8.

3.5 Participants and Setting

The sample was the undergraduate first year engineering students from the University of Ha'il who were enrolled in the Integral Calculus course. This course is a prerequisite for several engineering majors. All students are native speakers of Arabic language and the language of instruction of these students at the secondary education has been Arabic with minimal English. The university, located in Ha’il in the northern region of Saudi Arabia, was established in the year 2005 by the Ministry of Higher Education. The conditions for admission in the university require the secondary school graduates to pass a national aptitude test called “Qiyas” in Arabic meaning "Assessment and Measurement" conducted by the Ministry of Higher Education. Its purpose is to test academic achievement of students at the entry into the Kingdom's universities system. Upon qualifying this test and together with their performance in the secondary school, students are given the choice of registering for courses in various disciplines such as engineering, sciences, medicine, education and arts in universities throughout the country. Since the medium of instruction at the school is Arabic, the students at their entry into the UOH are given a preparatory year programme which is comprised of the English skills for academic purposes as well as the courses in basic sciences such as mathematics, physics, introduction to engineering and the personality development skills. Although students are taught all necessary English language and study skills, the gap created by the secondary school system is so wide that for many it cannot be completely filled by the preparatory year programme alone. Consequently students face a number of challenges in the first year of their studies in trying to come to terms with the academic demands. Students find it particularly very difficult to cope with the standards set by the engineering departments. The phase of transition exposes several inherent problems with the entire school system concerning students poor study habits, lack of motivation towards studies in general and particularly engineering courses. As a result, students’ do not fully comprehend the material taught in the first year mathematics.

In an attempt to overcome the challenges highlighted earlier, in this study the MATLAB software was used as a supplement to the traditional lecture method where the classroom and the computer lab sessions were carried out in a collaborative group setting, students were supplied with additional study material as well as they were given some bilingual support through their peers. It has already been mentioned in the introduction chapter that there was a need for supporting students due to their higher rate of failure repetitively in this course, their lack of interaction with the instructor and the material and their problems in having smooth progression to the next level of courses as well as constant complaining of engineering professors with regard to students weak mathematical background despite having an acceptable grade in their academic record. These students are required to get a grade of C or above in the preparatory-year maths course to get admission into the engineering programmes. The choice of major in engineering at their entry largely depends on their grades in English and mathematics courses. All students are required to successfully pass the prep-year programme and there are no other placement tests. The marks distribution scheme for the course is given in Table 3.2.

Table 3.2: Integral Calculus marks distribution scheme

	Paper-based examinations			
Groups	Major 1	Major 2	Final Exam	Other
Experimental	20 %	20 %	50 %	MATLAB-based assignments 4%, Individual & group work assignments 4% Home work assignments 2%
Control	20 %	20 %	50 %	Participation & Home work 5% Paper-based quizzes 5%

The end-of-course grade performance was based on the GPA (Grade Average Point) out of 4 points: A+=4, A=3.75, B+=3.5, B=3, C+=2.5, C=2, D+=1.5, D=1, F=0, DN=0,

This study involved a total of 218 students of the Integral Calculus course during the year 2012 in which a total of 99 students were assigned to the treatment group and 119 students were in the control group. The distribution of student population is shown in the Table 3.3. The course is a pre-requisite for all students who are pursuing their engineering majors within the Faculty of Engineering.

Table 3.3: Sample Student Population

Groups	Students' Number
Control Group	119
Experimental Group	99

3.6 Course Structure

The course is designed for the first year engineering students. It includes the topics of single variable calculus such as area problem, applications of definite integral, techniques of integration and sequences and series. A copy of the traditional course incorporated with MATLAB supported course syllabus has been attached in Appendix A. The Integral Calculus course is 4 credit hours and the class meets twice a week. Traditionally all lectures are conducted in a classroom without any exposure to any technology or software in teaching and learning of mathematics. However, instructors are encouraged to use appropriate software tools but there is no extra hours assigned as a tutorial hour or any computer lab assignment. The final exam of the course is comprehensive covering all the material. The exams are prepared by all instructors involved in the teaching of the course and the marking of all exams is a group activity.

All the MATLAB sessions were held in a computer lab where MATLAB was installed on PCs'. Students learning was in pairs anticipating that effective learning will take place when students are put in groups as reported by Webb (1991). MATLAB practical guide and manual was developed by the Instructor-Researcher with some Arabic support. This manual was used for developing some knowhow with the software but its main focus was the learning of the course related maths concepts. The worksheets designed for each concept were provided to students during computer lab sessions as well as on the World of Calculus website.

3.7 Control Group's Teaching and Learning

The teaching and learning style for the control group of students was traditional lecture method without the use of any of the strategies incorporated for the experimental group. The standard policy relating to the course was adopted which includes the standard course syllabus, the number of instructional hours, exam preparation and marking, and the textbook.

3.8 Experimental Group's Teaching and Learning

The research on non-traditional methods of teaching and learning mathematics at all levels is increasing significantly as supplement to traditional lecture classes. Several reforms movements in different parts of the world were initiated; alternative methods of instruction proposed and this is on-going in several international conferences and forums. The National Centre for Excellence in the Teaching of Mathematics (NCETM) works collaboratively with a number of professional organisations to enhance mathematics teaching in the UK. The state-supported organisation, NCTM in the USA, has produced a number of publications and standards on the topic. An adherence to the traditional maths instruction only is ineffective for the educational demands of the 21st century. On the concept of the computer supported collaborative learning, in this study MATLAB has been used in collaboration. Engineering students must use mathematics symbolically, numerically and graphically and MATLAB can handle all.

This section has four subsections comprising of all the four instructional strategies implemented in this study. Section one deals with the first strategy which is the use of MATLAB in a collaborative setup. The self-selected student groups learned the course contents in the computer lab where MATLAB was used as a supplement to the traditional classroom lecture. Section two discusses students' problem solving in the classroom in a collaborative setup which is termed as collaborative supported learning. In another strategy in which some concepts of the course were explained by students' peers in their native language which is termed as bilingual support. The last section covers the use of study support as one of the strategies in which students were provided with additional course material. Figures 3.1 and 3.2 represent the sequence of instructional activities performed for the experimental group of students:

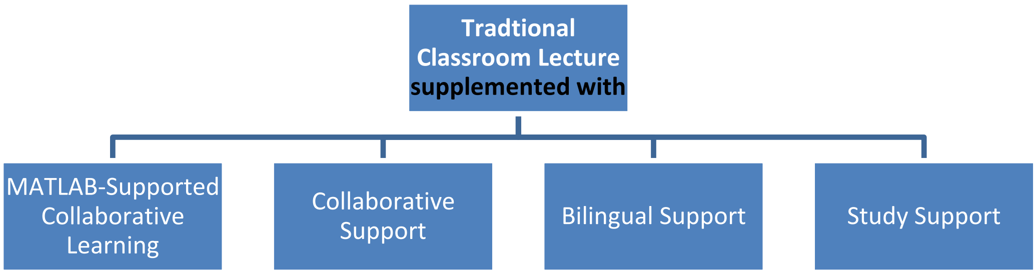


Figure 3.1: Traditional Class Lecture supplemented with ITIM

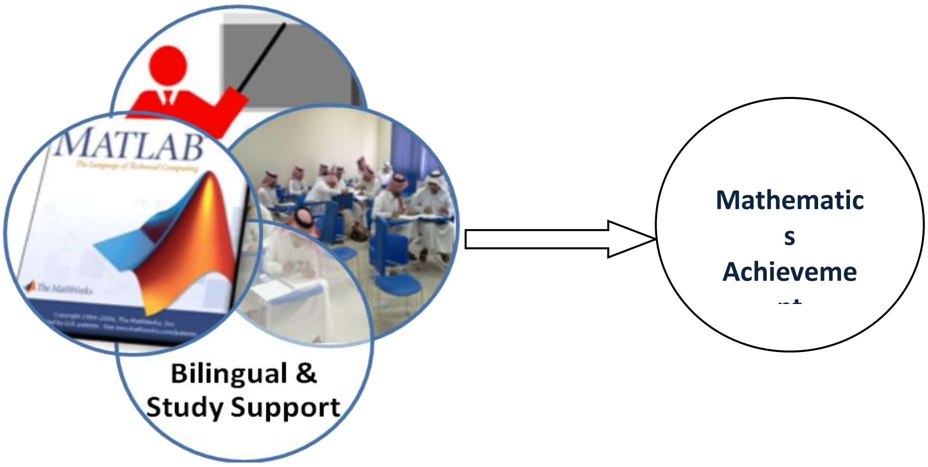


Figure 3.2: The instructional strategies used to enhance mathematics achievement

Table 3.4 shows the implementation of each instructional strategy.

Table 3.4: Supplemental Instructional Strategies

Instructional Strategies	**How strategies were used?**
MSCL	Use of MATLAB in small groups in computer lab.
CS	In-class collaborative problem solving.
BS	In-class peer-assisted instruction in native language for certain concepts of the course.
SS	Online and offline supply of course related material.

3.9 Research Instruments

This study has used both quantitative and qualitative techniques in data collection. According to Best and Kahn (1989), "both types of research are valid and useful. It is possible for a single investigation to use both methods". Each one of them has potential merits methodologically complementing and triangulating the other; thereby increasing the credibility and the validity of the research. Blaxter and Tight (1996) defined "Quantitative research is, as the term suggests, concerned with the collection and analysis of data in numeric form. It tends to emphasise relatively large-scale and representative sets of data, and is often, falsely in our view, presented or perceived as being about the gathering of `facts". The qualitative research, on the other hand, is concerned with collecting and analysing information in as many forms as possible mainly non-numeric in nature. It tends to focus on exploring, in as much detail as possible, smaller numbers of instances or examples which are seen as being interesting or illuminating, and aims to achieve `depth' rather than `breadth'". Cohen and Manion (2000) define triangulation as an "attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint." Ultimately, the unified aim of these research methods is to check whether the phenomenon under inquiry reach one point of convergence through different directions. Data collected through multiple sources are believed to achieve a high validity when triangulation techniques are employed. The triangulation will strengthen the overall reporting of the cause and effect studies.

Students' end-of-semester final grades were used to determine the effects of the intervention. Additionally, the grades of both the groups of students in the previous courses such as English, mathematics and computer were collected, firstly, to determine whether the groups were equivalent or almost similar at the start of the study and secondly to see how these previous courses are related with student achievement in the Integral Calculus course. The data were collected through students' academic record, student questionnaires and student interviews.

3.9.1 Quantitative Instruments: Student Questionnaire and Academic Record

Students' attitudes towards mathematics and toward the supplemental instructional strategies were measured through interviews and questionnaires. Mathematics attitude is one of the independent variables in this study. Attitudes and student self-efficacy are related with their mathematics achievement, McLeod (1994). The following questionnaire was used in this study:

1. A comprehensive post-study questionnaire was used to evaluate student attitudes toward the use of instructional strategies in teaching and learning of the Integral Calculus course. This questionnaire has the following categories:
    a. Attitudes towards the MATLAB-supported Collaborative Learning
    b. Attitudes towards the Collaborative support
    c. Attitudes towards the bilingual support
    d. Attitudes towards the study support
    e. Attitudes Towards Mathematics
2. Students' Academic Record

The design of the questionnaires was drawn up and guided by the research objectives and they were developed to collect comprehensive information about students' attitudes. These questionnaires were piloted, revised and subsequently modified and developed before they were finally used for data collection. The questionnaires relating to the use of MATLAB and the collaborative learning were also collected immediately at the end of each task.

The self-designed post-study questionnaire was prepared to determine whether there was any change in student attitudes towards the instructional strategies used during the semester as a supplement. This questionnaire was translated in Arabic by two university professors; one from the Faculty of Engineering and the other was from the Faculty of Science in the Department of Mathematics. It has questions relating to the use of MATLAB in the teaching and learning of Integral Calculus as well as a set of questions on students’ overall experience of all the supplemental strategies used. The questionnaire used the Likert-scale type questions in which the attitudes were represented into the numerical data. For statistical purposes and to infer timely generalisation, Cohen *et al.* (2007) consider quantifying the qualitative human attitudes as acceptable. The data were assigned five-point “Strongly Agree”, four-points “Agree”, one-point “Strongly Disagree”, two-points “Disagree”, and three-points “Neutral”. The questionnaire items were both positive and negatively worded to seek accuracy in responses. The questionnaires were valid and their reliability was computed for all categories of questions separately using the Cronbach's alpha reliability test using the SPSS software. In order to assess the level of difficulties of the MATLAB-based tasks, students responses were collected through Likert scale type questions. Students' academic records were used to collect the pre- and post-study data relating to their grades and for the calculation of GPA.

3.9.2 Qualitative Instruments: Interviews and Group Interviews

Interview is a form of conversation and it is conducted with a specific purpose, Dyer (1995) and the group interviewing is one of the techniques of data collection, Watts and Ebbutt (1987). Bogdan and Biklen (1992) added that group interviewing provides further insights into the understanding of the phenomenon under study. The aim of conducting interviews was to measure students' attitudes regarding the instructional strategies as supplement to the traditional lecture method. Only 10 students volunteered for individual interviews. The interview was semi-structured and it was loosely followed. All sessions took place in either classrooms or in the Instructor's office. A schedule was prepared according to each participant's convenient time and day. They had to be reminded by phone or in the classroom. The interviews were conducted for a maximum duration of 30 minutes but sometimes they were concluded in much shorter duration when the participant did not provide information relevant to the research objectives. Interviews were audio and video recorded. This record has been a valuable source at the time of transcribing interviews. The common emerging themes were identified. The interview questions are provided in Appendix B.

3.10 Validity and Reliability

The data triangulation method, which uses both the quantitative and qualitative techniques, was applied for an accurate and an in-depth understanding and description of the phenomenon under study. The implementation of the method, however, cannot imply the validation of the study, nevertheless, an attempt towards achieving it. The reliability of the questionnaire items was computed using the Cronbach's reliability coefficient.

3.11 Data Analysis Method

Both quantitative and qualitative methods were used in the analysis of the data. The statistical techniques used were the descriptive statistics, t-test, ANOVA, univariate analysis, Pearson-Product Moment correlation, and the stepwise regression analysis. The dependent variable was students' mathematical achievement which was measured through their final grades in the course. The independent variable was the use of ITIM as a supplement to the traditional lecture method. Additionally, students' performance in the pre-requisite courses (Mathematics, English and computer) was considered as covariates to see their relationship with the dependent variable.

3.12 Summary

In line with the purpose of the research which was to study the effects of the selected Integrated Technologies' Instructional Method (ITIM) on the mathematical achievement of the first year engineering students at the University of Ha'il, the research methods were designed and implemented. The methods included the design methodology, variables, hypotheses, participants, study setting, course structure, learning of control group and experimental group, research instruments, validity and reliability. The next chapter which is Chapter 4 discusses the use of instructional strategies.

CHAPTER 4

Integrated Technologies Instructional Method

4.1 Introduction

This section has four subsections comprising of all the four instructional strategies implemented in this study. Section one deals with the first strategy which is the use of MATLAB in self-selected student groups. Students learned certain course concepts in the computer lab with MATLAB software. Section two discusses students' in-class problem solving in self-selected groups. The third strategy used was in-class peer-assisted instruction in which some selected students explained certain concepts and problems of the course in students’ native language. The last section covers the use of study support as one of the strategies in which students were provided with additional course material.

4.2 MATLAB-Supported Collaborative Learning (MSCL)

The Integrated Technologies Instructional Method was used as a supplement to the traditional lecture method for the experimental group. The experimental group was taught by the Researcher and the control group was taught by other faculty member. The course syllabus was followed according to the departmental plan. The computer lab activities were incorporated in the traditional course syllabus. The classes were held two days a week through Saturday to Wednesday each lasting 100 minutes. The control group was taught by the traditional lecture method and they had access to only simple calculators without any graphing capabilities. The standard policies were the norms of the department with regard to the preparation and scheduling up until the marking of exams. The computer sessions were held in the lab especially prepared for engineering students. The "World of Calculus" webpage had online course resource such as MATLAB manual including m.files, worksheets, quizzes, homework sheets and the formulae sheets. The printed worksheets were also given to them for completing tasks within the lab. The labs were conducted once in two weeks each lasting 50 minutes. MATLAB software was used as a supplement to the traditional classroom lecture. One of the objectives of using the software was presenting certain mathematical concepts in multiple representations. A series of computer laboratory activities were designed for students to explore the course concepts such as the definite integral and its applications, indefinite integral, limits of functions, derivatives of functions and their relationship with their antiderivatives and power series. Students were not expected to do the coding in MATLAB. Instead they used, modified and executed the code as part of their exploration. Each lab session was succeeded by a short discussion and the reflection on learning objective. The discussion mainly focussed for instance on the process of approximation in the case of an integral through visuals and the numerical values produced by the programme. Students tabulated the values for each integral calculated. They were asked to explain the meaning of software output with justification. Students worked in pairs and there was no compulsion in choosing partners. Self-selected grouping is one of the instructional strategies found in the literature. American Association for the Advancement of Science (1989) stated that what students learn is greatly influenced by how they learn and many of them learn best through an active collaboration inside and outside the classroom. A typical classroom had overhead projector without computers and the Internet. MATLAB demonstrations on selected topics were presented in the class prior to introducing lab activities.

4.2.1 Computer Laboratory Sessions

This section describes the way MATLAB has been incorporated in a collaborative environment for teaching certain selected topics of the course. MATLAB-based activities worksheets were designed conceptually and their aim was to focus on learning and its reinforcement. Each worksheet contained simple MATLAB commands and the exercise problems for students to do them. Help was provided to students as they were in a transition stage of learning from a traditional classroom environment to the learning with a computer programme. It was fundamentally crucial for students to familiarise with the software and its use as a learning tool. The group work provided an opportunity to students to share their knowledge and understanding with their peers. They were encouraged to discuss with each other for finding the solutions to problems. In case of not reaching to a solution, students were provided necessary guidance. Completing the tasks within the limited time of the lab was very challenging and ensuring the similar problems to be performed in the class by hand. All exercises chosen for the computer lab were mainly to enhance students' conceptual and procedural understanding. At the start of each lab session, an introduction to the activity to be performed was given. This also involved students in discussion for ensuring that topic is understood by them and the tasks to be carried out. Students spend about 30 minutes working on the computer activities. The rest of the time is spent on discussing the topic and asking students questions relating it. At the end of each lab session, the completed worksheets are collected with a reminder of doing similar problems by hand in the subsequent class work. The problems were based on the Early Transcendental Calculus textbook by Anton *et al.* (2011). At the end of each worksheet, two to three Likert type questions were given to students to evaluate the usefulness of the activity and their attitudes towards the use of MATLAB for that particular assignment.

The Table 4.1 shows the topics which were chosen for teaching using the software.

Table 4.1: MATLAB supported collaborative learning of Integral Calculus in computer lab

Labs	Week	Course topics covered
1.	2	Basic MATLAB tutorial, Sketching and visualising graphs of mathematical functions
2.	4	Area problem using Riemann sums
3.	6	Relationship between differentiation and integration and computing IVP
4.	8	Visualising and calculating net-signed area, total area and area between two curves
5.	10	Applications of definite integral: Solids of revolution; disks and cylindrical shells methods
6.	12	Patterns in basic integration formulae, Techniques of integration using patterns recognition
7.	`14	Techniques of integration using patterns and multiple representation
8.	16	Sequences, Infinite sum, evaluating power series, course material review

Student sample work on each laboratory activity is provided in the results chapter.

4.2.2 LABORATORY ONE

Objectives:

- Brief introduction to MATLAB
- Sketching and visualising graphs of mathematical functions

In this lab, the software tutorial was given to students highlighting the following necessary basic commands as a hand-out:

1. Brief introduction to MATLAB
    a. MATLAB interface (command window, command history, workspace)
    b. Use of mathematical functions such as (abs(x), sin(x), asin(x), exp(x), pi,)
    c. Commands such as close all, clear all, clc, ctrl c, exit, quit
    d. general (format long, format short, %, >>, who)
    e. Modifying, executing and saving m file, help command
2. Basic arithmetic commands such as +, *, /, ^, ;
3. Defining variables (syms x, y, z)
4. Algebraic operations such as solve, factor, simplify etc.
5. Limits
    a. limit(1/x, x,0,'right')

   b. limit(1/x, x,0,'left')
6. Differentiation of order 2, 3 etc. (diff(y,x,2), diff(y,x), diff(y,x,2), c=sym('1'); diff(c), diff(f,x))
7. Integration
   a. general (int command, defining f and using int)
   b. indefinite integral int(f),
   c. definite integral int(x^2,0,2)
   d. IVP such as (y = dsolve('Dy = (cos(x))','y(0)=1','x'))
8. plotting (ezplot, ezmesh, ezsurf, fplot, plot, graphing features/properties)
   a. ezplot (ezplot(y,[2,4]),
   b. fplot *fplot('x^4-3*x^2+4',[-2,2]), fplot('[cos(x),sin(x)]',[1,10])*
   c. plot (set domain values/function/ plot(x,y,'r')),
   d. subplot(subplot(2,2,1))
   e. shading the area under the curve (x=0:0.01:2/y=x.^2/area(x,y))
   f. graphing features (title('y=2x-8'), zoom on, axes on, hold on, setting domain, area(x,y), axis off, axis on, axis([0 2*pi -1.5 2]), grid, plot(x,y,'b'), x=linspace(0,2*pi,30); xlabel('text'), ylim([-60,-40]), x=linspace(-3,3,50)/ y=sin(x)/plot(x,y,'b'), gtext

The basic information about the tutorial was provided to students in the form of a hand-out and a working manual. The tutorial activity was followed by a review of sketching graphs of some basic mathematical functions and an illustration of even and odd-power functions was given as shown in Figures 4.1 and 4.2. The cognitive tool such as MATLAB could facilitate in embedding graphic images of mathematical functions in the minds of students with a great ease and efficiency. Students' weak knowledge of graphing has always been a main concern in understanding the course. The knowledge of sketching graphs of functions is required almost in every branch of mathematics and its allied disciplines. It plays a very important role particularly for engineering students as it is a useful tool for understanding mathematics. The development of computer algebra systems such as MATLAB, Mathematica and Maple etc. has made significant changes in the approaches to problem solving in mathematics. They have graphing capabilities which provide instructors a powerful pedagogical tool saving ample traditional classroom hours with a lot of accuracy. Figures 4.1 and 4.2 are the illustrations of some of the graphical patterns. Computers draw dynamic and interactive graphical objects which can be easily manipulated without putting burden on students. However, the use of computer technology for students must be supplemental to their understanding of the rules and principles of mathematics involved in it because sometimes computers can produce misleading graphs.

In the current study, MATLAB was used to motivate and enhance students' mathematical knowledge and skills. Classroom lectures were used to demonstrate how plotting is performed using the software. Three different plotting commands 'ezplot', 'fplot' and 'plot' were explained to students along with various related features such as zooming, compression, translation, placing labels on graphs, defining domain and range etc. The software acted as a tool for reviewing the pre-requisite concepts of the course with great speed and accuracy. Students were provided with assignment worksheets with all necessary help needed to use the software.

MATLAB was also used to recognise and identify patterns in graphs by taking a number of examples of basic mathematical functions. Many students lack visualisation skills in mathematics and it is an essential skill highly common to many scientific disciplines. The visualisation of static and dynamic graphs of families of functions such as linear, quadratic, trigonometric and inverse trigonometric can be easily demonstrated to students with the use of the software.

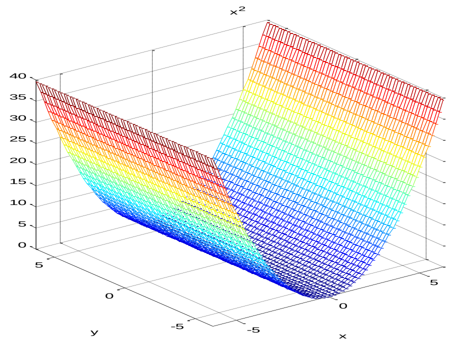


Figure 4.1: MATLAB-generated 3-D graph of a polynomial function

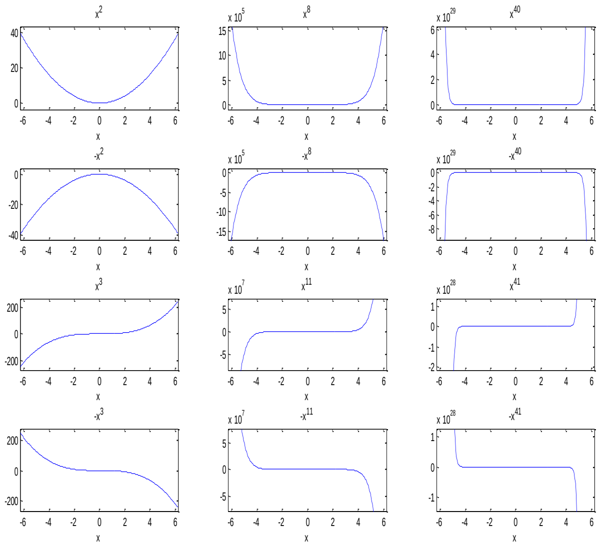


Figure 4.2: MATLAB-generated 2-D graphs of polynomial functions

Students identified patterns in the simple graphs of 2-D and 3-D functions and this exercise was aimed at enhancing their geometric sense using the software.

4.2.3 LABORATORY TWO

Area problem: The definite integral as the limit of the Riemann sum

Objectives:

- Computing Riemann sums for approximating area using midpoint, left end point and the right end point methods.

The first fundamental concept which students encounter in the Integral Calculus course is the area problem. The concept of computing area has a number of applications in the real world such as finding the area under a bridge, sum of forces and distance travelled as a car comes to a halt etc. Without calculus it will be difficult to find area as it is a versatile and valuable tool for engineering.

Integrals and derivatives which are considered to be the basic tools of calculus have numerous applications in science and engineering. Engineering students often apply calculus techniques to resolve engineering problems. In computing a definite integral, a set of n number of well-defined rectangles are constructed to approximate the area under a curve. The region between the graph of a function and the axis (x or y-axis) is calculated by making the width of the rectangles infinitesimally small virtually approaching to zero. Carrying out this process by hand is quite tedious. In a traditional classroom, the problem of Riemann sum is introduced using the antiderivative method emphasising algebraic treatment of the concept. However, a more rigorous approach is to use the rectangle method which uses the concept of the Riemann sums in which rectangles are added under the curve for approximating the area. This approach provides techniques for applying the concept of definite integral to computing area, volume and arc length.

The underlying concept in the calculation of an integral is the Riemann sum therefore an approach to begin with it is logical and appropriate. The students understanding largely depends upon their good grasp of this concept as the idea is spread all over the material in the course including the course concluding topic "sequences and series". Research on how students develop this concept is little and therefore a deeper inquiry is invaluable. Furthermore, the concept has wide applications in mathematics and engineering. In mathematics, this notion is used in approximating numerical methods such as left end point, right end point, midpoint, Simpson rule and Trapezoidal rule for approximating integrals. The notion of computing area under an arbitrary curve is connected with the Riemann sum. The concept of definite integral presents comprehension difficulties to students if taught traditionally which lack a proper visualization as the area as the Riemann sum, Bailey *et al.* (2001). The problem of students' visualising calculus concepts was also highlighted by Tall (1991a).

The aim of using MATLAB was to enhance students' understanding of the concept of the Riemann integration. A computer-aided visualisation can have direct benefits in understanding calculus concepts and therefore it should not be considered as an inferior approach to mathematical learning, Tall (1985). The author further argued that student can internalise the learning through the exploration of mathematical objects, Tall (1993).

To introduce this topic, a typical problem of area calculation has been used that was $f(x) = x^2, [a, b] = [0,1]$. The built-in 'rsums' command in MATLAB provides an interactive visual of Riemann sums for computing area under a curve. An approximation of the integral of the given function can be found by using the slider as shown in Figure 4.3. By dragging the slider from left to right students can see the dynamic changes occurring in the number of rectangles (regular partitions) and consequent improvement in the approximation of the integral value given at the top of the screen. This command provides an excellent dynamic visual into the summation process. Also, they can see the relationship between the computer-based visualisation to the mathematical meaning of an integral. The use of MATLAB provides both students and instructors with a unique opportunity to combine their learning and instruction of mathematical principles with real aspects of engineering, hence enhancing students' comprehension of both calculus and engineering. Furthermore, with the use of MATLAB, the notions of overestimation and underestimation of the definite integral as the limit of the Riemann sums in the context of finding areas can be visually explained. In this course they were given a demonstration of the use of Riemann sums interactive feature of MATLAB programme.

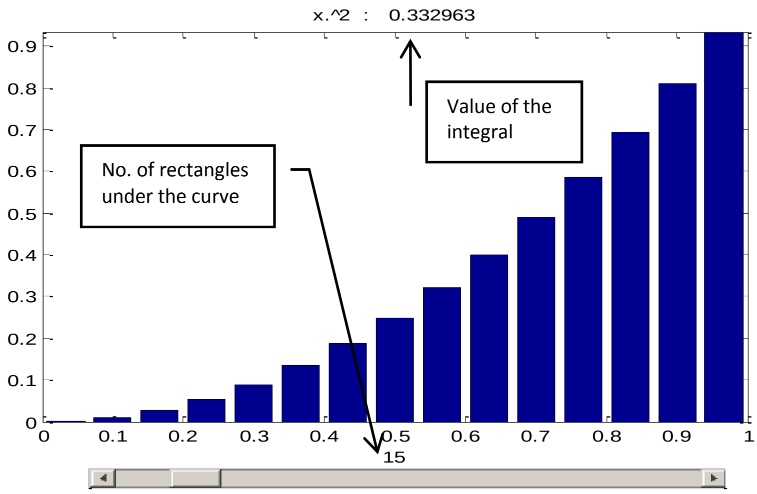


Figure 4.3: MATLAB output for the Riemann sum for f(x)=x^2,[a,b]=[0,1]

Students visualised a number of textbook-based problems using an interactive MATLAB programme developed by Hill (2002) in which the mid-point, left-end point and the right-end point methods were used as shown in Figure 4.4.

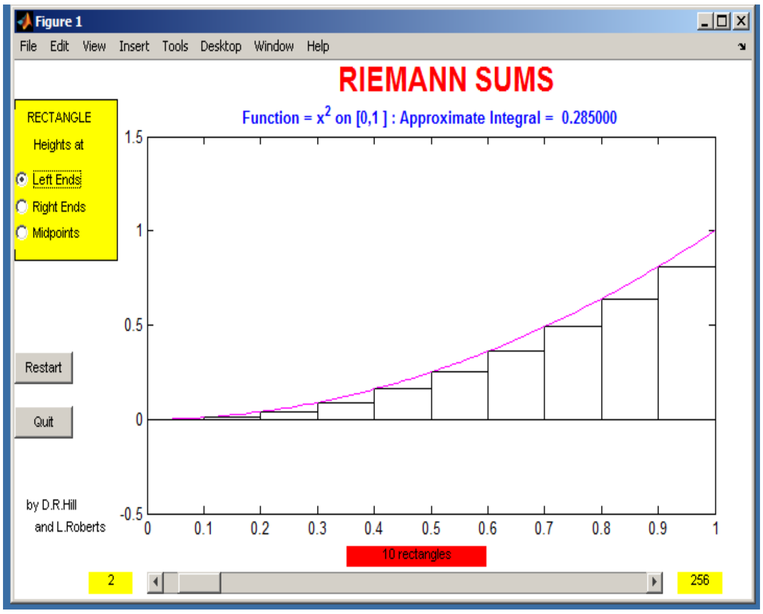


Figure 4.4: MATLAB screenshot for Riemann sum left-end points method for f(x)=x^2 over the interval [0,1], Hill *et al.* (2002)

At the end of each assignment, students were asked to describe and interpret the results produced by MATLAB. They tabulated the values generated by the programme for each integral calculated. They were asked to provide explanations to the programme's output and give justification to their correct responses. The degree of accuracy on the concept of overestimation and the underestimation of an integral with an indication of error were learnt by students.

Exercises:

Function	**MATLAB command**	**Number of rectangles =n**	**Calculated Area**
$f(x) = \sqrt{x}; [a,b] = [0,1]$	rsums (sqrt(x),0,1)	n=5	
		n=40	
		n=50	
		n=120	

Explain the following:

1. What is happening when you increase the number of rectangles?
2. What is the change that you see in the value?

Answer, yes or no:

1. When you increase the number of rectangles, would the width (breadth) of the rectangles:

   a. Increase ____

   b. Decrease ____

2. If you increase the number of rectangles to a very large number (say $+\infty$) then will the:

   c. width $\Delta x \to 0$ _____

   d. width $\Delta x = 0$ _____

A study by Orton (1983) focussed on the concepts of limit and integration on both school and college students. Interviews of students were conducted to examine their understanding of the topics. Students could not demonstrate an understanding that the process of integration is the limit of the Riemann sums and that the definite integral and area concepts are related. Using MATLAB, instructors would find much easier and intuitive to discuss the concept with students.

4.2.4 LABORATORY THREE

Relationship between differentiation and integration and computing IVP

Objectives:

- Demonstrating relationship between the function, its derivative and anti-derivative by multiple representations
- Demonstrating the limit of a function by multiple representations
- Computing Initial-Value Problem (IVP)

The role of multiple representations in the understanding of calculus concepts is extensively used; however, students' difficulties moving from one representation to the other have also been reported in the literature. These difficulties could be addressed with the use of computer technology in which connecting one representation such as algebraic to the geometric representation is quite intuitive. These different forms of computer-supported visualisations promote active learning thereby reducing student cognitive load. For instance, with the use of graphical representation students can conjecture the underlying relationship and its nature, McKenzie and Padilla (1984).

The Integral Calculus students despite completing the differential calculus course as a pre-requisite had weak knowledge in finding derivatives of even simple functions. A large number of problems, in this course, require a thorough knowledge and understanding of finding derivatives for evaluating integrals. A review of basic differentiation rules using the software was carried out. Additionally, the relationship between differentiation and integration, by taking a number of simple examples of differentiation and integration, has been explained as an illustration shown algebraically and geometrically in Figures 4.5 and 4.6.

$$y = \sin(x) - x * cos(x);\ \frac{d}{dx}(\sin(x) - x * cosx) = x * \sin(x), \int x * \sin(x)\, dx = \sin(x) - x * \cos(x) + C$$

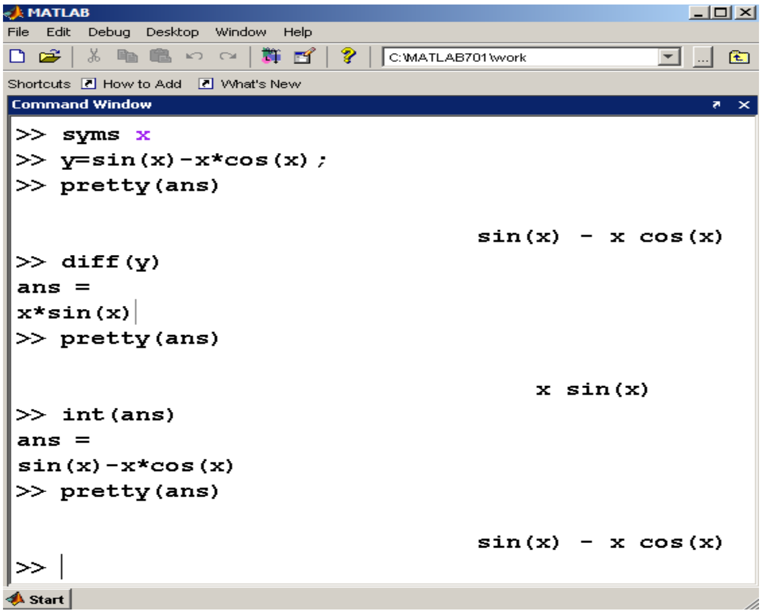


Figure 4.5: MATLAB generated screen to demonstrate symbolic relationship between a derivative and its antiderivative

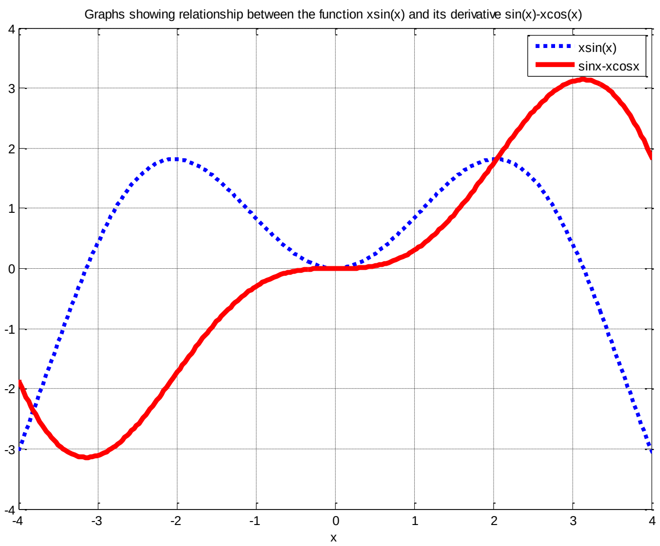


Figure 4.6: MATLAB generated screen to demonstrate graphical relationship between a functions and its derivative

The concept of limit is one of the basic concepts in the study of calculus as it plays an important role in the understanding of the processes of differentiation and integration leading to the concept of an infinite series. With the use of the software, this concept is presented numerically, graphically as well as algebraically, Figures 4.7 and 4.8.

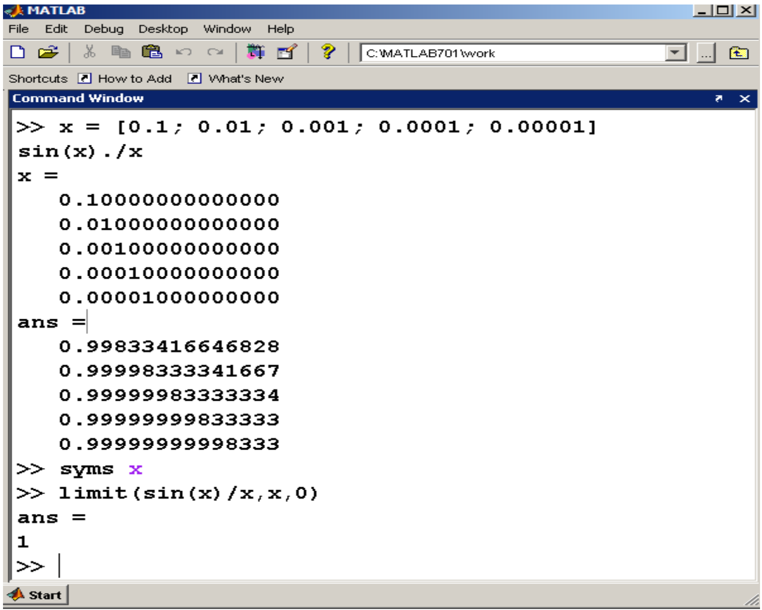


Figure 4.7: MATLAB generated numerical data of the limit of a function and its evaluation

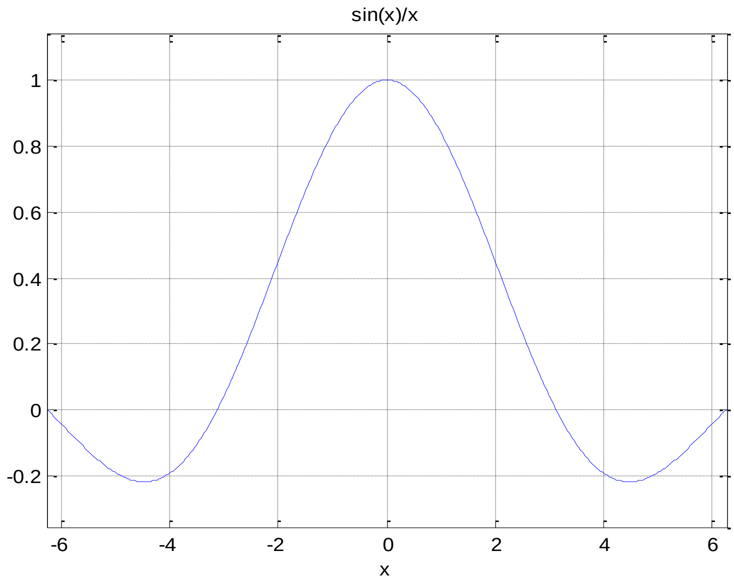


Figure 4.8: MATLAB generated plot for the function sin(x)/x

The pre-requisite concepts such as the limit of a function can be reviewed quite easily and efficiently with the use of the visuals generated by the software. This is essentially required for those students who lack an understanding in the basic mathematics.

In engineering and science, many applications can be modelled as initial value problem. A built-in command of MATLAB “dsolve” is used for finding the general solution of a differential equation symbolically with a fixed initial condition. An illustration of how an IVP problem is solved in MATLAB is given in Figure 4.9.

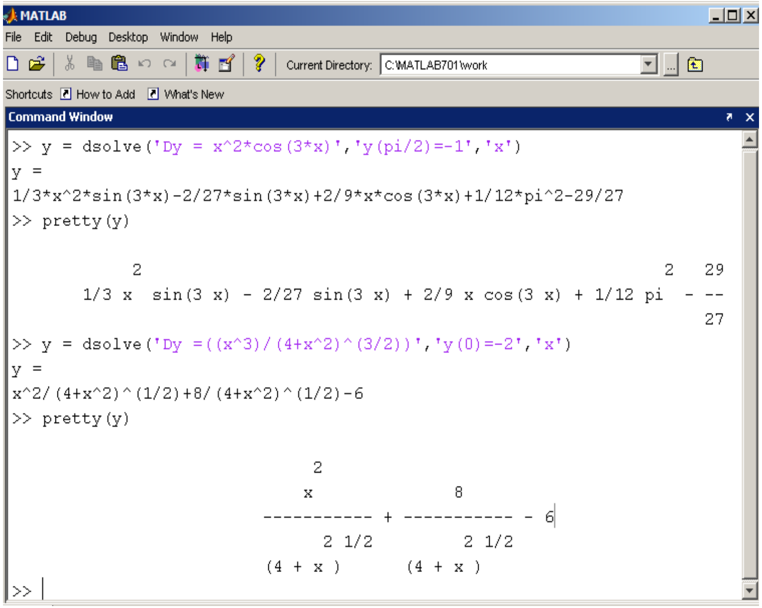


Figure 4.9: Illustration of an IVP problem in MATLAB

Students solved simple problems by hand and then they used the software for checking their answers. The immediate feedback provided by the software has been useful for students as only answers to odd-numbered exercises are given in the textbook. Besides, the textbook contains many problems requiring the use of a computer algebra system. Sometimes a computer algebra system produces a strange output which provides opportunities to students for modifying it to match the answer given in the textbook.

4.2.5 LABORATORY FOUR

Net-signed area, total area and area between two curves

Objectives:

- net-signed area
- total area
- area between two curves

A good example of the use of MATLAB to visualise certain functions could be to find the net-signed area bounded by the curve of the sine function and the x-axis for the interval [-2, 6] as shown in Figures 4.10 and 4.11. In this activity, students practiced a number of functions followed by MATLAB-based test consisting of 2 to 3 problems. Then they were asked to write their understanding and observations of the whole process on the practice worksheets.

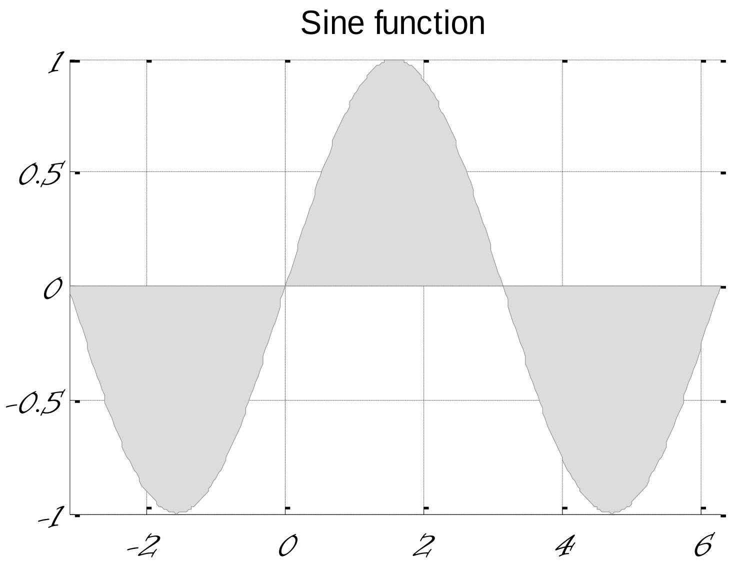


Figure 4.10: Net-signed area of the sine function

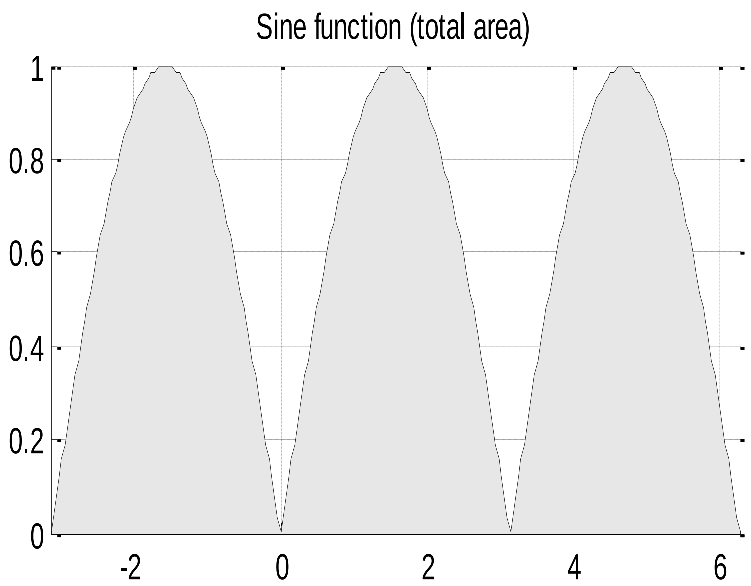


Figure 4.11: Total area of the sine function

The other problem which was discussed was to graph the function $f(x) = \frac{1}{100}(x+2)(x+1)(x-3)(x-5)$ and then using the graph to make a conjecture about the sign of the integral $\int_{-2}^{5} f(x)dx$ as shown in Figure 4.12.

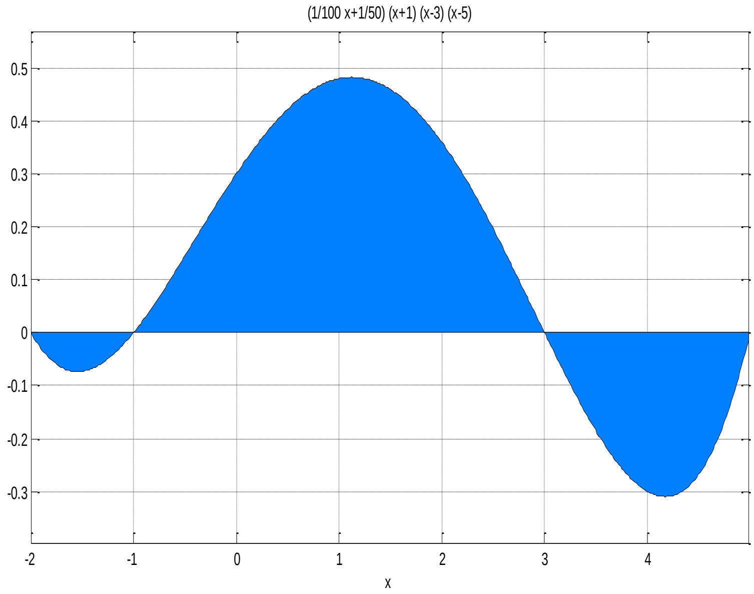


Figure 4.12: Net-signed area of the function f(x)

The problems relating to computing areas also included finding the total area of a function. The sine function was used to demonstrate the difference between the net-signed area and the total area. A quite intuitive single-command such 'int' can be used to evaluate the integral. The sequential steps such as visualising graphs of functions in MATLAB, identifying limits of integration and then calculating the areas increase both the conceptual understanding as well as the procedural understanding. Students learn the necessary steps involved in evaluating an integral when they use technology.

To find the area between the two curves shown in Figure 4.13, students need to know the shapes of the graphs of the functions to identify the upper and lower curves. The limits of integration can be found by equating the given equations and equations must be in the y=f(x) form. Their knowledge of algebraic manipulations is required here to complete the factorisation to get the lower and upper limits of integration. Finally, the integrand can be evaluated with the appropriate techniques of integration involved in the process. The basic algebraic manipulation and graphing functions are fundamental to student success but many do not seem to possess. A sample worksheet of MATLAB-Supported Collaborative Support is provided in Appendix D.

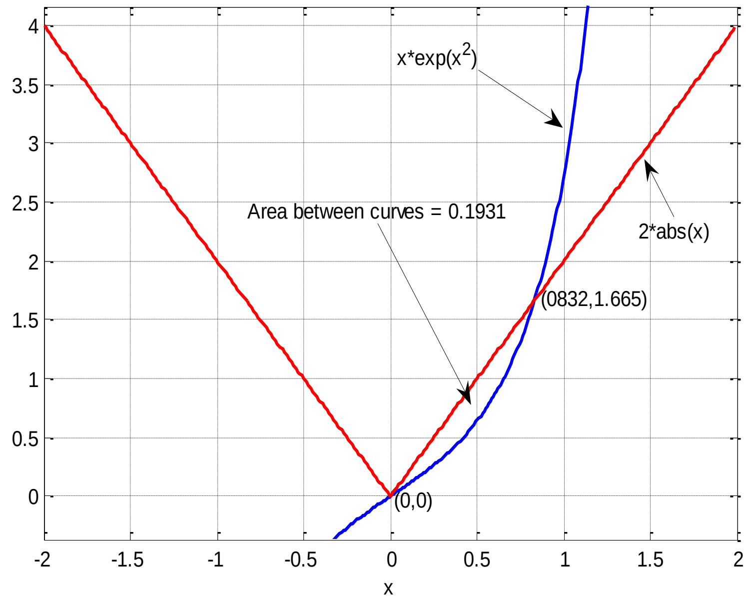


Figure 4.13: Area between two curves

Exercises: In-class by-hand collaborative activity

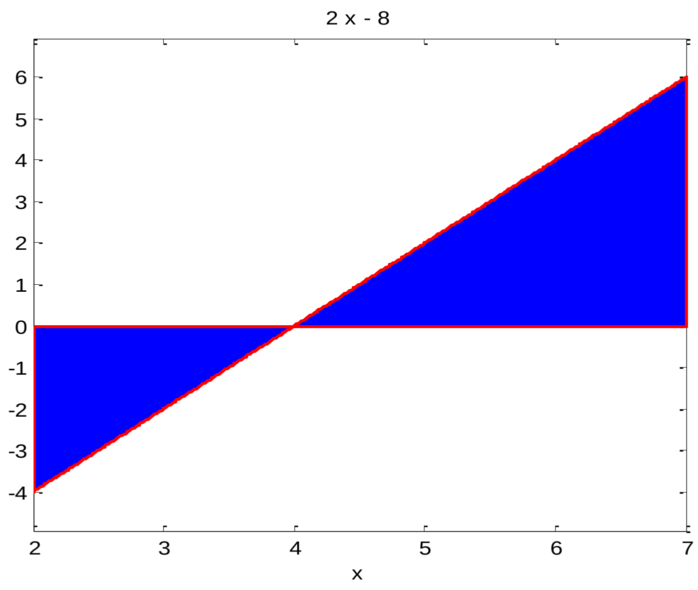


Figure 4.14: Area between two curves

Find the net signed area of $f(x) = 2x - 8$

Step 1: What is a = __________, b= ____________ (See the Figure 4.14)

Step 2: $\int_2^4 f(x)dx =$________________________

Step 3: $\int_4^7 f(x)dx =$________________________

Step 4: $\int_2^7 f(x)dx =$________________________

Region above the x-axis is: ________________________

Region below the x-axis is: ________________________

Problem: (Calculating area between two curves)

Find the area of the region that is enclosed between the curves $y = x^2$ and $y = x + 6$

Solution:

Step 1: Sketch the graph of $y = x^2$

Step 2: Sketch the graph of $y = x + 6$

Step 3: Top curve is :__________________

Step 4: Bottom curve is :__________________

Step 5: What is a = __________, b= ____________

(Points of intersection of graphs = limits of integration)

Step 6: Formula for finding area between two curves is
A=___________________________________

Step 7: Calculate the area between two curves is

4.2.6 LABORATORY FIVE

Applications of definite integrals using the Interactive MATLAB Programme:

Objectives:

- Applications of definite integrals (solids of revolution):
    i. Disks method
    ii. Cylindrical shells method

The definite integral has many applications in mathematics, physics and engineering; in particular, engineers heavily depend on it. In a topic on the applications of definite integral relating to finding the volumes of the solids of revolution using disks, washers and cylindrical shells methods, students find very difficult visualising the process of revolution of a function and generating the solids. This topic is important yet challenging for many calculus students. It demands a thorough understanding of graphing various mathematical functions as is the case with many related topics in the course. Students need to use their imagination, a challenging task for many, of how solids of revolution are formed when a function is revolved 360° about an axis.

Students, in collaborative small groups, used the interactive programme on disks method and cylindrical shells method for visualising the solids of revolution developed by Hill and Roberts (2002). The programme provides a good visual of the process of generating solids as it takes student through various steps. Some of the steps involved are shown in Figures 4.15, 4.16 and 4.17 as screenshots of the programme. This particular interactive MATLAB-based tool was used for demonstrating how a solid is formed. Both concepts and procedures could be effectively explained.

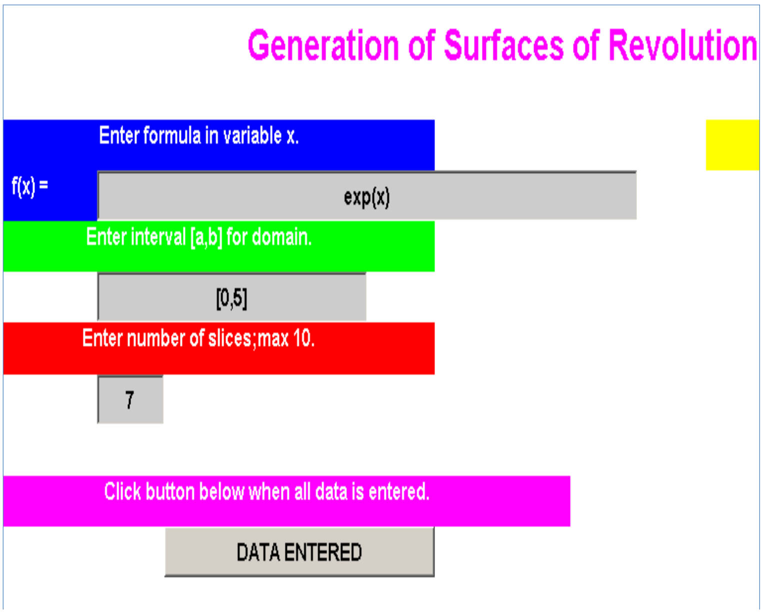


Figure 4.15: Illustration of disk method for finding volume of a solid. The programme was developed by Hill et al. (2002)

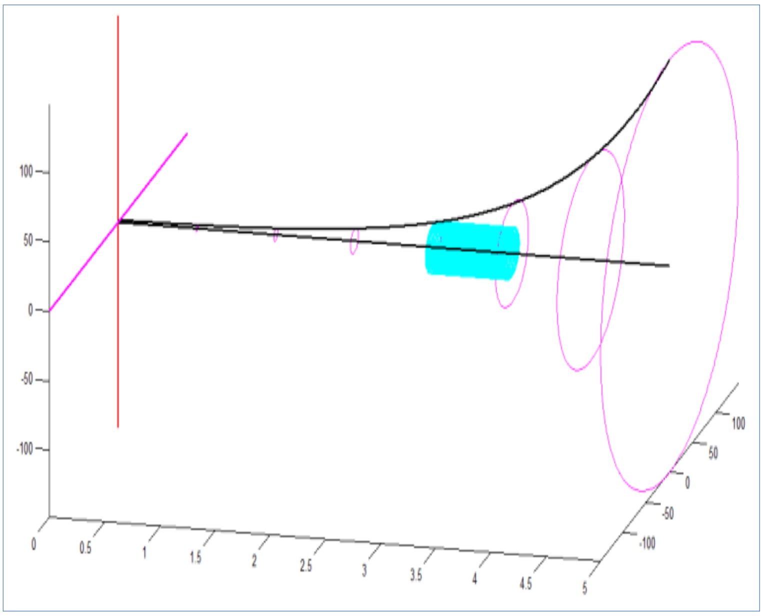


Figure 4.16: Illustration of disk method for finding volume of a solid. The programme was developed by Hill et al. (2002)

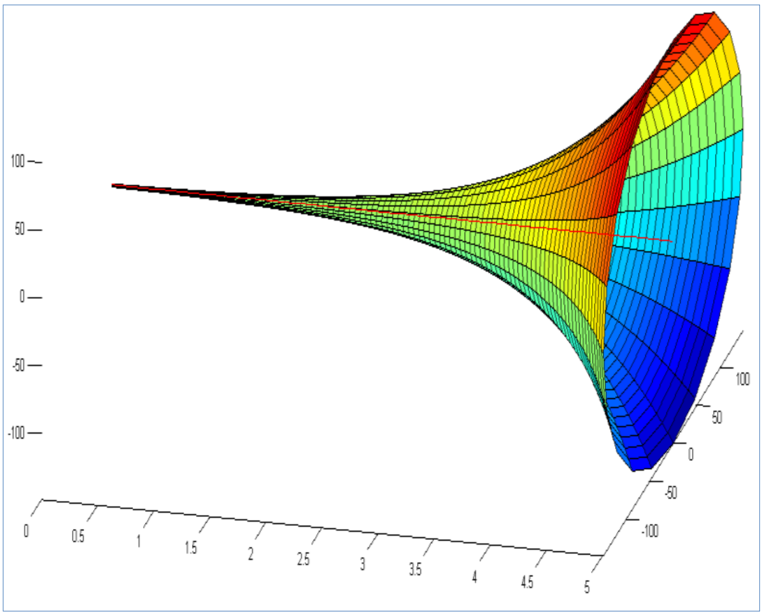


Figure 4.17: Illustration of disk method for finding volume of a solid. The programme was developed by Hill et al. (2002).

The following example was used to demonstrate both the disks method and the cylindrical shells method for visualising the solid and then computing its volume.

Example: Find the volume of the solid that is obtained when the region under the curve $y = 2x^2, y = 0 \ and \ x = 2$ and is revolved about the x-axis.

To sketch the graphs the following MATLAB code was used:

```
syms x x1
x1=sym(0);    % this step is to define the constants such as 0.
ezplot(x1)    % this step is used to graph y=0.
hold on
ezplot(2*x^2,[0,2])
grid
```

Then the software was used to compute the volume of the solid using two different methods as demonstrated below:

Disks method	**Cylindrical shells method**
$$V = \int_0^2 2x^2 dx$$	$$V = 2\pi \int_0^8 y(2 - \sqrt{\frac{y}{2}})dy$$
volume=int(pi*(2*x^2),0,2) single(volume)	syms y volume=int(2*pi*y*(2-sqrt(y/2)),0,8) single(volume)

With MATLAB, students learn to visualise the graphs of mathematical functions, positions of the curves, points of intersection, partitioning of the region into strips, summing process of the volumes of various strips and their approximation, the concept of limit in Riemann sums and evaluating and calculating the integral using the generic formula.

Oftentimes instructors in a traditional class express their inability in covering the required syllabus within the stipulated time. MATLAB will aid in presenting the mathematics concepts, it saves time and can enhances students' understanding of both calculus and engineering.

4.2.7 LABORATORY SIX

Patterns in basic integration formulae and Techniques of integration using patterns

Objectives:

- Exploring patterns in basic integration formulae
- Techniques of integration using patterns

Patterns abound in nature. Their understanding and appreciation could be a powerful tool for learning; exploring the unknown and attempting to better understand complex phenomena of the world. Mathematics is the science of pattern, Devlin (1997). According to the standards of the New Jersey Mathematics Curriculum Framework on patterns, relationships, and functions, the patterns are extremely powerful tools for doing mathematics as they can be used to analyse and solve problems. Mathematics helps in recognising pattern by observing, conjecturing, experimenting, exploring and discovering the phenomenon. It is through understanding regularities in the generated examples students can estimate if the similar pattern will appear when similar types of examples are used. Recognising and explaining patterns is part of the nature of mathematics and searching for patterns and their generalisation is closely linked to algebraic thinking in students; a connection between patterns and algebra. Manitoba Education (2009) describes patterns as one of seven characteristics that define the nature of mathematics; it is about recognizing, describing, and working with numerical and non-numerical patterns. Algebra provides a structure and a language with which to talk about patterns. Thus in this way an innovative and creative learning environment can be created. When students focus on underlying patterns and structures in similar and seemingly diverse situations they appreciate their understanding of the structure of mathematics. An optimum attention to patterns is related to the learning process. Students learn the inductive and deductive models of learning maths when they construct and observe the patterns from specific to general examples and vice versa. An understanding of the mechanism of pattern formation such as temporal patterns and dynamic patterns etc. produces drawing inferences through analogy thereby conjecturing in maths becomes more credible when analogous conjectures turn out to be true.

The study of pattern is useful not only in the learning of mathematics but also for a variety of allied disciplines such as engineering, science and technology. One of the three possible approaches of the use of symbolic software is to assist students in generating many examples from which they can search for symbolic patterns, Heid (2001). Researchers such as Smith (1996), Davies and Fitzharris (1995), Dugdale *et al.* (1995) and Gilligan (1993) have used CAS to discover patterns which helped students in their understanding and learning of mathematics. Patterns such as sequential, spatial, temporal, as well as linguistic and their combinations are frequently encountered in engineering. One of the effective and key strategies that the experts use in acquiring knowledge or solving problems is the observation of noticeable and meaningful patterns of information, Bransford *et al.* (1999). Engineers often use pattern based thinking to solve and analyse complex engineering problems. The use of MATLAB provides unlimited opportunity for problem solving, pattern recognition as well as building mathematical skills and confidence.

In this study, mathematical patterns are introduced to students using a worksheet containing several examples which highlight a number of meaningful patterns. The objective of this activity was for enhancing the learning of mathematics using MATLAB in small students groups. This section specifically focuses on the use of the software for teaching problem solving (inductive and deductive approaches) through the discovery of patterns in mathematics. This was accomplished through experimentation in which several indefinite integrals problems were evaluated and students identified a certain pattern which led to the discovery of some mathematical rules. The pedagogical pattern discovery can be more appealing for generating geometrical patterns of 2D and 3D graphs of mathematical functions which can give an aesthetically appealing feel of mathematics. An illustration of symmetrical patterns in the graphs of some polynomial functions is shown in Figures 4.18 and 4.19.

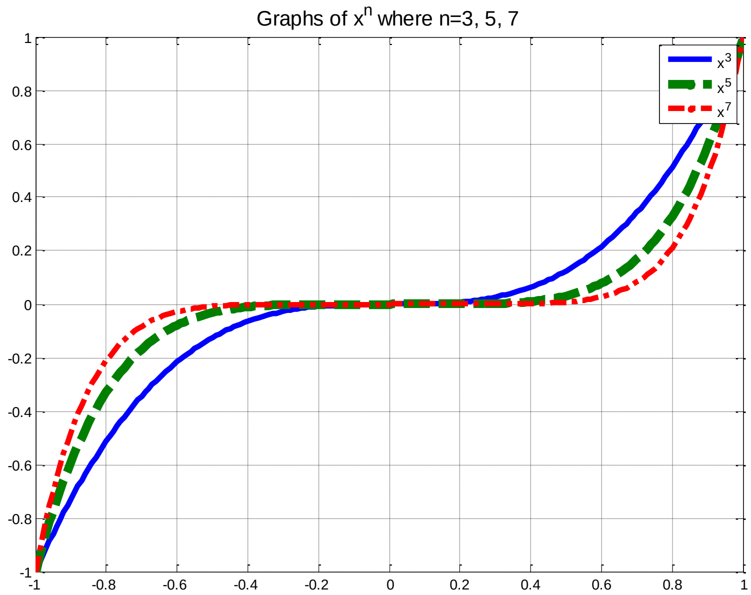


Figure 4.18: Patterns in graphs of simple polynomial functions of the form x^n where n is odd.

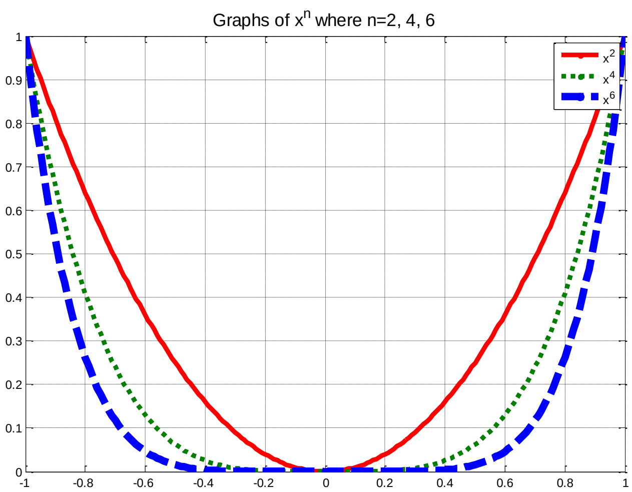


Figure 4.19: Patterns in graphs of simple polynomial functions of the form x^n where n is even.

Some patterns are easy while others are challenging. Simple patterns can be identified in evaluating many indefinite integrals such as the following:

$$\int x^n dx,\ \int x^{\frac{1}{n}} dx,\ \int x^{\frac{m}{n}} dx,\ \int \frac{1}{x^n} dx,$$
$$\int \frac{1}{ax} dx,\ \int \frac{1}{ax+b} dx,\ \int \frac{1}{b-ax} dx,\ \int \frac{2ax+b}{ax^2+bx+c} dx$$

The screen shot of the MATLAB output of evaluating the indefinite of the form $\int (a+bx)^n dx$, are given in Figures 4.20 and 4.21.

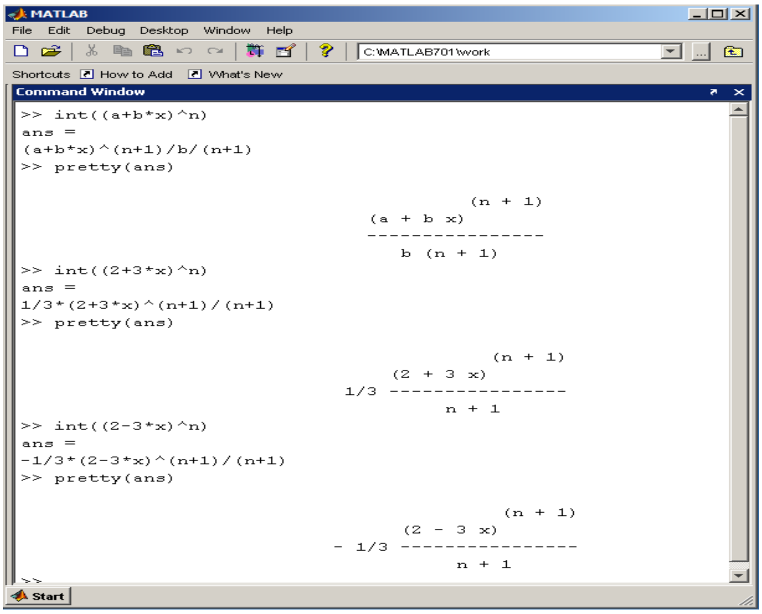


Figure 4.20: MATLAB screen-shot of the algebraic patterns in evaluating the definite integral of the (a+bx)^(1/n)

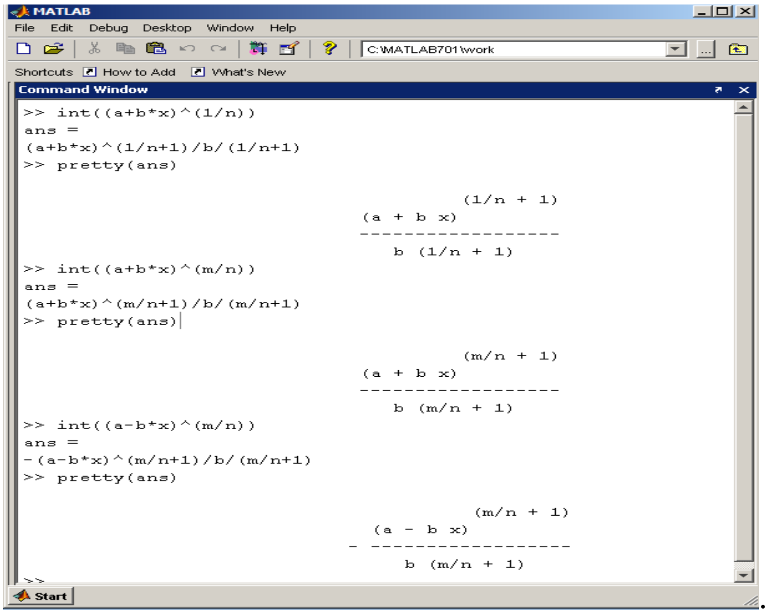


Figure 4.21: MATLAB screen-shot of the algebraic patterns in evaluating the definite integral of the (a+bx)^(1/n)

The ability to scan algebraic expressions, estimating patterns and thus embedding rich mathematical instructional tasks is an interesting area much to be explored by mathematics educators.

4.2.8 LABORATORY SEVEN

Techniques of integration using patterns and multiple representations

Objective:

- Technique of integration using patterns in indefinite integral formulae

The objective of this activity was to enhance the problem solving ability of students in mathematics through the use of MATLAB in small students groups by using patterns recognition as a tool. Again in this lab, like the previous one, students evaluated several indefinite integrals of two composite functions in which some patterns were identified. The concept of evaluating indefinite integrals by the "Integration by parts" method was taught in the classroom. For evaluating such integrals by hand students will not only require a thorough understanding of these integration techniques but will also need to learn the algebraic manipulation involved in the solution. In an attempt to recognise and extend problem pattern, Weimer (1998) asked students to evaluate the integral $\int x^n e^x dx$ by taking n as integers. In this MATLAB-generated screen shown in Figures 4.22 and 4.23, various families of indefinite integrals such as $\int x^2 e^x dx$, $\int x^3 e^x dx$ and $\int x^4 e^x dx$ are evaluated. Students were asked to discover patterns in two representations symbolically and geometrically. An emerging pattern in the output can be easily seen in which the exponential function is taken as a common term in all and the term with the biggest power is followed with its derivatives subsequently for the polynomial function with an alternating sign. Similarly, an interesting pattern can also be found in the graphs of the outputs of these functions as they all behave in the same manner. This type of activity is expected to provide opportunities to learn mathematics with deeper understanding. Students can see the dynamically evolving patterns and make an educated guess for the similar types of problems. The true conjecturing in maths is important; however, it needs to be tested for the accuracy of the solutions as some patterns could be bothersome and misleading.

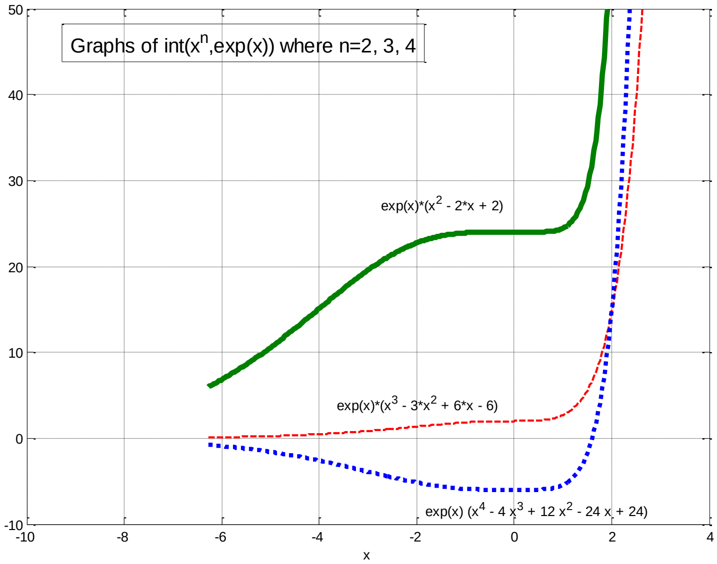


Figure 4.22: MATLAB screen-shot of the geometric patterns in evaluating the integral of the form int(x^n*exp(x))

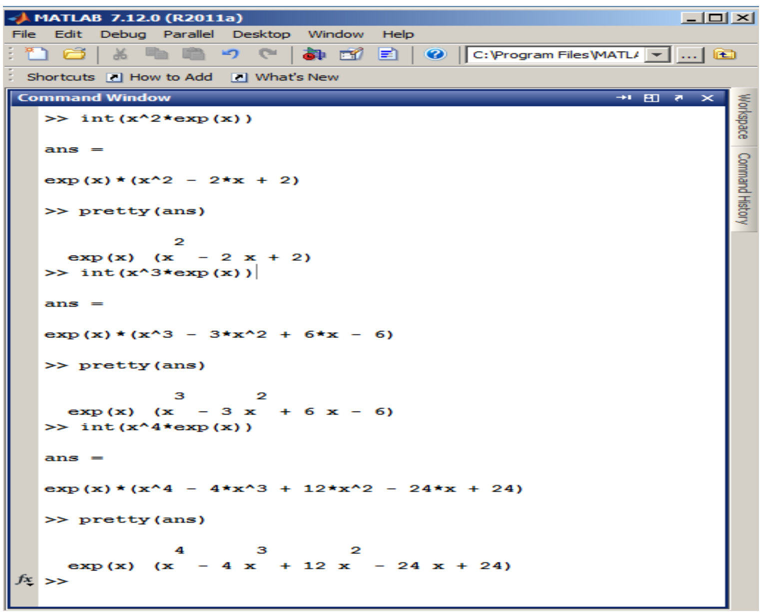


Figure 4.23: MATLAB screen-shot of the algebraic patterns in evaluating the integral of the form int(x^n*exp(x))

The software was used to evaluate a number of certain types of indefinite integrals. To achieve that, some MATLAB code m files were written. Students first evaluated these integrals on the screen followed by discussion with other students they identified the emerging patterns in the integrals. They then noted them in the worksheets provided to them. The approach used here was from specific examples to the general which is called deductive reasoning in mathematics. Much emphasis is given in teaching and learning of mathematics on this approach. Not only students carried out these activities for symbolic patterns but also they used m files for generating the geometrical patterns of the graphs of these integrals. In some cases such as the concept of limit, the students explored three different representations, namely, symbolic, geometric as well as numeric patterns. One of the main objectives of teaching mathematics in the 21st century is the presentation of a mathematical concept in a multiple format that is the rule of three to ease and strengthen the process of learning.

Through the use of MATLAB, students could explore patterns and get the solution in hardly one step compared to the otherwise multi-step analytical solution. A number of problems for evaluating indefinite integrals were demonstrated to students followed by their practice in the computer lab. Following the practice sessions of pattern recognition, students were given the paper-based classroom tests. They found no difficulty in solving the problems taught through the guided discovery using the software.

In the illustrations given below, students were shown many simple examples (starting with the power rule of integration by taking n as integer and rational number) and they were asked to look for the patterns for more generalised problems. An ability of the computer algebra system is that algebraic expressions can be scanned for estimating patterns, Fey (1990). Patterns can also be found in the functions, Stewart (2003) such as $\int x^n e^x dx$, $\int (lnx)^n dx$, $\int x^n lnx dx$, $\int sinax\ cosbx\ dx$, $\int \frac{1}{(x+a)(x+b)} dx$

In this section students used MATLAB to create and identify patterns in various integral formulae. The software acted as a motivating factor as well as a tool for learning mathematics. Recognising pattern will also help engineering students greatly in their core engineering subjects. The MATLAB screen shots of the algebraic and geometric patterns for the functions $\int x\ 2^x dx$, $\int x\ 3^x dx$, $\int x\ 4^x dx$ are give in Figures 4.24, 4.25, 4.26 and Figure 4.27.

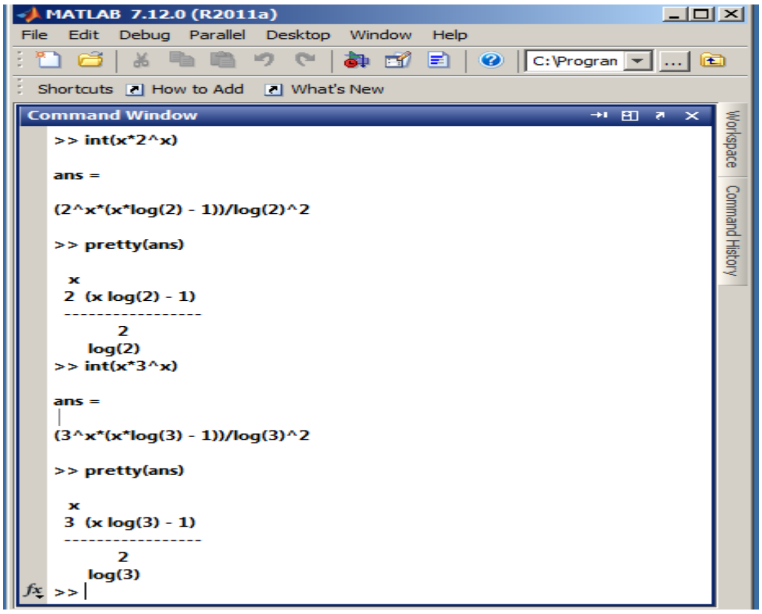


Figure 4.24: MATLAB screen-shot of the algebraic patterns in evaluating the integral of the form int(x*b^x)

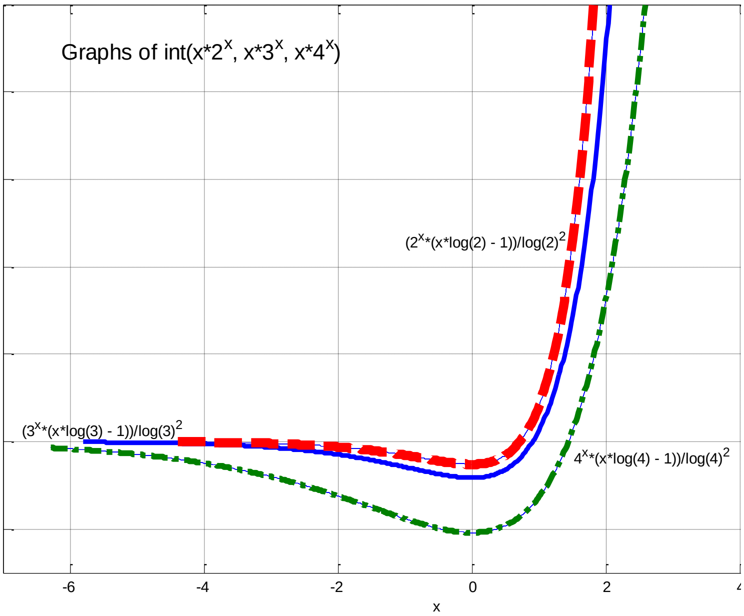


Figure 4.25: MATLAB screen-shot of the geometric patterns in evaluating the integral of the form int(x*b^x)

Graphs of $\int \frac{1}{(x+1)(x+2)} dx,\ \int \frac{1}{(x+2)(x+3)} dx,\ \int \frac{1}{(x+3)(x+4)} dx,\ \int \frac{1}{(x+4)(x+5)} dx$

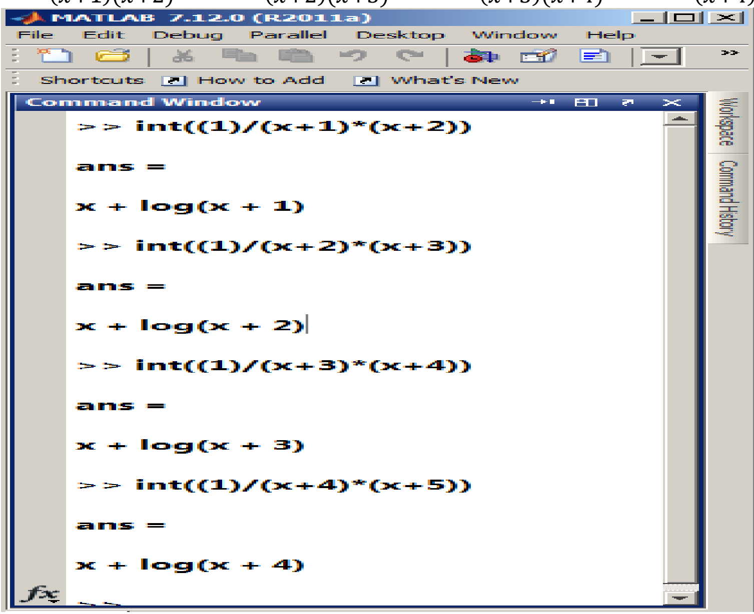


Figure 4.26: MATLAB screen-shot of the algebraic patterns in evaluating the integral of the form int(1/(x+a)(x+b)

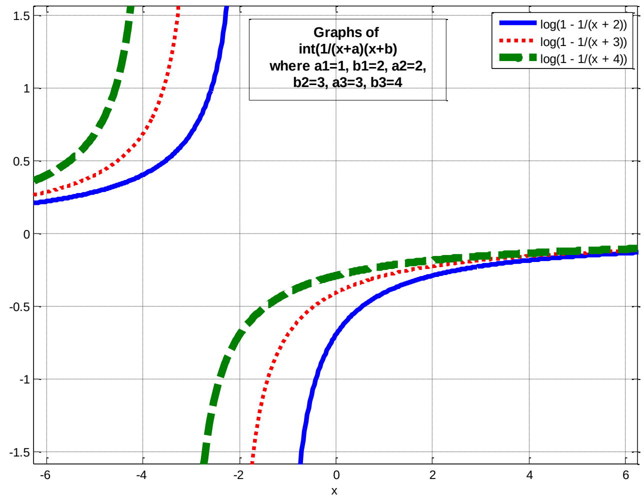


Figure 4.27: MATLAB screen-shot of the geometric patterns in evaluating the integral of the form int(1/(x+a)(x+b)

WORKSHEET: Problem of the type $\int (lnx)^n dx$

Dear Students:

What pattern do you see in the output of these functions? Please explain here.

Then, look at the pattern and guess the value of:

$\int (lnx)^6 dx$=____

$\int (lnx)^n dx$=____

By hand exercises:

What pattern do you see in the output of these functions? Please explain here.

Then, by looking at the pattern and guess the value of:

$\int x\ 5^x dx =$ ____

$\int x\ a^x dx =$ ____

Problems of the type $\int \frac{1}{(x+a)(x+b)} dx$

$\int \frac{1}{(x+5)(x+6)} dx$ =________________

$\int \frac{1}{(x+9)(x+10)} dx$ =________________

$\int \frac{1}{(x+11)(x+12)} dx$ =________________

What pattern do you see in the output of above functions in MATLAB? Please explain here. Then, look at the pattern and guess the value of $\int \frac{1}{(x+a)(x+b)} dx =$ ______________________if a≠b. What if a=b?

Students' sample work relating to patterns is provided in the appendix E.

4.2.9 LABORATORY EIGHT

Sequences, Infinite sum, power series and course material review

Objectives:

- Evaluating sum of an infinite series
- Evaluating power series and producing graphs
- Course Review

Sequences:

The number patterns are also important in finding the general term or formula of a sequence. In simple problem, this can usually be achieved through writing out a few initial terms of a sequence and observing a pattern in them. However, this kind of accepting the guessing process can sometimes lead to incorrect conclusions. Mathematical rigour is therefore required in order to develop a proper understanding of the topic.

Infinite sum:

As discussed in the lab on limits 4.2.1 (c) that this concept plays an important role in the understanding of the two important building blocks of calculus; the derivative and anti-derivative. The concept is also closely related to the understanding of infinite series which are the “sum” of an infinitely many terms. In the study of estimating numerically the behaviour of functions and in their convergence and divergence, the infinite series play an important role. Some of the basic transcendental and non-transcendental functions can be conveniently expressed and approximated in terms of infinite series. Some illustrations of finding sum of infinite series are given in Table 4.2.

Table 4.2: The problems and their MATLAB commands

Problem	MATLAB input command
Find the sum of the series $\sum_{k=0}^{\infty} \frac{5}{4^k}$	syms k symsum(5/4^k,0,inf)
Find the sum of the series $\sum_{k=0}^{\infty} x^k$	symsum(x^k,k,0,inf)
Find the sum of the series $\sum_{k=1}^{\infty} \left(\frac{3}{4^k} - \frac{2}{5^{k-1}}\right)$.	syms k, symsum((3/4^k)-(2/5^(k-1)),1,inf)

Power series:

An infinite series of the form $\sum_{k=0}^{\infty} c_k x^k$ is called the power series, Anton *et al.* (2010) and the Taylor series is one of the most popular power series. The Taylor series expansion of a function is considered the theoretical foundation in mathematical and computational analysis. With the help of this series, any mathematical function can be expressed in terms of its derivatives to the nth order. The Taylor series is powerful in modeling continuous systems in engineering and several other areas of engineering. The series can be applied to get the value of any complicated function at some point provided the functions meet the criteria of differentiability and continuity at that point.

Students find difficulties in understanding it when presented in a traditional format of a lecture method. With the help of MATLAB, coefficients of the series can be constructed easily, graphs can be drawn with little effort and polynomials of high degree can be manipulated, thereby students can spend more time on the underlying principles. The use of the software increases students' interest and motivation in the subject. The syntax of initiating the computation of a Taylor series is: taylor() which returns the nth degree Taylor series for *f* with respect to the variable *x* extended about the value of x_0. The burden of computing the approximations can be shifted to any CAS or built-in CAS capability programme such as MATLAB which would leave more time for exploration of the more meaningful problems rather than mechanical manipulation. Students can differentiate between the linear, quadratic, quartic terms and so on of the functions and recognise the meanings such as the first term, second term involving the first derivative, and the third term involving a second derivative as the value of the function, its slope, concavity respectively. Graphs of functions and their higher derivatives are easy to obtain as shown in Figure 4.28. The obstacle of not enough classroom time could be overcome easily. An illustration of the procedure of finding the Taylor expansion of the $\ln x$ function is described below:

Table 4.3: The MATLAB code for the Taylor approximation of the natural logarithm

MATLAB m.file code

x=0.5:.01:2.5;
p1=log(x);
p2=log(1)+(x-1);
p3=(x-1)-((x-1).^2)./2;
p4=(x-1)-((x-1).^2)./2+2*((x-1).^3)./6;
plot(x,p1,'k-',x,p2,'k--',x,p3,'k-.',x,p4,'k:')
legend('ln(x)','n=1','n=2','n=3')
title('Taylor approximation of ln(x) near x=1','Fontsize',14)

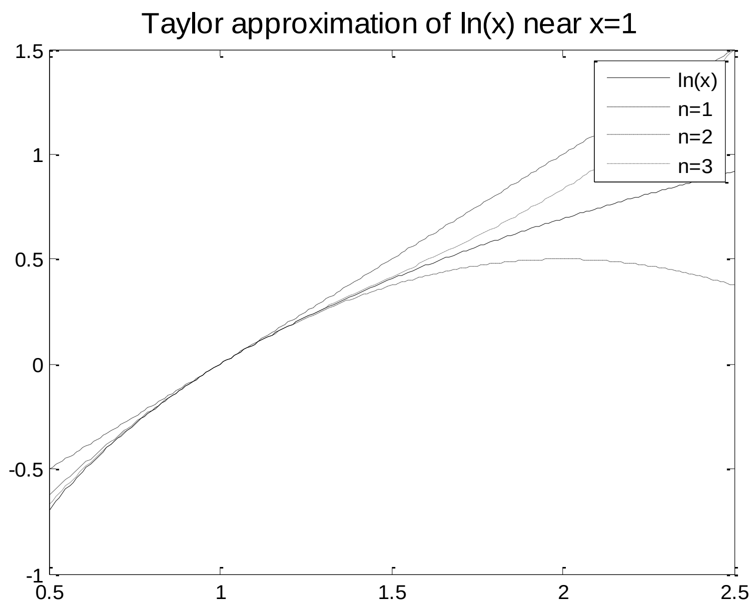


Figure 4.28: MATLAB screen-shot of the graph of Taylor series for the natural logarithm function near x=1

Exercises:
Compute the Taylor series of the functions $f(x) = e^x, at\ x = 1, f(x) = \frac{1}{x-1}\ at\ x = 2.$

The role of computer technology in collaborative small group work in the learning of mathematics is increasingly being considered by universities and colleges around the world. The research in mathematics education is much needed to understand how the computer technology could be effectively used within collaborative classroom environments.

4.3 Collaborative Support (CS)

Among the five types of peer teaching described by Whitman (1988), the work group type is the one in which students are "co-peers" in that they are at the same level and the group share a common task. Students' learning can be enhanced when the opportunities are provided to them in which they can interact with each other in a variety of ways. Johnson *et al.* (2002) have identified five elements for effective cooperative groups and they are positive interdependence, individual accountability, promoting interaction, social skills, and group processing. Students learn mathematics, interactively, collectively and dynamically sharing each other ideas and understanding. According to Johnson *et al.* (1990), students working together in small groups optimises the learning of individual students as well as the entire group. The cooperative learning combined with peer tutoring reduces mathematics anxiety and increases confidence in learning the subject. “The idea is that lessons are created in such a way that students must cooperate in order to achieve their learning objectives”, Slavin (1990).

This strategy was aimed at providing in-class support to students in learning of mathematics by forming small groups. The group formation was informal called self-selected groups and there was no compulsion on students in choosing their learning partners. In this approach, the self-selected groups of students were given mathematical problems worksheets to be completed within the class collaboratively. These problems were designed for students to solve certain conceptual problems as well as the problems already completed in the computer lab with the aid of MATLAB. Basically it was a problem-centered approach in which instructor decides what problems to be given to students according to what has already been covered in the lecture followed by a similar activity in the computer lab. In a typical practice session, students would work on the problems given to them in the printed worksheets. The learning session would not last more than 15 to 20 minutes of the class time as the activity normally involves simple 2 problems centered on a specific concept. The Instructor would ensure that all students are equally involved in the learning activity as all sessions are Instructor-supervised. Students were given all necessary help by the Instructor in order to solve a problem. However, they were encouraged to solve problems on their own. Although the tasks were performed in groups but the submission of the completed worksheet was required by each individual student separately. A sample of the worksheet is attached in Appendix F.

Students actively participate in solving problems and their communication and interpersonal skills are developed. The social setup in learning produces an environment in which students feel motivated to work, they learn new strategies and thinking from their peers and learn new perspectives thereby modifying the existing ones. The responsibility of the group task basically lies on each team member and the traditional threat of being examined in an individual learning and testing does not exist.

Qualitative and quantitative data were collected using student questionnaires; for each activity some questions were given in the worksheets to know students' opinion on the activity and the tasks' usefulness and interviews with some students.

4.4 Bilingual Support (BS)

Several challenges posed by students at the University of Ha'il have been highlighted in Chapter 1 and one of them is the language of instruction. Mathematics for engineering students is taught in English whereas their native language is Arabic. To improve and support students' learning experiences, two types of academic supports were provided to them, firstly, a concept-wise glossary of the Integral Calculus course translated in Arabic and secondly, bilingual peer teaching by students who had relatively a good grasp of both the languages.

Student assisting their fellow student is not a novel strategy in teaching and learning of mathematics. Student acting as teachers has long been in existence in the educational institutions and according to Whitman (1988) its popularity under various names is increasing in higher education as well. The support of senior students is normally sought in tutorial and help sessions in universities around the world. Those who teach others, which is traditionally enjoyed by the Instructors, develop a certain level of cognition in the content to be taught. Schwenk and Whitman (1984) believe that the peer learners benefit because of the ability of peers to teach at the right level.

Peer-tutoring is an instructional technique in which some chosen students peers play the role of instructor in the classroom. This works best in most of the situations and cases where students know the other students very well like the classrooms at this university where all students are Saudi Arabian nationals. Their native language, culture, traditions and even the dialects are almost the same. Simple peer tutoring model was used in the class in which the instructor would teach a concept or a solution to a given problem followed by one of the students from the class to explain the solution in students' native language. Therefore, sampled selected students' peers have been used for explaining a part of the lesson called peer-teaching to strengthen students' understanding of the important concepts of the lessons. The sampling of these peer-tutors was primarily based on a simple test of mathematics vocabulary conducted in the beginning of the semester as well as the instructor's own judgment due to the interaction with them. Additionally, students were also provided with a glossary of difficult words concept-wise in Arabic particularly the vocabulary used in the course as well as the necessary words needed during the everyday lectures. Knowing the vocabulary is essential but the words in mathematics have multiple meanings which require constructing knowledge through proper understanding. Reading comprehension involves skills beyond the word level, such as constructing meaning from text, using metacognitive strategies, and participating in academic language practices, Pressley (2000). There is a strong correlation between the knowledge of vocabulary and the overall academic achievement in students, Biemiller (2001). But students must develop a very good understanding of mathematics vocabulary in order to achieve the mastery over the subject and they should further be able to apply it in relevant situations, Thompson and Rubenstein (2000). The vocabulary distributed to students was made meaningful and contextual by focussing on the concepts taught during lectures. This strategy helps students' in two very important psychological domains of learning and they are cognitive and affective. The next section discusses on improving students study habits and providing them course related material support during the important stages of their preparation.

4.5 Study Support

Students study habits play an important role in their success or failure in academic life. As highlighted in the introduction chapter that many students at the University of Ha'il lack serious and effective approach towards their studies despite the fact that they were taught personality development course at the Preparatory-Year Programme. In this work, the study support is taken as "all those elements capable of responding to a known learner, or group of learners, before, during and after the learning process", Thorpe (2002). The primary goal of this support was to improve the study skills of the engineering students. It was aimed at meeting with students' needs by providing supplementary help.

Following the work of Boelkins *et al.* (1997), the worksheets supplemental to the prescribed textbook were designed and made available on the World of Calculus Website, Appendix H, in order to help and guide students in their studies:

1. A full semester suggested study schedule planner in consultation with some selected students from the class was given to students which included:
    a. homework problem sheets to be done on a daily basis
    b. important notes related to daily lectures
2. General study tips prepared in Arabic by a Professor of Mathematics from KFUPM together with more tips prepared by the instructor in English specific to the course.
3. Learning support resources:
    a. conceptual formulae sheets,
    b. separate sheets on major concepts and theorems of the course,
    c. exam preparation tips,
    d. academic success tips,
    e. sheets on motivation and how to increase concentration in study,
    f. time management sheet,

g. What is calculus? sheet
h. English-Arabic glossary of terms sheet for mathematics adopted from the Preparatory Year Mathematics Programme, KFUPM
i. Complete chapter review summary
j. connections between various course concepts

4.6 Summary

A detailed discussion on each instructional strategy (MSCL, CS, BS and SS) is given. How each computer laboratory session was conducted with the use of MATLAB in small student group is given. It also included the importance of topic to the course and the effectiveness and relevance of computer technology.

CHAPTER 5

RESULTS

5.1 Introduction

This chapter deals with the quantitative and qualitative results obtained in the study. Various inferential statistics were used to measure the effects of the intervention on the mathematical achievement of the Integral Calculus course of the undergraduate Arab engineering students.

A t-test was used to compare the means of the experimental and control groups of students. The regression analysis and Pearson correlations were conducted to determine the relationship between student attitudes towards the instructional strategies and their achievement in mathematics. Univariate analysis was done to examine the effects of covariates on mathematical achievement.

5.2 Quantitative results

A number of statistical techniques (t-test, regression analysis, univariate analysis and Pearson correlation) were used relevant to the data collected for this study.

The independent t-test is an inferential statistical test which determines whether there is a statistically significant difference between the means of two unrelated groups. Two scenarios are popularly reported in the hypothesis testing which are as follows:

1. When the means of both the groups are equal, i.e., H_0: $M_{EG}=M_{CG}$ then the null hypothesis is accepted.

2. When the means of both the groups are unequal, i.e., H_A:$M_{EG} \neq M_{CG}$ then the null hypothesis is rejected and the alternative hypothesis is accepted at a certain significance level such as 0.05.

The General Linear Model of the univariate procedure is used when the study has one dependent and the multiple independent variables. It combines the regression analysis and the analysis of variance. With this procedure, the interaction among variables and covariates can be examined. The Pearson Correlation is used to measure the linear correlation between the dependent and the independent variables ranging between +1 (highly positive), −1 (highly negative) inclusive and the 0 means no correlation. A further sophisticated technique which is stepwise regression was used to estimate the relationship between the dependent variable and the independent variables. The dependent variable was mathematical achievement of students measured by their end-of-course grade. The independent variables were students' attitudes towards mathematics and towards the instructional strategies measured by the self-designed post-study questionnaires. Students' mathematics aptitude, English aptitude and the computer aptitude were chosen as covariates and the grades for these courses were taken from students' academic transcripts/records. The covariates in this study are the pre-requisite courses that students had completed prior to enrolling into the Integral Calculus course. They were used to determine their effects on the dependent variable. A comparison of students' aptitudes of both groups of students is given in the Table 5.1 and Figure 5.1 by calculating their means.

Table 5.1: A comparison of pre-study means of aptitudes of experimental and control groups of students

Aptitudes	Control Group GPA out of 4 points	Experimental Group GPA out of 4 points	Mean Difference (in percentage)
Differential Calculus course	1.726	1.918	4.797
English course	2.226	2.321	2.373
Computer course	2.130	2.709	14.471

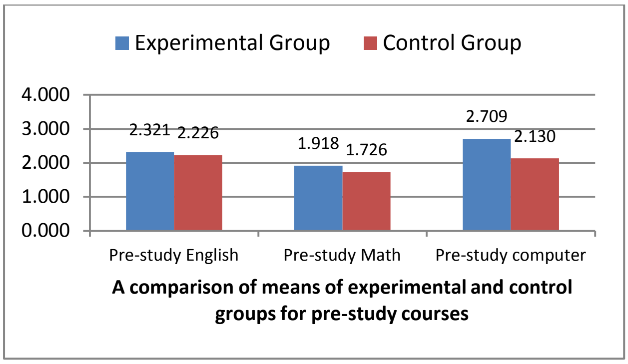


Figure 5.1: Histogram showing the means of aptitudes of experimental and control groups

It can be seen from the comparison that the groups were almost equivalent in pre-study English course with a slight difference of about 2.37%. There is a variation in terms of the pre-study mathematics course with a difference of about 4.79% whereas 14% difference in terms of their computer aptitudes is found.

The true pretest-posttest experimental designs compare and measure the quantitative and qualitative change occurred as a result of intervention (the use of ITIM here) between two or more groups of students. It can be seen from the Table of comparisons that the groups GPAs were almost equivalent with a slight difference of about 2.37% in pre-study English course and 4.79% in pre-study mathematics course. It is important to highlight here the fact that the GPA of the experimental group of students was 14% higher than that of the control group in terms their pre-requisite computer course and the overall marks in the post study mathematical achievement of the experimental group was 13% higher than that of the other group. Since the focus of attention in this study was the mathematical achievement of students, it can be noticed that there was a slight variation in the mathematical aptitudes of the groups at the start of the study. Based on the experience and observation of this instructor teaching students over a number of years, the increase in the computing GPA of students of the experimental group would not be an enough impetus for students to perform significantly better in the mathematical achievement. Moreover, in the pre-study computer course, students are taught computer fundamentals and it is a very basic introductory course. Students with challenges in learning mathematics at this level with the variation in GPA in this particular course would not make a significant difference. Additionally, the examination patterns do not take into consideration the use of computer technology in the teaching and learning of mathematics and not even the use of calculators required in solving all paper based examinations conducted throughout the semester.

From the results of the comparison Table, it is evident that not only the overall success rate of students of the experimental group was 13 % higher than that of the control group; there was a difference of 22% in terms of their grades C and above. A total of 42% of the experimental group achieved higher grades compared to only 20% of that of the control group as can be seen from the Table 5.2 and Figure 5.2. The attributing the difference in the performance of students to higher GPA is difficult as the use of MSCL is one of the four instructional strategies of the ITIM. It could be the synergy effects of the use of the ITIM which might have not only motivated students but also could have provided them enough learning opportunities.

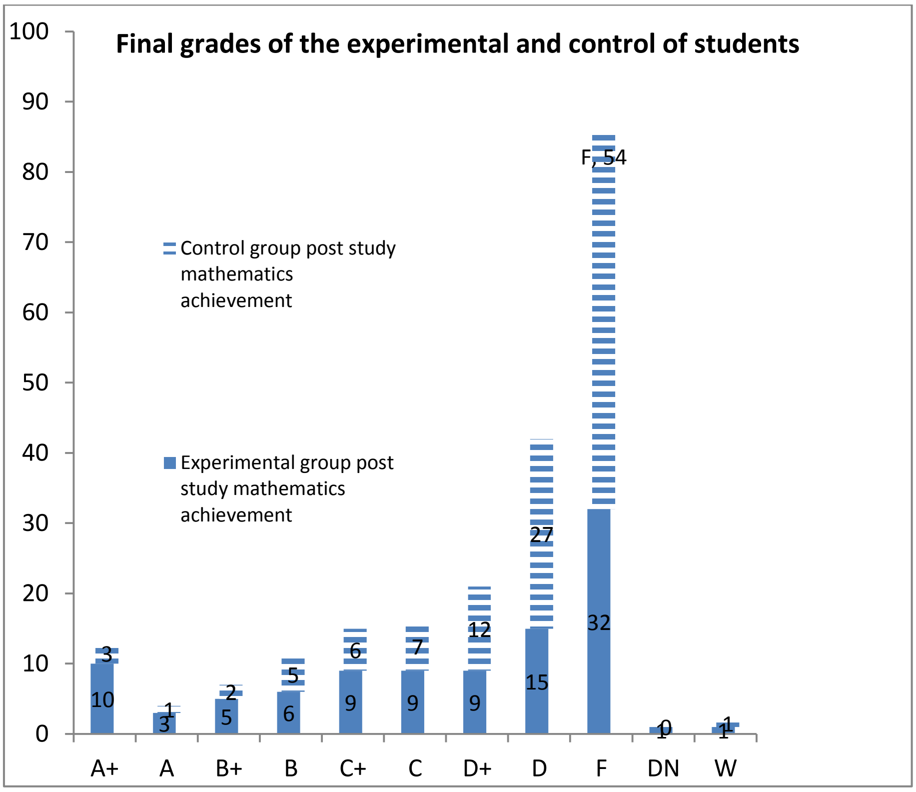


Figure 5.2: A comparison of final grades of experimental and control groups of students in the post-study mathematics

No pre-test was conducted for measuring the equivalence of the groups prior to the study. Equivalence of groups is an important condition in an experimental design research. Differential calculus is a pre-requisite for the Integral Calculus course which is considered a sufficient proof of equivalence at the start of the study.

The post-study analysis of student performance revealed that the pass percentage of the experimental group of students was 66% whereas for the control group it was 53%; a difference of 13% increase. The grades distribution is given in the Table 5.2.

Table 5.2: Grades distribution comparison between experimental and control groups

Grades	Numerical value of each grade (out of 100)	Experimental	Control
C and above	≥66	42%	20%
D/D+	61-65	24%	34%
F	≤60	32%	45%
DN/W	0	2%	2%
Total Pass Percentage		66%	53%

The post-study mathematics course GPA of the experimental group is 1.589 whereas 0.995 is that of the control group with the standard deviations 1.427 and 1.115 respectively. The experimental group of students have higher averages than the control group and a difference of almost 0.634 is evident. These values together with the p-value are indicative that there is a significant difference between the averages of both the groups at the 5% level. The averages of the final grades of the control and the experimental groups of students are given in Table 5.3.

Table 5.3: A post-study comparison of mean scores of both the groups of students

Course	Control	Experimental
Integral Calculus	0.955/4	1.589/4

In the section to follow, research hypotheses outlined in the Methods Chapter are tested statistically first. The study has used a combination of quantitative and qualitative techniques for a comprehensive overall assessment of the impact of the intervention. Data triangulation helps to ensure credibility and verisimilitude, Stake (2010), Patton (2002). The quantitative instrumentations used were questionnaires, students' academic records and their performance in examinations.

5.2.1 Testing null hypotheses

Hypothesis one: There is no significant difference between the achievement of the experimental and the control groups in the Integral Calculus course when the experimental group was taught by the traditional lecture method supplemented with the ITIM.

The end-of-course mathematics achievement between the control group and the experimental group was computed by the independent two-sample t-test to determine the significance of the intervention. The groups' statistic Table 5.4 shows that the averages and the standard deviations of both the groups are different. Keeping this point in view the t-statistic was computed between these two groups and a significant difference was found. This can be seen from the independent t-test Table 5.5 for equal variances assumed. The probability p=0.000 which is tested at the 5% level of significance. Similar analysis is done for testing the difference of variances by Snedecor's F-test and it was found that variances are same. That means there is a significant difference between the control and the experimental groups this is because p=0.000. Therefore, the null hypothesis is rejected and the alternative hypothesis is accepted.

Only 117 students of the control group and 98 of the experimental group were chosen in this study due to students' DN and withdrawals from the course.

Table 5.4: Group Statistics

	Target	N	Mean	Std. Deviation	Std. Error Mean
Integral Calculus	Control	117	0.96	1.115	0.103
	Experimental	98	1.59	1.427	0.144

Table 5.5: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Integral Calculus	Equal variances assumed	13.964	0.000	3.656	213	0.000	0.634	0.173	0.292	0.976
	Equal variances not assumed			3.579	181.895	0.000	0.634	0.177	0.285	0.984

The multiple regression model revealed a dependence of 60% on the criterion variable which is the end-of-semester final grade in the Integral Calculus course. This can be seen from the Model Summary Table 5.6 in which the R^2 value is 0.600.

Table 5.6: Regression Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.775[a]	.600	.562	.95464	.600	15.742	8	84	.000	2.121

a. Predictors: (Constant), Pre_study_computer, Attitudes_towards_MATLAB, Attitudes_towards_maths, Attitudes_towards_bilingual_support, Attitudes_towards_study_support, Pre_Study_maths, Attitudes_towards_Collaborative_support, Pre_study_English

b. Dependent Variable: Post_study_maths

Hypothesis two: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of MATLAB supported collaborative learning as a supplement.

To answer this question, a bivariate coefficient correlation was computed and the value obtained was 0.475 which is much higher than 0.05. This indicates that the variables considered are not associated. This fact can be seen from Table 5.10 of correlations. Therefore, the null hypothesis is accepted. However, the data collected through student questionnaire and the interviews revealed positive attitudes of students towards the use of MATLAB as a supplement to the traditional lecture method. More than 70% of students expressed the usefulness of MATLAB in the course.

Hypothesis three: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of collaborative support as a supplement.

To answer this question, a bivariate coefficient correlation was computed and the value obtained was 0.383 which is much higher than 0.05. This indicates that the variables considered are not associated. This fact can be seen from the Table 5.10 of correlations. Therefore, the null hypothesis is accepted. However, the data collected through student questionnaire and the interviews revealed strong positive attitudes of students towards the use of collaborative supported learning as a supplement to the traditional lecture method. More than 76% of students expressed the usefulness of this strategy in the course.

Hypothesis four: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of bilingual support as a supplement.

To answer this question, a bivariate coefficient correlation was computed and the value obtained was 0.202 which is much higher than 0.05. This indicates that the variables considered are not associated. This fact can be seen from Table 5.10 of correlations. Therefore, the null hypothesis is accepted. However, the data collected through student questionnaire and the interviews revealed strong positive attitudes of students towards the use of bilingual support as a supplement to the traditional lecture method. About 86% of students expressed the usefulness of this support in the course.

Hypothesis five: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of study support as a supplement.

To answer this question, a bivariate coefficient correlation was computed and the value obtained was 0.248 which is much higher than 0.05. This indicates that the variables considered are not associated. This fact can be seen from Table 5.10 of correlations. Therefore, the null hypothesis is accepted. However, the data collected through student questionnaire and the interviews revealed positive attitudes of students towards the use of study support as a supplement to the traditional lecture method. About 63% of students expressed the usefulness of this supplement in the course.

Hypothesis six: There is no significant relationship between the achievement in Integral Calculus and the English aptitude of the experimental group.

To answer this question, a bivariate coefficient correlation was computed and the value obtained was 0.000 which is much lower than 0.05. This indicates that the variables considered are strongly associated. This fact can be seen from the Table 5.10 of correlations. Therefore, the null hypothesis is rejected and the alternative hypothesis is accepted.

Hypothesis seven: There is no significant relationship between the achievement in Integral Calculus and the computer aptitude of the experimental group.

To answer this question, a bivariate coefficient correlation was computed and the value obtained was 0.000 which is much lower than 0.05. This indicates that the variables considered are strongly associated. This fact can be seen from the Table 5.10 of correlations. Therefore, the null hypothesis is rejected and the alternative hypothesis is accepted.

Hypothesis eight: There is no significant relationship between the achievement in Integral Calculus and the mathematics aptitude of the experimental group.

To determine whether these two variables are related or not, a paired sample statistic was carried out. The paired sample statistic Tables 5.7, 5.8 and 5.9 show that the averages and standard deviations of both the groups are different. Keeping this point in view, paired sample correlation was computed between these two courses and found a significant difference. This can be seen from the paired sample correlation, the probability p = 0.000 which is tested at the 5% level of significance. Similar analysis is done for testing the correlation whose value is 0.675. Therefore, the null hypothesis is rejected and the alternative hypothesis is accepted.

Table 5.7: Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Study Math	1.918	98	0.985	0.099
	Integral Calculus	1.589	98	1.426	0.144

Table 5.8: Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-Study Maths Integral Calculus	98	0.675	0.000

Table 5.9: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1	Pre-study maths Integral Calculus	0.239	1.052	0.106	0.118	0.540	3.094	97	0.003

Hypothesis nine: There is no significant relationship between the achievement in Integral Calculus and the Attitudes Towards Mathematics of the experimental group.

To answer this question, a bivariate coefficient correlation was computed and the value obtained was 0.396 which is much higher than 0.05. This indicates that the variables considered are not associated. This fact can be seen from Table 5.10 of correlations. Therefore the null hypothesis is accepted.

Table 5.10: Bivariate coefficient correlation

		Integral Calculus	English aptitude	Maths aptitude	Computer aptitude	MSCL	CSL	BS	SS	Attitudes Towards Maths
Pearson Correlation	Integral Calculus	1.000	0.558	0.676	0.514	0.007	0.031	-0.088	-0.072	0.028
	English aptitude	0.558	1.000	0.463	0.539	-0.012	-0.094	0.092	-0.028	0.034
	Maths aptitude	0.676	0.463	1.000	0.349	0.092	-0.108	-0.082	-0.004	0.111
	Computer aptitude	0.514	0.539	0.349	1.000	0.004	-0.059	-0.073	-0.093	0.011
	MSCL	0.007	-0.012	0.092	0.004	1.000	0.200	-0.107	0.195	0.028
	CSL	0.031	-0.094	-0.108	-0.059	0.200	1.000	0.215	0.068	-0.213
	BS	-0.088	0.092	-0.082	-0.073	-0.107	0.215	1.000	-0.156	0.129
	SS	-0.072	-0.028	-0.004	-0.093	0.195	0.068	-0.156	1.000	0.198
	Attitudes Towards Maths	0.028	0.034	0.111	0.011	0.028	-0.213	0.129	0.198	1.000
Sig. (1-tailed)	Integral Calculus	.	0.000	0.000	0.000	0.475	0.383	0.202	0.248	0.396
	English aptitude	0.000	.	0.000	0.000	0.454	0.185	0.191	0.394	0.373
	Maths aptitude	0.000	0.000	.	0.000	0.190	0.152	0.219	0.486	0.146
	Computer aptitude	0.000	0.000	0.000	.	0.485	0.288	0.243	0.187	0.460
	MSCL	0.475	0.454	0.190	0.485	.	0.028	0.153	0.031	0.395
	CSL	0.383	0.185	0.152	0.288	0.028	.	0.019	0.259	0.020
	BS	0.202	0.191	0.219	0.243	0.153	0.019	.	0.068	0.109
	SS	0.248	0.394	0.486	0.187	0.031	0.259	0.068	.	0.028
		0.396	0.373	0.146	0.460	0.395	0.020	0.109	0.028	.

5.2.2 Regression

To explore the effect on experimental group's mathematics course marks versus all the independent variables (the use of MATLAB-supported Collaborative Learning, Collaborative support, bilingual support, study support as supplement to the traditional lecture method in addition to the pre-study English course, pre-study mathematics course and pre-study computer course as covariates) and Attitudes Towards Mathematics, a powerful statistical technique called stepwise regression was employed. Its purpose was to see which independent variables influence the dependent variable. The results are given in the Table 5.13 and the model summary

Table 5.6. This technique fits the data into three models with the dependent variable as the experimental group's post-study mathematics course. While the dependent variable is the post-study mathematics course with the covariate as pre-study mathematics course as the first model, the second model with the same dependent variable and the covariates are considered as pre-study mathematics course and pre-study computer courses and the third model is pre-study mathematics, pre-study computer and pre-study English. The independent variables of the study are attitudes towards the use of ITIM and mathematics and they revealed no effect on the dependent variable as evident from the model summary Table 5.13. The dependent variable that is post-study mathematics course marks prediction is dependent on the three covariates as described in the model. The stepwise regression gives 45.6% dependence on pre-study mathematics course marks as indicated by the R^2=0.456 in the first model Table 5.6. The second model Table 5.13 shows that the dependent variable has a dependence of 53.6% on the pre-study mathematics and pre-study computer courses as indicated by the R^2=0.536 while the third model Table 5.13 indicates that the combined dependence of all three covariates is 55.8% as indicated by the R^2=0.558. These R^2 values are significant indicating that the models fitted are the best models for estimating the dependent variable. Also, for these models the coefficients are tested through the t-test and found all the independent variables considering the three models are necessary to predict the achievement in the Integral Calculus course.

Table 5.11: Mean, Standard Deviation and Number of students in the experimental group

	Mean	**Std. Deviation**	**N**
Integral Calculus	1.631	1.442	93
Pre-study English	2.328	0.973	93
Pre-study mathematics	1.935	0.999	93
Pre-study computer	2.693	1.043	93
MSCL	3.820	0.743	93
CSL	3.588	0.624	93
BS	4.073	0.738	93
SS	3.540	0.654	93
Mathematics attitudes	3.206	0.490	93

Table 5.12: Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	Integral Calculus Pre-study English Pre-study maths Pre-study computer MSCL CSL BS SS Maths attitudes[a]		

a. All requested variables entered.
b. Dependent Variable: Integral Calculus

Table 5.13: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.675[a]	0.456	0.450	1.057	0.456	80.450	1	96	0.000	
2	0.732[b]	0.536	0.526	0.928	0.080	16.370	1	95	0.000	
3	0.747[c]	0.558	0.544	0.963	0.022	4.651	1	94	0.034	2.186

a. Predictors: (Constant), Pre-study mathematics
b. Predictors: (Constant), Pre-study maths, Pre-study computer
c. Predictors: (Constant), Pre-study maths, Pre-study computer, Pre-study English
d. Dependent variable: Post-study maths GPA (Integral Calculus)

Table 5.14: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	90.005	1	90.005	80.450	0.000[a]
	Residual	107.401	96	1.119		
	Total	197.406	97			
2	Regression	105.792	2	52.896	54.851	0.000[b]
	Residual	91.614	95	0964		
	Total	197.406	97			
3	Regression	1110.11	3	36.704		0.000[c]
	Residual	87.295	94	0.929	39.523	
	Total	197.406	97			

a. Predictors: (Constant), Pre-study maths
b. Predictors: (Constant), Pre-study maths, Pre-study computer
c. Predictors: (Constant), Pre-study maths, Pre-study computer, Pre-study English
d. Dependent variable: Post-study maths GPA (Integral Calculus)

Table 5.15: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.286	.235		-1.217	.227
	Pre_study_math	.977	.109	.675	8.969	.000
2	(Constant)	-1.137	.303		-3.753	.000
	Pre_study_math	.837	.107	.578	7.825	.000
	Pre_study_computer	.414	.102	.299	4.046	.000
3	(Constant)	-1.318	.309		-4.266	.000
	Pre_study_math	.753	.112	.520	6.727	.000
	Pre_study_computer	.300	.113	.217	2.651	.009
	Pre_study_English	.280	.130	.187	2.157	.034

a. Dependent Variable: Post_study_math_GPA

The regression equations from the coefficient Table 5.14 are as follows:

10. Y(DV)= -0.286+Experimental Group (Pre_study_math)(0.977);
11. Y(DV)= -1.137+Experimental Group (Pre-study_math)(0.837)+ Experimental Group (Pre-study_computer)(0.414)
12. Y(DV)= -1.318+Experimental Group (Pre-study_math)(0.753)+ Experimental Group (Pre-study_computer)(0.300)+Experimental Group (Pre_study_English) (0.280)

5.2.3 Self-Designed Questionnaire relating to students' Attitudes Towards Mathematics

The self-designed questionnaire consisted of three subscales (confidence, liking, usefulness) relating to students' attitudes toward mathematics given in Table 5.16 and the graph of the question “With MATLAB, I found the sketching of graphs” is shown in Figure 5.3. The graphs of each question of the questionnaire are provided in the Appendix C. From the graphs, it can be seen that students have shown positive attitudes towards mathematics.

Table 5.16: Means of maths attitude sub-scales

Subscale	Self-Designed Questionnaire (Post-Study)
Confidence	57.46%
Usefulness	57.03%
Liking	60.00%

For establishing the reliability of the questionnaire, Cronbach's alpha coefficient was computed using the SPSS software and the values are given in Table 5.17.

Table 5.17: The Cronbach's alpha coefficient of the post-study questionnaire

Instructional Strategies	Cronbach's alpha Coefficient
MATLAB-Supported Collaborative Learning	0.97
Collaborative Support	0.91
Bilingual Support	0.93
Study Support	0.94
Attitudes Towards Mathematics	0.96

5.2.4 Students' attitudes towards the use of MATLAB

The graphs of each question of the questionnaire are provided in the Appendix C. From the graphs, it can be seen that students have shown positive attitudes towards MATLAB. One of the research questions of this study was to examine student attitudes toward the use of MATLAB supported collaborative learning. In the measurement of attitudes, the subscales which were used were confidence, enjoyment, liking and usefulness. More specifically, the questions examined were the following:

- How confident students felt while using technology in the learning of maths?
- Did they like its use?
- What are their attitudes toward the usefulness of this particular computer programme?
- How much they enjoyed learning maths using MATLAB?

Table 5.18: Attitudes towards the use of MSCL

Confidence	65%
Liking	78%
Enjoyment	70%
Usefulness	66%

The MATLAB-based worksheets for mathematical tasks had questions relating to the usefulness of the software. Overall 60% students rated as shown in Figure 5.3 that the sketching of graphs using MATLAB was easy and 40% expressed not easy.

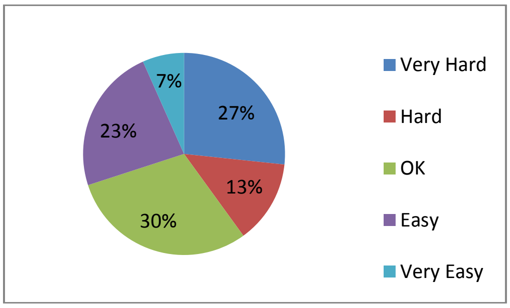


Figure 5.3: Students' responses to the question "With MATLAB, I found the sketching of graphs"

Students expressed their opinion about the use of MATLAB for finding patterns in simple integration problems and it can be seen from the Figure 5.4 that 8% felt that it was hard to use whereas 75% expressed OK and 17% felt that it was easy to use.

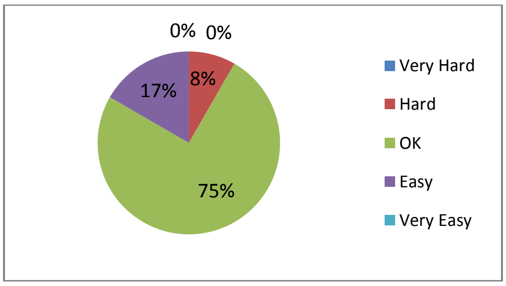


Figure 5.4: Students' responses to the question "With MATLAB, I found the patterns in simple integration problems"

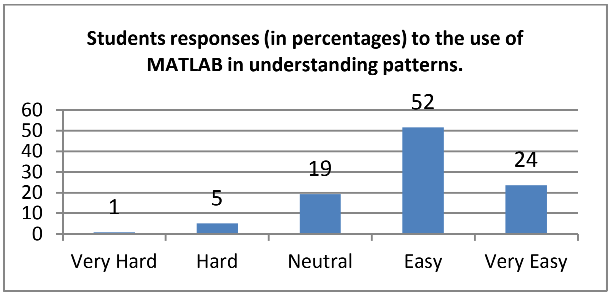


Figure 5.5: Students responses (in percentages) to the use of MATLAB in understanding patterns

It can be seen from the Figure 5.5 that a significant percentage of students (76%) found MATLAB to be helpful in understanding patterns in the Integral calculus course. However, 6% of the students found it hard to figure out the patterns and the remaining expressed no opinion.

5.2.5 Students' attitudes towards the use of collaborative support

Relating to the attitudes towards the use of learning in collaboration as a supplement, a majority of students expressed their confidence, liking, usefulness and enjoyment as referred to in Table 5.19. When students were asked about whether the use of Collaborative support helped in learning mathematics, more than 80% felt that this strategy has helped them whereas less that 20% disliked it as shown in Figure 5.6. The graphs of each question of the questionnaire are provided in the Appendix C. From the graphs, it can be seen that students have shown positive attitudes towards group work.

Table 5.19: Attitudes towards the use of CS

Confidence	66%
Liking	69%
Enjoyment	77%
Usefulness	76%

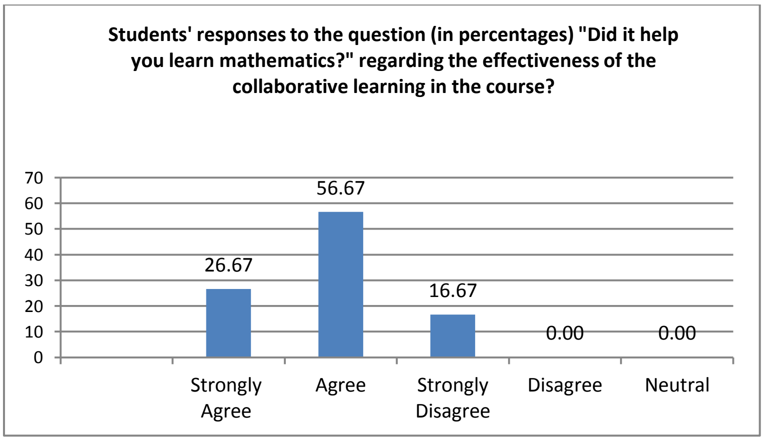


Figure 5.6: Responses to collaborative support worksheet assignment

5.2.6 Students' attitudes towards the use of bilingual support

With regard to this strategy as shown in Table 5.20, an overwhelming number of students expressed positive attitudes towards the usefulness; liking and enjoyment towards the use of the bilingual support in their learning. The graphs of each question of the questionnaire are provided in the Appendix C. From the graphs, it can be seen that students have shown positive attitudes towards bilingual support.

Table 5.20: Attitudes towards the use of BS

Liking	81%
Enjoyment	77%
Usefulness	86%

5.2.7 Students' attitudes towards the use of study support

Hawkes and Savage (2000) recommended implementing a wide range of follow-up strategies and various ways of finding to deal with the mathematics teaching of first year undergraduates. These include computer assisted learning of mathematics, support centres, supplementary lectures and the provision of study support. According to Green *et al.* (2003) collaborative work, academic support, offline and online lecture notes enhance the learning of mathematics for engineering undergraduates. The students in this study have expressed a strong liking and usefulness of this strategy in their learning of mathematics and thus their overall achievement in the course. This reporting is indicative of the data obtained in this study. The graphs of each question of the questionnaire are provided in Appendix C. From Table 5.21 it can be seen that students have shown positive attitudes towards study support.

Table 5.21: Attitudes towards the use of SS

Liking	60 %
Usefulness	63 %

5.3 Qualitative Results: Interviews relating to students' attitudes towards strategies

Interviews and the group interviews regarding the attitude toward the use of strategies were conducted.

5.3.1 MATLAB-Supported Collaborative Learning

Interviews of individual students were conducted by the Instructor-Researcher at two different times; one during the mid-semester and the other was towards the end of the semester. The interviews scheduled in the middle of the semester were to review the effectiveness of the implemented strategies and subsequently to know students' experiences. Because there were a range of instructional strategies together with the challenge of conducting interviews in English with students, some of the interviews lasted for about 30 to 40 minutes. The English proficiency of the participating student and their willingness to take part in the process were two important factors for the successful interviewing. Interviews were audio-taped as suggested by Spradley (1979). Although the interviews were conducted in English, occasionally the interviewer had to use some difficult key words in Arabic and oftentimes the questions had to be repeated. Therefore their verbatim transcription is not being provided here.

The interviews analyses revealed a number of emerging insights and patterns. Taylor and Bogdan (1989) consider vocabulary, meanings, and feelings among others as insights based on patterns. The main themes were centred on the instructional strategies used in the study. MATLAB supported collaborative learning had some of the themes relating to the ease of use of the software, its use in student groups, worksheets and usefulness of the software used. In some instances, direct quotes of students are mentioned.

When students were asked about the need for training or tutorial classes for learning the software, more than 60% of them said that one or two introductory classes would be enough to get the familiarity with it. They perceived executing the m.files as not much different from using a calculator. One student commented that "if a student's English is good, he can learn it without the help of a teacher'. Students appreciated the immediate feedback provided by the software. One student commented that if a mistake in typing the command is done then the software will immediately display an error message. The student believed that they learn from this immediate feedback. He compared this with a traditional class in which a mistake is done which many a time remains unnoticed. Moreover, students observed that writing or modifying m.files in a particular sequence of steps helps in understanding the concepts and procedures in mathematics. They believed that such type of exercise is more useful than copying the notes from the traditional white board. One student expressed his view that he normally doesn't learn much by simply copying from the board in a traditional class.

Another student expressed that one of the biggest challenges for him in exams is to ensure that his answers are correct. He described that the algebraic and geometric visuals patterns could help him in exams. "If you know the answer before you begin solving a problem then half of your job is done". Another student said that if the homework is not checked and no timely feedback is given then he would be uncertain about his solutions and he might do the same in exams. Student liked that the software can give answers to the problems. As the key to the even numbered exercises is not provided in the textbook, students used the software to find their answers. They particularly used it for homework problems. Getting an immediate feedback to students' homework problems has normally been a concern for them.

To the question about the best and the most interesting aspect of the software, students described that they liked sketching graphs of mathematical functions. Upon further probe, they said that the 2-D and 3-D graphs of several functions can be drawn in a little time with lot of ease and efficiency which otherwise takes lot of time if performed in a traditional way. Generating multiple graphs helps in remembering and recalling their shapes while solving problems remarked one student. In contrary, a couple of students mentioned that the amount of time they have spent on MATLAB for learning mathematics was not worth-spending when compared with their learning in a traditional environment. Their disliking could be partly due to the fact that the software was not an integral part of the teaching, learning and testing and this has been their first experience using a computer as a learning tool.

More than $3/4^{th}$ of the participating students suggested spending 50% time in-class and the rest of the 50% in the computer lab. This means that from a total of 4 hours a week, students preferred to use 2 hours in a traditional class and 2 hours in a computer lab. Those who did not like the software or were unsure about its benefits suggested using it for 1 hour a week that is 25% of the total weekly time. However, a majority felt that if the software is used in exams then more time can be allocated for its use and if no exam can be given with the software then still it can be used for improving students' knowledge. This can be done after completing a topic in the class in a traditional manner and then reinforcing it in the lab. A few students have even spoken about incorporating MATLAB in a formal course. "I don't want to do graphing and even integration by hand when a computer can do it", one student said.

The Instructor-Researcher held group interviews during the class times in which all participating students were involved. They were given a few minutes to form groups of their choice so that they could involve those peers with whom they had normally completed the in-class and in-lab tasks. A brief introduction to the purpose of the group interview was given to students.

Students freely expressed their views about the strategies used as intervention during the semester. Many of them appreciated the use of the strategies in general without much variation in their opinions. They particularly liked the software and a majority of them favoured incorporating it as a compulsory component for teaching and learning calculus. Some students suggested that the software should be taught as a course prior to taking the calculus course and a similar view was expressed in individual interview with students. They expressed a concern that simultaneous learning of the software as well as learning of mathematics is a heavy task. Students liked the visualisation of graphs the most followed by exploring the patterns in indefinite integrals. They also liked the programme for generating the volume of the solids of revolution. The quick computation capability was also preferred by many students. One student said that the programme helps to visualise patterns in the solution of various indefinite integrals problems and the student called this a short-cut method. It gives the answer in only one step which is otherwise a multi-step complicated process in a traditional analytical way. One student suggested that MATLAB could also be used more as a demonstration tool in the class instead of students' spending time in the lab.

The students who did not like the software at all have categorically opposed the idea of using it for learning mathematics. They held firmly to their past beliefs of learning of mathematics traditionally. These students believe that the software would not help them in learning mathematics. One student firmly rejected the idea of using the software in learning mathematics. His argument was that more maths can be learnt in a traditional class than in a computer lab. This student had attended all MATLAB sessions and was an active participant. However, over time his opinion had changed. When this student was reminded about his positive responses in the questionnaire, his reply was that what he had expressed earlier was not true. He believed that hardly 25% of students liked to use MATLAB in maths and other did not like it at all. He further commented that the responses provided by students in questionnaire are not true reflection of their opinions and views as they are contrary to their actual feelings. Students have the habit of saying positive things because of some unknown reasons, he added. The student said that it is better to offer a separate course for learning MATLAB prior to learning the maths course. It was difficult to figure out why there was a change in this particular student's opinion. Although he opposed its use but he at one stage suggested this to be introduced as a separate course.

Some students although liked the graphing capability of the software but still preferred to use the pen-paper method. Part of the reason for their disliking the software was probably due to the traditional nature of exams at the university without having access to any computer software.

Summarised below are students' views about the use of the software and its usefulness expressed through semi-structured interviews and in group interviews:

- It is good that the software gives the answer not the steps. Because there are different ways of solving a problem in maths. In our course, there are lots of rules and ways of doing one problem.
- The software will be more useful if we know it well. It is good to be familiar the use of the software in the freshman year.
- It is a reliable programme, therefore allocate some marks for its use and make it an integral part of the syllabus.
- Patterns are interesting. Problems of a particular type can be taken and patterns could be explored in them.
- Graphing is easy and interesting. It is best for sketching graphs.
- It should be used once a week.
- It is a helping device. It assists in understanding maths.
- It translates maths to computer language.
- Commands are easy to use.
- Some relevance of maths in our life can be seen from the shapes of functions generated in MATLAB.
- Many problems can be solved in a short time.
- It is accurate, fast and provides instant feedback.
- Solving together with other students is fun.
- It is good to learn because it is used in the future.
- Time spent learning the software is not wasted.
- I learnt many things.

Students were also asked about the best and the worst parts of their experiences of using the software. Most positive aspects of the software:

- Its speed of solving.
- Sketching graphs.

- More fun and interesting to use.
- Short steps.
- Increases curiosity

Most negative or frustrating aspects of the software:

- Errors (syntactical, typo, use of parentheses).
- In some cases, MATLAB’s output was different from the textbook answer.
- It is not used in final exam.
- Sometimes not sure which command to use?
- No steps for solution.

Students enjoyed seeing intuitive animations and visuals in problems such as solids of revolutions. Usually they find this topic challenging when presented in a traditional class. Students' opinions were asked about using MATLAB as a supplemental tool for learning the Integral Calculus. A vast majority of them liked the use of computer lab and suggested this approach to be implemented for all maths courses. The problems which are done in the class can be repeated in the lab and more complicated problems could be tried. Students sample work as given in Figures 5.7 (a), (b), & (c), 5.8 & 5.9 (a) and (b).

Patterns in integrals:

	Problem	MATLAB command	Answer
1.	$\int \ln x dx$	int(log(x))	$x(\log x - 1)$
2.	$\int x \ln x dx$	int(x*log(x))	$x^2(\log(x) - \frac{1}{2})/2$
3.	$\int x^2 \ln x dx$	int(x^2*log(x))	$x^3(\log(x) - \frac{1}{3})/3$
4.	$\int x^3 \ln x dx$	int(x^3*log(x))	$x^4(\log(x) - \frac{1}{4})/4$
5.	$\int x^7 \ln x dx$	int(x^7*log(x))	$x^8(\log(x) - \frac{1}{8})/8$

What pattern do you see in the answer above?

If there are two functions on is (x^n) and the other is $(\ln x)$ function the answer will be (x) with $(n+1)$ multiply by $(\ln x)$ minus$(-)$ one (1) over $(n+1)$ and all over $(n+1)$

Based on the pattern above:

1. Guess the value of the integral $\int x^n \ln x dx$:

$$\frac{x^{n+1} \ln x - \frac{1}{n+1}}{n+1}$$

2. Evaluate the answer by hand.

Figure 5.7: Students' MSCL sample work

Patterns in integrals:

	Problem	MATLAB command	Answer
1.	$\int \frac{1}{(x+2)(x+3)}dx$	int(1/((x+2)*(x+3)))	$\log(x+2) - \log(x+3)$
2.	$\int \frac{1}{(x+1)(x+5)}dx$	int(1/((x+1)*(x+5)))	$\frac{\log(x+1)}{4} - \frac{\log(x+5)}{4}$
3.	$\int \frac{1}{(x+2)(x-5)}dx$	int(1/((x+2)*(x-5)))	$\frac{\log(x-5)}{7} - \frac{\log(x+2)}{7}$
4.	$\int \frac{1}{(x+2)^2}dx$	int(1/(x+2)^2)	$-\frac{1}{x+2}$

What pattern do you see in the answer above?

إذا كانت د الثين مضروبتين في المقام وكانت متشابهتين بالإشارة نطرح العددين
يكون الناتج هو لوغاريتم الدالة الأولى مطروحه من لوغاريتم الدالة
الثانية مقسومة على ناتج ~~طرح~~ الطرح بين العددين

Based on the pattern above:

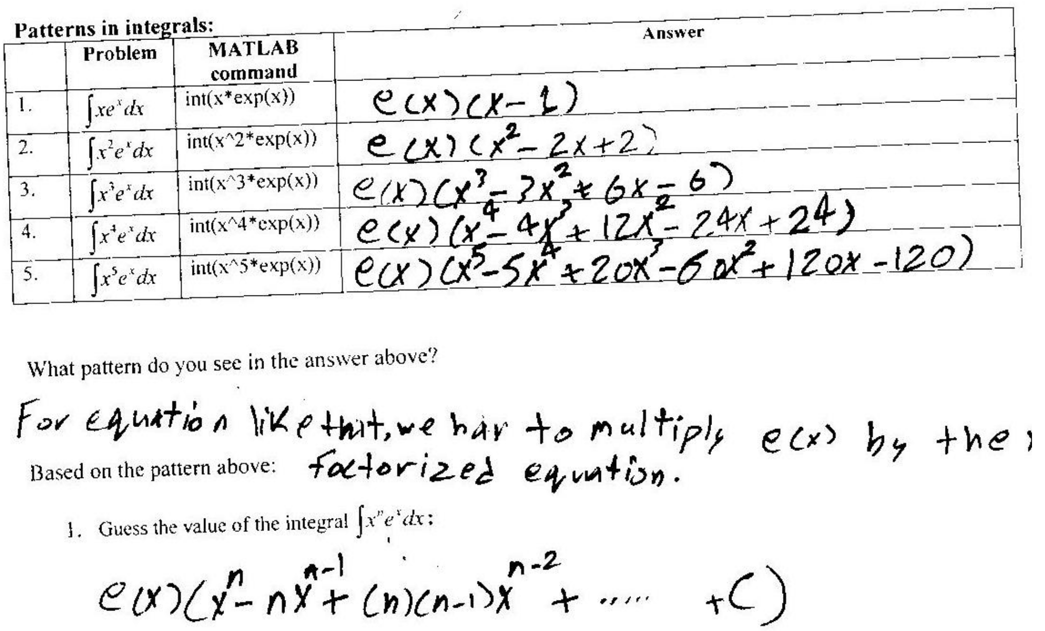
1. If a ≠ b then guess the value of : $\int \frac{1}{(x+a)(x+b)}dx$: $\frac{\log(x+a)}{|a-b|} - \frac{\log(x+b)}{|a-b|}$

2. What if a = b? $\frac{1}{(x+k)(x+k)} = \frac{1}{(x+k)^2} = -\frac{1}{(x+k)}$

3. Evaluate the answer by hand using partial fractions method that you will get in 2.

أما إذا كانت الإشارة بين الدالتين غير متشابهتين بالإشارة نجمع العددين
فيكون الناتج هو لوغاريتم الدالة الأولى مطروحه من لوغاريتم الدالة الثانية مقسومة على ناتج جمع
العددين أما إذا كانت الدالة في المقام بأس فرفع الدالة للبسط و [illegible] الدالة

Figure 5.8: Students' MSCL sample work



Patterns in integrals:

	Problem	MATLAB command	Answer
1.	$\int xe^x dx$	int(x*exp(x))	$e(x)(x-1)$
2.	$\int x^2e^x dx$	int(x^2*exp(x))	$e(x)(x^2-2x+2)$
3.	$\int x^3e^x dx$	int(x^3*exp(x))	$e(x)(x^3-3x^2+6x-6)$
4.	$\int x^4e^x dx$	int(x^4*exp(x))	$e(x)(x^4-4x^3+12x^2-24x+24)$
5.	$\int x^5e^x dx$	int(x^5*exp(x))	$e(x)(x^5-5x^4+20x^3-60x^2+120x-120)$

What pattern do you see in the answer above?

For equation like that, we hav to multiply e(x) by the factorized equation.

Based on the pattern above:

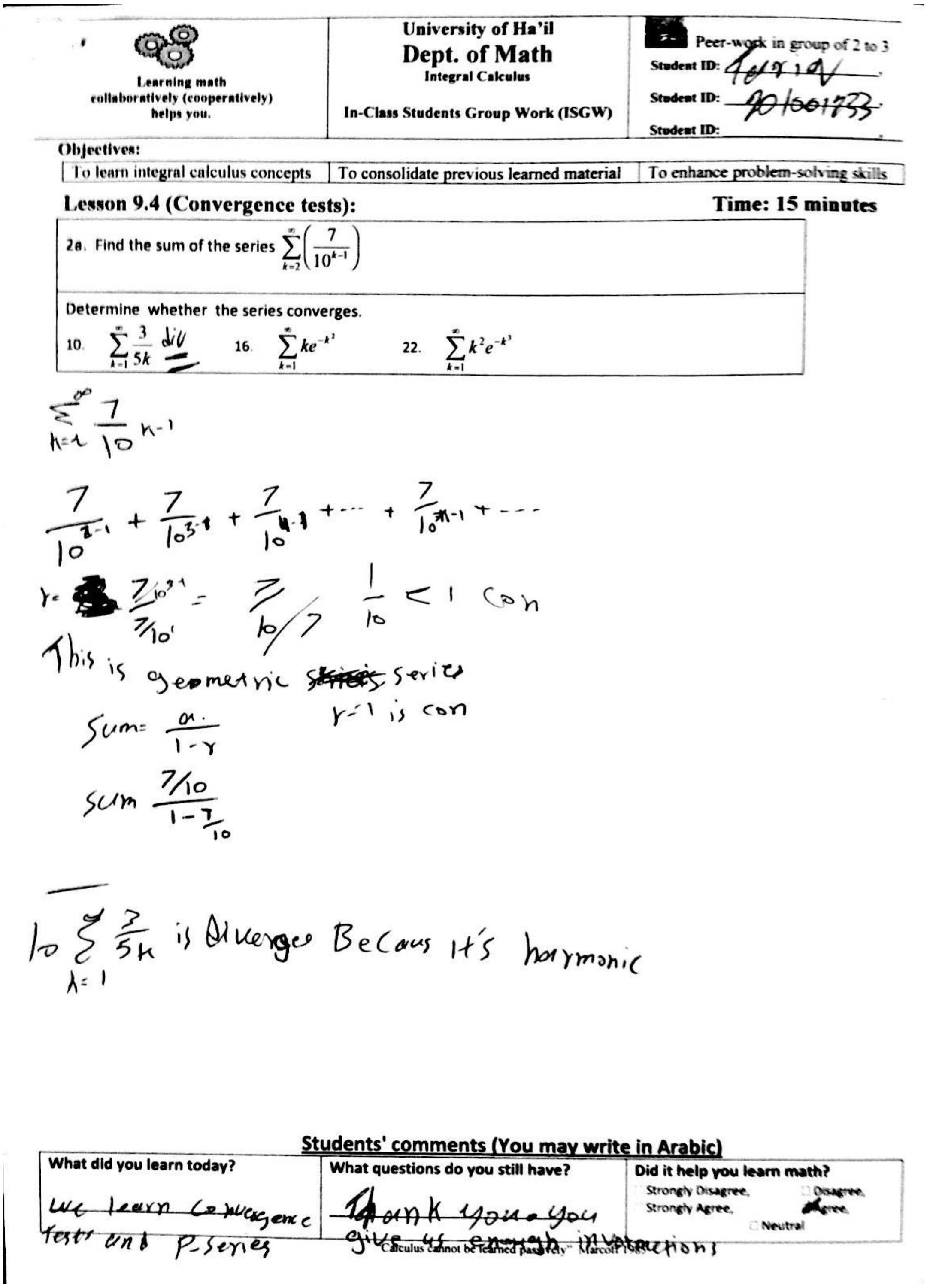
1. Guess the value of the integral $\int x^n e^x dx$:

$e(x)(x^n - nx^{n-1} + (n)(n-1)x^{n-2} + \dots + C)$

Figure 5.9: Students' MSCL sample work

5.3.2 The Collaborative support in-class and in-lab

Varying opinions were received from students on learning the course in groups both in-class and in-lab. Many of them preferred to use the software in group and particularly with their friends. One student said that learning becomes easier and fun when it occurs in a group of friends. Working with friends is perfect and easier however it is difficult to work with someone who doesn't like you. Students agreed that the in-lab group activities pushed them towards learning and it was less stressful and no intimidation. However, for in-class activities some of them liked to work alone. They did not like to depend on others for learning probably because the exams are not conducted in groups, "I don't like it in the class but I like it in the lab" remarked one student. The student commented that “you need to use your ideas and your own thinking to solve problems after all you will solve it yourself in the exam not with others”. In-lab working in group of a maximum of 2 is better but not more, commented one student. The learning first takes place in interaction with the instructor and then from peers, by teaching you learn yourself, he commented.



Learning math collaboratively (cooperatively) helps you.

University of Ha'il
Dept. of Math
Integral Calculus

In-Class Students Group Work (ISGW)

Peer-work in group of 2 to 3
Student ID: 4419 14
Student ID: 201501733
Student ID:

Objectives:

To learn integral calculus concepts	To consolidate previous learned material	To enhance problem-solving skills

Lesson 9.4 (Convergence tests): **Time: 15 minutes**

2a. Find the sum of the series $\sum_{k=2}^{\infty}\left(\frac{7}{10^{k-1}}\right)$

Determine whether the series converges.

10. $\sum_{k=1}^{\infty}\frac{3}{5k}$ div   16. $\sum_{k=1}^{\infty}ke^{-k^2}$ 22. $\sum_{k=1}^{\infty}k^2e^{-k^3}$

$\sum_{k=2}^{\infty}\frac{7}{10}^{k-1}$

$\frac{7}{10^{2-1}}+\frac{7}{10^{3-1}}+\frac{7}{10^{4-1}}+\cdots+\frac{7}{10^{n-1}}+\cdots$

$r = \frac{7/10^{3-1}}{7/10^{1}} = \frac{7}{10/7}$ $\frac{1}{10}<1$ con

This is geometric ~~series~~ series

Sum $=\frac{a}{1-r}$ $r<1$ is con

sum $\frac{7/10}{1-\frac{1}{10}}$

10 $\sum_{k=1}\frac{3}{5k}$ is diverges Becaus it's harmonic

Students' comments (You may write in Arabic)

What did you learn today?	What questions do you still have?	Did it help you learn math?
we learn convergence tests and P-series	Thank you you give us enough instructions	Strongly Disagree, Disagree, Strongly Agree, Agree (marked), Neutral

"Calculus cannot be learned passively" Marcott 1985

Figure 5.10: Students' CS sample work

In general, student expressed that working on problems in group has been beneficial from different perspectives. They liked it when they noticed different approaches their peers used in solving a particular problem. For in-class activity, students preferred a short 10 minutes work. The learning in group is quite effective if it is used for exam preparation, one student commented. Another student said that there is a link between learning in group with that of the future careers.

Several students expressed their views that the collaborative learning was very useful for them as many times their peers helped in clarifying doubts and checking each other’s work.

5.3.3 The Bilingual support in-class and in-lab

Some questions were also asked about the use of MATLAB in learning mathematics course despite students' weakness in the language of instruction that is English. One student commented that although some students' language is weak but they are good in computer skills as they can even design websites. The software could also be helpful to those whose English is weak commented another student. By using the software, we can learn graphs by looking at their shapes; you don't need the language there, he continued. The other aspect of the bilingual support was peer assistance. Peers were used to explain some key concepts of the lesson, Figures 5.13, 5.14 and 5.15, under the direct supervision of the Instructor. Student opinions and views were mostly positive about it. One comment made by a student was that it was good to see peers explaining a part of the lecture in Arabic. He believed that student level of understanding most of the time matches to the level of most of the class including the usage of the particular language and dialect. I don't think that students' have enough knowledge to explain a part of the lesson; a negative remark was passed by one student. Opposing the idea of peer-assistance in explaining part of a lecture, students' believed that more group study sessions could be conducted in which students learn from their peers more rather than their peers explaining the material.

Students were also provided with important key words translated in Arabic because many students did not know English well. When asked about it, one student said that although this helped them in the course but he preferred writing or using the only difficult words on the board rather than distributing them as a list of vocabulary. Some students hire private tutors just because they don't understand the lecture in English, commented one student.

5.3.4 The Study support

The material such as the formulae sheets, semester planner, effective study tips, weekly homework and study flow chart and so on were provided on university's website. Upon asking question with regard to accessing the online resources available on the "world of calculus" website, less than 50% of students joined the web group. Students expressed a liking towards the weekly homework sheets, Figures 5.16 and 5.17, but not many returned the completed sheets. One student said that he visited only once during the entire semester. Apart from making the resource online, they were also given the material in a printed form. The opinions expressed by students in individual interviews were further confirmed in group interviews. Their overall experience was positive and encouraging.

Daily Study Schedule

December 16 to 18, 2012

Sunday
16 December

Today's Lesson 9.4 & 9.5

9.4 home work problems

4. For each given p-series, identify p and determine whether the series converges.

(a) $\sum_{k=1}^{\infty} k^{-4/3}$ (b) $\sum_{k=1}^{\infty} \frac{1}{\sqrt[4]{k}}$

6. Apply the divergence test and state what it tells you about the series.

(a) $\sum_{k=1}^{\infty} \frac{k}{e^k}$

(b) $\sum_{k=1}^{\infty} \ln k$

(c) $\sum_{k=1}^{\infty} \frac{1}{\sqrt{k}}$

(d) $\sum_{k=1}^{\infty} \frac{\sqrt{k}}{\sqrt{k}+3}$

Determine whether the series converges.

10. $\sum_{k=1}^{\infty} \frac{3}{5k}$

16. $\sum_{k=1}^{\infty} ke^{-k^2}$

22. $\sum_{k=1}^{\infty} k^2 e^{-k^3}$

Monday
17 December

Do 9.5 home work problems today.

Make a guess about the convergence or divergence of the series, and confirm your guess using the comparison test

2. $\sum_{k=2}^{\infty} \frac{k+1}{k^2-k}$

6. Use the comparison test to show that the series converges $\sum_{k=1}^{\infty} \frac{\ln k}{k}$

7. Use the limit comparison test to determine whether the series converges.

$\sum_{k=1}^{\infty} \frac{5}{3^k+1}$

8. $\sum_{k=1}^{\infty} \frac{k(k+3)}{(k+1)(k+2)(k+5)}$

10. $\sum_{k=1}^{\infty} \frac{1}{(2k+3)^{17}}$

Use the ratio test to determine whether the series converges. If the test is inconclusive, then say so.

11. $\sum_{k=1}^{\infty} \frac{3^k}{k!}$

14. $\sum_{k=1}^{\infty} k\left(\frac{1}{2}\right)^k$

15. $\sum_{k=1}^{\infty} \frac{k!}{k^3}$

Tuesday
18 December

9.5 Home work problems

Use the root test to determine whether the series converges. If the test is inconclusive, then say so.

17. $\sum_{k=1}^{\infty} \left(\frac{3k+2}{2k-1}\right)^k$

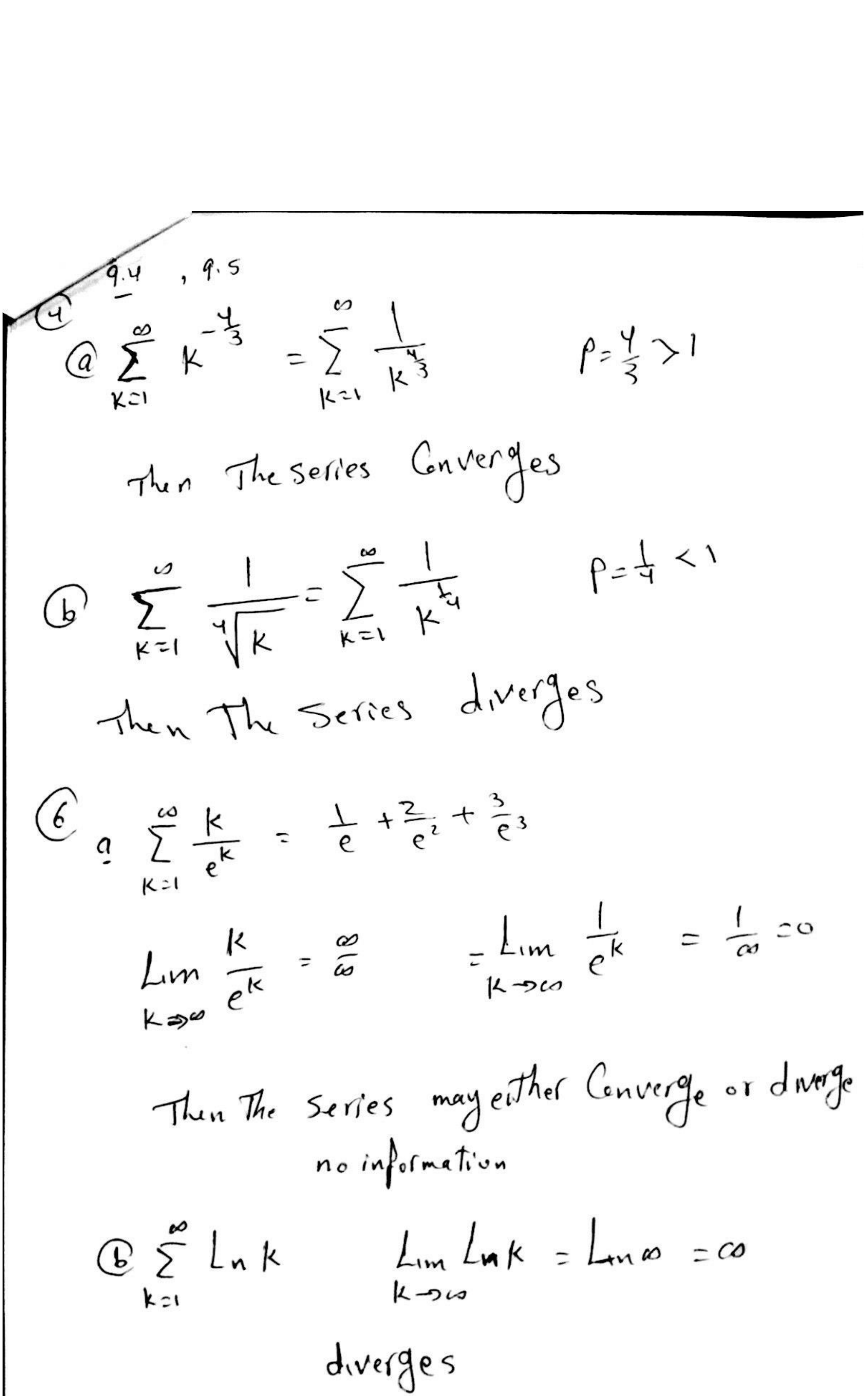
20. $\sum_{k=1}^{\infty} \left(1-e^{-k}\right)^k$

Use any method to determine whether the series converges.

28. $\sum_{k=1}^{\infty} \frac{k!10^k}{3^k}$

36. $\sum_{k=1}^{\infty} \frac{k!}{k^k}$

Figure 5.11: Study support sample homework sheet



9.4 , 9.5

(4)

(a) $\sum_{k=1}^{\infty} k^{-\frac{4}{3}} = \sum_{k=1}^{\infty} \frac{1}{k^{\frac{4}{3}}}$ $\quad p=\frac{4}{3}>1$

Then The series Converges

(b) $\sum_{k=1}^{\infty} \frac{1}{\sqrt[4]{k}} = \sum_{k=1}^{\infty} \frac{1}{k^{\frac{1}{4}}}$ $\quad p=\frac{1}{4}<1$

Then The Series diverges

(6) a $\sum_{k=1}^{\infty} \frac{k}{e^k} = \frac{1}{e} + \frac{2}{e^2} + \frac{3}{e^3}$

$\lim_{k\to\infty} \frac{k}{e^k} = \frac{\infty}{\infty} \quad = \lim_{k\to\infty} \frac{1}{e^k} = \frac{1}{\infty} = 0$

Then The Series may either Converge or diverge
no information

(b) $\sum_{k=1}^{\infty} \ln k \quad \lim_{k\to\infty} \ln k = \ln \infty = \infty$

diverges

Figure 5.12: Student's sample homework sheet (SS)

The students' responses to each question of the questionnaire have been provided in the appendix C in the form histogram.

5.4 Summary

Various inferential statistics are used to measure the effects of the intervention on the mathematical achievement of the Integral Calculus course of the undergraduate engineering students. A simple independent t-test with group statistic was used to compare the means of the experimental and control groups of students. The experimental group outperformed the control group. The regression analysis and Pearson correlations were conducted to determine the relationship between student attitudes towards the instructional strategies and their achievement and it is stated that no relationship was found. The regression model, however, revealed a significant relationship between the aptitudes of English, mathematics and computer courses (covariates) with student achievement in mathematics. There was weak to moderate relationship between the attitudes towards instructional strategies and the mathematics achievement. Univariate analysis was done to see the effects of covariates on mathematical achievement and it confirms the results predicted by stepwise multiple regression analysis model.

CHAPTER 6

DISCUSSIONS

6.1 Introduction

The findings are discussed and interpreted here based on the quantitative and qualitative results obtained in the study.

6.2 Quantitative Results

The study was conducted to examine the difference in mathematical achievement of the experimental group of students who were exposed to the ITIM as a supplement to the traditional lecture method in comparison with the control group of students who were taught with the traditional lecture method only. An assessment of the effectiveness of the use of MATLAB-Supported Collaborative Learning, collaborative support, bilingual support and the study support supplemental to the traditional lecture method was carried out. This was done using both qualitative and quantitative techniques. The participants of the study were a total of 218 undergraduate engineering students who were enrolled into the Integral Calculus course at the University of Ha'il during the year 2012.

The instructional strategies were based on Vygotskian's Social Constructivist Theory and the Theory of Semiotic Representations by Duval (1999). Students learning activities took place mainly in small group collaboration both in the computer lab where they used MATLAB as a learning tool for certain concepts of the course as well as the in-class problem solving. The third strategy in which the peers were involved in explaining some selected concepts of the course in students' native language. This strategy is termed as bilingual support. The fourth strategy was mainly relating to improving students' study skills by providing academic material related to preparation of their course. Additionally, attitudes towards mathematics and covariates (English, mathematics and computer) were also taken to see their effects on the dependent variable.

The results of the research hypotheses are discussed here:

Hypothesis one: There is no significant difference between the achievement of the experimental and the control groups in the Integral Calculus course when the experimental group was taught by the traditional lecture method supplemented with the ITIM.

The null hypothesis is rejected and the alternative hypothesis is accepted. This hypothesis is rejected based on the statistical inferences described in the results section. The experimental group of students' performance was better than that of the control group of students as measured by the end-of-semester final grade. The result is consistent with a number of studies in which similar results are reported when the intervention was provided to students as a supplement to the traditional lecture method. Keller *et al.* (1997) reported a positive impact on the mathematical reasoning of students when they were exposed to the CAS technology integrated in a group discussion technique. Similarly, Mevarech *et al.* (1991) concluded that the small group instruction helped students to overcome some of the barriers to successfully learning mathematics with a computer. Cottrell (1968), Yushau (2009), Setati and Adler (2001) and Olusola O. Adesope *et al.* (2010) reported a positive impact of the use of bilingual support in student mathematics achievement. The study by Boelkins *et al.* (1997) has reported positive effects of the use of the study support on student mathematics achievement. Lasley (2001) reported a strong relationship between the conceptual ability of students and their computer aptitude and similarly Mevarech *et al.* (1991) reported a positive relationship between the use of computer technology and collaborative small group work. Students' performance in previous courses is reported to be a good predictor of their achievement in subsequent courses such as Meece *et al.* (1982) on mathematics, Yushau (2004) and Aiken (1971), McLeod (1988), William *et al.* (2005) and Koller (2001), Reyes (1984) Ernest (2003), Aiken (1970) on mathematics achievement and attitudes. However, it is inconclusive to attribute the increase in performance only due to the effects of the combined instructional strategies. No single study in the literature was found in which the combination of all these strategies has been used. Therefore, in this sense, this study is considered unique particularly in the context of the University of Ha'il. No similar study has been conducted at this university so far.

The stepwise multiple regression was performed and there was no relationship between the attitudes towards the use of ITIM and the mathematics achievement of students in the Integral Calculus course. However, the questionnaire and interviews data showed a strong positive relationship. The regression model revealed a significant relationship between the three covariates (English aptitude, mathematics aptitude, and the computer aptitude) and the dependent variable.

Hypothesis two: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of MATLAB supported collaborative learning as a supplement.

The null hypothesis is accepted and the alternative hypothesis is rejected. The relationship between the attitudes towards the use of the MATLAB supported collaborative learning with mathematics achievement of the experimental group of students has not been significant. The independent variable in terms of attitudes is not correlated with the dependent variable. However, some weak and negligible positive correlation was found between the MSCL and:

a) The CS and the values are: the Pearson Correlation $r=0.200$, $p=0.028<0.05$
b) The SS and the values are: the Pearson Correlation $r=0.195$, $p=0.031<0.05$

This result is contrary to the studies available in the literature in which Keller *et al.* (1997) and Mevarech *et al.* (1991) have reported positive effects of computer technology and learning in collaborative setup on attitudes.

Hypothesis three: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of collaborative learning as a supplement.

The null hypothesis is accepted and the alternative hypothesis is rejected. The relationship between the attitudes towards the use of collaborative support with mathematics achievement of the experimental group of students has not been significant. The independent variable is not correlated with the dependent variable. However, a weak correlation was found between the CS and:

a) The MSCL and the values are: the Pearson Correlation $r=0.200$, $p=0.028<0.05$.
b) The BS and the values are: the Pearson Correlation $r=0.215$, $p=0.019<0.05$.
c) The Attitudes Towards Mathematics and the values are: the Pearson Correlation $r=-0.213$, $p=0.020<0.05$.

Contrary to the current study, the literature survey revealed a strong correlation between the collaborative support and the students' academic success, Boaler *et al.* *(*2004), Bookman and Friedman (1998), Yerushalmy and Schwartz (1998) and Koehn and Ganter (1999). Students have shown strong positive attitudes towards the use of this strategy, however, they have not performed adequately well in examination consequently no correlation was found between the dependent and the independent variables. Since the study has used the triangulation technique in the collection of data to reach a more reasonable and a balanced conclusion and it is obvious that the studies which involve humans must have qualitative measurements in place therefore the qualitative interviews were also conducted with the students. From the individual and group interviews it became evident that students have expressed a strong liking (overall 73%) and 80% for the use of collaborative support strategy in their learning of mathematics. They confirmed that the discussions held in collaborative sessions were useful and benefitted in them solving many mathematics problems which were otherwise difficult for them to do on their own.

Hypothesis four: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of bilingual support as a supplement.

The null hypothesis is accepted and the alternative hypothesis is rejected. The relationship between the attitudes of students towards the bilingual support on mathematics achievement of the experimental group of students has not been significant. The independent variable in terms of attitudes is not correlated with the dependent variable. However, some weak positive correlation between the BS and CS was found and the values are $r=0.215$, $p=0.019<0.05$. The result obtained from the current study is contrary to many studies available in the literature in which the positive effects of some kind of bilingual support given to students have reported increased mathematics achievement, Cummins (1976), De Avila and Duncan (1985), Yushau (2009), Setati and Adler, (2001), Olusola O. Adesope *et al.* (2010) and Bernardo (2002) and Mestre (1988). Researchers such as Yushau (2009), Setati and Adler, (2001) have reported benefits of providing a translation of key words into students' first language. Furthermore, Secada and Cruz (1996) have recommended involving students who have comparatively stronger bilingual ability for translating the important key concepts into students' native language.

Hypothesis five: There is no significant relationship between students' achievement in Integral Calculus and their attitudes towards the use of study support as a supplement.

The null hypothesis is accepted and the alternative hypothesis is rejected. The relationship between the attitudes towards the use of the study support with mathematics achievement of the experimental group of students has not been significant. The independent variable in terms of attitudes is not correlated with the dependent variable. However, some negligible positive correlation was found between the SS and:

- **a)** The MSCL and the values are: the Pearson Correlation $r=0.195$, $p=0.031<0.05$.
- **b)** The Attitudes Towards Mathematics and the values are: the Pearson Correlation $r=0.198$, $p=0.028<0.05$.

This strategy has not produced statistically significant relationship between the attitudes towards the implementation of study support and the mathematics achievement of students. However, Boelkins *et al.* (1997) and Hallet (2010) have reported positive results on the achievement of students when they were provided an additional study support.

Hypothesis six: There is no significant relationship between the achievement in Integral Calculus and the English aptitude of the experimental group.

The null hypothesis is rejected and the alternative hypothesis is accepted. There is a significant relationship between the English aptitude and the achievement in the Integral Calculus course of the experimental group. The variables are strongly correlated with each other. The strong positive correlation was also found between the English aptitude and:

a) The mathematics aptitude and the values are: the Pearson Correlation $r=0.463$, $p=0.000<0.05$.
b) The computer aptitude and the values are: the Pearson Correlation $r=0.539$, $p=0.000<0.05$.

This finding corroborates with the study by Cottrell (1968) in which positive impact of the verbal ability of the language of instruction on students' achievement in mathematics was reported. The proficiency in the language of instruction is a positive indicator of student success in academic disciplines.

Hypothesis seven: There is no significant relationship between the achievement in Integral Calculus and the computer aptitude of the experimental group.

The null hypothesis is rejected and the alternative hypothesis is accepted. There is a significant relationship between the computer aptitude and the achievement in the Integral Calculus course of the experimental group. The variables are strongly correlated with each other. The strong and moderate correlation was also found between the computer aptitude and:

a) The English aptitude and the values: the Pearson Correlation $r=0.539$, $p=0.000<0.05$.
b) The mathematics aptitude and the values are: the Pearson Correlation $r=0.349$, $p=0.000<0.05$.

Lasley (2001) reported a strong relationship between the conceptual ability of students and their computer aptitude. Mevarech *et al.* (1991) have also attributed the student success when the instructions integrated with computer were given in small group. A correlation was reported by Wileman, Konvalina and Stephens (1983) between the success in computer programming with the cognitive ability of students. Anand *et al.* (2000) identified computer illiteracy and the lack of access to computer resources as barriers to using technology. Pitcher (1998) considered students' computer skills as vital to enable them to use the tools effectively, however, a negative association between computer-assisted instruction and student mathematics achievement scores was found.

Hypothesis eight: There is no significant relationship between the achievement in Integral Calculus and the mathematics aptitude of the experimental group.

The null hypothesis is rejected and the alternative hypothesis is accepted. There is a significant relationship between the mathematics aptitude and the achievement in the Integral Calculus course of the experimental group. The variables are strongly correlated with each other. The strong to moderate correlation was also found between the mathematics aptitude and:

a) The English aptitude and the values are: the Pearson Correlation $r=0.463$, $p=0.000<0.05$.
b) The computer aptitude and the values are: the Pearson Correlation $r=0.349$, $p=0.000<0.05$.

The findings obtained from the study confirm the literature survey studies, Meece *et al.* (1982), Begle (1979), Yushau (2004) and Aiken (1971). These studies have found a correlation between students' mathematics aptitude and their mathematics achievement. Students' performance in previous mathematics courses is a good predictor of their achievement in subsequent mathematics courses, Meece *et al.* (1982).

Hypothesis nine: There is no significant relationship between the achievement in Integral Calculus and the Attitudes Towards Mathematics of the experimental group.

The null hypothesis is accepted and the alternative hypothesis is rejected. There is no significant relationship between the Attitudes Towards Mathematics and the achievement in the Integral Calculus course of the experimental group. The variables are not associated with each other. However, a weak/negligible correlation was found between the Attitudes Towards Mathematics and:

a) The CS and the values are: the Pearson Correlation $r=0.213$, $p=0.020<0.05$.
b) The SS and the values are: the Pearson Correlation $r=0.198$, $p=0.028<0.05$.

Although there is no significant difference, in the current study, between students' Attitudes Towards Mathematics with their achievement, however, a number of researcher have reported a positive relationship between these variables, McLeod (1988), William *et al.* (2005) and Koller (2001), Reyes (1984), Ernest (2003), Aiken (1970), Royster and Schoeps (1999), Hannula (2002), Tapia and Marsh (2001), Lent and Gore (1997), Thorndike-Christ (1991), Gallagher and DeList (1994), Shashaani (1995), Midley *et al.* (1989), Papanastasiou (2002), Higbee and Thomas (1999), and Williams (2005). The success and failure cycle in mathematics is largely dependent upon student attitudes, Ernest (2003), Aiken (1970).

There was an overall positive effect on the mathematical achievement for the experimental group of students when their achievement was compared with that of the control group of students. The rationale for using these strategies has been outlined in the first chapter of this thesis; nevertheless the multiple regression model has not revealed any statistical significant effect of the intervention. The students' opinions and perceptions have been quite positive about the use of intervention as described by them in interviews and group interviews.

6.3 QUALITATIVE RESULTS

6.3.1 MATLAB-Supported Collaborative Learning

Attitudes play an important role in students' learning environment when computer technology and other instructional strategies are used. In this study, the questions concerning their attitudes towards the use of MATLAB in collaborative environment in the teaching of mathematics was also explored. The use of MATLAB in a collaborative learning was a supplementary instructional strategy used in this study for teaching the Integral Calculus course. Some discussion has been provided in the literature review chapter of this thesis with regard to the role of attitudes to computer technology and its relationship to mathematics achievements. The increased use of computer technology for engineering mathematics students has drawn a lot of interest to examine its impact on student learning. A number of studies have been conducted on the use of the computer-supported learning of mathematics by Templer *et al.* (1998), Park (1993), Mackie (1992), NBEET (1996) in the mathematics classrooms as well as laboratories and their effects on student attitudes.

Attitudes of students towards the ITIM were measured through questionnaire and interviews. The graphs pertaining to students attitudes towards ITIM have been provided in the Appendix C. The questionnaire data and qualitative interviews both indicate that students overwhelmingly liked the intervention. In the post-study questionnaire, about 65% students expressed their confidence in using MATLAB as a supplement for the learning of mathematics. About 78% liked the software, 70% enjoyed using it and about 66% expressed that it was useful. With regard to the use of MATLAB in the course, students particularly preferred it for sketching graphs of functions, visualising solids of revolution and identifying patterns in integration formulae. Questions relating to the use of MATLAB and their mathematics achievement were explored using the questions such as 'I learnt many things about graphing using MATLAB', 'MATLAB made it easy for practicing integration problems', and 'MATLAB is good for understanding solids of revolution'. About 77% students believed that the software has helped them in learning graphing in mathematics. Regarding the topics on the understanding of integration problems and the solids of revolution, about 63% and 75% of students found the software useful and an overall 72% appreciated it. In general students have expressed no difficulties with regard to the use of the software, however, in the beginning; some struggled to use it. They had difficulties using correct parentheses. They didn't like remembering the MATLAB commands. Students liked the worksheets which had necessary commands needed to do tasks. Most of them expressed no trouble in using them but some of the students did not see its relevance to their course. The commands are intuitively easy to use based on simple English. Their ease of use of the software could be attributed to their prior experience of completing a course in C programming. Students viewed MATLAB as simpler and easier compare to their learning of a computer programming. The use of MATLAB-based worksheets played a crucial role in transforming traditional mathematics activities. Initially students were confused about understanding the instructions printed on the sheets. Students used the software for learning techniques of integration based on patterns recognition. In this exercise, they were given a number of problems for evaluating indefinite integrals as their solutions were tedious and sometimes not possible to compute by hand. Illustrations are given in the section on patterns in Chapter 4.

To the question about the best and the most interesting aspect of the software, students described that they liked sketching graphs of mathematical functions. Upon further probe, they said that the 2-D and 3-D graphs of several functions can be drawn in a little time with a lot of ease and efficiency which otherwise takes a lot of time in a traditional way. Generating multiple graphs helps in remembering and recalling their shapes while solving problems, remarked one student. In contrary, a couple of students mentioned that the amount of time they have spent on MATLAB for learning mathematics was not worth spending when compared with their learning in a traditional environment. Their disliking could be partly due to the fact that the software was not an integral part of the teaching, learning and testing and this has been their first experience using computer as a learning tool.

One student firmly rejected the idea of using the software in learning mathematics. His argument was that more mathematics can be learnt in a traditional class than in a computer lab. This student had attended all MATLAB sessions and was an active participant. However, over time his opinion had changed. When this student was reminded about his positive responses in the questionnaire, his reply was that what he had expressed earlier was not true. He believed that hardly 25% of students liked to use MATLAB in mathematics and others did not like it at all. He further commented that the responses provided by students in the questionnaire are not true reflection of their opinions and views as they are contrary to their actual feelings. Students have the habit of saying positive things because of some unknown reasons, he added. The student said that it is better to offer a separate course for learning MATLAB prior to learning the mathematics course. It was difficult to figure out why there was this drastic change in this particular student's opinion. The student opposed its use but at one stage he suggested the software to be taught as a separate course.

Sample work of student carried out in the computer is provided in the results chapter. Students were able to complete most of the assigned tasks successfully. They observed the patterns emerging from the output of the software and deduced the possible solution to the generalised problem. Many of them had no difficulty in figuring out the underlying patterns in simple cases. In some problems, they had to simplify the output to get to the solution which could be easily understandable. An analysis of student responses revealed that they were actively involved in the learning process in not only carrying out the activities but also communicating their work with their group members as well as the students in the other groups.

6.3.2 Collaborative Support

The usefulness of students learning mathematics in collaborative groups is extensively reported in the literature. For a traditional course, this strategy plays an important role as students learn the subject without intimidation but also helps them in preparation of their exams. Students' related the use of collaborative learning to their achievement in the course. About 78% students said that they leant many things when they studied with other students in the class, and 65% said that their knowledge of mathematics improved when they studied in a group, 80% said that discussing with other students in the group has helped them a lot when they could not solve a mathematics problem themselves, 62% said that collaborative study has also helped them understanding mathematics in English. Overall 73% students believed that this strategy has helped them in their course achievement. As the exams are still paper-based, students' preference was more towards the use of group work as they learned many problems with the help of their peers. They found the direct benefit of this strategy compared to the one in which the computer was used.

6.3.3 Bilingual and Study Support

The bilingual support was also appreciated by many students. A feasible work plan with day to day academic activities was drafted and an online webpage by the name "World of Calculus" was developed on the university's website where the lecture notes and all the course related resource were uploaded. These notes were also given in printed form as some students had no access to online resources. Students overall attitudes towards the study support was quite positive. Those who used the resource mainly were in preparation of examinations.

6.4 Summary

There has been no statistical significance of the effects of the attitudes towards the use of all the instructional strategies as calculated through the independent t-test, univariate analysis and stepwise multiple regression. The multiple regression models showed no contribution of these strategies on the Integral Calculus achievement of the experimental group of students. No effects can be attributed to the intervention; however, the end-of-semester comparison showed a significant difference between the mathematics achievements of the experimental group with that of the control group as the former outperformed the later. Students' performance in their previous courses such as mathematics, English and computer were found to be highly correlated. The regression models provide a significant association between the mathematics achievement of the experimental group and students' performance in their previous courses. The model 1 depicts a relationship of mathematics achievement with students' aptitudes in mathematics that is their performance in previous mathematics course and findings corroborates with Yushau (2004). The model 2 revealed the relationship of the dependent variable with the two previous courses; namely mathematics aptitude and computer aptitude. The MSCL found to be correlated with the CS and SS.

Students liked the use of the combination of instructional technologies as a supplement to the traditional lecture method in the course. They unanimously favoured the traditional lecture to be an integral part of the teaching and learning process but appreciated the use of various technologies. The sample students perceived the benefits of MATLAB in their engineering studies and in their professional career as engineers. They particularly liked the use of the software as a supplement for several mathematical concepts. The collaborative learning was also highly rated as a useful strategy in learning mathematics especially for those who lack basic skills in maths and somehow more disadvantaged due to their limited English language proficiency. Students particularly liked the theoretical background and the traditional approach provided in lectures on the course and supplemented with the computer programme as reinforcement to their classroom learning. This was further strengthened by putting students in collaborative groups where they learned problem solving actively. Students' believed that collaborative learning has greatly helped them in learning various problems, provided some motivation to learn on their own and ultimately prepared them well for their examination. The synergy effects of the strategies left positive impression on students' overall learning experience during this study.

CHAPTER 7

Conclusions and Recommendations for Further Work

7.1 Findings

The study confirms many of the findings from the existing literature that the use of collaborative learning with computer technology combined with in-class learning produce positive results. The significance of this finding lies in the fact that both groups were almost equivalent at the start of the study. It is, however, believed that there will always be achievement gaps in student understanding of pre-requisite mathematical concepts despite satisfying the criteria set for an entry into a course. The data indicate that the students who completed the course with intervention were able to strive and perform significantly better than their counterparts in the control group. However, all the results of this study did not strongly support the literature findings when it comes to mathematical achievement. There was no statistical significance between the attitudes of students towards the instructional strategies and the achievement in the Integral Calculus course and it confirms the findings by Tall *et al.* (1992).

Overall, it was noticed that the failure rate of the experimental semester was significantly lower than the previous semesters. The modification in the course through the application of instructional strategies seems to have provided weaker students an opportunity to improve their learning of the subject and subsequently enabling them to progress to the next course. While there appears to be a kind of spoon-feeding for students to provide with the study material which even included the ready-made homework and class work sheets, however, it was necessary in view of student challenges highlighted in the first chapter of this thesis. Only 20%

of the time was spent for intervention, nevertheless, the tasks performed in the class strategies were according to the objectives of the course outlined in the syllabus.

Findings obtained from the statistical measures provide conclusive evidence that the primary null hypothesis is rejected. The experimental group of students outperformed the control group in terms of their achievement in the post-study Integral Calculus course. However, it must be noted that some confounding factors such as students' abilities of this particular experimental group and/or the instructional delivery of the course might affect the outcome variable which is the mathematics achievement. With regard to the attitudes towards the use of the individual instructional strategies, the inferences obtained from the statistical analysis did not reveal significant relationship with students' mathematical achievement. Nevertheless, the data collected through questionnaires and qualitative interviews revealed that a vast majority of students favoured the use of the intervention in their learning of the course as well as they showed very positive attitudes. Graphs of each question of the questionnaire are provided in the appendices.

The instructions designed in this study were based on the Socio-Constructivist Theory and the theory related to semiotic representations. It is believed that such theoretical bases provide student-centred instructions, increase interaction between instructor-students and among students themselves, motivate students towards learning and remove boredom and monotony from the class. They also help linguistically weak students as they interact and participate in their native language and as a whole it involved students actively in a social setting in the learning process.

It was observed that students learnt the course, their participation in the learning process enhanced, their final course grades improved as evidenced by the Table 5.2, a comparison between experimental and control groups. About 42% of the experimental group of students achieved a final grade of C and above compared to a 20% of the control group whereas the pass grades (D/D+) was higher (34%) in the control group compared with the experimental group (24%). 32% of the experimental group of students failed the course whereas 45% failed in the control group.

7.2 MATLAB-Supported Collaborative Learning (MSCL)

MSCL as a supplement to traditional classroom instruction promoted active learning. The software provided the flexibility to present some of the course concepts in multiple formats/ways. It was noticed that the use of the software has benefitted both weak and strong students in many areas of the course. Students' performance in the course has improved significantly unlike the past record of teaching a number of students groups of similar background over the years.

Visualisation of graphs and 3-D volumes of solids of revolution were one of the areas which benefitted students the most throughout their course followed by pattern recognition in evaluating integrals of mathematical functions.

Students learning of MATLAB and submitting their assignments in pairs has helped them in their learning of mathematics; motivated them towards learning; increased interaction among students as well as with their instructor, and somehow alleviated students inadequate competence in English.

7.3 Collaborative support

A majority of students enjoyed working in small groups in the class as it was beneficial and less stressful as compared to the individual learning. They also liked different approaches and methods used by their peers in solving problems.

One of the positive aspects highlighted by students was that the group study work gave them some confidence in the preparation of their exams.

7.4 Bilingual support

Students appreciated the involvement of their peers in the explanation of certain concepts in the class in their native language. This was implemented to the maxim that teaching others is the best way to learn. Secada and Cruz (1996) have recommended involving students who have comparatively stronger bilingual ability for translating the important key concepts into students’ native language.

With regard to this strategy, an overwhelming number of students (usefulness, 86%; liking 81%, and enjoyment 77%) expressed strong positive attitudes towards the use of the bilingual support in their learning of mathematics. Students' weakness in the language of instruction is another major obstacle in learning mathematics. Therefore, they favoured its use for important concepts of the lesson. To the statement 'I learnt more mathematics from students in the class when they explained it in Arabic', about 77% students related the use of Arabic to their overall achievement in the course.

7.5 Study Support

The mathematics textbooks currently used are mainly written for the native speakers of English with little attention to the second language learners. Therefore, the course material was simplified for students, which was termed as study support due to the challenges of using the prescribed mathematics textbook.

Based on the works of Green *at al.* (2003) and Boelkins *et al.* (1997), the offline and online lecture notes were provided to students in an attempt to enhance the learning of mathematics for engineering undergraduate students. The students in this study have also expressed a strong liking, (60%) and (63%) usefulness of this strategy in their learning of mathematics and thus their overall achievement in the course. There was a mismatch between students' positive attitudes towards the study support, expressed by students in questionnaire and interviews, with that of accessing the resources and making a proper use of them. Very few students accessed the online resource.

7.6 Implications of the study

The study has direct implications for many stake holders such as educators, policy makers, mathematics education students, software and e-learning developers and the instructional designers. The material developed and used in this study can be used by instructors. The course objectives of such mathematics courses demand the use of a computer algebra system and the software like MATLAB can be a good choice for engineering students. MATLAB is among the most widely used programmes for mathematics, Broadbridge and Hendersen (2008).

Educators may adopt the strategies which appropriately fit into their own circumstances. The study may be extended to all calculus courses and other engineering related mathematics courses as well.

Hawkes and Savage (2000) in a report commented that there is no simple solution- no panacea to students declining knowledge and skills of mathematics which is rapidly becoming one of the most challenging problems in the universities. The output of this research suggests that in view of the students' challenges as highlighted in chapter one, the use of computer technology might be effective if students learn mathematics in small groups coupled with additional academic supports.

7.7 Recommendations for further work

Based on the results of this study, the intervention appears to be an effective way for students in order to lead them to a successful way forward through an important gateway course such as the calculus and ultimately through an engineering major to graduation.

The MATLAB software was used as a supplement in this study. It provides ample opportunities for conceptualisation and problem solving in mathematics. Because of its relevance to mathematics and engineering disciplines, it is recommended to be integrated as a compulsory component of the curriculum. However, certain factors need to be taken into consideration such as the careful design of the course; when to use technology, what concepts to teach using MATLAB; and how to use it appropriately keeping in view of the characteristics of students. The software's implementation also places demands on instructors to be competent enough for using the technology for pedagogical purposes.

The MATLAB supported collaborative teaching and learning of mathematics can be made online rather than restricting its use within the computer lab. This will provide an easy access to students anytime from anywhere.

The GPA of the pre-requisite computer course of both the groups of students was not same. In this course, the students are taught computer fundamentals and an increase in GPA of the experimental group of students at this particular level would not bring any drastic change in the mathematical achievement of students. The focus of attention of this study was the mathematical achievement and the GPA in the pre-requisite mathematics course was equivalent. It is recommended that in a true experimental design research the groups must be equivalent in areas in which their performance is being evaluated.

Among the various strategies for enhancing student mathematics achievement, the importance of bilingual support in teaching and learning of mathematics has been reported by Yushau (2004). There are a very few studies in this area as these studies and others have not reported very strong correlation between student language skills and their impact on mathematical achievement. A more thorough and in-depth study is needed to explore the role of the native language in learning maths for at-risk students.

In view of the inadequacy of students in English which is their language of instruction, special attention needs to be given in the adoption of textbooks for them. The mathematics textbooks currently used are mainly written for the native speakers of English with little attention to the second language learners. Strategies and methodologies should be established so that the bilingual and study support provided to students will help them to overcome their specific linguistic challenges.

Students' aptitudes particularly in mathematics and in the language of instruction play important roles for success in their subsequent courses. Therefore, these aptitudes must be taken into consideration in setting the selection criteria for admission into professional disciplines.

Some of the questions could further be explored in terms of how these strategies might help students in other courses including more challenging engineering topics.

How much time can be spent on all of these and some of the strategies utilised here may require a deeper inquiry.

It would be more appropriate if both the experimental and control groups of students are taught by the same instructor in order to overcome the effects of teachers' factors. A number of studies reported a positive correlation between teachers' knowledge and the students achievement in mathematics.

More rigorous and stringent measures must be taken into consideration for ensuring the probabilistic randomisation of sample.

For students with similar challenges of learning mathematics, the strategies can be used to inculcate active learning.

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APPENDICES

APPENDIX A: Integral Calculus syllabus with MATLAB supported collaborative learning of mathematics

Textbook: Calculus Early Transcendentals by Howard Anton, I. Bivens and S. Davis, 9th Ed.

	Topic	Homework Problems	Review
	CHAPTER 5: INTEGRATION		
	MATLAB Introduction (basics)		
5.1	Overview of the area problem	1,14,15,18,27,28	
	Riemann sums interactive MATLAB session		
5.2	The indefinite integral	10, 12,16,18,25,33,43,53	41,42,58,59,60
5.3	Integration by substitution	1(a),2(a),6(a),9(a),16,22,40,59	66,73,74
5.5	The definite integral	10,14,18,22,24,28,33,34	56,66,
5.6	The fundamental theorem of calculus	6,8,14,19,28,29,32,35	
	MATLAB activity: **1. evaluating definite and indefinite integrals** **2. evaluating functions of the type ( )** **3. finding answers to the textbook problems**		
5.8	Average value of a function and its applications	4,8,10,23,26	30
5.10	Logarithmic and other functions defined by integrals	4(d),8(a),12(a),15,16,26(a),27	23,44,49
	MATLAB activity: **4. plotting basic graphs of mathematical functions** **5. finding points of intersection**		
	CHAPTER 6: APPLCATIONS OF DEFINITE INTEGRAL IN GEOMETRY, SC. & ENGINEERING		
6.1	Area between two curves	1,3,6,14,17,28,38	19-26,31-34
	MATLAB activity: **1. plotting multiple graphs of mathematical functions** **2. plotting graphs of complicated functions** **3. plotting functions and finding positive and negative areas of functions**		
6.2	Volumes by Slicing; Disks and Washers	7,17,23,42,44	51-54
	MATLAB activity: **1. using disk method to visualise the solids of revolution** **2. finding volumes of the solids of revolution**		
6.3	Volumes by Cylindrical shells	9,13,29,31	21-23
6.4	Length of a plane curve	5,13,28,31	13,14,22-26,33
6.5	Area of surface of revolution	3,7,35,37	9-16,34
	CHAPTER 7: PRINCIPLES OF INTEGRAL EVALUATION		
7.1	An Overview of integration methods	5,14,18,28,29	
7.2	Integration by parts	9,17,32,51,61	
7.3	Integrating trigonometric functions	2,4,3,9,10,16,19,30,32,33,48,49,51	
7.4	Trigonometric substitutions	7,11,23,37,41	49-50
7.5	Integrating rational functions by partial fractions	2,10,17,26,29	45-48
7.8	Improper integrals	3,4,5,6,7,8,9,10,27,28,29,30,31,32	41-44, 53,54,60,64,70
Rev.	**Making connections**		
	CHAPTER 9: INFINITE SERIES		
9.1	Sequences	2, 8, 10, 12, 14, 16, 20, 35, 36	45
9.3	Infinite series	1,2, 4, 7, 6, 8, 12, 30, 32, 35	40
9.4	Convergence Tests (Divergence and Integral tests only)	2(a), 4(a, b), 6, 10, 16, 22	35, 41,42
9.5	The comparison, Ratio, and Root tests	2, 4, 6, 7,8,10, 11, 14, 15, 17, 20, 28, 36	
9.6	Alternating series; Absolute convergence Up to Page 640	1, 2, 3, 5, 6	47
9.8	**Maclaurin and Taylor series; Power series (MATLAB activity)**	**1, 3, 4, 5, 6, 9 ,10, 20, 22, 30, 32,38,39,40**	52,61

APPENDIX B: Interview questions relating to students' attitudes toward the use of MATLAB in collaborative setup:

1. Describe your experience of using MATLAB.
2. What are the difficulties you faced while using it?
3. How much time should be spent on the MATLAB in learning the course?
4. How it has helped you in understanding mathematics?
5. How helpful it has been in exams preparation?
6. Has it motivated you to learn maths?
7. For what use, the software is best?
8. Tell me what is MATLAB best for?
9. What do you think about using MATLAB with other students of your class?
10. Did you help other students of your class in using MATLAB?
11. Did other students of your help you in using MATLAB?
12. What do you think about the use of computer for learning maths?
13. What was the most interesting part of learning?
14. What do you think about the disk method that we have used for generating solids of revolution?
15. What do you think about its use for sketching graphs of functions?
16. What do think about its use for learning integration?
17. What do you think about seeing patterns in integration problems?

The following questions were also asked related to the concept of area between two curves:

Example: **Area between two curves using MATLAB in a group**

1. What was your experience of using the software for this concept?
2. Was it helpful?

3. Was the understanding in the classroom lecture more easier or by the use of MATLAB?
4. Can you tell me the steps of finding the area between two curves?
5. Tell me the procedure for finding the limits of integration?
6. Can you write the formula here?
7. Can you tell me a bit more about it?
8. Was the way you were taught before good or you like this change?
9. Were you finding another way of learning?

Interview questions relating to students' attitudes toward the use of collaborative work:

The following questions were centred on the themes such as students' perceptions and attitudes toward the use of group work and team work for learning the integral calculus course:

1) Can you describe your work in the computer lab?
2) Can you describe your work in the class as a group?
3) What do feel about the group work in learning your course?
4) Do you like to work alone or in group?
5) Do you think working in groups make calculus more interesting?
6) Did you get help from other students?
7) Did you give help to others?
8) Do feel comfortable asking questions from other students in the group?
9) Do you always or sometimes want to learn maths in group?
10) Do you think learning in group is good for doing hard problems?
11) Do you make friends if you work in groups in the class?
12) Do you want to learn with friends?
13) Can you work with anyone in the class?
14) Did it help you for exams?
15) Did it help you in learning the course?

16) Did it help you to talk to easily with class fellows?
17) Do you want to work alone?
18) Can you talk to anyone in the class?
19) Do you think you can get new ideas if you learn in groups?
20) Did it learn you learn new methods and solutions?
21) Do you want to work with same students always?

Group interviews questions relating to students' attitudes toward the use of MATLAB in a collaborative setup:

1. How would you describe MATLAB as a tool for learning calculus?
2. What is the biggest advantage that you have seen for using it?
3. What is the biggest disadvantage that you have seen for using it?
4. How do you see the change in the teaching and learning by the use of MATLAB?
5. Can you tell me what you feel about calculus?
6. What do you think calculus is?
7. Why do you think calculus is?
8. What does maths mean to you?
9. When you hear the word 'maths' what comes to your mind?
10. Can you tell me more about this?

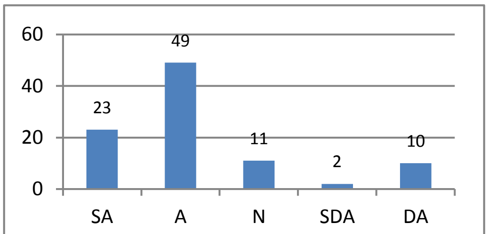
The benefits, usefulness and the impact of the use of MATLAB/Group Study/Bilingual/Maths Learning Support were explored:

1. difficulties in using
2. conceptual understanding (mental connections/conceptions/ideas)
3. procedural understanding (plugging into formula' performance.)
4. in terms of exam preparation
5. performance in exam
6. students competence

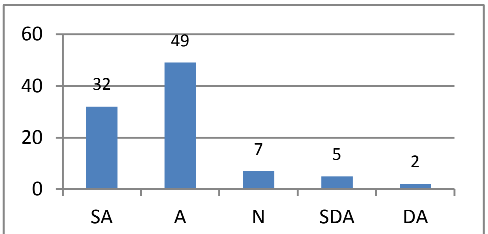
7. motivation towards learning
8. Reflection questions (describing solutions of other students and asking student's opinion and understanding)

APPENDIX C

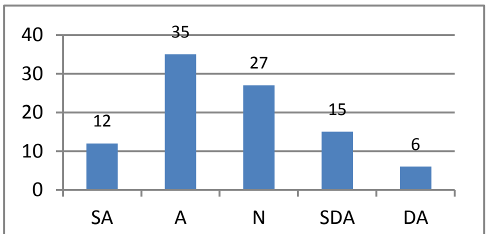
C1: Graphs of each question of the self-designed questionnaire: Students' attitudes towards mathematics



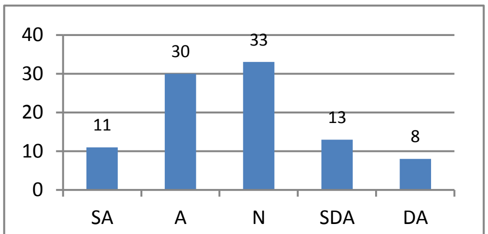
I like maths.



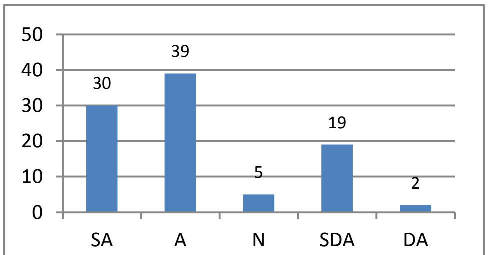
Maths is important for studies.



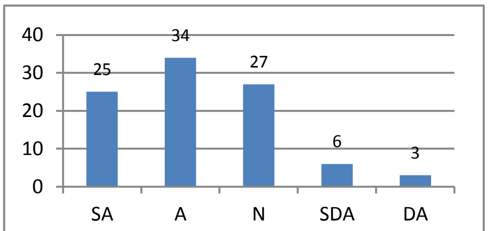
I can handle difficulties in maths.



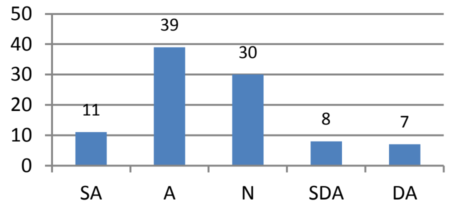
I am confident in maths.



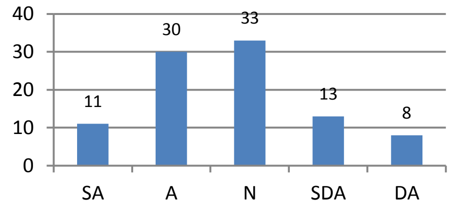
I like to learn new ways of solving maths problems.



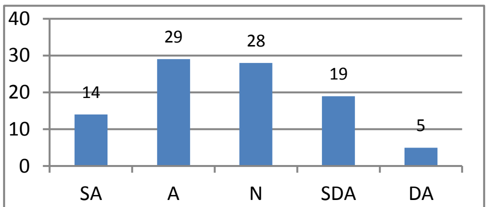
I am sure I can succeed in maths courses.



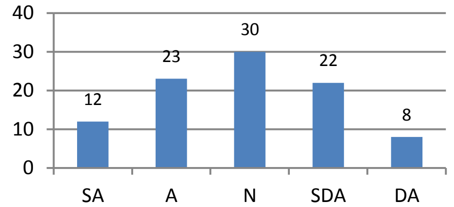
I understand vocabulary in maths.



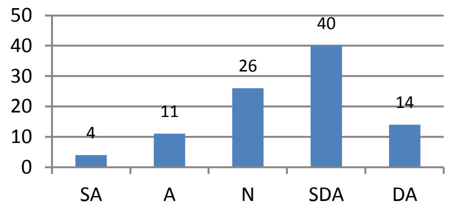
I am confident in maths.



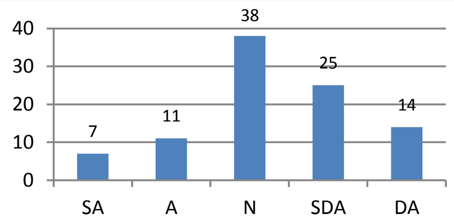
I don't like solving problems which has many steps.



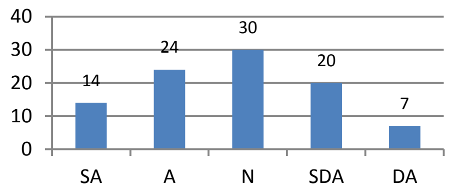
I want to do maths but I don't know formulae.



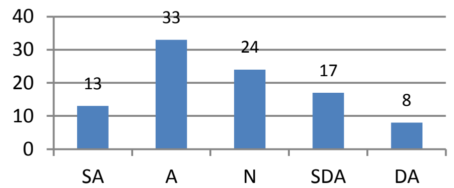
I don't like to understand maths.



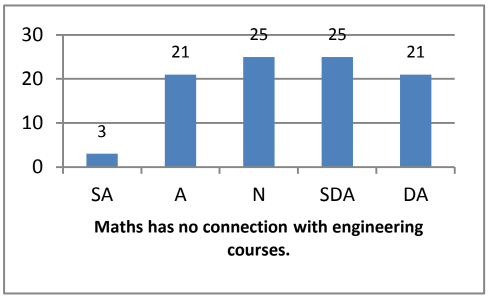
Learning maths is stressful.

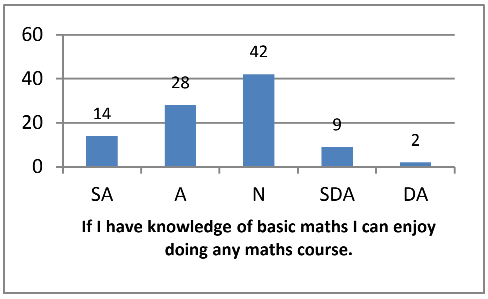


I like to attend lectures where maths is discussed.

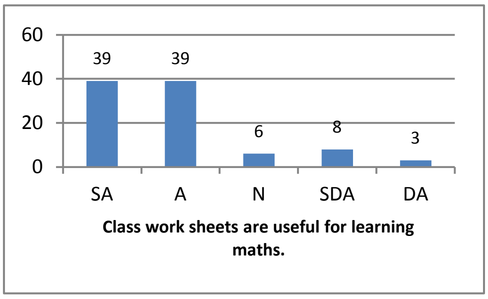


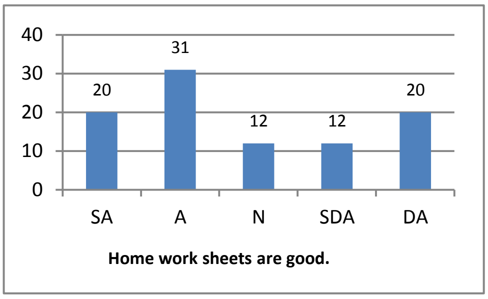
Maths is important only because I have to pass the course.

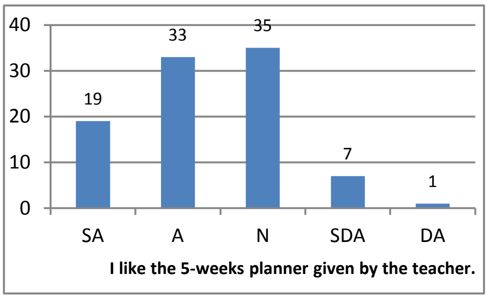


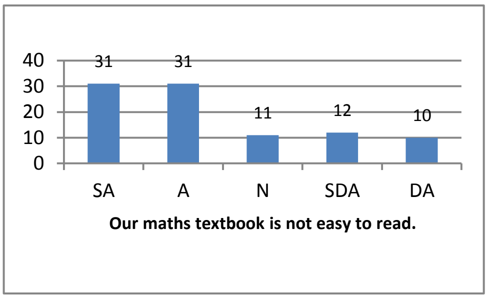


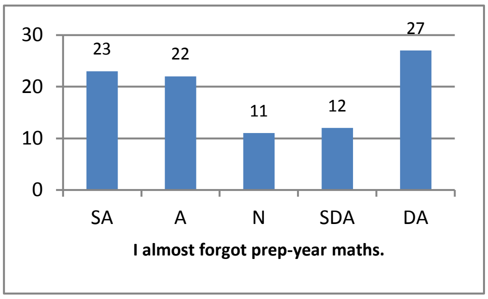
C2: Graphs of each question of the self-designed questionnaire: Attitudes towards the study support

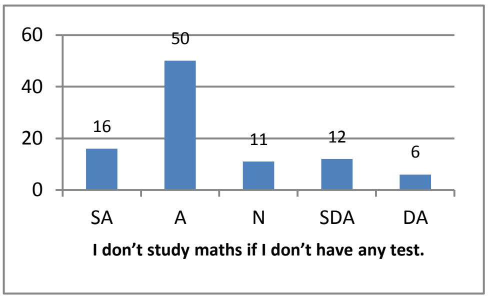


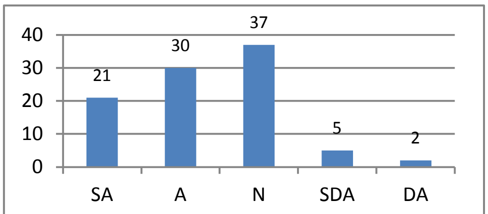






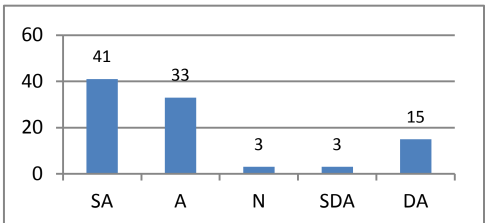




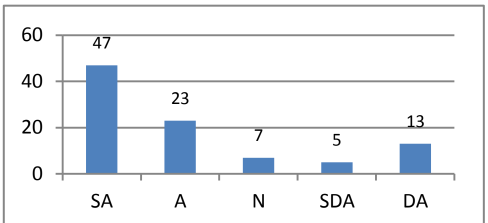


I like the information available on "World of Calculus" Group.

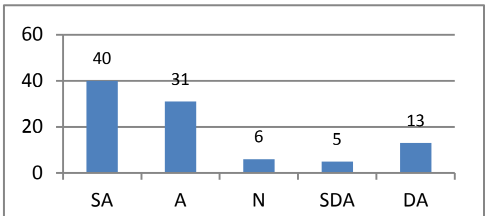
C3: Graphs of each question of the self-designed questionnaire: Attitudes towards bilingual support



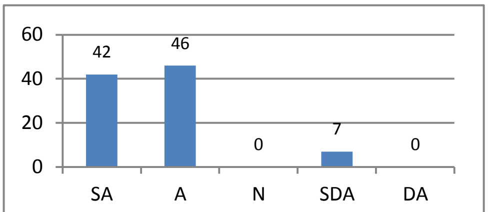
I like the idea of students explaining maths in Arabic on the board.



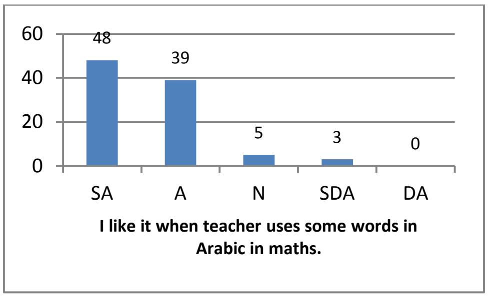
Listening to other students explaining maths problems in Arabic is fun.

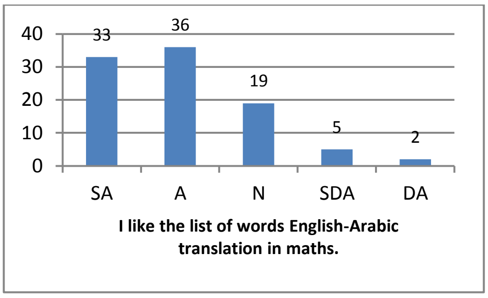


I learnt maths from students in the class when they explained maths in Arabic.

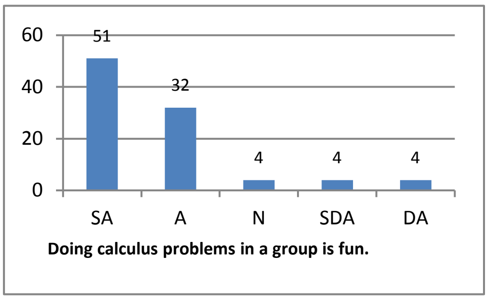


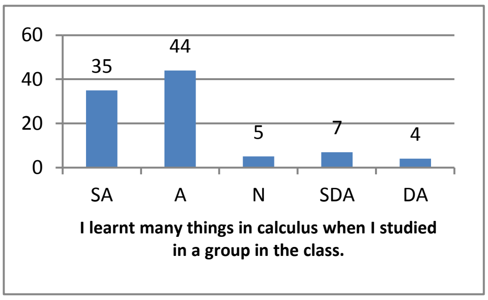
Arabic translation of some words is good to have.

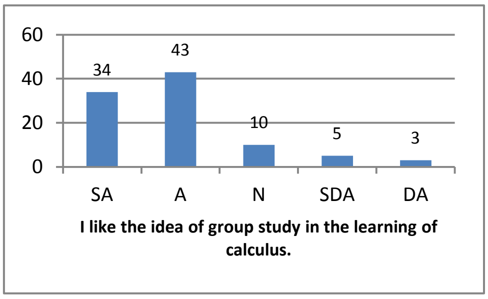


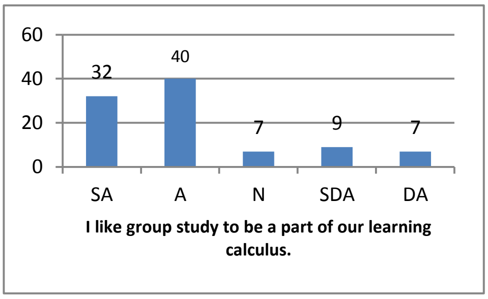


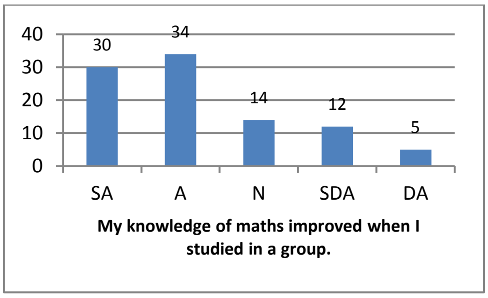
C4: Graphs of each question of the self-designed questionnaire: Attitudes towards collaborative support

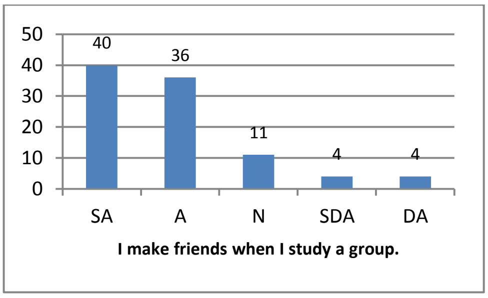


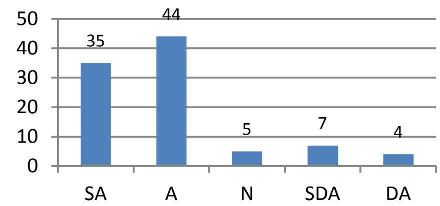




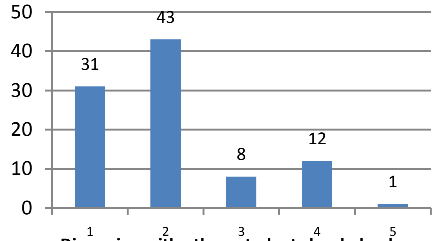




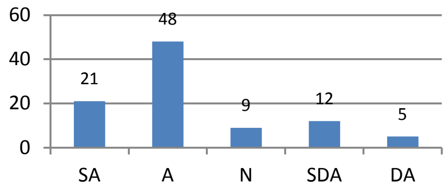




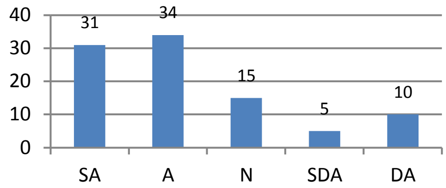
Discussing with other students in the group has helped me a lot when I could not solve a maths problem myself.



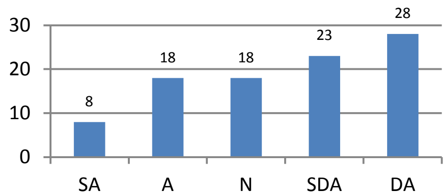
Discussing with others students has helped me understand calculus concepts betters.



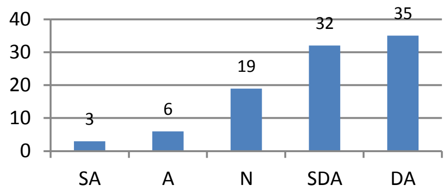
My interest in maths increased when I discussed with other students in a group.



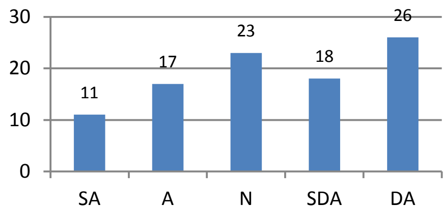
Group study has also helped in understanding maths in English.



Maths should be done alone not with others in a group.

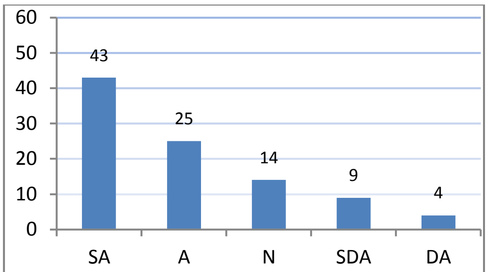


I don't feel good to discuss maths problems with others in a group.

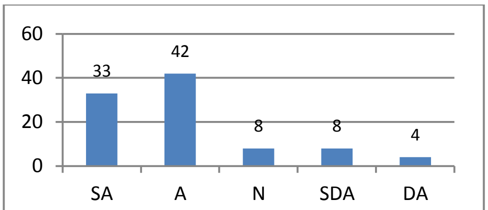


I like to study calculus alone.

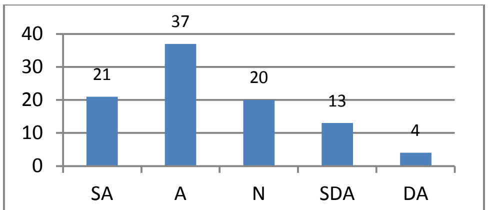
C5: Graphs of each question of the self-designed questionnaire: Attitudes towards MATLAB supported collaborative learning



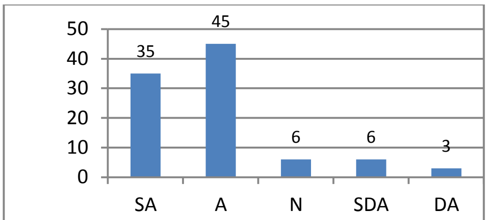
I enjoyed doing calculus with MATLAB.



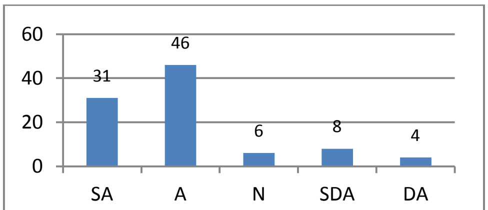
I enjoyed doing integration problems with MATLAB.



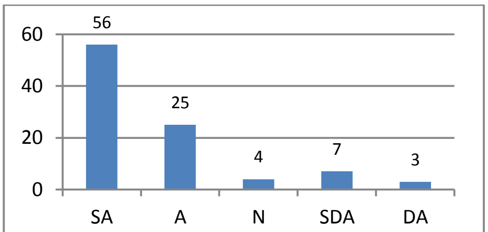
I can learn any computer program needed for my course.



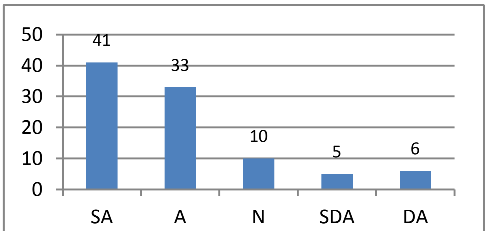
I learnt many things about graphing using MATLAB.



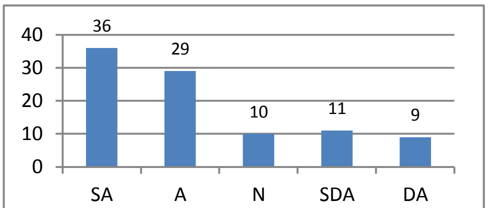
MATLAB is good to use for understanding solids of revolution.



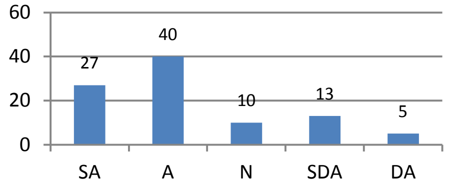
Sketching graphs is easy in MATLAB.



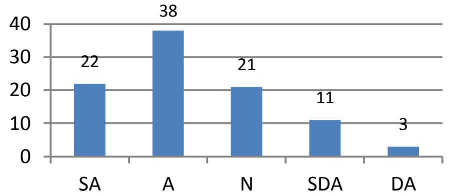
Sketching graphs is fun using MATLAB.



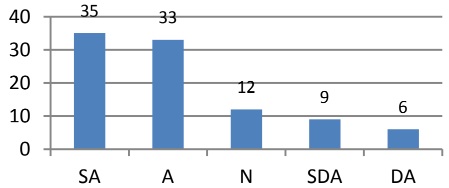
MATLAB is easy to use.



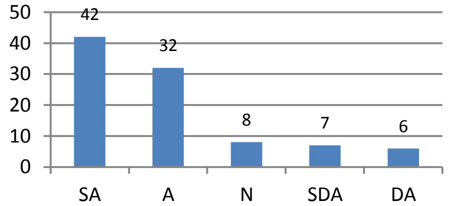
It was interesting to learn power rule of integration using MATLAB.



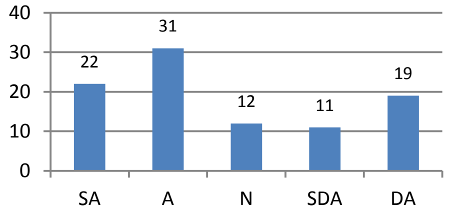
MATLAB made is easy for practicing integration problems.



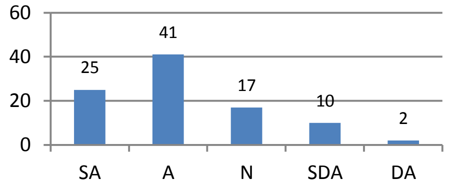
I like MATLAB because it is important for engineering.



I like to learn calculus with MATLAB in a group.



Doing calculus with MATLAB alone is not easy.



I can enjoy using MATLAB if I use it more and more.

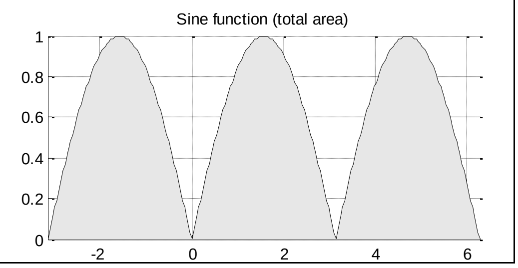
APPENDIX D: MSCL Worksheet

University of Ha'il
MATLAB-Based Computer Lab Projects
Integral Calculus course: Math 102
Worksheet No. 3: Total Area problem

Work in group of 2: ID Nos.: ____________________ ____________________

Example of total area

MATLAB code	

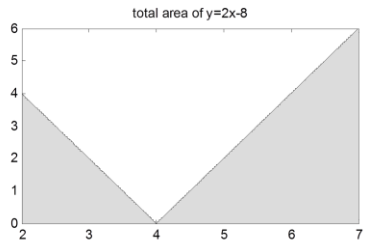
x=-pi:pi/100:2*pi;
f=sin(x);
plot(x,f)
plot(x, abs(f))
	

BY-HAND EXERCISE

Problem: (Calculate total area)

Find the total area of $f(x) = 2x - 8$

Solution:



Step 1: What is a = _________, b= ___________ (See the figure)

Step 2: $\int_2^4 f(x)dx =$____________________

Step 3: $\int_4^7 f(x)dx =$____________________

Step 4: $\int_2^7 f(x)dx =$____________________

QUESTIONNAIRE

I found the total area problem.

Very Hard	Hard	OK	Easy	Very Easy

Now my understanding of the total area is.

Not Very Good	Not Good	Neutral	Good	Very Good

The use of MATLAB helped me in understanding the total area problem.

Not Very Helpful	Not Helpful	Neutral	Helpful	Very Helpful

APPENDIX E: Student Sample Work

Patterns in integrals:

	Problem	MATLAB command	Answer
1.	$\int \frac{1}{(x+2)(x+3)}dx$	int(1/((x+2)*(x+3)))	$\log(X+2) - \log(X+3)$
2.	$\int \frac{1}{(x+1)(x+5)}dx$	int(1/((x+1)*(x+5)))	$\frac{\log(X+1)}{4} - \frac{\log(X+5)}{4}$
3.	$\int \frac{1}{(x+2)(x-5)}dx$	int(1/((x+2)*(x-5)))	$\frac{\log(X-5)}{7} - \frac{\log(X+2)}{7}$
4.	$\int \frac{1}{(x+2)^2}dx$	int(1/(x+2)^2)	$-\frac{1}{X+2}$

What pattern do you see in the answer above?

we have to take the logar-itme of the domenitar and divided →

Based on the pattern above:

1. If a ≠b then guess the value of : $\int \frac{1}{(x+a)(x+b)}dx$: $\frac{\log(X+a)}{a-b} - \frac{\log(X+b)}{a-b}$

2. What if a = b? answer will be $= \frac{-1}{(x+a)}$

Patterns in integrals:

	Problem	MATLAB command	Answer
1.	$\int xe^x dx$	int(x*exp(x))	$e(x)(x-1)$
2.	$\int x^2e^x dx$	int(x^2*exp(x))	$e(x)(x^2-2x+2)$
3.	$\int x^3e^x dx$	int(x^3*exp(x))	$e(x)(x^3-3x^2+6x-6)$
4.	$\int x^4e^x dx$	int(x^4*exp(x))	$e(x)(x^4-4x^3+12x^2-24x+24)$
5.	$\int x^5e^x dx$	int(x^5*exp(x))	$e(x)(x^5-5x^4+20x^3-60x^2+120x-120)$

What pattern do you see in the answer above?

For equation like that, we har to multiply e(x) by the factorized equation.

Based on the pattern above:

1. Guess the value of the integral $\int x^n e^x dx$:

$$e(x)(x^n - nx^{n-1} + (n)(n-1)x^{n-2} + \dots + C)$$

Patterns in integrals:

	Problem	MATLAB command	Answer
1.	$\int \frac{1}{(x+2)(x+3)}dx$	int(1/((x+2)*(x+3)))	$\log(x+2) - \log(x+3)$
2.	$\int \frac{1}{(x+1)(x+5)}dx$	int(1/((x+1)*(x+5)))	$\frac{\log(x+1)}{4} - \frac{\log(x+5)}{4}$
3.	$\int \frac{1}{(x+2)(x-5)}dx$	int(1/((x+2)*(x-5)))	$\frac{\log(x-5)}{7} - \frac{\log(x+2)}{7}$
4.	$\int \frac{1}{(x+2)^2}dx$	int(1/(x+2)^2)	$-\frac{1}{x+2}$

What pattern do you see in the answer above?

إذا كانت د الدالتين مضروبتين في المقام وكانت متشابهتين بالإشارة نطرح العددين فيكون الناتج هو لوغاريتم الدالة الأولى مطروحه من لوغاريتم الدالة الثانية مقسومة على ناتج ~~طرح~~ الطرح بين العددين

Based on the pattern above:

1. If a ≠ b then guess the value of : $\int \frac{1}{(x+a)(x+b)}dx$: $\frac{\log(x+a)}{|a-b|} - \frac{\log(x+b)}{|a-b|}$

2. What if a = b? $\frac{1}{(x+k)(x+k)} = \frac{1}{(x+k)^2} = -\frac{1}{(x+k)}$

3. Evaluate the answer by hand using partial fractions method that you will get in 2.

أما إذا كانت الإشارة بين الدالتين غير متشابهتين بالإشارة نجمع العددين فيكون الناتج هو لوغاريتم الدالة الأولى مطروحه من لوغاريتم الدالة الثانية مقسومة على ناتج جمع العددين أما إذا كانت الدالة في المقام بأس نرفع الدالة للسالب وتكامل الدالة

Patterns in integrals:

	Problem	MATLAB command	Answer
1.	$\int \ln x dx$	int(log(x))	$x(\log(x) - 1)$
2.	$\int x \ln x dx$	int(x*log(x))	$x^2(\log(x) - \frac{1}{2})/2$
3.	$\int x^2 \ln x dx$	int(x^2*log(x))	$x^3(\log(x) - \frac{1}{3})/3$
4.	$\int x^3 \ln x dx$	int(x^3*log(x))	$x^4(\log(x) - \frac{1}{4})/4$
5.	$\int x^7 \ln x dx$	int(x^7*log(x))	$x^8(\log(x) - \frac{1}{8})/8$

What pattern do you see in the answer above?

If there are two functions on is (x^n) and the other is $(\ln x)$ function the answer will be (x) with $(n+1)$ multiply by $(\ln x)$ minus(-) one (1) over $(n+1)$ and all over $(n+1)$

Based on the pattern above:

1. Guess the value of the integral $\int x^n \ln x dx$:

$$\frac{x^{n+1}\left(\ln x - \frac{1}{n+1}\right)}{n+1} \qquad -1$$

2. Evaluate the answer by hand.

APPENDIX F: Collaborative Support Sample Worksheet

7.3 Integrating trigonometric functions
We will do the following problems in the class (and remaining questions you will do at home)
Problems #1: $\int \sin^4 x \cos^5 x\, dx$

a. n=5 odd meaning we will split off (انشقت) cosine function. How (see the next step)
b. $\cos^5 x = (\cos^4 x).(\cos x)$
c. $\cos^4 x = (1-\sin^2 x)^2$, *you know that* $(\cos^2 x = 1 - \sin^2 x)$
d. Take $u = \sin(x)$, *then* $du = \cos(x)\, dx$
e. $\int \sin^4 x\ (1-\sin^2 x)^2 \cos(x)\, dx$
f. Complete the solution والآن إكمال الحل

Problems #2: $\int \sin^4 x \cos^4 x\, dx$

a. n=4 even meaning we will split off (انشقت)sine function and cosine function.
b. $\int (\sin^2 x)^2 (\cos^2 x)^2\, dx$
c. *you have to use these formulas*$:(\sin^2 x = \frac{1}{2}(1-\cos 2x), (\cos^2 x = \frac{1}{2}(1+\cos 2x)$
d. Complete the solution…والآن إكمال الحل

Problems #3: $\int \tan^2 x \sec^4 x\, dx$

a. n=4 even meaning we will split off (انشقت) secant function.
b. $\int \tan^2 x (\sec^2 x \sec^2 x)\, dx$
c. $\sec^2 x = \tan^2 x + 1$
d. $u = \tan(x)$, *then* $du = \sec^2(x)\, dx$
e. Complete the solution

Problems #4: $\int \tan^3 x \sec^3 x\, dx$

a. m=3 odd meaning we will split off a factor of sec(x) tan(x).
b. take u = sec(x), $\tan^2 x = \sec^2 x - 1$
c. complete the solution

APPENDIX G: Collaborative Support Sample Worksheet

Students Group Study Plan
"Working together helps everyone"

University of Ha'il
Mathematics Department
Math 102

Calculus cannot be learned passively. Marcoff 1985

9.6 Alternating series

1. Show that the series $\sum_{k=1}^{\infty}(-1)^{k+1}\frac{k+3}{k(k+1)}$ converges by confirming that it satisfied the hypothesis of the alternating series test.
2. Show that the series $\sum_{k=1}^{\infty}\frac{(-1)^{k+1}}{2k+1}$ converges by confirming that it satisfied the hypothesis of the alternating series test.

9.6.1 THEOREM (*Alternating Series Test*) *An alternating series of either form* (1) *or form* (2) *converges if the following two conditions are satisfied:*

(*a*) $a_1 \geq a_2 \geq a_3 \geq \cdots \geq a_k \geq \cdots$

(*b*) $\lim_{k \to +\infty} a_k = 0$

APPENDIX H: World of Calculus

Your Location: Group Homepage / Group Files

Folders	Files in World of Calculus
World of Calculus Chapter 5 Chapter 6 Chapter 7	A WEEKLY FLOW CHART FOR STUDYING.pdf English Arabic Math Dictionary.pdf English-Arabic glossary.pdf Learn calculus with computer animations.doc Syllabus-math102-term 121.pdf connection between chain rule of diff and u-subs of integ.pdf how to be success in math and what is calculus.pdf theorems.pdf

Add a new File to World of Calculus

7.7.1 File and Folder Search

Search for:	☑	File Names	☑	Folder Names	☑	File Content
that contain:						Search

APPENDIX I: AREA BETWEEN TWO CURVES

Three main steps:

1. Graph the equations.
2. Determine the points of intersection. Put one equation equal to the other and solve them.
3. Set up and evaluate the definite integral.

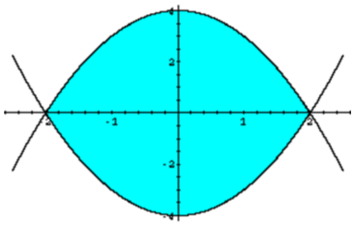
Formula

$$Area = \int_a^b (upper\ curve - lower\ curve)\,dx \qquad Area = \int_a^b (right\ curve - left\ curve)\,dx$$

Example: Find the area between the curves f (x) = 4 - x^2 and g (x) = x^2 - 4.

Steps:

1. **graph the functions**



   a. graphing will help you to find:
      i. which function is on top
      ii. which function is on the bottom

2. **find the points of intersection** (where the graphs meet)

$$4 - x^2 = x^2 - 4 \to -2x^2 = -8 \to x^2 = 4 \to x = -2 \text{ or } x = 2$$

3. **Set up and evaluate the definite integral**

$$Area = \int_{-2}^{2} \left[\left(4 - x^2\right) - \left(x^2 - 4\right)\right]dx = \int_{-2}^{2} (8 - 2x^2)\,dx$$

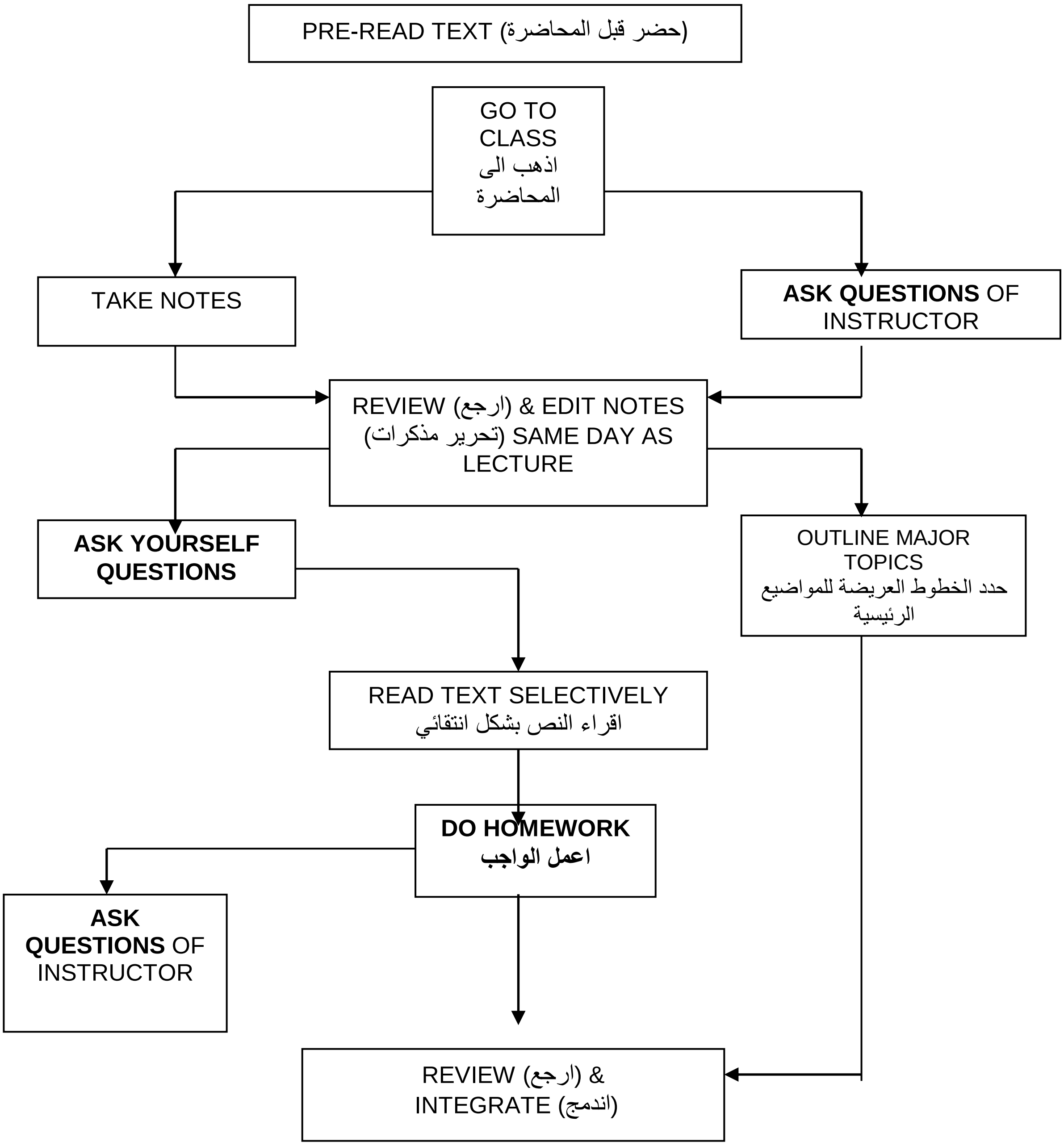
$$= \left[8x - \frac{2}{3}x^3\right]\Big|_{-2}^{2} = \left(8(2) - \frac{2}{3}(2)^3\right) - \left(8(-2) - \frac{2}{3}(-2)^3\right),$$

$$= \left(16 - \frac{16}{3}\right) - \left(-16 + \frac{16}{3}\right) = \frac{64}{3}$$

http://faculty.eicc.edu/bwood/math150supnotes/supplemental24.html

APPENDIX J: Study Support Sheet

A WEEKLY FLOW CHART FOR STUDYING (خطط لدراسة)



Adapted from *Academic Skills Center*, Dartmouth College 2001

Association is a key to memory.

You remember approximately 10% of what you read.	تتذكر ما يقرب من 10٪ من ما تقرأ.
You remember approximately 20% of what you hear.	تتذكر ما يقرب من 20٪ من ما تسمع.
You remember approximately 30% of what you see.	تتذكر ما يقرب من 30٪ من ما تراه.
You remember approximately 50 % of what you hear and see together.	تتذكر ما يقرب من 50٪ من ما نسمع ونرى معا.
You remember approximately 70% of what you say (if you think as you are saying it).	تتذكر ما يقرب من 70٪ من ما تقوله. (إذا كنت تعتقد وأنت تقول ذلك)
You remember approximately 90 % of what you do.	تتذكر ما يقرب من 90٪ من ما تفعله.

from Edgar Dale's Cone of Experience

APPENDIX K: Study Support Sheet

Interconnected concepts

The definite integral is sometimes called the Riemann sums.

$$\int_a^b f(x)\,dx = \lim_{\max \Delta x_k \to 0} \sum_{k=1}^{n} f(x_k^*)\Delta x_k$$

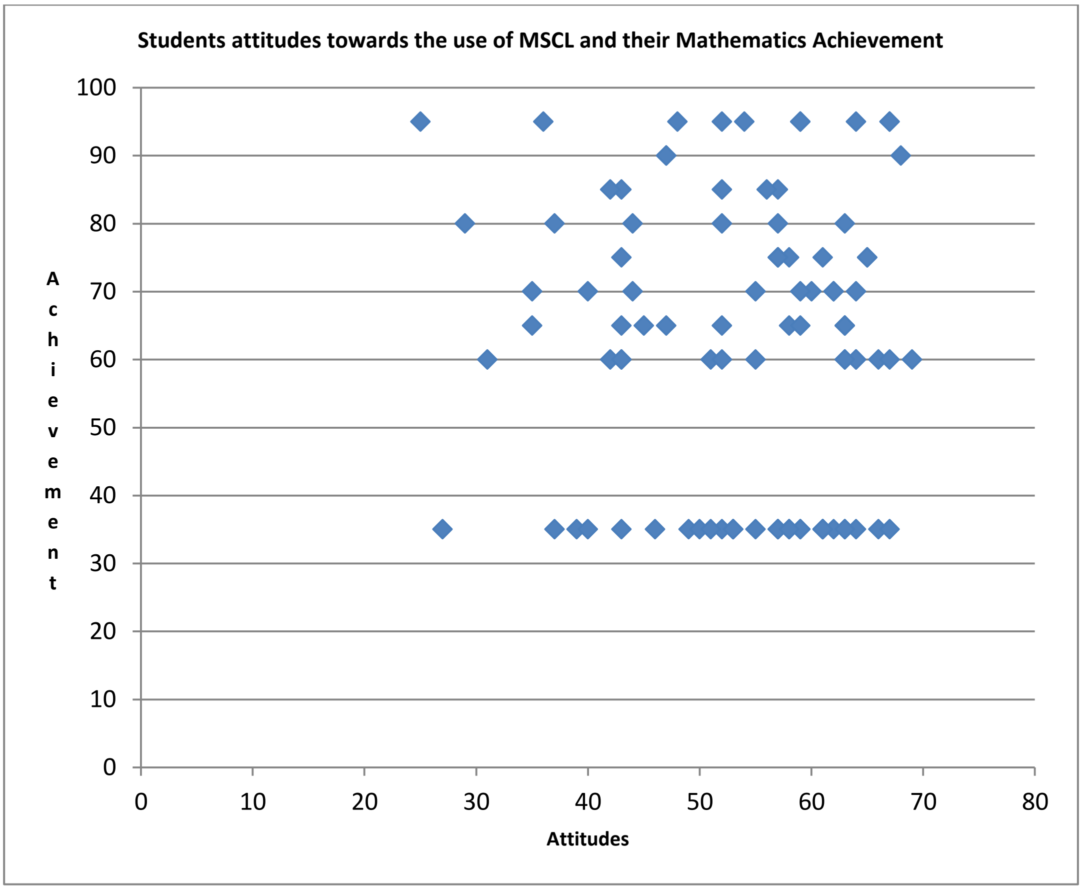
RHS is the Riemann sum. $\Delta x = \frac{b-a}{n}$

LHS=RHS if the limit exists.

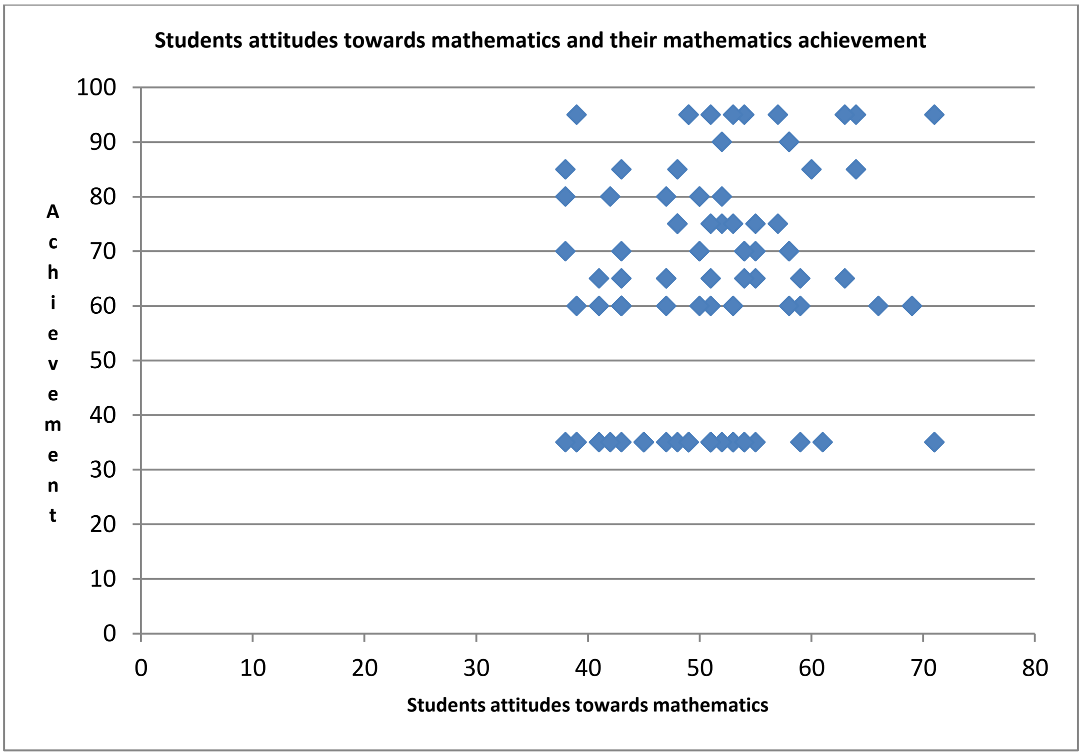
Note: This is used to:

1. Compute an area.
2. Find the distance travelled by an object.
3. Solve problems in Chapter 9 that is Infinite Series.

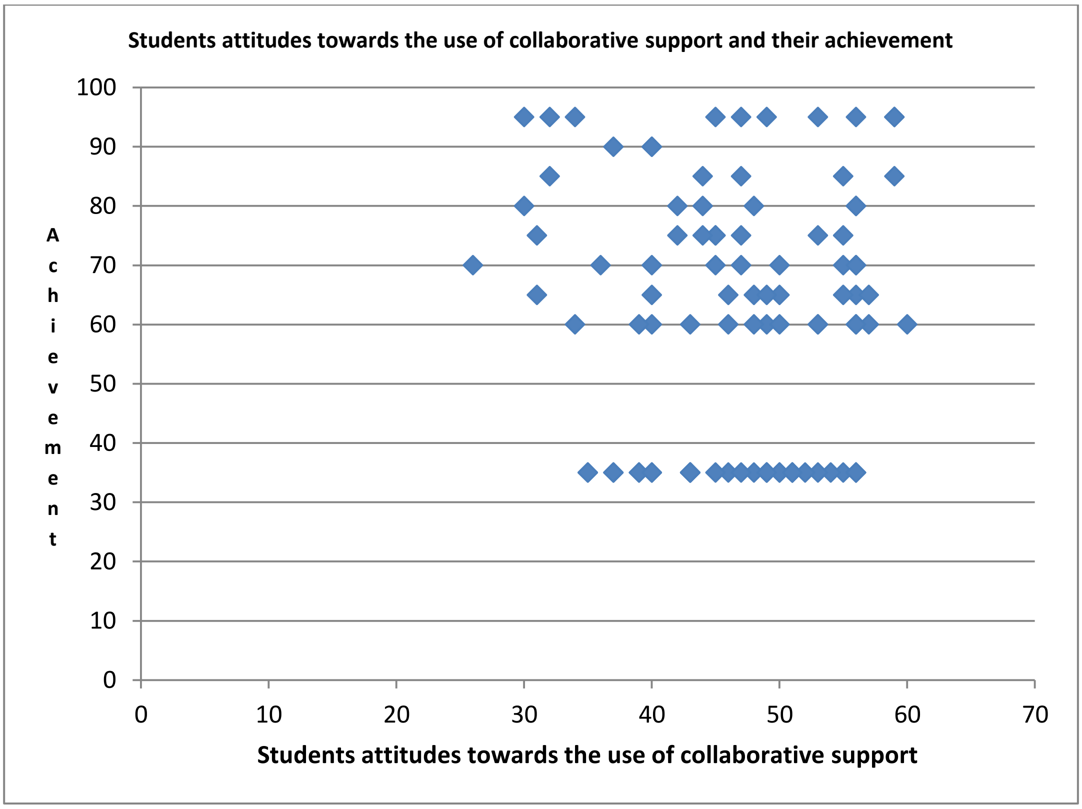
APPENDIX L: Scatter Plot



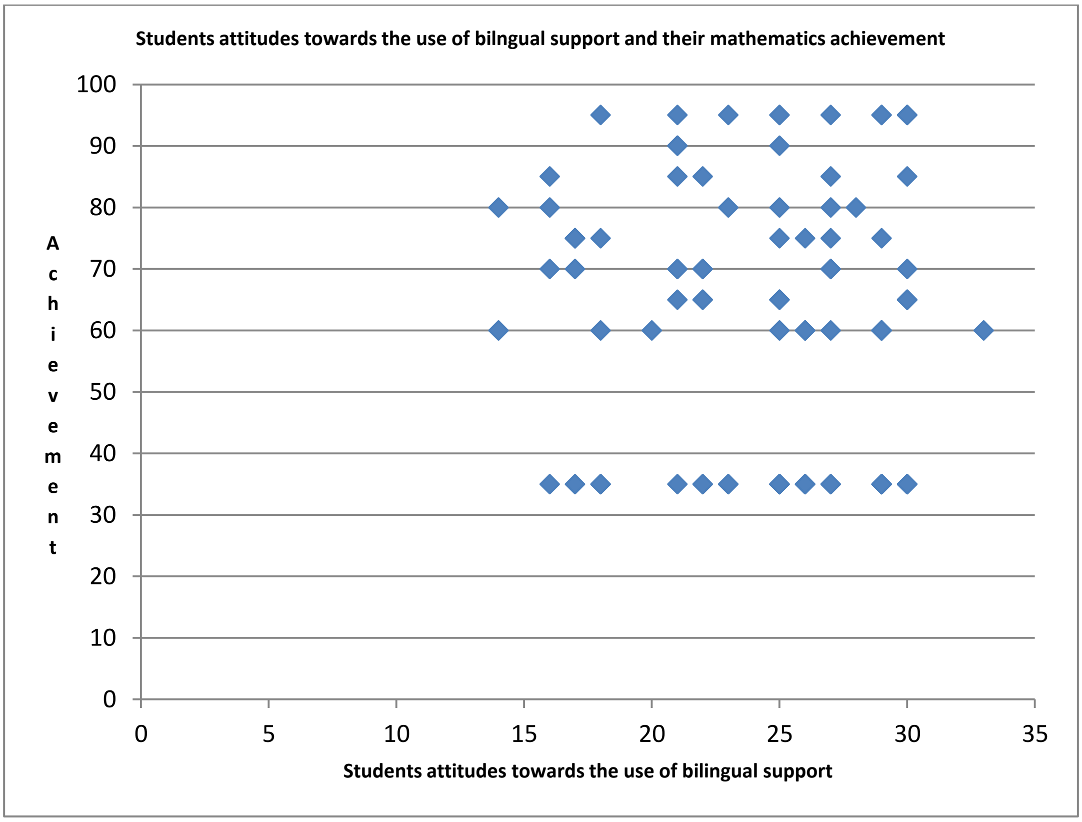
APPENDIX M: Scatter Plot



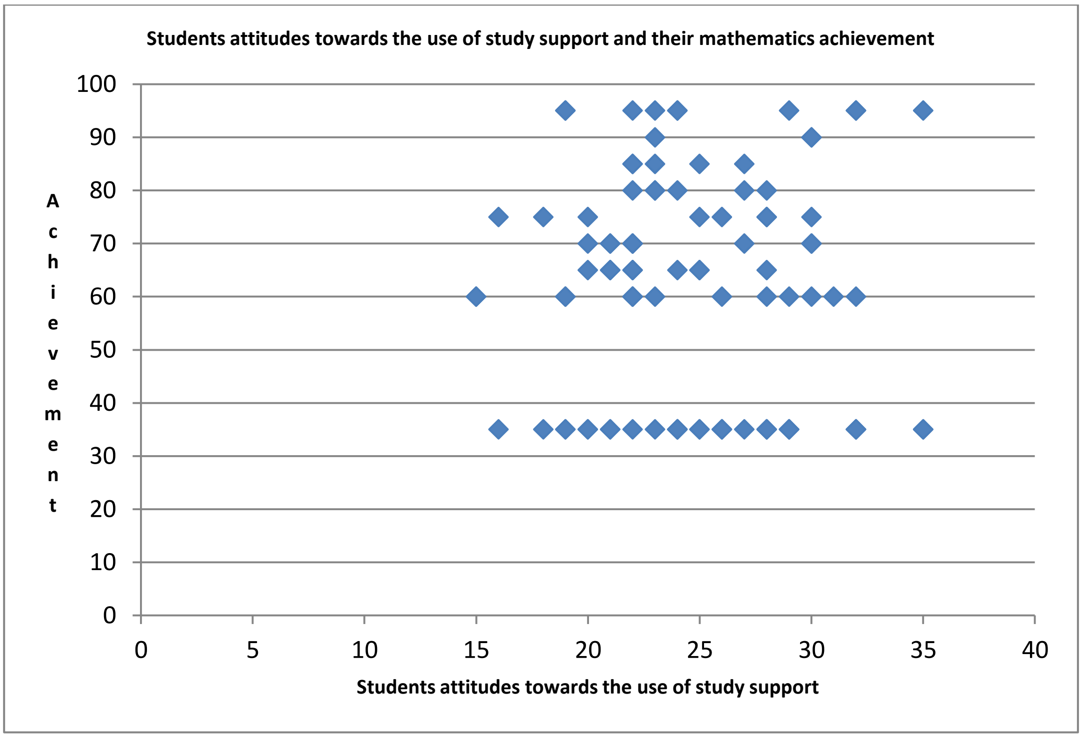
APPENDIX N: Scatter Plot



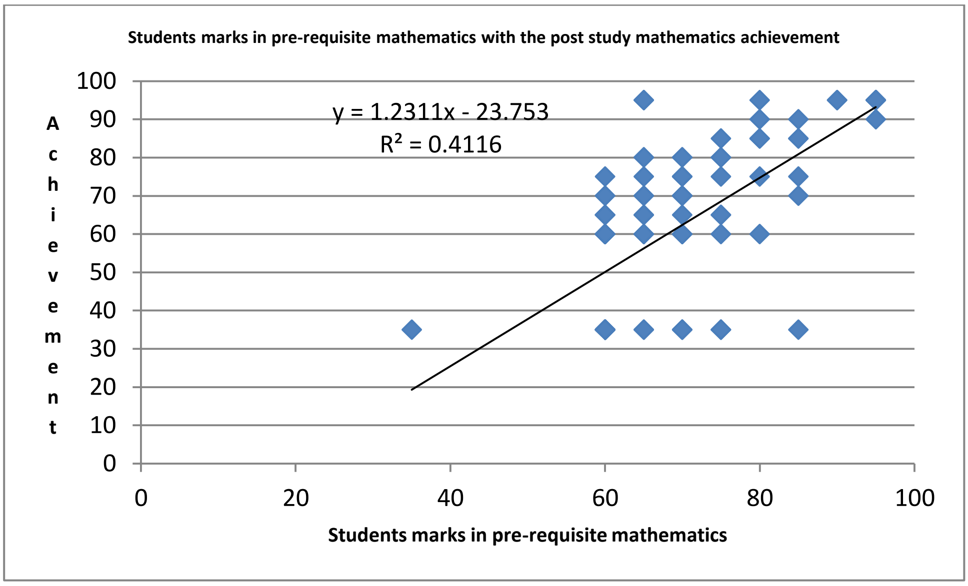
APPENDIX O: Scatter Plot



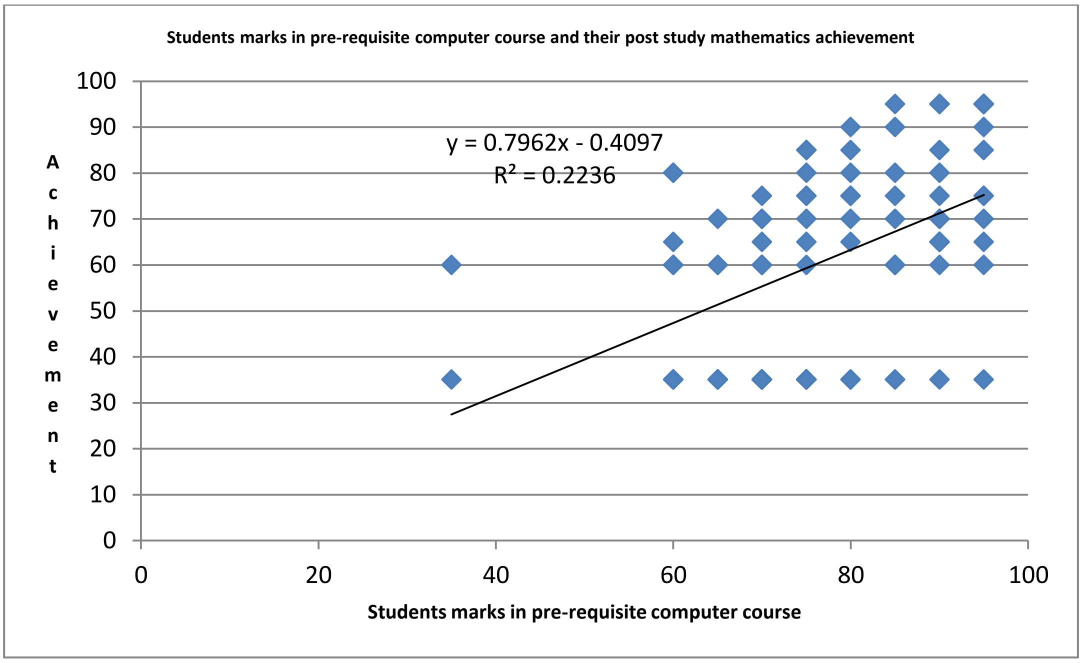
APPENDIX P: Scatter Plot



APPENDIX Q: Scatter Plot



APPENDIX R: Scatter Plot



APPENDIX S: Scatter Plot