THE PREDICTORS OF SUCCESS OF COMPUTER AIDED LEARNING OF PRE-CALCULUS ALGEBRA

by

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ABSTRACT

Mathematics achievement has been of great concern to researchers involved in mathematics education. This concern has resulted in research seeking to determine for example, the factors that positively or negatively contribute to student performance in mathematics. Many of the reported studies in the literature have investigated the factors within the context of mathematics teaching and learning in general. Very few studies have investigated the factors contributing to student achievement in mathematics when learning takes place in a computer aided environment. With the pervasiveness of computers in education in general, studies in this direction become imperative. The present study fills this gap in the literature by examining the extent to which selected variables (mathematics attitude, mathematics aptitude, computer attitude, computer prior experience, computer ownership, proficiency in language of instruction, and learning style) contribute to students' achievements in pre-calculus algebra classes that are supplemented with a computer lab program. The participants in the study were 120 students sampled from the population of students enrolled in the second pre-calculus algebra course at the preparatory year program of King Fahd University of Petroleum & Minerals during the 2003/2004 academic session. The instruments used to measure the study constructs were the mathematics attitude scale (Aiken, 1979), the computer attitudes scale (Loyd & Gressard, 1984a), and the learning styles questionnaire (Honey & Mumford, 1992). New instruments to measure computer prior experience and computer ownership were developed for the present study.

Hypotheses formulated for the study were tested using multiple regression and other statistical techniques. The results show that mathematics aptitudes and English language proficiency are the most significant contributors to students' mathematics achievement. No other variables show statistically significant effects on students' achievement. Together, the selected variables explain more than 41 percent of the total variance of students' achievement.

Theoretical and policy-making implications of the results are outlined and discussed.

DECLARATION

I declare that THE PREDICTORS OF SUCCESS OF COMPUTER AIDED LEARNING OF PRE-CALCULUS ALGEBRA is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete reference.

…………..................... ……………………..
SIGNATURE DATE
(B. YUSHAU)

DEDICATION

To Almighty Allah for making it possible and for not disappointing those who believe I can do it.

To my friends indeed, who gave me the challenge, the inspirations and the encouragement.

To my honorable wife Hafsah and her children: Muzammil, AbdulBasit, AbdulIlah and Fatima, who understand why I had to stay away most of the time in the course of this study.

To my students, who kept on asking 'did you finish your PhD? or when are you going to finish your PhD?

To those who understand the value of education and are ready to sacrifice anything for it

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May God bless all.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

KEY WORDS

Pre-calculus, Technology, Mathematics achievement, Predictor of success, Computer aided learning, Mathematics education, Learning styles, Computer attitudes, Mathematics attitudes, Mathematics aptitude, Computer ownership, Computer prior experience, English language proficiency, Bilingualism, Arabs, Language of Instruction.

CHAPTER ONE

Background of the Study

1.1 Introduction

Computers are gradually becoming the most powerful tool of all human inventions with applications spreading to almost all aspects of human endeavor. One aspect in which computers have had a significant impact is education. The advent of educational technology has been regarded as a major revolution within the educational system (c.f. Ashby, 1967; Fourth Revolution, 1972). However, from the far-reaching role computers are playing in education, one can argue that the discovery of the computer and the World Wide Web is another revolution within the educational and technological revolution. With this development, the face of the whole educational system has changed forever.

Computers have been used in education for more than four decades, and they have now become an integral part of the entire educational system: as teacher, study mate and more especially as tools to improve the entire teaching and learning processes. This usage is dramatically on the increase, and predictions have it that this trend will continue to accelerate (Bransford, Brown, & Cocking, 1999). The various ways of computer usage in education include, but are not restricted to: tutorials, drills, simulations, games, tests, problem solving, and at a more advanced level in what is known as Intelligent CAL (ICAL), Intelligent tutoring, and Computer-Controlled Video (Alessi & Trollip, 1985).

In this development, no subject has benefited from, and has stronger intrinsic links with computers than mathematics. Kaput (1992) noted that the role of computers in mathematics education is so significant that it is difficult to describe, and it changes so rapidly that it is difficult to follow.

> Anyone who presumes to describe the roles of technology in mathematics education faces challenges akin to describing a newly active volcano – the mathematical mountain is changing before our eyes, with myriad forces

operating on it and within it simultaneously (Kaput, 1992:515).

Over the last two decades, there has been a growing interest in the use of computers for supporting learning and teaching mathematics, especially in higher education (Crowe & Zand, 2000). The reason is connected with the long-time quest for an appropriate approach that will make mathematics accessible to as many students as possible. The main issue is that mathematics remains a difficult and inaccessible subject to most students. This fact is not only accepted globally, but it is, consciously or unconsciously, being passed on from one generation to another. Despite this difficulty, mathematics remains a fundamental requirement for all science and engineering courses, or rather what Sells (1973) called a "critical filter" to the academic and vocational future of many students. In addition, the failure rate in mathematics is apparently high compared to other subjects. According to Papert (1980), the failure of so many students to learn mathematics is largely due to a lack of mathematics culture in adults, and the scarcity of adults within mathematics who know how to 'speak mathematics' (Noss, 1997:290). Papert (1980) is of the opinion that computers have the potential to provide "the kind of rationale for symbolic/formal expression with which conceptual frameworks for mathematical learning can be built" (Noss, 1997:290).

A number of mathematics educators share this belief with Papert. In fact, this is part of the reason why computers are becoming more popular and acceptable as mathematics teaching/learning aids compared to other traditional learning systems. Computers have the capacity to interact with users, regulate the pace of lessons, and cope with several students simultaneously. With the interactivity of the computer, "it is now easier to create environments in which students can learn by doing, receive feedback, and continually refine their understanding and build new knowledge" (Bransford *et al*., 1999, chapter 9, para. 3).

Another unique feature of the computer as a teaching and learning tool is *visualization*. Dreyfus (1993) observed that during the last thirty years, mathematics as an activity has become more experimental and more visual. In line with this development, the computer is a unique tool that has the potential of enhancing both visual and experimental features. For instance, the powerful visualization capacity of the computer is

unprecedented and incomparable with traditional teaching aids. Abstract concepts that have proved difficult for teachers to explain or for students to grasp using traditional teaching approaches or aids can now easily be produced and understood by using the powerful animation and graphical display capabilities of computers. With this, students reasoning and manipulative power are facilitated especially by computer graphics. In addition, students can work with visualization and modeling software to simulate a concept or idea that is similar to real life situations. Not only will this increases the experimentation, exploration and understanding of the students, but it also increases the likelihood of transferability of knowledge from school to real life settings (Dreyfus, 1993; Bransford *et al.*, 1999), and therefore making mathematics sensible to students.

In the area of evaluation, computers can assess and evaluate both students and lessons; they have the capacity to handle a large volume of information, and therefore holding great promise both for increasing access to knowledge and as a means of promoting learning (McGettrick, 1979; Bransford *et al.,* 1999).

Many studies have been carried out to ascertain the effectiveness of computers in education in general, and in the teaching and learning of mathematics in particular. The results of all these studies have revealed that computers, if used appropriately, are highly effective and have great potential to enhance students' mathematics learning (Gershman & Sakamoto, 1981; Burns & Bozeman, 1981; Kulik & Kulik, 1985 & 1986; Satterlee, 1997; Bransford *et al*., 1999). However, because of the innovative nature of computers, most of the early studies on the use of computers in education were exploratory that concentrated on understanding the effectiveness of the programs in comparison with traditional methods. Some of these early studies include Grayson (1970), Edwards, Norton, Taylor, Weiss & Dusseldorp (1975) Thomas (1979), and Burns & Bozeman (1981).

From a review of the literature, there now seems to be a general consensus among the theorists and practitioners that computers are not only an effective tool of teaching and learning mathematics, but can trigger advanced cognitive mathematical activities (c.f.

Tall, 1991). Therefore, the argument has been advanced towards considering computer as a cognitive tool (Pea, 1987; Dörfler, 1993).

Now that the pedagogical effectiveness of computers in mathematics education is carefully realized, the topic of discourse among mathematicians and mathematics educators is no longer a dispute about whether to use the computer or not in the teaching and learning of mathematics, but a shift to some debate about the when and how to utilize it. This has expanded research interest, and led to the evolution of specialized research in the area. The research is now moving away from assessing the relative effectiveness of computer-mediated instruction versus traditional approaches and towards (i) systematic exploration of effective components of computer-related instruction and, (ii) understanding the parameters necessary for a successful computer based mathematics learning and teaching program. In this respect, research has diversified into the design and development of educational software, evaluating educational software, the use of educational software in the real classroom, and understanding attributes of students that lead to better achievement in the program. The idea is to make mathematics more accessible to as many students as possible by providing them with richer and more diverse learning resources that will improve their mathematics understanding and achievement.

There are many variables associated with success in the teaching and learning of mathematics. However, Begle (1979) noted that most of the variables that affect mathematics learning reside within the student. Studies have shown that the use of computers in the teaching and learning of mathematics does improve students' mathematical achievements (Kullik, Kullik & Bangert-Drowns, 1985; Chambers & Sprecher, 1980; Kulik, Bangert, & Williams, 1983; Kullik, Kullik, & Cohen, 1980; Rivet, 2001). What is not clear is the class of students that benefit most in a computer-based mathematics teaching and learning environment (Bangert-Drowns, Kullik, & Kullik, 1983; Chambers & Sprecher, 1983; Edwards *et al*., 1975; Moonen, 1987). This necessitates the need to look deeply into factors that contribute to students' mathematics achievements in computer-aided learning environments. From a review of the academic literature, it appears that not many studies have been carried out that attempt to identify

these variables, particularly in pre-calculus algebra. Identifying such variables is important as it will ensure the selection of appropriate candidates for computer-based mathematics learning programs. It will also help in counseling students who have opted for the programs. Several variables have been established and identified as predictors of success in mathematics (Pugh, 1969; Elgamal, 1987; Blansett, 1988; Eshenroder, 1987; Bridgeman & Wendler, 1991; Shaughnessy, 1993; Armstrong, 1997; Buerman, 1998) and also in computer science (Bauer, Mehrens & Visonhaler, 1968; Huse, 1987; Shaffer, 1990; Al-Badr, 1993). It is possible, therefore, to project that some of the variables that have been found to predict success in mathematics and in computer science are also very likely to influence success in the computer-aided learning of mathematics environment.

1.2 Study Setting: The King Fahd University of Petroleum & Minerals

King Fahd University of Petroleum & Minerals (KFUPM) is one of the leading universities not only in the Kingdom of Saudi Arabia, but also in the entire gulf region. KFUPM is a male only institution that is oriented towards engineering, computer and physical sciences programs. It was started as the College of Petroleum and Minerals (CPM) by the Saudi Arabian-American oil company (ARAMCO) in 1963 with the aim of training the local middle class population in order to meet the manpower requirements of the company. Later, the college initiated its degree programs and the first batch of graduates with engineering degrees passed out in 1971. This event is regarded as a milestone in the history of the university. In 1975, the college was elevated to the level of university and was named as the University of Petroleum and Minerals (UPM). This change was not observed merely in the name but also in the academic status of the institution, which was heading toward meeting the technical requirements of the Kingdom. In 1986, the University was renamed as the King Fahd University of Petroleum & Minerals (KFUPM).

 The metamorphosis of KFUPM in both name and academic activities has been to meet the complex and exciting challenges that the discovery of oil has posed in the areas of scientific, technical, and management education within the Kingdom of Saudi Arabia.

KFUPM has adopted the course of advanced training in the fields of sciences, engineering, and management as one of its prime goals, and thus, it plays a leading role in providing leadership and technical service, particularly to the Kingdom's petro-chemical industries. The university also enhances the knowledge base through research in the fields of sciences, engineering, and management.

As rightly noted by Al-Doghan (1985), KFUPM differs from all other universities in the Kingdom of Saudi Arabia both in terms of its curriculum and its medium of instructions. More precisely, KFUPM stands for the development of sciences and engineering in the Kingdom with English as the principal language of instruction and Western books adopted as recommended texts for the courses.

KFUPM comprises of six colleges namely:

1. *The College of Sciences* (CS) which consists of Chemistry Department (CHEM), Earth Sciences Department (ES), Islamic & Arabic Studies Department (IAS), Mathematical Science Department (MATH), and Physics Department (PHYS).

2. *The College of Engineering Sciences* (CES) comprising of Chemical Engineering Department (CHE), Civil Engineering Department (CE), Electrical Engineering Department (EE), Mechanical Engineering Department (ME), Petroleum Engineering Department (PET).

3. *The College of Applied Engineering* (CAE) comprising of Applied Chemical Engineering Department (CHE), Applied Civil Engineering Department (CE), Applied Electrical Engineering Department (EE), Applied Mechanical Engineering Department (ME), Applied Petroleum Engineering Department (PET).

4. *The College of Computer Science and Engineering* (CCSE) consisting of Computer Engineering Department (COE), Information and Computer Science Department (ICS), and Systems Engineering Department (SE).

5. *The College of Industrial Management* (CIM) consisting of Management Information System & Accounting (MISAC)**,** Finance & Economics Department (FINEC), and Management & Marketing Department (MGMK).

6. *The College of Environmental Design* (CED) comprising of Architectural Engineering Department (ARE)**,** Architecture Department (ARC), City & Regional Planning Department (CRP), and Construction Engineering & Management Department (CEM).

Another unique program that distinguishes KFUPM from other universities of the Kingdom of Saudi Arabia is its two-semester preparatory (orientation) program. This program is intended to bridge the gap between high school and the university, especially in the language of instruction, which is English. Most of the students entering KFUPM are graduates of the Arabic medium schools. Therefore, in principle, all students admitted to KFUPM are required to complete a one-year preparatory program before starting their undergraduate studies. This program mainly consists of a rigorous English language program and an intensive review of some basic high school mathematics, mainly algebra and trigonometry. In addition, students take the courses related to Graphics, Mechanical Engineering Workshop, and Physical Education during the preparatory year. However, the system is flexible in the sense that students may be exempted from the entire or a part of the preparatory program according to their performance in the promotion exams in English language, and algebra and trigonometry conducted at the start of each term. According to the Undergraduate Bulletin of KFUPM (2001-2003), the main aim of the preparatory year program is to prepare students for undergraduate study, in particular to achieve the following goals:

a) to improve the proficiency of students in English before they undertake undergraduate study;

b) to develop and improve the students' knowledge of mathematical and analytical techniques through the medium of English;

c) to introduce students to new subject areas and techniques such as workshop and graphics, thus improving their mental and manual skills;

d) to familiarize students with the various majors available at the University;

e) to improve students' physical health and stamina through the Physical Education program;

f) to familiarize students with the requirements of undergraduate study, including study skills and discipline in all its forms.

(KFUPM Undergraduate Bulletin, 2001-2003:29-30).

Although the grades earned by the students in the preparatory year courses are not considered in the calculation of the students' cumulative grade point average (CGPA) for the undergraduate program, the grades are recorded in the students' transcript together with the semester grade point average (GPA) and CGPA. More notably, a students' performance at the preparatory year program is largely considered as a predictor of his success in the undergraduate program (c.f. Al-Doghan, 1985). Therefore, the preparatory year is a 'critical filter' for the students, and crucial for all stakeholders in the university – the university administration, the students, parents, and government.

1.3 Statement of the Problem

The main purpose of this study was to investigate the potential variables that contribute to the achievement of students enrolled in the pre-calculus algebra courses supplemented with a computer lab program. Here, pre-calculus algebra was chosen as a subject for research because it is a prerequisite for all sciences, engineering, and social science courses at university level. It has been established that the mathematical skills in this pre-calculus algebra are one of the best predictors of success at university level and at KFUPM in particular (Al-Doghan, 1985). Since computers are widely used in these courses with an aim to optimize the potential of the students to succeed, it became imperative to determine the variables that may predict success among the beneficiaries of the program.

1.4 Research Objectives

Literature is replete with variables that have been identified to predict success of the students in algebra in particular, and in mathematics and computer science in general. In

the present study, the assumption was that some of the variables might also be associated with success in a pre-calculus algebra course that is supplemented by a computer laboratory program. A preliminary analysis of the variables that used to predict success identified, mathematics attitudes, mathematics aptitude, computer prior experience, computer ownership, proficiency in English, and learning styles to be variables with a potential to influence achievement. The principal goal of this research was to establish a relationship between the identified variables and students' achievement in the computer laboratory supplemented pre-calculus algebra course. The objective was to isolate the variables that contributed to success in the pre-calculus algebra course, and possibly categorize students based on achievement potential in a computer-based environment. In undertaking this task, the following goals were addressed:

1. Reviewed literature on what mathematics is, its nature and method of teaching and learning. In particular, we looked into the role of technology (computer) in the teaching and learning of mathematics, and its relationship with creativity.

2. Reviewed literature related to the predictor of success. This review leads us to a conceptual framework that guided the study. We also reviewed literature on the selected variables from both theoretical and empirical perspectives, and that indicated the potentiality of the selected variables.

3. Explained in detail the ingredients of the one semester experiment, which served as the experimental design. Here, the population, participants, variables, instruments and their psychometrics, historical background, the vehicle, data collection processes, and the statistical analysis of the study were explained.

4. Carried out a one-semester experiment that enables the collection of data for the study.

5. Analyzed the data collected using statistical techniques and packages, summarized the findings and discussed them in line with what is available from current literature. In turn, this lead to the acceptance or rejection of the research hypotheses.

6. Gave some educational implications of the findings, and made recommendations for carrying out further research to improve and throw more light in the same direction.

Therefore, the objectives of the study are to investigate if:

1. There is a significant positive relationship between mathematics aptitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

2. There is a significant positive relationship between attitudes towards mathematics and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

3. There is a significant positive relationship between computer attitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

4. There is a significant relationship between computer ownership and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

5. There is a significant relationship between computer prior experience and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

6. There are significant differential effects of learning styles on achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

7. There is a significant relationship between proficiency in the language of instruction and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

8. The predictor variables (mathematics attitudes, computer attitudes, mathematics attitudes, computer ownership, proficiency in language of instruction, and learning styles) will contribute a significant portion of the variance in the achievement of the students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

1.5 Motivation and Significance of the Research

The impact of computers in the educational system is growing fast and this is expected to continue well into the future. The application of computer-aided learning (CAL) is also expanding very fast among educational institutions. So far, most of the studies related to CAL programs are exploratory. Research is only beginning to move into an explanatory stage, where programs are evaluated to identify what works best, and how to achieve the objectives of the programs. Part of the motivation for this research is to contribute to this trend towards developing a general theory of what works best in CAL programs. Also, KFUPM where the researcher is based has initiated different pilot programs on computer aided learning of mathematics. The aim of these programs was to improve students' understanding and achievement in mathematics. A spin-off from the programs was the proper utilization of the "fourth hour" - popularly known as CAL hour. The researcher, being faculty at KFUPM and part of the program implementation group, was further motivated to establish ways to maximize the impact of the program.

The study is significant in several ways. It will contribute to the knowledge in an area that has not previously been intensively looked into, especially at KFUPM. Earlier research has however, explored predictors of success in mathematics, and in computer assisted learning relating to the computer science course. Not many studies appear to have investigated the predictors of success for pre-calculus algebra that is supplemented by a computer laboratory program. The importance of mathematics in general university education makes it necessary to undertake such research. The research therefore, addressed this specific need with the intention of contributing to the development of theories related to CAL. Also, the research contributes useful knowledge that is necessary for the management of CAL programs. It appears that CAL does not affect all

students uniformly. So, it is important that managers of CAL programs are provided with information or have knowledge of those who stand to benefit most. Such information should pave the way for the selection of suitable students for programs. Also, the empirical evidence of the relationship between students' characteristics and success might provide useful data for counseling purposes. The knowledge generated from the study is also useful for courseware developers. This is because such knowledge will enable courseware developers to take into consideration individual differences among product users.

Although not carried out in Saudi Arabia, the present study in a sense is an extension of studies conducted in other parts of the world, for example, the United States. Importantly, the results should be useful in promoting computer usage in education in Saudi Arabia. Among developing countries, there is still a lack of sufficient information regarding computer usage in mathematics. Therefore, generalizing, based on available knowledge on CAL is extremely difficult and in fact inappropriate. Hence, extending the research on computer usage to countries other than the developed should help improve the availability of such information. Since the aim of any scientific inquiry is to establish a universal generalization that is independent of the setting in which the inquiry was conducted, the need to gather data from a wide range of populations with diverse cultural differences for such generalizations cannot be over emphasized.

Al-Doghan (1985) observed that some of the differences between Saudi Arabia and the Western world involve "divergent philosophical, moral, and religious values; diverse economic, industrial, and technical levels; and dissimilar political, social and educational system" (p.13). It is believed that these differences affect the schooling in general and the students' performance in particular. Other differences, especially in the higher educational system include: tuition-free university education in Saudi Arabia (in fact, the students receive a monthly allowance at KFUPM), on campus free residence, free textbooks, and subsidized food. On the other hand, higher education in Saudi Arabia, especially in the scientifically oriented universities, is similar to that of the Western world in the sense that "the curriculum, the language of instruction, and the

university system are borrowed from the Western world, especially from the United States" (Al-Doghan, 1985:13).

1.6 Assumptions

Our assumptions in this study were:

a) All participants answered the surveys frankly.

b) The sample is representative of pre-calculus algebra students in the preparatory year mathematics program.

c) The participants were able to understand English to interpret the surveys.

1.7 Definition of Terms and Abbreviations

The following terms and abbreviations are defined in the context in which they are used in this study.

Term	Explanation
Achievement	Refers to student's final grade in MATH 002, which results from the sum of lab assignment scores, midterm exams, and final exam of the participants of this study
blended e-learning	Refers to some combination of classroom lecture, linking traditional classroom training to e-learning activities, such as asynchronous work (typically accessed by learners outside the classroom at their own time and pace) in teaching MATH 002
CAL	Computer Aided Learning. Some other similar terms that are used 'interchangeably' in the literature include: CAI - computer-assisted instruction, CBI - computer-based instruction, CBL - computer based learning or CMI - computer-managed instruction. For the purpose of this study, these are all forms of computer-assisted learning

CAL-program	Refers to all the lab activities and instructional sequences that are carried out in the supplementary lab class of MATH 002
CALM	Computer Aided Learning of Mathematics
CAS	This term is used in this study with two unrelated meanings. However, the context in which the term is used will make the categorical difference between the two. The first refers to: *Computer Attitude Scale*, while the second connotes *Computer Algebra System*
Dependent Variables	Refers to a variable whose values are dependent on changes in the values of other variables. In this study, the dependent variable is the sampled students' final grade of MATH 002
Independent Variable	Refers to a variable whose values are independent of changes in the values of other variables. In this study, independent variable refers to the following: mathematics attitude, mathematics aptitude, computer attitude, computer ownership, computer prior experience, learning styles and proficiency in the language of instruction
KFUPM	King Fahd University of Petroleum & Minerals
Prediction	Forecasting the probability of a future phenomenon's occurrence from available observations. In this study, prediction refers to forecasting students' performance in the final grade of MATH 002
Predictor	A variable that precedes the desired criterion and is used or considered to forecast it. In this study, this refers to: mathematics attitude, mathematics aptitude, computer attitude, computer prior experience, computer ownership, English language proficiency, and learning styles
Prep-Year or Preparatory	An orientation program in which most of the newly-admitted students at KFUPM spend their first year in order to develop the basic skills,

year	**or**	especially English language and mathematics, needed for university
Orientation		degree program,

Prior	This refers to the number of years a subject has been using a computer
computer	either at home or at school
Experience	

1.8 Overview of the Study

This dissertation is organized into six chapters. Chapter I basically discusses the background of the study, study setting, statement of the problem, and objective of the study. Others include: motivation of the study, significance of the study, research assumptions, definition of the key terms, and overview of the study.

Chapter II deals with what Ernest (1994) called "the central problem of philosophy of mathematics education" (p.4). That is the issue of the relationship between the philosophies of mathematics and mathematics education.

Chapter III provides the theoretical framework of the study. Also the chapter reviews some pertinent literature regarding predictors of success with special interest on the selected variables for this study.

The research design and methodology, the study sample, variables, and collection of data are described in chapter IV, which also includes the statistical analysis employed in the study.

The results of the data analysis are contained in chapter V. The findings are interpreted and the results are discussed in the light of the background of the study and related literature.

Chapter VI presents the summary of the findings, the conclusions, limitations of the study and recommendations for further research.

CHAPTER TWO

Review of Literature

2.1 Mathematics: Conceptions, Learning and Teaching

Our aim in this chapter is to review the literature relevant to what Ernest (1994) called "the central problem of philosophy of mathematics education" (p.4). That is, the issues concerning the nature of mathematics and its implications to instructional practices. In the course of this discussion, we look into the questions: what is mathematics, what is the nature of mathematics, and what is the nature of mathematics learning. This in turn helps us to form the basis of the discussion on the nature of successful mathematics teaching and learning. The chapter was concluded by arguing that computers, as teaching and learning aid, have the potential of assisting students to learn mathematics in an effective way as well as fostering their creativity. Furthermore, computers can assist teachers in the effective presentation of mathematics in an unprecedented way.

2.1.1 What is Mathematics?

There is no consensus on the question of what mathematics is all about. Even within the community of mathematicians, mathematics is defined differently, sometimes as if they are talking of entirely different things. As noted by Kanser and Newman (1949):

> A large and varied body of thought which has grown up from the earliest times purports to answer this question. But upon examination, the opinions which range from those of Pythagoras to the theories of the most recent schools of mathematical philosophy reveal that it is easier to be clever than clear (cited in Baron, 1972:21)

The lack of consensus in the definition of mathematics stems from the fact that people who attempt to define mathematics are, consciously or unconsciously, influenced by their background, experience, and area of specialization. For instance, some defined mathematics as a *method* used to discover certain truths, while others see it as the *truth* to be discovered (Baron, 1972).

At one end of the spectrum, mathematical knowledge is seen as a body of facts and procedures dealing with quantities, magnitudes, forms, and relationships among them. At the other end, it is conceptualized as the "science of patterns," an (almost) empirical discipline closely akin to the science in its emphasis on pattern-seeking on the basis of empirical evidence (Schoenfeld, 1992:334-5).

Some other continuums have looked at mathematics in terms of *utility* versus *cultural*, *application* verses *esoteric, invention* verses *discovery* etc. In fact, there are some that look at mathematics as a senseless game guided by some rules and regulations, which is being played by mathematicians. A statement attributed to Bertrand Russell (1917) attests to that. He was purported to defined mathematics as the "subject in which we never know what we are talking about, nor whether what we are saying is true" (quoted in the site www.mathsnet.net). In all of the above perspectives each describes only some aspects of mathematics, and none gives a conclusive description of the subject. As a matter of fact, a complex field of endeavor like mathematics cannot be defined neatly in a few sentences or paragraphs. However, there is no doubt that the more a definition is inclusive of all perspectives the more it approximates the meaning of the subject (Davis & Hersh, 1980). Therefore, one is tempted to look at mathematics as something that incorporates all the above perspectives with its nucleus rooted in what Wittmann (1995) called "specialized mathematics" (p.359). The main body includes, but is not restricted to, mathematics developed and used in sciences, engineering, economics, computer science, statistics, industry, commerce, craft, art, daily life and so forth (Wittmann, 1995). This unifying definition takes note of the crucial importance of informal and social aspects of mathematical inquiry in the history and philosophy of mathematics (Ernest, 1991). It also allows the theoretical mathematicians to "do mathematics for mathematics sake", and the applied mathematicians to "use mathematics as a tool" to solve real problems. The definition is also considered as a good reference point for mathematics education (c.f. Wittmann, 1995).

2.1.2 What is the Nature of Mathematics?

It is believed that in any attempt to discuss or define mathematics, one has, consciously or unconsciously, some assumptions on the nature of mathematics (Schwarzenberger, 1982). Similarly, it is unlikely that the controversy of what constitutes good mathematics teaching and learning can be resolved without first addressing the important issues about the nature of mathematics (Thompson, 1992). In view of this, Begle (1979) considers a clear understanding of the nature of mathematics as a prerequisite to any study on learning and teaching of mathematics. Unfortunately, like mathematics, the discussion on the nature of mathematics is challenging and controversial (Vergnaud, 1997). The controversy is perhaps due to the fact that the word mathematics can be used in many distinct and different senses. According to Dossey (1992), this controversy has been present since the time of Plato and Aristotle. Despite the controversy, there are many attempts by scholars to characterize people based on their conception of the nature of mathematics. Thompson (1992) in her analysis of the teacher's conceptions of mathematics reviewed five of these characterizations. The first characterization is by Lerman (1983); who broadly categorized people's conception of the nature of mathematics into two, which he called *absolutist* and *fallibilist.* The second characterization is by Ernest (1988) who distinguished three conceptions of mathematics; the *problem-solving* view, *platonist* view, and *instrumental* view. The third attempt is by Copes (1979) who looked at it from historical point of view. Copes proposed four types of conceptions: *absolutism, multiplism, relativism,* and *dynamism*. The fourth is rather a scheme of intellectual and ethical development by Perry Jr. (1981) who identified "nine stages or 'positions' that describe the intellectual and ethical development of college students from the viewpoint of their conception of knowledge" (Thompson 1992:132). Perry's scheme according to Thompson has been used by a number of researchers to analyze and characterize people's conception of mathematics. The fifth categorization is as a result of Skemp's (1978) work. Skemp proposed two conceptions of mathematics: *instrumental* and *relational*.

However, for the purpose of this discussion, we look at the nature of mathematics from the Lerman (1983) perspectives (Absolutist and Fallibilist) with Ernest (1988; 1991 and

1996) articulations. For a more detailed discussion on the other conceptions Thompson (1992) provides a more comprehensive view, which is beyond the scope of this present study.

There are many perspectives in the philosophy of mathematics which can be termed *'absolutist'* (c.f. Ernest, 1996). A common denominator among them is their view of mathematics as an "objective, absolute, certain and incorrigible body of knowledge, which rests on the firm foundations of deductive logic" (ibid, sec. 1, para. 1). This view of mathematics is based on the epistemology of logical positivism that are of the belief that the foundations of mathematical knowledge are not in any sense social in origin, but lie outside human action (Nickson, 1992). According to this school of thought, mathematics is 'abstract', consists of immutable truths, has unquestionable certainty and hence is removed from human activity and the context of everyday life (ibid). Among the twentieth century perspectives in the philosophy of mathematics that fall into this category are: Logicism, Formalism, and to some extent Intuitionism and Platonism (Ernest, 1991). This view of mathematical knowledge encountered problems at the beginning of the twentieth century when a number of paradoxes and contradictions were "invented" in mathematics, which show that something is wrong in the foundation of mathematics (ibid). According to Ernest (1991), the emergence of *Logicism*, *Formalism*, and *Constructivism,* as a school of thought in the philosophy of mathematics is a result of attempts to remedy these problems and maintain the "certainty" of mathematical knowledge. However, despite all efforts, none of these schools of thought is without its 'mathematical self-contradictions' (ibid). Consequently, the absolutist's view of mathematics has been seriously criticized, and rethinking of what mathematics is all about was inspired by the seminal work of Lakatos (1976).

The thrust of Lakatos' (1976) view is his opposition to the absolutist view of mathematics as the only fundamentally 'true' form of human knowledge. Indeed, he makes it clear that both mathematical and logical viewpoints change historically and culturally, and the nature of 'truth' is influenced by both factors (Crowe & Zand, 2000).

This more or less recent position in the philosophy of mathematics is now popularly known as *fallibilism*. Fallibilists view mathematics as a human invention rather than a discovery, hence, fallible, corrigible, and eternally open to revision and corrections. In essence, the truth of mathematical knowledge can be challenged, discussed, explored and tested, and possibility of error and inconsistency in mathematics must always remain (Nickson, 1992; Ernest, 1991 & 1996). Wheeler (1970) puts this more succinctly:

> Mathematics is made by men and has all the fallibility and uncertainty that this implies. It does not exist outside the human mind, and it takes its qualities from the mind of men who created it. Because mathematics is made by men and exists only in their minds, it must be made or re-made in the mind of each person who learns it. In this sense mathematics can only be learnt by being created (Wheeler, 1970:2).

In view of this, the proponents of this school of thought considered the searching for a concrete foundation for mathematics in the absolutist approach as a misplaced priority. Rather, searching for the foundation of mathematics should be based on its contemporary practice, keeping in mind that the current practice is inherently fallible (Dossey, 1992). This view, according to Ernest (1996), "embraces as legitimate philosophical concerns of the practices of mathematicians, its history and applications, the place of mathematics in human culture, including issues of values and education" (sec. 2, para. 1).

This view of mathematics is getting more popular among the community of mathematics educators and some mathematicians. It is considered as well grounded theoretically, and well suited for school mathematics. As a result, almost all recent mathematics reform movements have fallibilist conception of mathematics (c.f. Cockcroft, 1982; NCTM Standard, 2000; Realistic Mathematics, etc.).

Whatever might be one's conception of mathematics, Absolutism or Fallibilism, embedded in these conceptions are some ramifications to educational practices. In the next two sections, we shall discuss the implication of these conceptions to the teaching and learning of mathematics.

2.2 The Implication of Mathematics Conceptions to Teaching

There are many models of teaching mathematics. Thompson (1992) reported four that are considered as "dominant and distinctive". Her review is based on intensive work of Kuhs and Ball (1986). These models are:

1. *Learner-Focused*: mathematics teaching that focuses on the learner's personal construction of mathematical knowledge.
2. *Content-Focused with emphasis on conceptual understanding:* mathematics teaching that is driven by the content itself but emphasizes conceptual understanding.
3. *Content-Focused with emphasis on performance*: mathematics teaching that emphasizes student performance and mastery of mathematical rules and procedures.
4. *Classroom-Focused:* mathematics teaching based on knowledge of, and about an effective classroom

All these models, as rightly noted by are built based on some philosophy of mathematics (Thom, 1973). The statement also holds the other way round, that is, conceptions and beliefs of mathematics have practical implications for teaching practices (Hersh, 1979; Dossey, 1992; Ernest, 1996).

Studies involving teacher's beliefs and conceptions of mathematics along with their implication to teaching practices are relatively new area. However, a lot of research has been carried out and much still remains (Thompson, 1992; Ernest, 1996). For a synthesis of research in this area, Thompson (1992), Ernest (1991, 1994 & 1996), and Dossey (1992) have reported extensively. Their findings have indicated the existence of a strong relationship between teachers' beliefs, conceptions of mathematics and classroom practices. As might be expected, the relationship is complex and non-deterministic. As a result, it is difficult to connect teachers' conceptions and beliefs to their instructional practices (Ernest, 1991 & 1994). The difficulty arises as a result of reported cases of what Ernest (1988) called "mismatch", whereby the teachers' beliefs differ from his practice. According to Ernest, the two main causes of mismatch are: the

powerful influence of the social context in one hand, and the teacher's level of consciousness of his or her own beliefs and practices on the other.

The three key components of a teacher's belief are: (a) the view or conception of the nature of mathematics, (b) the view of the nature of mathematics teaching, (c) the view of the process of learning mathematics (Ernest, 1988). In the light of this discussion, we shall categorize teachers into two types; Absolutists and Fallibilists and then see the implication of these conceptions to the teaching of mathematics.

2.2.1 Absolutist Perspective

Ernest (1988) placed mathematics teachers into three categories: *Instructors*, *Explainers* and *Facilitators*. The *Instructor* is reported to consider mathematics as "an accumulation of facts, rules and skills to be used in the pursuance of some external end" (sec. 1, para. 6). In addition, an instructor has the view that "knowledge of mathematical facts, rules and methods as separate entities" (sec. 1, para. 5). As a teacher, the *Instructor* considers his role as making students master skills with correct performance. On the other hand, the *Explainer* has a Platonist view of mathematics, whereby mathematics is considered as a "static but unified body of certain knowledge" (sec. 1, para. 4). The role of an *Explainer* as a teacher therefore, is to enable students to conceptually understand and see mathematics as a body of unified "truth".

It is not difficult to see that both the *Instructor* and *Explainer* fall in the category of absolutists in their conception of mathematics. These views of mathematics and approaches of teaching mathematics have dominated our classrooms till today, in spite of the apparent failure of the approach to make mathematics student-friendly. The emphasis in this traditional approach is on procedures. Little attention is given to helping students develop their conceptual ideas, or even to connect the procedures they are learning with the concepts that show why the ideas work (Nickson, 1992; Hiebert, 1999). That is why "for far too long, far too many students have not connected the mathematics they study in school with the outside world. Their perception is that mathematics doesn't make sense" (NCTM, 2002:2. Making a living). Nunes & Bryant (1997) considered this as universal problem, and put it more concisely in the

introduction to their book "Leaning and Teaching Mathematics: International perspective" by pointing out:

> For us, in particular, learning mathematics was practicing a series of techniques to try to master them and using the same techniques over and over again in a series of problems. Although we grew up in different countries, our mathematics lessons were in a way very much the same. Mathematics was a collection of rules about how to set up numbers, how to expand or simplify equations, how to demonstrate theorems, and our task was to learn how to use these rules to solve the problems we were given. If this sounds boring to you, that is because it was boring (p. xiii).

Odili (1986) in his narration of history of mathematics in Nigeria observed that students found the so-called modern mathematics, boring, and lacking motivation, with no good reason to study it. Students considered it more for memorization than understanding and therefore, made them developed a hatred of anything related to mathematics. This problem as observed by Nunes & Bryant (1997) is global. All these observations coupled with lack of success in achieving desirable results are believed to be a result of the type of mathematics taught in the schools and the implementation of teaching methods reflecting this formalist perspective (Nickson, 1992). It is not a coincidence that this conception of mathematics is what is being spread widely. Furthermore, it is what is generally accepted by the public, where mathematics is seen as "difficult, cold, abstract, theoretical, ultra-rational, but important and largely masculine,…..remote and inaccessible to all but a few super-intelligent beings with 'mathematical minds'" (Ernest, 1996, Absolutist Philosophies, Images and Values, para. 3).

2.2.2 Fallibilist Perspective

The third teacher in Ernest's (1988) model is the *facilitator*. The conception of mathematics from a *facilitator's* perspective is that mathematics is "a dynamic, continually expanding field of human creation and invention, a cultural product…a process of enquiry and coming to know, not a finished product, for its results remains open to revision" (Ernest, 1988, sec.1, para 4). Therefore, the facilitator's role as a teacher is to make students confident problem posers and problem solvers. Clearly, the philosophical stance of a *facilitator* is fallibilist. There is no doubt that if one conceives

mathematics as a dynamic and continually expanding field of human creation and invention, it became necessary for him to deviate from the traditional approaches of teaching in order to put this into practice. Furthermore, with this conception of mathematics the roles of the teacher, the learner and the learning environment must also be necessarily different in order to meet the new challenges. Under this construe, mathematics will then be seen as dynamic, "...warm, human, personal, intuitive, active, collaborative, creative, investigational, cultural, historical, living, related to human situations, enjoyable, full of joy, wonder, and beauty" (Ernest, 1996, sec. 2, para. 4). The teacher's role in a fallibilist's philosophy is not delivering a "finished product". Rather, the teacher is like a mentor with a carefully crafted plan that will facilitate a genuine mathematical learning process. Also the role of a student is not listening but inventing and verifying mathematics at his or her own level.

The next section discusses the implication of mathematics conceptions with respect to the learning of mathematics.

2.3 The Implication of Mathematics Conceptions to Learning

> It is difficult to conceive of teaching models without some underlying theory of how students learn mathematics, even if the theory is incomplete and implicit. There seems to be a logical, natural connection between the two (Thompson, 1992:135)

Whilst much progress has been made on the teachers' beliefs and conception of mathematics and their implication to the classroom practices, very few researchers have looked at the students' side (Schoenfeld, 1992). The influence of a mathematics teacher on the students' conceptions of mathematics is tremendous. The messages communicated to students about the subject and its nature greatly influence students, and also affect the way they grow to view mathematics and its role in their world. Studies have shown that teachers' beliefs about mathematics teaching and learning are formed right during schooling years and are shaped by the teachers' experiences as a student of mathematics (Thompson, 1992). This shows how influential a teacher's views may be to students. Evidence (e.g., Dossey, 1992; Nickson, 1992; Thompson, 1992; Ponte, Matos, Guimaraes, Leal, & Canavaro, 1994) of classroom practices has shown

that, in general, teachers have an absolutist and instrumental view of mathematics. In such practices, mathematics is seen as a linear subject, mainly concerned with mechanistically teaching of facts and skills

> …giving students mainly unrelated routine mathematical tasks which involve the application learnt procedures, and by stressing that every task has a unique, fixed and objectively right answer, coupled with disapproval and criticism of any failure to achieve this answer (Ernest, 1996, sec. 1, para. 5).

Studies (e.g., Tobias, 1981) have shown that this direct and deductive instructional approach to teaching mathematics causes fear and anxiety which results in students avoiding mathematics. Also it makes them develop unwarranted and wrong beliefs that have a negative effect on how they learn the subject (Schoenfeld, 1987). In the last three decades there have been calls for reforms in the teaching and learning of mathematics, all aimed at addressing the bad image of this subject among students. Most of the reforms have called for abandoning the traditional approach of teaching mathematics. In essence the reforms have insisted on shifting the role of a teacher to that of a facilitator and that of a student to an apprentice mathematician. This should enable students to be fully involved, active participants in the invention and discovery of mathematical objects. This hopefully will change students' views of mathematics from a "divine" subject to something invented by people like them that they too could reinvent.

Recent findings from longitudinal studies on reform have shown some promises. For instance, Schoenfeld (2002) has provided an analysis of data collected after a decade of implementation of new approaches to mathematics education in the United States. Here, the summary of the results in comparison to the traditional approach is given:

1. On tests of basic skills, no significant difference was found in students' performance between students who learn from traditional or reform curricula.
2. On tests of conceptual understanding and problem solving, students who learn from reform curricula consistently outperform by a wide margin students who learn from traditional curricula.
3. There are some encouraging evidences that reform curricula can narrow the performance gap between whites and underrepresented minorities.

Indeed, this is good news for the community of mathematics educators and mathematicians. The next sections look at what successful mathematics teaching and learning entails.

2.4 The Nature of Successful Mathematics Learning

> "Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand." (old Chinese proverb)

Learning is a very complicated phenomenon that is largely taken for granted as a natural process. However, the existence of numerous definitions and theories of learning attests to the complexity of this process. Since the primary aim of all mathematics teachers is to make students learn mathematics, the necessity to have a good idea of how students learn mathematics and the nature of the learning process cannot be over emphasized. Psychology books reveal "the complexity of understanding how humans learn is reflective of our complexity as biological, social and cognitive animals" (Forrester & Jantzie, 2002, Behaviorism, para. 5). Many theories exist, all focusing on different aspects of our make-up as humans. For instance;

> Sigmund Freud focused on our sub-conscious, Skinner on our observable behavior, cognitive psychologists on our mental processes, humanistic psychology on our social and interpersonal development. While others like Howard Gardner took a more holistic approach in describing our cognitive profiles (Forrester & Jantzie, 2002, Behaviorism, para. 5).

As a result, many learning theories have been developed. However, the first major contribution to address learning problems scientifically is by researchers known as behavioral psychologists. Behaviorism originated from Pavlov's work, and based on his view about human learning. Later, the area was developed by Watson, Hull and Thorndike. The behavioral school of thought reached its heyday in B.F. Skinner's work on operant psychology and reinforcement (Kelly, 1997; Ellingtone, 2002). The main thrust in this approach arises from the fact that since we cannot observe what is happening in the human brain, we should limit our measurements and theories to merely what is going in (the stimulus) and what is coming out (the response), hence, treating the human brain as a "black box" (Kelly, 1997). It is worth noting that behaviorists do not deny the existence of mental processes during learning. In fact, they acknowledge

their existence as an unobservable indication of learning. However, what they deny is the ability to explain these complex processes. According to Kelly (1997), by mid-century, the stimulus/response S-R view was so powerful and had tremendously influenced educational thinkers, and also dominated many other fields of concern such as linguistics and sociology.

Jean Piaget showed that children go through stages of development that have no relation to external stimuli, which was a blow to behaviorism. Indeed, it was his explanation of the cognitive developmental process that led to the demise of the behavioral school of thought. Piaget indicated that the brain is not dormant; rather it is actively involved in the learning process. As a result of Piaget's theories, there has been a distinct and major paradigm shift in educational thinking from behavioral to cognitive approach and latterly towards constructivism (Jonassen, Davidson, Collins, Campbell & Haag, 1995). Although constructivism is recognized as a unique learning theory in itself, it has something in common with cognitive psychology. That is, as a theory of learning, both focus on the learner's ability to mentally construct meaning of their own environment and to create their own learning (Kelly, 1997). As a result of this major discovery, it is claimed that Piaget was the first to take children's thinking seriously, which therefore, enable him to lay a concrete foundation for genuine learning theories (Kelly, 1997).

The influence of Behaviorism learning theory in our educational system is vivid. It is considered to be the guiding principle of absolutist instructional approaches (Threlfall, 1996; Forrester & Jantzie, 2002), whereby students are regarded as passive recipients of knowledge (Bell, 1978). In behaviorism, the role of a student is to listen attentively and do their homework as ascribed by the teacher who is regarded as a 'knowledge giver'. It has been argued earlier in this present study that this approach to mathematics teaching is not good for students and it leaves them at the receiving end. It bombards students with rules and manipulative tricks, that most either do not make sense of, or understand their sources.

Cognitive psychology theories are making the cognitive process involved in student learning of mathematics clearer in comparison to the behaviorists' 'stimuli-response'

approaches. In addition, the possible cognitive-conflict that might hinder the process of learning mathematics is also becoming clearer (Tall, 1991). These findings are all pointing towards the fact that genuine "learning proceeds through *construction,* not *absorption*" (Romberg & Carpenter, 1986:868).

It is worth noting that most of Piaget's experiments focused on the development of mathematical and logical concepts related to children. However, many of the theories by now have been extended to advance mathematical thinking (Tall, 1991). For instance, the Piaget concept of "Reflective Abstraction" has been extended by Dubinsky (1991) to advanced mathematical thinking. In this work, Dubinsky has also shown how reflective abstraction can be a powerful tool in the study of advanced mathematical thinking. Moreover, how the concept can provide a theoretical basis that supports and contributes to our understanding of what this thinking is and how students can be helped to develop the ability of engaging in it (Dubinsky, 1991). Furthermore, Piaget's theories, though cognitive in nature, have since been extended to the social arena. Schoenfeld (1992) has cited many works that extended Piaget theories from the purely cognitive sphere to the social sphere.

In essence, the constructivist view of mathematics learning gives us a way for analyzing the fact that the "extant mathematics instruction has not been sufficiently successful in promoting students' development of powerful mathematics ideas and useful conceptions of mathematics" (Simon, 1994:77). In fact, what the new approach requires is succinctly articulated by the National Research Council (1989:84):

> Although the language of mathematics is based on rules that must be learned, it is important for motivation that students move beyond rules to be able to express things in the language of mathematics. This transformation suggests changes both in curricular and instructional style. It involves renewed effort to focus on
>
> - Seeking solutions, not just memorizing procedures;
> - Exploring patterns, not just memorizing formulas;
> - Formulating conjectures, not just doing exercises.
>
> As teaching begins to reflect these emphases, students will have opportunities to study mathematics as exploratory, dynamic, evolving

discipline rather than as rigid, absolute, closed body of laws to be memorized. They will be encouraged to see mathematics as a science, not as a canon, and to recognize that mathematics is really about patterns and not merely about numbers.

2.5 The Nature of Successful Mathematics Teaching

Although a social constructivist view of mathematics learning provides no model for instruction, it provides a foundation on which we can build such a model (Simon, 1994:77)

As noted earlier, behind every teaching model there is a learning theory, even if the theory is incomplete and implicit (Thompson, 1992). History has shown that many mathematics teachers and teacher educators centered their teaching methods on knowledge of the subject (Bell, 1978). Therefore, a lot of time is spent on teacher preparation on how to pass-on this knowledge systematically. This no doubt, is an artifact of behaviorism, which in a way considered knowledge as separate to the human mind, and so must be transferred to the learner through teacher. However, as a result of Piaget's theory of human cognition, new generations of teachers understand that students are not empty vessels to be filled with knowledge but rather active builders of their own knowledge. Contrast this with the traditional pedagogical theory that dominated our classroom. The concern or emphasis on observable indicators (behaviorism) as the only way to know that learning is taking place is now replaced with the recent view of learning in cognitive psychology as mental processes of the mind. The underlying philosophy here is constructivism, which asserts that students learn mathematics by active involvement with mathematical models that allow them to internally construct their own understandings and concepts.

Therefore, it is believed that mathematics teaching can only be successful if it takes into cognizance of all the recent developments on how students learn mathematics. Furthermore, it must give students ample opportunities to learn mathematics, and make them have a good conception of mathematics. Successful mathematics teaching entails a program that meaningfully "engages students in active exploration of mathematical situations….as mathematicians, creating mathematics, evaluating mathematics that has been created by members of mathematical community" (Simon, 1994:72). In this sense,

learning is considered as "peripheral participation" (Lave & Wenger, 1991:92) in mathematics activities.

As stated earlier, constructivism is a learning theory not an instructional approach. Recently, a number of mathematics instructional approaches came up in an attempt to fill-in this instructional gap. The common name for them is Problem Solving (in every sense of the word). What is common among these new instructional approaches is that they are all student-centered, aimed at actively involving students at different levels in solving mathematics problems, and making mathematical sense out of that.

According to Koehler & Grouws (1992), the constructivist assumption about how students learn changes the assumption about what teacher actions or behaviors might be desirable, therefore, "the goal is no longer one of developing pedagogical strategies to help students receive or acquire mathematical knowledge, but rather to structure, monitor, and adjust activities for the students to engage in" (p.119). Contrary to Behaviorism, the consensus among the proponents of the new approach is that they conceive "mathematics learning as inherently social as well as a cognitive activity, and an essentially constructive activity instead of an absorptive one" (Schoenfeld, 1992:340).

It is a fact that how much mathematics students learn, and how well they learn it, depends to a great extent on the dimensions of the quality or quantity of the mathematics instructional programs they encounter (NCTM, 2000). Inline with this, there are efforts to develop a viable mathematical instructional approach that will be congruent to the constructivist theory of learning. For instance, the NCTM principle and standard, Schoenfeld's metacognition, Tall's procept, Dubinsky's distributed system, Freudethals' realistic mathematics for example, are efforts in this direction. It is interesting to note that, in almost all of these attempts, the use of the computer as an instructional aid has proved essential. Studies have shown that if used effectively, computers have the potential of engaging students in genuine mathematical activities. It can also help teachers to effectively teach mathematics. In view of this, we have dedicated the next section to review literature on the effectiveness of computers as learning and teaching

tool in mathematics education. We shall advance the argument by showing that computers can also foster creativity in mathematics teaching and learning.

2.6 Computers and Creativity in the Teaching and Learning of Mathematics

> The question of whether a child can learn and do more mathematics with a computer … versus traditional media is moot, not worth proving. That computational aids overall do a better job of converting a child's intellectual power to mathematical achievement than do traditional static media is unquestionable. *The real questions needing investigation concern the circumstances where each is appropriate* (Kaput 1992:518).

The use of computers in education has captured the attention of many mathematics educators. The reason is not unconnected with the long time quest for an approach that will make mathematics accessible to as many students as possible. Computers have been used in education for more than four decades, and they have become an integral part of our entire educational system. This usage is increasing rapidly and has generated new challenges.

The purpose of using computers in the teaching and learning of mathematics is for the "enrichment and improvement of the conditions in which human beings learn and teach" (The Fourth Revolution, 1972:89). In this sense, computers are subservient to teaching and learning and not an end in themselves. Although there is no consensus among mathematicians and mathematics educators on the educational merits of using computers in the teaching and learning of mathematics, research has strongly supported the use of computers as a catalyst for improving and enriching the learning and teaching environment (Kadiyala & Cryines, 1998). For instance, out of several studies, reviews, and meta-analyses on the impact of computers in mathematics education, most results positively support the program (Kadiyala & Crynes, 1998). According to Jeffries (1989), numerous meta-analyses of research in CAI (computer aided instruction) have arrived at the following conclusions:

1. CAI is at least as effective as direct instruction when measured in terms of student achievement for students at all grade levels and in a wide variety of

subject areas (Bangert-Drowns, Kullik, &Kullik, 1985; Chambers & Sprecher, 1980; Kulik, Bangert, & Williams, 1983: Kullik, Kullik, & Cohen, 1980). See also Rivet (2001).

2. CAI may be more effective for lower-ability students (Bangert-Drowns, Kullik, & Kullik, 1985; Chambers & Sprecher, 1980; Edwards, Norton, Taylor, Weiss & Dusseldorp, 1975; Splittgerber, 1979).

3. Students demonstrated a more favorable attitude toward learning with computers than with direct instruction (Bangert-Drowns, Kullik, & Kullik, 1985; Chambers & Sprecher, 1980; Roblyer, 1988).

4. CAI is reported to have reduced learning time when compared to traditional instruction (Splittgerber, 1979; Kullik, Kullik, & Cohen, 1980; Chambers & Sprecher, 1980).

Similarly, computers have been found to be cost-effective in the teaching and learning of mathematics (Levin, 1986; Niemiec & Walberg, 1987; Moonen, 1987; Cryer-Hittson, 1987). The result of another meta-analysis revealed that the average effect size of CAI was to raise student mathematics achievement by .33 to .45 standard deviations (Burns & Bozeman, 1981; Kullik, Bangert & Williams, 1983). In addition, CAI improves students' attitude toward mathematics and computers (Bangert, Kullik, & Kullik, 1983), as well as toward academic self-concept and perception of the quality of school life in general (Mevarech & Rich, 1985). From all the research reported on the use of computers in teaching and learning mathematics, it appears that computers have a tremendous potential to improve mathematics education and consequently science and technology education.

For more elaboration on the advantages of using computers in mathematics education, one can see for instance The Fourth Revolution (1972), Roblyer (1989), Dunham & Dick (1994), Kadiyala & Cryines (1998), Corcoran (2000), and Setzer (2000).

In addition to all the advantages computers bring, we plan to argue that if used effectively, they can be a good instrument for fostering creativity in mathematics

students as well as instrumentally assisting teachers to effectively teach mathematics more meaningfully.

2.6.1 What is Creativity

> The creative act is often portrayed as a mysterious and even mystical process, more akin to divine inspiration than to mundane thought… However, with the advent of contemporary cognitive science, psychology has come much closer to appreciating the mental processes that must participate in the creative act (Simonton 2000:152).

Creativity is a very complex phenomenon that is very difficult to define (Standler, 1998; Meissner, 2000). Consequently, many experts from different disciplines have resorted to a descriptive approach. Simonton (2000) describes creativity as "one of the special ways that human beings display optimal functionality" (p.151). Quigley (1998) simply puts it as "…the ability to produce something effective and novel" (p.1). While Standler (1998) resorts to giving the difference between creativity and intelligence vis-à-vis creative person and intelligent person. According to him intelligence is the ability to learn and to think, while creativity is to do things that have never been done before. A tacit implication of this definition is that creative people are intelligent but the converse is not always the case.

It has been argued (e.g., Jacob, 1996) that creativity can be categorized into two distinct types, (1) flash out of the blue and (2) process of incremental revisions. In 'flash out of the blue', creativity arrives in a sudden warm embrace, leaving one with a giddy sense of inspiration, vision, and purpose which results in a moment of clarity that is both inexplicable and undeniable (Ibid). While in the 'process of incremental revisions' creativity is hard work, where one starts with a vague creative seed to spend countless hours of revision and rethinking to hammer out a work of blood, sweat, tears, but mostly frustration (Ibid). This is an experience also identified and explained by De Villiers (2004).

2.6.2 How do we Promote Creativity in a Mathematics Classroom

The nature-nurture relationship forms a basis and circumstances that seem to influence the emergence of creative personalities. Embedded in this relationship are many other sub-factors. These include according to Simonton (2000) the birth order, early parental loss, marginality, availability of mentors and role models. Other developmental variables refer to an individual's experience and performance in the school system (primary, secondary, and higher education). Simonton (2000) has pointed out that "…the acquisition of creative potential requires the simultaneous contribution of both nature and nurture" (p.154). As teachers we have very little or no control over the nature factors, however, a lot can be done in the mathematics classrooms that can nurture the creative potential of our students. The good news is that studies have shown that creativity comes more from environmental factors than from hereditary factors (Simonton 2000). Research has also shown that creative people do not like to go in a conventional way. They have a desire to shake things up. They are dissatisfied with the status quo. They are restless, rebellious, courageous, diligent, arrogant and independent (Cangelosi, 1996; Meissner, 2000). In the mathematics classroom, Cangelosi (1996) has reported that mathematics creativity is displayed by students who think divergently. These are students who generate ideas, conjectures, algorithms, or problem solutions. Cangelosi (1996) describes divergent thinking as *atypical* reasoning that is different from the 'normal' way of thinking. It occurs in situations where 'unanticipated and unusual' responses are anticipated and accepted. Creativity thrives in an environment in which ideas are valued on their own merit, rather than on the basis of how they were produced or who produced them. This shows how relevant motivation, engagement, imagination, relative freedom, independence of thinking, relative originality and flexible thinking are for fostering creative thinking (Cangelosi, 1996; Meissner, 2000). To enhance creativity, it is critical therefore, that these qualities are encouraged and developed in the mathematics classroom. Although the creative process is not well understood, some recommendations have been proposed for teachers that can encourage creativity in their classrooms. A review of this is found in (Yushau, Mji & Wessels, 2003).

2.6.3 What Kills Creativity?

An alarming fact for educators is the rate at which the enthusiasm of young children for mathematics disappears step by step as they get older (Meissner, 2000). It has been shown that children are generally highly creative with vivid imaginations. They learn by exploring, risking, manipulating, testing, and modifying ideas (Paul & Kathy, 1990). However, as they enter school, their divergent thinking gradually exchanges to its antithesis — convergent thinking. Convergent thinking, according to Cangelosi (1996) is reasoning that produces predictable responses for most people. This type of thinking results in a steady decline in curiosity and creative activity during the school years. Consequently, in order to enhance creative thinking, there is need for curious students who dare to ask *why* rather than a docile lot that always says *yes I understand*. Teaching approaches that project mathematics as a rule-based subject (absolutist, discussed earlier) are not conducive to creative thinking. Typically, students' curiosity is stifled in such instances and the most creative minds are discouraged. The classrooms with such approaches are 'torture zones' for most creative students because they cannot express themselves. It may be remembered that creative people are unique in their ability to achieve anything. This means that they hardly function optimally under restricted conditions or when things have to be done in accordance with confining rules. It can be seen here that creativity is incompatible with the type of mathematics teaching that does not allow students 'free expression'.

2.6.4 Use of Computer in Fostering Creativity

It is common knowledge that people use and follow different ways of collecting and organizing information into useful knowledge. Some learn best through interaction with their peers, others accomplish this through lone study and contemplation. Certain individuals, on the other hand, prefer to learn a skill by manipulating concrete objects, watching, listening, or by reading an instruction manual (Cross, 1976). Issues such as time constraints, lack of abundant resources, teachers' experience and so on, make it extremely difficult for any teacher to cater to these individual differences. This situation sometimes results in learning difficulties for some students. To address these, some

teachers resort to more or less prescriptive teaching, where rules and mechanics of teaching are followed. On the other hand, some other teachers follow creative teaching, which approaches situations in an unprecedented way.

Paul and Kathy (1990) distinguished between good learning and creative learning. They define creative learning as a natural healthy human process that occurs when people are curious and excited. Good learning on the other hand requires students to follow skills such as recognition, memory and logical reasoning, which are the abilities frequently assessed in tests of intelligence and scholastic aptitude (Paul & Kathy, 1990). Creative thinking and learning involves the ability to sense problems, inconsistencies and missing elements, fluency, flexibility, originality, elaboration and redefinition (Paul & Kathy, 1990). However, these are abilities that are rarely developed in mathematics classrooms despite "good" teaching intensions. To promote these, mathematics should be viewed differently - as a science of pattern rather than as a set of rules. In this regard students should be given control over what they learn. They should be actively involved in the learning process for knowledge to be meaningful. It has been shown that students prefer to learn in creative ways. They learn better and sometimes faster rather than just memorizing information provided by a teacher or parents (Paul & Kathy, 1990; Simonton, 2000). It is our submission that the computers can assist teachers in developing a creative learning situation that takes cognizance of individual learning differences. Also, it empowers and provides students all the tools necessary for promoting creativity.

There is no doubt that a valuable asset a teacher may have is to have access to a computer because of its versatility. For instance, one of the most important activities that preoccupies teachers' time is the preparation of presentable material for their classrooms. With the help of computers, a teacher can effectively address the challenge of organizing mathematics instruction in such a way that attracts and develops the abilities of the greatest number of students possible (NCTM, 2000). With multimedia capabilities, computers have the capabilities of appealing to our eyes, ears and feeling. Therefore, they can widen and enrich the content and scope of our educational experiences. With this, the individual differences in learning style can be taken care of

in an unprecedented way. With computers, students can visualize mathematical concepts which are difficult to comprehend without computers. In a typical classroom, computers provide easier and clearer illustrations than those a teacher would make. As a matter of fact, there are relatively few teachers that have the time or artistic talent to produce illustrations by "hand with chalk, overhead transparency pens, or marking pens that can compete with those generated with computer" (Cangelosi, 1996:202), or that can even compete with a graphing calculator. This can be seen for instance in a case of three-dimensional objects. Such objects are difficult to draw on the chalkboard and much more difficult to be visualized by the students. With the help of computers and graphic calculators students themselves may creatively draw three dimensional objects, and also see different views of the object, thus saving teachers' precious and limited time as well as building a concrete image of the object in the students' minds.

Similarly, computers can give students a more self-reliant role in their own education, and can make them become more active agents in their education and invariably independent learners.

Computers have the capacity to simulate projects that teach students teamwork, problem solving and critical thinking as well as increase their enthusiasm for learning. Furthermore, computers give students an access to instructional programs designed with huge resources, more expertise and greater talent than can be found on a single campus. They can enrich and supplement the available classroom instruction. They can give a student alternative modes of instruction for the same subject or topic.

Experience has shown that working with the appropriate computer software, students can get a large amount of graphing experience in a relatively short amount of time. In addition, the students deal with more graphs than what they typically experience in a normal classroom (Dugdale, 1982; Yushau, 2004b). In a study on the influence of visualization, exploring patterns and drawing generalizations, Nixon (2003) reported that her students indicated visual representation in a computer screen as beneficial to their understanding as compared to diagrams displayed in books.

Motivation is considered as a driving force for most of human endeavors. In fact motivation has been a major research topic in the area of the psychology of teaching and learning (Perry, Menec & Struthers, 1996). Bell (1978) outlines four general reasons for people to be motivated to learn in and outside school. These are, "to create things, to make things work, to obtain recognition, and to find personal satisfaction" (p.33). If students are to be motivated and their enthusiasm enhanced, it is important that instruction be flexible enough to create room for creativity to prosper. Computers have the potential of making this possible, and consequently can develop high level of motivation necessary for creativity. Studies have shown that proper use of computers in education has a motivating force that can attract students toward mathematics (c.f Robison, 1996, Cox, 1997; Ravenscroft & Hartley, 1998). On the students' side, creative potential seems to require "certain exposure to diversifying experiences that help weaken the constraints imposed by (a) conventional socialization and (b) challenging experiences that help strengthen a person's capacity to persevere in the face of obstacle" (Simonton, 2000:153). The intrinsic features of computers such as immediate feedback, animation, sound, interactivity, and individualization are more likely to motivate students to learn than any other media (Yang & Chin, 1996). Similarly, using a variety of technological tools, such as calculators, computers, and hands-on materials, under the guidance of a skillful teacher creates a rich mathematical learning environment. Such an environment helps in exposing and preparing students for diversified experiences (Beal, 1998). This is the exposure that is required and necessary to nurture creativity, a point supported by De Villiers (2004) and Nixon (2003).

One of the factors that limit students' creativity in mathematics is their inability to recognize and connect mathematical structures and objects in different situations. In this respect, computers have the ability to help students uncover shared and unshared patterns of a class of mathematical objects. For instance, the multiple representation of a function (tabular, graphical, symbolic) turns out much easier by using computers. This in a way, exposes the students to different sides of the 'mathematical coin' and allows them to see mathematics from different (and seemingly unrelated) angles. Such exposure helps students to visualize, explore and deeply understand mathematical

concepts in a spectacular way (Cangelosi, 1996), and therefore, fostering students' mathematical creativity. It is this exposure which informs students that mathematics is not a linear subject and that there are a variety of ways of tackling problems. It also removes pervasive beliefs that the only way of tackling mathematics is by following rules, which in fact hurt creativity.

Learning is an active process; however, a lot of commonly used teaching strategies put students in passive and receptive roles. This results in situations where students have very little control, if any, over the learning environment (Bell, 1978). Computers have the ability to enrich the content of students' learning experiences, provide greater flexibility and give students a more self-reliant role in their own education. In that respect students become more active and participative agents in their education. Creativity is more or less a solitary business (Standler, 1998). Similarly, learning is more effective and efficient when instruction can be tailored to unique needs of each learner. With the aid of technology, especially computers, instruction can be flexible and adaptable to individual needs. Also student-teacher interaction and learning are significantly more student-centered, thereby, creating room for students' optimal functionality-creativity.

Today's students will live and work in the twenty-first century, in an era dominated by computers, by worldwide communication, and by a global economy. Jobs that contribute to this economy will require workers who are prepared to absorb new ideas, to perceive patterns, and to solve unconventional problems (Steen, 1989). Under this dispensation, there is no gift that students can get from school more than that of empowering them with the necessary tools to face these challenges. It has been established that a good use of computers can empower students to be critical thinkers, better problem solvers and also enhance their creative capabilities (Kaput, 1992; Roblyer, 1989).

Thinking mathematically is considered (by many people) to be critical in the development of everyday life skills. People use mathematics skills daily to identify problems, look for information that helps solve problems; they consider a variety of

solutions, and communicate the best solution to others. However, the connection between the mathematics learned at school and the mathematics used in daily life is missing more often than not. To bridge this gap, mathematics classrooms should provide practical experience in mathematical skills and their application in the real world, and also, allow explorations that develop an appreciation of the beauty and value of mathematics (Beal, 1998). Again the use of computers is a key for bridging this gap. This may be accomplished by providing students with a variety of challenging real life problems that are fascinating, interesting, exciting, thrilling, important, and thought provoking – a wonderful asset for fostering creativity.

2.7 Conclusion

In this chapter we have looked into the nature of mathematics and the implication of some conceptions of the nature of mathematics to the teaching and learning of mathematics. Since the aim of every mathematics teacher is to guide students to learn mathematics in an effective way, we have looked into the true nature of successful mathematics learning and concluded that good mathematics teaching is one that helps students learn and appreciate mathematics. We rounded up the chapter by arguing that computers have proven to be an effective media for the teaching and learning of mathematics. More importantly, computers, if used effectively can foster mathematics creativity among students.

Now for the simple fact that most studies have shown that the use of computers in the teaching and learning of mathematics is an effective and successful approach. The next natural question is *why* are the computers effective and successful?

The next chapter discusses the predictors of this success. Our attention shall focus on the factors that contribute to students' achievements in mathematics and computer science. More specifically, this will be on the seven variables that we have identified to be the potential factors that might contribute to students' achievements in pre-calculus algebra.

CHAPTER THREE

Predictor Variables: A Review of Literature

3.1 Introduction

The aim of this study was to determine the factors that are contributing to students' success in mathematics, specifically in pre-calculus algebra supplemented with a computer aided learning programs. With this consideration, some potential variables were identified and selected for the purpose of investigation. This chapter presents reviews of literature both theoretical and empirical on the role of these selected variables in predicting students' achievements in mathematics and computer sciences. The chapter is divided into three parts: After a brief introduction, we discuss the theoretical framework that underlies the study. The third section deals with a review of some theoretical and empirical research conducted to examine the role of the selected variables in predicting students' achievements.

3.2 Theoretical Framework

> There have been numerous attempts to discover what kinds of information
> we should have about students at one point in time in order to predict that
> student's mathematical achievement at a later point in time (Begle 1979:96)

In his book, Critical Variables in Mathematics Education, Begle (1979) noted that "many of the variables which affect mathematics learning reside within the student himself" (p.85). There are several type of students variables. Begle (1979) for instance, categorized them into six. Nevertheless, he concluded that the variables that have been studied for the prediction of success are mainly the affective, cognitive and non-intellective variables. According to Begle (1979):

1. The cognitive variables measure the different dimensions along which students can vary as they carry out cognitive activities. These variables include: IQ, logical thinking, mathematical ability, memory, etc.

2. The affective variables refer to the attitude and feelings which students possess about mathematics. These have been classified and studied under different headings. They include: anxiety, attitude, motivation, personality, etc.

3. The non-intellective variables are those which are different from the cognitive and affective and have the potential of affecting students learning of mathematics. They include: ethnicity, socioeconomic status, gender, etc.

Since the aim in this study is prediction, the variables selected for this purpose are basically from the three main categories of student variables described by Begle (1979). Their selection is informed by the importance of these variables as a result of their recurrence in the theoretical and empirical literature on the subject. The selected variables are: Mathematics Attitude, Mathematic Aptitude, Computer Attitude, Computer Prior Experience, Computer Ownership, Learning Style, and Proficiency in the language of instructions (English language in this case). Intensive review of literature has indicated that each of these variables have significant relationships with students' achievements. A detailed review of literature from both theoretical and empirical perspectives on each of the variables is presented in the next section. Figure 1 shows a model of the predictors and hypothesized relations investigated in this study.

Figure 1 Model of hypothesized relationships
+ indicates hypothesized positive relationship for non categorical variable
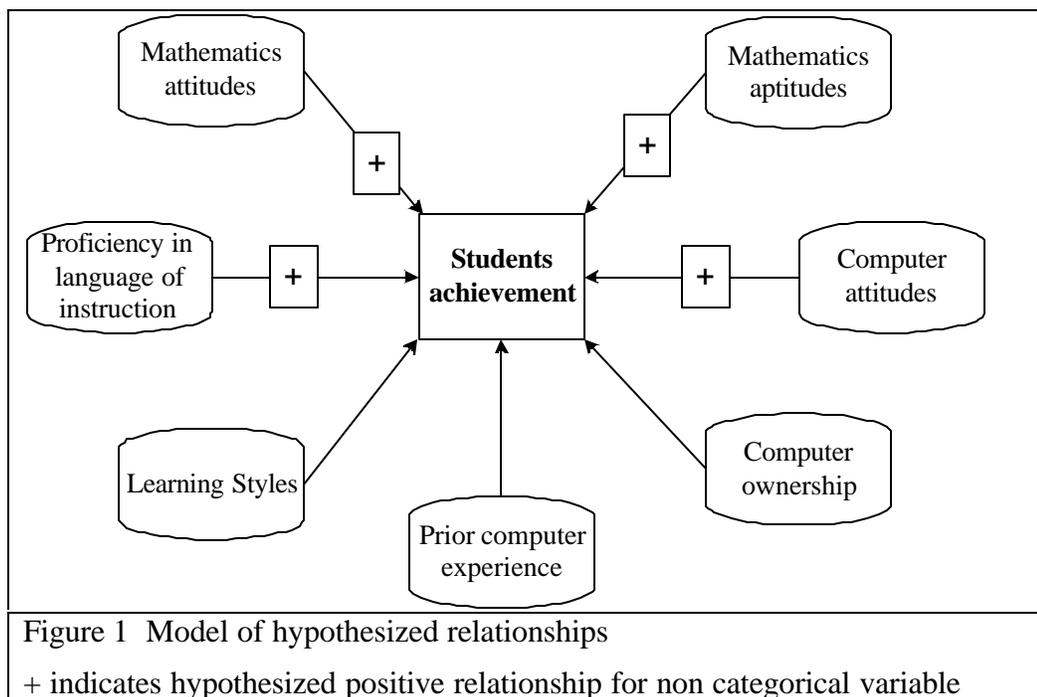
3.3 Literature Review of the Selected Variables

This section reviews literature related to the selected variables with a special interest on how they relate with students' achievements. In each case, we start with the theoretical review followed by some empirical studies. The sections are categorized based on the selected variables.

3.3.1 Attitudes toward Mathematics

There is no consensus on the exact meaning of the term attitude. However, combining the common element of its various definitions, Aiken (2000) defined attitude as "a learned predisposition to respond positively or negatively to a specific object, situation, institution, or person" (p.248). There are three interrelated components that constitute and form attitude. These are: The cognitive component, the affective component, and the behavioral or connotative component.

Attitude is regarded as stumbling block for progress or otherwise in learning mathematics as it is believed to have a strong correlation with mathematics achievement (Aiken, 1970; Reyes, 1984). Students that have a positive attitude toward mathematics tend to do well in the subject, while students that have negative attitude toward mathematics tend to perform badly in it (Begle, 1979). Similarly, students with low mathematics abilities are likely to have more negative attitudes towards mathematics, and less inclination towards making the effort to improve their mathematical abilities. On the other hand, students who like mathematics tend to persevere in their mathematics learning (c.f. Collins, 1996). Although most of the research indicated that poor attitudes toward mathematics are related to low levels of students' achievement in mathematics, it has not always been found to be so (Brown, 1979; Collins, 1996).

College students on the average seem to have more positive attitudes towards academic work than their non-college counterparts. This may be due to their maturity in both an academic and in a physiological sense. As a result, the frequency of the negative attitudes towards mathematics is not frequently reported. Therefore, the variability of the distribution of the attitude scores is usually lower for college students than for the

other students. With this presumption, Aiken (1970) concluded that smaller correlation between attitudes and achievement in college is expected as compared to that in high school. Similarly, average attitude is not much of a determiner of achievement when compared to the two extremes in the attitude continuum; highly positive and highly negative. Although the relationship between attitude and achievement is significantly positive, very few studies found attitudes to be among the most important predictors of achievement in mathematics, but was found to be secondary to ability as a forecaster of achievement in many instances (Aiken, 1976).

Many empirical studies have reported a strong relationship between students' attitudes toward mathematics and their achievements in mathematics. In a study conducted by Williams (1995) to determine the relationships between student learning style preferences, calculus achievement, mathematics attitudes, and frequencies of graphics calculator usage in an introductory calculus course, it was found that students achievements in calculus was related to attitudes toward mathematics, in particular attitudes toward the usefulness of mathematics.

Charles (1987) conducted a study at a Southeastern US community college during the spring of 1985. The participants in the study were 334 students enrolled in developmental and non developmental mathematics courses. 164 students enrolled in developmental courses and 170 students enrolled in non-developmental courses. The aim of the research was to determine if there was a significant relationship between the academic performance of students enrolled in the two mathematics courses and the following variables: (1) achievement motivation, (2) self-concept, (3) attitudes toward mathematics, and (4) various demographic data. Charles (1987) concluded that out of the seven variables found to be significantly related to the academic performance of developmental mathematics students, five were mathematics attitudes.

Studies have shown that mathematics attitudes are major predictors of success in mathematics. For instance, Thorndike-Christ (1991) conducted a study with 1516 students enrolled in public middle and high school mathematics courses (722 male, 794 female). The aim of the study was to investigate the relationship between attitudes

toward mathematics, mathematics performance, gender, mathematics course-taking plans, and career interests were investigated. The results showed that attitudes toward mathematics were predictive of final mathematics course grade and also to the intention to continue to participate in mathematics courses once enrollment became optional. Attitudes also discriminated among students with different career interests. Students in more accelerated mathematics "tracks" had more positive attitudes and greater intention of taking optional mathematics classes. They were also found to be interested in more mathematically-related careers.

In a similar study, Simich-Dudgeon (1996) investigated the relationship between the mathematics attitudes of over 32,000 Hispanic and Asian students by gender and ethnicity, and by their mathematics performance scores. The study was conducted under the auspices of the 1992 National Assessment of Educational Progress (NAEP) mathematics trial state assessment, Among his findings was that most of the attitude variables were significant predictors of Hispanic and Asian students mathematics achievements, with slight differences between Hispanic and Asian 4th grade students of both gender groups regarding attitudes to be important predictors of mathematics achievement. This result was supported by a study conducted in Saudi Arabia by AL-Rwais. AL-Rwais (2000) examined the relationship between students' attitude toward learning mathematics, students' mathematical creativity and students' school grades, with achievement in mathematics in eighth grade in boys' public schools in the Riyadh district. According to the findings of this research, the combination of these three independent variables explained approximately 58% of the mathematics achievement. Moreover, the researcher noted that attitude toward learning mathematics was the best predictor of students' achievements. Therefore, he strongly recommends that both mathematics teachers and educators should pay attention to improving students' attitude toward mathematics in their teaching.

The use of computers in the teaching and learning of mathematics has been shown to have the potential of positively influencing student's attitudes toward mathematics. Studies have shown that technological aids such as calculators and computers have improvement effects on student attitudes toward mathematics (c.f. Aiken, 1976 and

Collins, 1996). In research conducted by Kulik (1984), it was found that students' attitudes towards mathematics were more positive in a classroom that used CAL than in classrooms without CAL. Similarly, students from a classroom that used CAL showed a slightly more positive attitude toward instruction than student from classroom without CAL (Collins, 1996).

Ganguli (1992) investigated the effect of using computers as a teaching aid in mathematics instruction on student attitudes toward mathematics. He used computer as a supplement to normal class instruction. The sample in the study consisted of 110 college students enrolled in four sections of an intermediate algebra class offered by the open-admissions undergraduate unit of a large Midwestern state university. The instruction focused on how to develop the concept of relationship between the shape of a graph and its function. The results indicated that the attitudes of the experimental group which was taught with computer aid were significantly changed in a positive direction whereas the control group that was taught without computer aid failed to show a similar result. Similarly, the results have shown that students in the microcomputer treatment group experienced a more positive self-concept in mathematics, more enjoyment of mathematics and more motivation to do mathematics than their counterparts in the control group. Furthermore, both instructors who participated in the study both indicated that the computer-generated graphics led to more active classroom discussions in experimental sections and consequently created more rapport between the teacher and the students than in the control sections.

In a similar study, Funkhouser (1993) also studied the influence of problem solving computer software on the attitude of high school mathematics students toward mathematics. There were 40 participants in the study enrolled in either geometry or second-year algebra course in a public high school. A rigorous schedule of computer-based and non-computer-based students' activities was developed. The students were given the National Assessment of Education Progress (NAEP), and skills-based test of problem solving ability developed by Mayer & Weinstein (1986). The researcher concluded that "Students who use problem solving software tend to develop a more

positive view of their own mathematical abilities and a more positive disposition toward mathematics as a subject" (p: 345).

In another study, Alkalay (1993) investigated the effects of using the computers for independent exploration on student attitudes toward mathematics and on student attitudes toward computers. A total of 27 students in the study were divided into two classes. The Mathematics Attitude and Computer Attitude Scales were administered at the beginning (pre-test) and conclusion (post-test) of the study. The software pre-calculus by Kemeny and Kurtz was used as the laboratory material. The students completed three units in the laboratory manual that were divided into four laboratory sessions. An analysis of the attitude scales revealed that the students indicated highly positive reactions toward using the computer in a laboratory setting for pre-calculus. They also agreed that the computer was an appropriate learning tool.

These results and many others are indicating that the use of the computer in teaching and learning of mathematics positively influences student attitudes towards mathematics as well as students' achievements in mathematics. In essence, mathematics attitude is one of the variables found to be correlated with students' achievements in mathematics and computer science. Therefore, mathematics attitude is a potential factor that can contribute positively in students achievement in pre-calculus algebra supplemented with a computer lab program. Clement (1981) suggested that the affective reactions of students toward the presence of microcomputers in the teaching-learning process might be an essential factor to explore in successful implementation of this technology. However, this is by no means a claim that research on the effect of computers in changing the attitude of student towards mathematics is conclusive. There is a small portion of studies pointing to the contrary (e.g, White, 1998).

3.3.2 Mathematics Aptitude

There is always a need for the maximum utilization of both human and natural resources; this is due to the fact that the resources are always limited. In educational sectors, selection processes for admission from one level of education to the other is a routine that is practiced globally. The selection is more rigorous from high school to

university. The aim of the selection is largely in finding a way of maximizing the minimum resources. In a way, the selection is a way of determining the potential candidates that will most probably benefit from a program. A technical name for this ability is *aptitude*. Aptitude is defined as the "… ability to profit readily from instruction, training, or experience in a defined area of performance" (Bruno, 1986:13). From this definition, it is easy to see that, many ways can be used to determine the student aptitude towards a particular program. These ways can either be through a standardized approach like in SAT (Standardized Aptitude Test), or through a non-standardized approach like using student's previous academic records such as high school GPA (grade point average), teacher's recommendations, etc. In either case the rationale is to help in predicting future performance of a particular candidate.

Researchers use many different ways to determine the aptitude of an individual in a particular domain. However, in an academic environment, high school GPA and entrance examinations are mostly utilized for this purpose. Begle (1979) observed that though many different types of studies on prediction of student achievement in mathematics have been carried out, none has received more attention than that of the beginning high school algebra course. In an intensive review of empirical studies in the area, Begle conclude that "it turns out that the best predictors of success in beginning algebra are measures of the student's previous success in mathematics, as measured by his grades in mathematics courses" (p.97), and "hardly does any other variable contribute significantly to the predictive power of previous mathematics achievement measure" (p. 97). In this study therefore, students' mathematics aptitude was measured by students' performance in the most recent algebra course they took, and that is MATH 001.

There are many recent empirical studies that attest to the Begle's conclusion. For instance, Tuli (1980) conducted a study on a sample drawn from the 9th grade secondary school students of Punjab state, the aim of which was to explore the relationship of mathematical creativity as it relates to aptitude for achievement in and attitude towards mathematics. The hypotheses examined in the study were: (1) Mathematical creativity is significantly related to aptitude for mathematics. (2) A

significant relationship exists between mathematical creativity and attitude towards mathematics. (3) Mathematical creativity contributes significantly towards achievement in mathematics. (4) Aptitude for mathematics and attitude towards mathematics conjointly contribute to mathematical creativity. One of the findings of his investigation was that aptitude for mathematics and achievement in mathematics were predictors of creative ability and fluency in mathematics.

In a study conducted by Jamison (1994) to determine the effects of high school performance, demographic characteristics, Myers-Briggs personality preferences and mathematics attitudes on three measures of college mathematics achievement (a problem-solving test, an algebra skills final examination and course grade for all seven classes of 175 undergraduate students taking pre-calculus in fall semester 1993). Among his finding was that high school performance explained the most variation for all the three measures of mathematics achievement investigated in the study.

In his four-year longitudinal study aimed at measuring the ability of two South African mathematics tests to predict mathematics performance of Grade 9 high school pupils, Kelly (1999) investigated the ability of measures of mathematics aptitude and ability to predict future school mathematics performance. The Initial Evaluation test in Mathematics (IET) and the Arithmetic Reasoning test (ART) were applied to Grade 9 pupils. Results on these tests were correlated with pupils' mathematics marks from Grades 9-12 over a four-year period. Results suggested that neither of the measure was a better predictor of mathematics achievement than were school marks. Therefore, Kelly concluded that the best predictor of subsequent mathematics achievement in Grades 10-12 was found to be a pupil's final Grade 9 mathematics marks.

Soares (2001) conducted research to determine whether students' mathematics profile of aptitude and attitude is related to their success on advanced placement calculus and statistics examinations. For this purpose, an aptitude test and an attitude questionnaire were used to develop student profiles of the 323 students who participated in this study from 5 different schools in the New York Metropolitan area. In addition, 19 mathematics teachers and 8 guidance counselors completed questionnaires that were

designed to explore their view about the advanced mathematics courses and to get their opinion on student placement in these courses. The results suggested that a relationship exists between student aptitude as determined by the instrument used in the study and success on either of the advanced placement mathematics examinations. Also, the results indicated that both the mathematics teachers and the guidance counselors believed that student aptitude, the junior mathematics grade, and teacher recommendation were the most important considerations for student placement in advanced mathematics courses.

In a study conducted at the College of Petroleum & Minerals (now, King Fahd University of Petroleum and Minerals), Dhahran Saudi Arabia, Al-Doghan (1985) examined the predictive validity of selection measures and related variables used by the university in selecting new students. The independent variables considered were at two stages. The independent variables at the first stage were: high school total scores, admission test scores, admission English, physics, mathematics, chemistry subtest scores, and student's age. While the second stage variables were preparatory year GPA and preparatory English, mathematics, mechanical engineering, and systems engineering scores. All these variables were found to be statistically significant at different level. However, high school total scores and admission test scores had almost equal correlations with success criteria.

Konvalina, Stephens & Wilemen (1983) conducted a study to examine the variables that affect both aptitudes and achievement in computer science courses. The predictor variables used were: age, high school achievement, hours worked per week, previous computer science education, previous non-programming computer work, previous computer programming experience, years of high school mathematics, and number of college mathematics courses. The sample of the study consisted of 165 college students who enrolled in an introduction to computer science course. The results of this study showed that high school performance was the most statistically significant factor for both achievement and aptitude.

A similar result was found by Huse (1987) in her study where she investigated the existence of relationship between some intellectual and non-intellectual factors and success in a college introductory computer science courses. Several intellectual and non-intellectual factors were considered. Among the intellectual predictor variables were: previous GPA, and composite, verbal, and mathematical ACT scores. The non-intellectual predictor variables considered were level of fluency, flexibility, originality, elaboration, and primary brain dominance. A total of 105 students participated in the study from two state universities in Texas: East Texas and Sam Houston State Universities. Students' final grades were used as the dependent variables. Among the several intellectual factors, only previous GPA was found to be a valid predictor for students' success in an introductory computer science course. However, with significance set at 0.05, the result indicated that none of the non-intellectual factors studied can be used to predict success of students in an introductory computer science course.

Hebert (1997) examined predictors of persistence and achievements of students enrolled in a special admission student program at a New England regional state university. The study attempted to identify correlates of persistence and success of students enrolled in a student support service program. Data were collected on students' high school rank, SAT scores, scores on study strategies inventory and on persistence and achievement in the freshman and sophomore years. Discriminant function analysis was employed to identify predictors of persistence, and stepwise regression analysis was employed to identify predictors of achievement. The freshman cumulative grade point average emerged as the single significant predictor of retention to the sophomore year. The pre-college summer program grade, and high school rank in class emerged as effective predictors of achievement. SAT scores failed to predict persistence or achievement for the sample. Hebert concluded that his findings are in line with other research findings which indicate that SAT scores are not a good predictor of success for minority and first generation college students.

3.3.3 Attitudes toward Computers

Given the pervasiveness of computers in all levels of the educational system, it is likely that students will have developed some attitudes towards these machines. There are large numbers of people, both teachers and students alike, that are known to have computer anxiety; also known as computerphobia. These are terms that appear in the literature as a result of computer resistance in the classroom by the teachers or students. According to Nickerson (1983), the resistance to computers stems from feelings of stupidity, fear of obsolescence, fear of the unfamiliar, and the thought that computers have a dehumanizing effect (Al-Badr, 1993). There is no doubt that how we think and feel has a large influence on how we behave. This is also true regarding our attitudes towards computers (Levine & Donitsa-Schmidt, 1997). In a classroom setting, studies have shown that students often experience reactions towards computers either positively or negatively. This in turn either enhances or interferes with their development of effective computer skills (Geer, White & Barr, 1998). A student with a negative attitude towards computers may not pay attention to anything to do with computers. Similarly, students that are computer enthusiasts may pay attention to any program that is computer based, and consequently, this may influence their attitudes toward the subject. In fact, there is a strong link between computer attitude and computer anxiety, it is only recently that a clear difference between the two is emerging. Shaft & Sharfman (1997: Section 2, para 1) observed that:

> In the past, computer anxiety and attitudes towards computers have been seen as synonymous (i.e., an individual who experiences high levels of computer anxiety can be said to have a negative attitudes towards computers (Meier, 1985)), or as separate variables with common antecedents (Igbaria & Parasuraman, 1989). However, evidence suggests that computer anxiety is an intervening variable between variables such as demographics and attitudes towards computers (Igbaria & Parasuraman, 1989).

It is believed that if computer anxious users have a positive attitude toward computers, there is a tendency that they can reduce anxiety through continued computer experience (Orr, 1997). Findings in (Marcoulides, 1988) have indicated that computer anxiety is a better predictor of success in computer use, and hence a factor that can negatively affect student attitudes. Therefore, understanding peoples' attitudes towards computers can

help in predicting people specific computer-related behaviors, their choices and performance (Ajzen & Fishbein, 1977; Batte, Fiske & Taylor, 1986). For a student to benefit from any computer based program, the student's positive and anxiety free attitude towards computers is essential, and in fact a necessary for a success of any computer based program. Studies have shown that attitude towards computers do influence not only the acceptance of computers in classroom, but also future behavior such as using computers as a professional tool or introducing computer applications into the classroom or work place (Al-Badr, 1993).

Four types of attitudes towards computer have been identified by Loyd & Gressard (1984a). These are: computer anxiety, computer liking, computer confidence, and computer usefulness. All the four were found to have a significant effect on students' achievements on computer tasks.

It appears that the use of computers in the teaching and learning of mathematics does influence the attitude of students towards computers and mathematics as well. Consequently, there seems to be some improvement in students' understanding and achievements in mathematics. For instance, in a study conducted by De Blassio & Bell (1981), a significantly positive relationship was found between computer use in the teaching of mathematics and the students' attitudes towards mathematics, the instructional setting, achievement in mathematics and programming, and previous programming experience.

In a study conducted in Saudi Arabia, Al-Rami (1990) examined the students' attitude toward learning about and using computers and correlated their attitudes with their achievements in computer classes. The participants in the investigation were 172 males comprising of first, second, and third semester students. Student attitudes were determined at the beginning and end of the semester using the computer attitude scale by Loyd & Gressard (1984a). Academic achievement was based on end-of-semester scores. Findings indicate that students' attitudes toward computers were positive the entire semester and at all levels, and almost the same at the beginning and end of the semester. Both pre-test and post-test attitude results were statistically significant in

predicting achievement. Particularly, the post-test was more reliable in predicting achievement.

Marty (1985) investigated the effect of games in the students' attitude towards, and achievement in mathematics. The computer games Algebra Arcade was used with experimental class in lieu of the in-class assignment during the 15-20 minutes at the end of mathematics classes. Analysis of results revealed the following findings: (1) a significant difference, at the .08 level, in change of class means on mathematical achievement favoring use of the computer game, (2) very little difference (p = .38) in the change of class means on attitudes toward mathematics, and (3) a significant difference, at the .005 level, in change of class means on graphing ability favoring the use of the computer game.

Clarke (1986) in a pilot study of using Logo measured the attitudes toward mathematics and general ability of 43 girls before and after a Logo learning experience. Results suggested that the Logo experience had a positive effect on general ability and on expressed interest in learning mathematics.

In a similar study, Benson (1989) investigated the effects of using computer software as a tool in the teaching of Gauss-Jordan elimination and linear programming in students' achievements in, and attitude towards mathematics. The participants in the study were students enrolled in finite mathematics for Business and Social Sciences, and were divided into a control and an experimental group. Among the findings of this study, students' attitude toward computers in the treatment sections improved significantly more than the attitude of students in the control sections. Also, using computers to replace manual computation did not lower students' achievements in any of the measures except the Gauss-Jordan elimination unit items. Even this did not affect attitude toward mathematics.

Wood (1991) investigated the effects of integrating two forms of computer-based education on overall mathematics achievement, conceptual mathematics achievement, computational achievement, attitude toward mathematics, and attitude toward computer-based education. The participants in his study were divided into three groups, two used

different forms of computer based education, and the third did not utilize computers. The two forms of computer-based education integrated into the regular instruction were a computer tutorial program and a computer tool program. In this way two experimental groups were formed, and the group with no computer utilization served as the control group. A total sample of 104 participants from second-year algebra classes at a comprehensive high school in Indiana state participated in this study. Pre-tests and post-tests on mathematics achievement, attitude toward mathematics, and attitude toward computers were administered before and after the treatment respectively. The results of the study showed that the computer tool group scored significantly higher in conceptual achievement, and the control group scored significantly higher in computational achievement. In addition, the computer tool group demonstrated a significantly more positive attitude toward mathematics after the treatment than the other two groups.

Wohlgehagen (1992) investigated the effect of computer based instruction in teaching Algebra I compared to the teaching of the same topics using traditional approaches. The achievement level of the two groups and three aspects of attitude toward mathematics were considered. Students selected for the study belonged to a large suburban school in Texas. The sample consisted of 243 students. The experimental group used the computer lab daily for the duration of 55 minute class period, and the control group, not using the computer, was taught the same Algebra I topics with traditional instructional approaches without involving computers. Out of eleven Algebra I classes involved in the study, five were designated as the experimental group, and six as the control group. Pre-test and post-test scores on three Fennema-Sherman Attitude Scales (Mathematics Anxiety, Confidence in Learning Mathematics, and Attitude Toward Success in Mathematics) were analyzed. Also the scores from the Texas Essential Skills Test for Algebra I (Forms A and B) were included in the analysis. Among the findings of the study was that the experimental group improved significantly on both the Confidence in Learning Mathematics and Mathematics Anxiety Scales, and while they improved on their achievements and attitude toward success scores, but they were not statistically significant.

In another study conducted by Aho (1992), the aim of the study was to investigate the effect of two instructional-design methods in changing mathematics anxiety and attitude toward computer-assisted instruction (CAI). On post-test mathematics scores, Aho (1992) found a significant effect of the program in changing mathematics anxiety. However, no statistically significant result was found in the post-test mathematics scores.

All these results points to the strong correlations between students' computer attitudes and their achievements in mathematics and computer related courses. Therefore, computer attitude is a potential variable that may predict students' success in pre-calculus algebra supplemented with a computer lab program.

3.3.4 Computer Ownership

There is no doubt that computer ownership increases individual computer accessibility. As the accessibility increases, there is tendency toward an increase in the amount of time spent working with computers. Studies have shown that the amount of time students spend in working with computers is significantly related to students' attitudes to working with computers (Orpen & Ferguson, 1991; Cockroft, 1994). Similarly, access to a computer is known to be associated with higher levels of computer literacy and confidence (Fife-Shaw, Breakwell, Lee & Spencer 1986; Lowe & Krahnn, 1989, Geer, White & Barr, 1998). For instance, students in possession of a computer at home seem to have more confidence in using the technology with well developed technical skills as compared to those who have no access to computer at home. Regarding this disparity, Barlin (2000, conclusion, para. 1) put a word of caution as follows:

> Whilst we recognise the increase in home ownership it is important not to ignore equity issues surrounding the disparity in access to computers and associated resources in homes. The educational gap between the 'haves' and the 'have nots' is of concern to us all and we should continue to strive to narrow that gap in whatever way we can. Just as schools have developed strategies to compensate for the inequality of opportunities to develop literacy and numeracy skills for some children, so we will need to develop strategies to compensate for the differences in access to computers at home. (Conclusion, para 1).

It has been shown that computers, if accessible to the students, can reduce mathematics anxiety (Orr, 1997). The more students use computers, the more experienced, confident and comfortable they are with the machine. Studies have shown that computer experience is correlated with a more positive attitude towards computers (Shoffner, 1990). As a result, many universities in the USA, for instance, are now making it a matter of policy for all newly admitted students to have their own computers (Lowry, 2001).

Many other studies have shown that there is a significant relationship between computer ownership and students' achievements in computer related courses. For instance, Brown, Day & Meade (1989) investigated the impact of computer ownership and lab attendance on College of Business students' performance on an examination in an introductory course on information systems. Results indicated that both owning a computer and attending lab sessions were associated with a student earning a better course grade.

In another study, Gattiker & Hlavka (1992) examined the relationship between trainees' attitudes and learning performance in computer courses. The study looked at how attitudes held before attending a computer course differed on the basis of gender, intention to purchase a computer, and ownership of a computer. The participants in the study were 156 students who had enrolled in a required university computer literacy course with a 70% participation rate. The study revealed that gender and ownership of a computer were responsible for attitudinal differences, and ownership of a computer eliminated almost all gender differences in computer attitudes.

Similarly, a link between computer confidence and computer ownership was established in a study conducted by McInerney, McInerney & Sinclair (1990) in their investigation of the effects of increased computing experience on the computer anxiety of 101 first year pre-service teacher education students at a regional university in Australia, McInerney *et al*. found that computer confidence is linked with computer ownership.

Taylor & Mounfield (1991) examined the factors that contributed to achievement among 300 college students enrolled in an introductory computer programming course. The

factors that were found to contribute to achievement in this course were: having a job, computer ownership, and high school programming courses. Computer ownership was found to have significantly contributed in predicting success in computer science for the males.

Nash & Moroz (1997) revisited the issue of the relationship between gender and computer usage as independent variables on one hand, and computer anxiety, computer liking, computer confidence, and perceived usefulness of computers on the other. The aim was to see if new information could be obtained on the subject. Data was collected from 289 graduate educators and subjected to correlations and independent t-tests with standardized effect sizes. Results showed that while gender did not affect attitudes towards computers, gender-related computer activities did. The study statistically established that computer ownership had significant influence on the measured composites of attitude towards computers, and that it had a similar influence on intensity and frequency of computer activities at work and at home.

Cates (1992) collected data on computer ownership and use from 121 graduate students enrolled in a course on education research. These data were correlated with 2 measures of the participants' academic achievements: course grade and performance on a set of research analysis activities. Students who owned microcomputers had significantly higher achievements on both measures. However, Cates cautioned that the results may be attributable to socioeconomic status of the students.

Nichols (1992) investigated the influence of home-computer ownership and in-home use of computer on achievement in a school's computer programming curriculum. The sample of the study was 96 second graders and 79 fifth grade students. The students were taught BASIC programming for three marking periods and Logo programming for one marking period. For analysis, the students were grouped by ability, gender and computer ownership. No statically significant difference was found among the groups. However, Nichols concluded that there was a tendency for computer owners to outperformed non-owners in certain situations. "This was especially true for high-ability fifth graders, where computer owners outperformed the non-owners on both BASIC and

Logo post-test scores, and programming homework score averages" (Nichols, 1992, abstract, para. 1).

Perkins (1993) also examined whether computer anxiety is different if the measure is administered by computer rather than by paper and pencil. Other variables considered include owning a computer, graduate versus undergraduate status, previous use of computers, and gender. The study compared two groups of students (N=83) who were gathered from three undergraduate sections and one graduate section of a required computer class for in-service and pre-service teachers using anxiety level and performance as measures. Both groups took a written pre-test; but one group was administered an anxiety scale (pre and post) and post test on the computer using a HyperCard stack, while the other group used a paper and pencil version of these measures. Statistical analysis of the data revealed that computer ownership had an effect on both performance and anxiety.

In their cross-cultural technology training and education program, Chisholm, Irwin & Carey (1998) investigated computer training preferences, computer attitudes and perceptions, and computer access among Chinese, Ghanaian, and American students in college business and education classes at the college level. Computer access was found to be closely linked to competency. Also, the attitudes of Chinese and Ghanaian students were positive towards computers, even though they had little experience and competence in using them.

In a longitudinal study, Staehr, Martin & Byrne (2001) investigated students' attitudes to computers and the perceptions of a computing career. The participants in the study were students enrolled in an introductory computing course from the years 1995 to 1998. It was found that ownership of a computer at home had a positive effect on computer anxiety and computer confidence.

Velazquez-Zamora (2001) examined the anxieties of secondary teachers' regarding computers, and also the sources of this anxiety. The participants in the study were secondary teachers of private Catholic schools in Ponce, Puerto Rico. The variable considered were: age, gender, computer confidence, computer ownership, and the

number of computer courses taken by the participants. The participants for the research consisted of 91 secondary teachers of both gender distributed among eight secondary private Catholic schools located in Ponce, Puerto Rico. Gender distribution consisted of 73 females and 18 males. Among the findings of this research was that computer ownership and computer anxiety are dependent on each other.

Therefore, from these entire studies one can see that there is a tendency for computer ownership to also influence students' achievement in pre-calculus algebra supplemented with a computer lab program.

3.3.5 Computer Prior Experience

Learning is considered a sequential and cumulative process. The speed at which one is able to absorb new information is determined to a large extend by his previous knowledge. Previous knowledge is something that is inherently 'sitting' in all learning theories. According to the new school of thought called Experiential Learning, learning is nothing other than accumulation of experience. Prior knowledge or experience provides a learner with a large amount of relevant information in specific domain as well as the strategies of organizing the knowledge (Berieter & Scardamalia, 1986). It has been claimed that individual differences, which are well acknowledged phenomenon in all classrooms are as a result of differences in prior knowledge (Yates & Chandler, 1991). In general, learners are attracted more with something that they are familiar with. Therefore, motivation and attention to a new learning material can only be facilitated when a learner has some good familiarity with the previous knowledge or experience in the area. Studies have shown that if students enter a program with a wide range of prior knowledge and experience, it will help them to quickly learn, adopt and develop confidence in the new skills they are learning (Yates & Chandler, 1994; Geer, *et al*., 1998). It is opined that the major difference between higher and the lower achievers is that the former are capable of using their previous knowledge to learn new information, whereas the latter lack that capability (Al-Badr, 1993). Some consider prior knowledge as more important than good lesson presentation, since however good a lesson is presented, learning can only be meaningful if there is no conflict between the new

knowledge and the previous one (Stein, Bransford, Franks, Owings, Vye & McGraw, 1982).

In a computer oriented program, if students are confident technology users it is more likely that they will explore the wide variety of sources available using computers, and will in turn benefit tremendously from these resources. Studies have shown that computer experience influences perceived efficacy with computer technologies. Also, positive educational experiences have been found to be predictor of self-efficacy (Hill, Smith & Mann, 1987; Delcourt & Kinzie, 1991; Geer *et al.,* 1998).

Prior knowledge or experience is a two-way traffic; it can be advantageous to learner as well as hindrance to a learner who is deficient in it. For instance, if new knowledge conflicts with prior knowledge, then it will results in confusion and misconceptions, both of which are detrimental to the learning process.

Another problem that might result from previous knowledge is when the learner is familiar with the material to be learned. In this case there is likelihood that he may not pay attention to the lesson. This negative effect is more likely to result from instruction delivered by media that does not allow for learner control (Davey & Kapinus 1985; Carver, 1985). Therefore, there is a need for an instructional approach that can engage students and arouse their interest in the subject. In this regard, computers are potentially beneficial and have the motivational influence on student learning (Cox, 1997). In a study by Ravenscroft & Hartley (1998), the students reported that computers make a subject more interesting and lead them to higher level employment, which according to Cox (1997) are two strong indicators of motivation. According to Loyd & Gressard (1984b), prior experience with computers creates a more positive attitude toward computing. Students with more computer experience are significantly more confident about computer related tasks than those with less prior computer experience.

> ...it is becoming increasingly evident that familiarity with computers and the ability to use them effectively will be of critical importance to success in many different fields. Computer experience is therefore gaining wide recognition as crucial component of the educational process, as our

educational system seeks to prepare new generational of students for effective participation in our society (Loyd & Gressard 1984b:67).

Computer anxiety can be attributed to a lack of experience and unfamiliarity with the technology. Studies have shown that students who have had little or no exposure to computers before coming to university can feel very anxious and threatened by these machines (Campbell & Williams, 1990, Corston & Colman, 1996). Schuh (1996) found that university students often had high levels of computer anxiety, which eventually became a factor in the students' academic success.

As the computer usage in mathematics education is increasing, it is now evident that both familiarity with computers and the ability to use them effectively are of critical importance to success of the program. Consequently, "computer experience is now widely recognized as a crucial component of the educational process as our educational system seeks to prepare a new generation of students for effective participation in our society" (Loyd & Gressard, 1984b:67). Prior experience with computers creates a more positive attitude toward computing, and students with more computer experience are significantly more confident about computer related tasks than those with less prior experience (Loyd & Gressard, 1984b).

Studies have shown that one of the strongest predictors of both computer aptitude and attitude is prior experience with computers. In addition, computer prior experience has been shown to be related to students' achievements in computer related areas. In a study conducted by Russell (1988), the aim of which was to investigate the factors that predict achievement in individualized computer courses. The factors in his study were high school performance, standardized reading scores, standardized mathematics scores, previous computer experience, college hours, age, learning styles, introvert factor, and sign-up factor. The participants in the study were 109 college students enrolled in an individualized computer programming courses at Lee College, Baytown, Texas in the spring semester of 1988. The result indicated that previous computer experience is one of the seven factors found to have a significant correlation with the final grade.

In a similar study, Howard (1990) examined the relationship between achievement and several factors: cognitive style, locus of control, gender, age race, prior computer experience, computer ownership, mathematics background, motivation for taking the course, knowledge of standardized test scores, and instructional variations. The participants in the study were 128 college students enrolled in an introduction to microcomputer software class. It was found that prior experience of using a computer and motivation for taking the computer course both significantly influenced performance in the introduction to microcomputer course.

Nash & Moroz (1997) in their study considered the role of gender and experience on computer attitudes among professional educators. They found that gender alone was not a predictor of attitude, but rather, the type of gender-related computer activity. They concluded that the frequency of specific computer-related activities at work and at home, is a predictor of attitude toward computers.

3.3.6 Proficiency in the Language of Instruction

> One of the most fundamental aspects of all cultures is language, and it should be of serious concern that so many mathematics education researchers appear to have paid little more than lip service to the centrality of language factors in all aspect of mathematics teaching and learning (Ellerton & Clarkson 1996:1017).

Language plays a vital role in the teaching and learning of mathematics. As a matter of fact, the development of mathematics is mediated through language, and language is the means by which mathematics is communicated (Austin & Howson, 1979; Ernest, 1988; Durkin & Shire, 1991; NCTM P&S, 2000).

Sapir-Whorf hypothesis theorized that the language habits of our community predispose certain choices of interpretation (Durkin & Shire, 1991). This simply means, according to Durkin & Shire (1991), that people think and perceive things in a way made possible by "the vocabulary and phraseology of their language" (p.12). Hence, "concepts not encoded in their language will not be accessible to them, or at least will prove very difficult" (p.12). Even though the Sapir-Whorf hypothesis has not been generally accepted, especially in the domain of mathematics education (c.f. Zepp, 1989), there is

evidence that shows the language we speak has an influence on our thought patterns (Brodie, 1989; Durkin & Shire, 1991; Silby, 2000).

One of the reasons why the language factor needs special attention these days is the fact that many students are currently learning mathematics in their second or third language (Austin & Howson, 1979; Ellerton & Clarkson, 1996). This phenomenon is gradually becoming the norm rather than the exception (Secada, 1991). The reason for this in the developed countries is largely due to the increase in immigration, while in the developing countries it is due to the legacy of colonialism, and the diversity of local languages. Another reason which can be described as a much stronger one is the fact that the language of science, technology and the internet is slowly but surely narrowing down to a few languages. Therefore, textbooks and other learning and teaching materials are increasingly more likely to adopt these few languages. Although studies on the consequences of this bilingualism and multilingualism on student mathematics learning are inconclusive (Morrison & McIntyre, 1972; Austin & Howson,1979; Davidenko, 2000), some studies have shown that there is a relationship between the degree of bilingualism and logical reasoning (Secada, 1991; Ellerton & Clarkson, 1996; Brodie, 1989). Furthermore, several other studies have indicated that the language problem is one of the major factors contributing toward the poor performance of many students in mathematics; especially those who are bilingual and multilingual (c.f. Secada, 1992; Barton & Neville-Barton, 2003). Studies have shown that students that are found to be very weak in the language of instruction have the tendency toward ill-comprehension as well as poor participation in classroom discourse (c.f. Setati, 2002). Consequently, they cannot meet the desired objectives of their studies due to lack of communication skills, and this also puts teachers in the dilemma of how to correctly assess the sources of student difficulty: is it mathematics or is it language? (Secada & Cruz, 2000).

For students who are acquiring a language of instruction as well as learning mathematics in the new language, the language of mathematics is another source of difficulty and confusion in the process of learning mathematics. Mathematical terminology is often complex and the words used therein are endowed with meanings, which in most cases are

completely different from their normal usage. For instance, the words: *root*, *similar*, *power, or* and *odd* have a different sense from the usual meanings when used in mathematics. Sometimes it may be difficult, "even for students who are not bilingual, to determine which meaning of 'odd' is intended in a problem (odd as in something peculiar or odd as in numbers that are not divisible by two)" (Raborn, 1995). Studies have shown that bilingual students, even at university level, confuse the meanings of some of these mathematical terms (c.f. Setati, 2002). The problem is greater for bilingual students such as the preparatory year students at King Fahd University of Petroleum & Minerals, who are acquiring the language of instruction simultaneously with mathematics. This class of students has to cope with the difficulty of learning to understand the special terminology and syntax of mathematics (c.f. Brodie, 1989; Durkin & Shire, 1991).

Many frameworks have been developed from both a sociolinguistic as well as a psycholinguistic point of view in an attempt to link the various elements of language and mathematics. Among these frameworks is the one developed by Gawned (1990). According to Ellerton & Clarkson (1996), Gawned's framework is based on a "sociolinguistic premise" (p.990). The framework acknowledges that the language of the classroom has a "formative effect on the learners' understanding of mathematics" (p.990). According to the framework, as far as the mathematics learner is concerned, "mathematical concepts only have meaning within the linguistic and social context from which they were derived" (p.994). As noted earlier, studies are inconclusive on the effect of bilingualism and multilingualism on student mathematical learning. However, some studies have shown that student proficiency in his or her first or second language plays a role in his or her cognitive activities. (Qi, 1998; Secada, 1992; Silby, 2000; Galligan 2004). Cummins's 'threshold hypotheses' states that for learners who speak two or more languages, the interplay in the learning process between the language codes may either assist or detract them from learning. On one hand, if a bilingual or multilingual student has reached a "threshold" of competence in the two or more languages, then the learner may have a cognitive advantage. On the other hand, those bilingual or multilingual students who are not really fluent in either of the two or more languages tend to experience difficulty in mathematics (Ellerton & Clarkson, 1996).

At the start, Cummins (1979) distinguished between what he called basic interpersonal communicative skills (BICS) and cognitive academic language proficiency (CALP). According to Cummins, while conversational fluency is often acquired to a functional level within about two years of initial exposure to the second language, it takes at least five years to catch up with native speakers in academic aspects of the second language. Cummins's distinction between the conversational and academic language, though remaining controversial, has made a lot of impact on many educational policies and practices in both North America and the United Kingdom (c.f. Cline & Frederickson, 1996). Similarly, many of the current empirical studies on the implications of bilingualism revolve around this distinction. All these results point to the fact that linguistic factors have a significant effect on student learning of mathematics. However, it has been observed that most of the research on bilingualism and multilingualism is carried out in developed countries. Therefore, the need for urgent research investigation, particularly in developing countries, to determine the extent and nature of the role of bilingualism has been called upon (Austin & Howson, 1979; Ellerton & Clarkson, 1996). Similarly, Setati (2002) noted that:

> This field of research has been criticized because of its cognitive orientation and its inevitable deficit model of the bilingual learner (Baker, 1993). The argument is that school performance (and by implication, mathematics achievement) is determined by a complex set of inter-related factors. Poor performance of bilingual learners thus cannot be attributed to the learners' language proficiencies in isolation from the wider social, cultural, and political factors that infuse schooling (Setati, 2002:7)

In any case, many empirical studies have been carried out to ascertain the role of language in students' achievements. Most of the findings in these studies have indicated that verbal skills are the best single predictor of advanced achievement in schools and colleges (Woldetekle, 1972). According to Woldetekle (1972), one of the cultural variables that have an unfavorable effect on the predictive effectiveness of verbal ability is bilingualism. Studies have shown that for bilingual students, learning mathematics in a language different from their first language have a significant effect on their mathematical achievement. For instance, Taole (1981) investigated the effect of studying a selected secondary school mathematics topic in the vernacular on students'

achievements. The study was carried out in Lesotho immediately after they changed the language of instruction from Sesotho, the vernacular, to English. The participants in the study were in the fifth year of a seven-year elementary school program. Taole tested the following hypotheses: (1) Students studying a selected topic in first year secondary mathematics in Sesotho will perform better than those studying the same topic in English. (2) The level of English proficiency of pupils who perform at a passing level in a selected mathematics topic after receiving instruction in English is higher than that of pupils whose performance is below a passing level. Four hundred and forty-four pupils and 10 teachers from six secondary schools participated in the study. Within each school the pupils were divided into three groups. One group was taught in English, using the regular textbook; the second group was taught in Sesotho, using translated materials. The third group, which was taught bilingually in English and Sesotho, had access to both versions of the materials. An achievement test was administered to all students. Also, measures of students' English proficiency and their mathematics aptitude were also obtained. The results showed that pupils taught in Sesotho performed slightly better than those taught in English, and pupils taught bilingually performed slightly better than those taught in the vernacular. It was found that among pupils taught in English those who passed the achievement test had a higher level of English proficiency than those who failed. The difference in English proficiency was statistically significant. On the other hand, the difference was not significant among pupils who were taught in Sesotho.

In another study, Chan (1982) investigated the differences in discourse patterns between bilingual and monolingual Mexican-America students when tutoring mathematics to bilingual Mexican-America students and the effects of these differences on achievement. Tests of significant effect sizes revealed that bilingual tutors used more general explanations with examples and non-examples than monolingual tutors. Bilingual tutors also used and received more accepting, agreeing, or acknowledging responses. Monolingual tutors used and received more negating or rejecting responses and responses with questions. In this study, no significant differences were found in mathematics achievement. However, the researcher concluded that the differences in discourse patterns support the conclusion that more communication occurs when a

bilingual is taught by another bilingual rather than a monolingual. The conclusion of this researcher was supported by many other studies as reported in Setati (2002).

In a similar study, Dawe (1983) investigated the effect of teaching mathematics in English to students that have English as their second language. The participants in the study were of bilingual Punjabi, Mirpuri, Italian, and Jamaican children aged 11-13 growing up in England. The result revealed that first-language competence was an important factor in the childrens' ability to do mathematical reasoning in English as a second language.

Ferro (1983) investigated the influence of language on mathematics achievements of Capeverdean students. Three basic patterns of instruction were considered: teaching entirely in English, teaching in some mixture of Capeverdean and English, and teaching in some mixture of Portuguese and English. The research questions were: (1) What are the comparative results of the three instructional treatments? (2) Is there a statistically significant difference between male and female achievements in basic mathematics, geometry, and algebra? (3) What relationships, if any, exist between the dependent variables (achievement in basic mathematics, geometry, and algebra) and certain independent variables taken collectively? A week before the instruction began, 89 Capeverdean bilingual students enrolled in the first year of a two-year course in basic mathematics were tested to determine their English, Portuguese, and Capeverdean proficiency. They were also tested on three mathematical topics (basic mathematics, geometry, and algebra). The following week, instruction was given on basic mathematics. The participants were then post-tested. The same instruction and testing procedure was used with a geometry unit and an algebra unit. The teachers presented each unit according to given instructions and all the activities were done twice. In the Portuguese/English instruction group, the activities were in Portuguese and were repeated in English; in the Capeverdean/English group, they were in Caperverdean and were repeated in English; in the English/English group, they were in English and were repeated in the same language. This study tends to support the hypothesis that students who have Capeverdean as a native language, and were taught mathematics with the Capeverdean/English treatment will increase their mean achievement scores relatively

more than those taught with an English/English treatment or a Portuguese/English treatment.

Cuervo (1991) studied the effects of mathematics instruction in two languages (English/Spanish) on the performance of Hispanic bilingual college students on mathematics tests of CLAST competencies and on a mathematics final examination similar to the CLAST mathematics subtest. The research question was: To what extent is the language of instruction related to Hispanic bilingual college students' course achievements in mathematics? The sample consisted of Hispanic bilingual students enrolled in five sections of MGF 1113, at the South Campus of Miami Dade Community College, during the Winter term of the academic year 1990-91 academic year. Two bilingual sections, with 32 students, all Hispanics, made up the experimental group. Three regular sections, with 118 students, of which 62 were Hispanics, made up the control group. The experimental group participated in bilingual instruction (English/Spanish) and the control group in traditional instruction (English only). Both groups received the same mathematical instruction from the same book. The same concepts, skills and algorithms were uniformly taught to both groups their respective class. The same tests were administered to both groups on the same dates. The difference was language of instruction. Students in the bilingual group took the bilingual version of the four partial tests, which had the same questions but written in both English and Spanish. The final examination was in English only for both groups. The study found that Hispanic bilingual college students who participated in bilingual instruction achieved significantly higher scores in the mathematics areas of logic, probability/statistics and geometry, but not in algebra. Scores on a final examination similar to the CLAST mathematics subtest were significantly higher for Hispanic students in the bilingual experimental group. The researcher concluded that bilingual instruction (English/Spanish) was more effective than traditional instruction (English only) in promoting overall higher academic achievement for Hispanics on CLAST mathematics competencies examinations. This result was supported by other two studies conducted by Clarkson (1992) in a Papua New Guinea. In the first study, Clarkson (1992) found that the influences of English, the language used in the schooling of 227 sixth graders from Papua New Guinea, as well as the influence of their native

language, Pidgin, have a significant impact upon their mathematical performance. In the second study, he found that bilingual students who were competent in both languages scored significantly higher on two different types of mathematical tests than both low-competence bilingual students and monolingual students.

Bearde (1993) investigated the correlation of oral language proficiency and mathematics achievement for students included in "norming" the Woodcock-Johnson Psycho-educational Battery-Revised, (WJ-R). Participants in the study were 1494 students in grades three, five, eight, and eleven. The Oral Language Proficiency cluster, grade placement, and gender were used as predictor variables in multiple regression analyses of mathematics achievement as measured by the Basic Mathematics Skills and the Mathematics Reasoning clusters. It was found that oral language proficiency was a strong predictor of both mathematical reasoning and basic skills. Deeper analysis revealed that each of the five oral language tests measures a different aspect of language ability, and each was used as a predictor variable in multiple regression analyses of mathematics achievement. Tests measuring deeper levels of language (context reduced, word meaning and analysis) were stronger predictors than tests measuring verbal attention and memory. Results suggest a surface level understanding of language is insufficient for mathematics achievement; a deeper level of language, involving an understanding of relationships, is needed.

Maro (1994) investigated the ability of Tanzanian secondary school students to reason in English as a second language. The study also tried to isolate particular variables which best discriminate high from low achievers on tasks of reasoning and problem solving in mathematics among Tanzanian secondary students, for example, language spoken at home, encouragement and socio-economic status. English and Kiswahili versions of a mathematics reasoning test were developed and used to test students' reasoning ability in the two languages. A test of logical connectives comprised of mathematical statements was also used to determine the relationship between reasoning in English and familiarity with English logical connectives. The fourth instrument was an adapted non-verbal test of intelligence used to sort students into different mathematical development levels based on Piaget's cognitive development levels.

Lastly, students' language background was obtained for this study through the use of a questionnaire. The results revealed that the performance of Tanzanian students on the tests of mathematical reasoning ability varies depending on the language used in the test with better performance on the Kiswahili version.

Han (1998) investigated the relationship between the clarity of specific mathematical terms and students' mathematics achievements. Participants were volunteers from an urban junior high school. The participants formed three testing populations. One group constituted of newly immigrated, monolingual Chinese-speaking, ethnic Chinese students. The second group was composed of American-born, monolingual English-speaking, ethnic Chinese students. The third comprised of bilingual Chinese/English-speaking students. Statistical analysis showed that Chinese language ability was a strong predictor of students' mathematics scores. The clarity of Chinese mathematical terms did positively relate to achievement in the mathematics test for those students who could read and write Chinese. The overall conclusion that was drawn from this study is that the English and the Chinese language are inherently different in the ways they express mathematics ideas. A convincing interpretation is that the relative clarity of mathematical terms in the Chinese language contributed to the performance of Chinese-speaking students.

Lim (1998) studied the relationship between language and mathematics among Korean American students. The research investigated the associations between various background factors (such as reading skills, self-reported English proficiency, parents' educational background, Korean language school attendance, gender, and length of residence in the United States) and the students' mathematics achievements. The associations were examined in relation to two separate mathematics sections; problem-solving (written English) and computation (written numbers and operational symbols). Seventy-one Korean American students in seven high schools completed a self-administered background information questionnaire including items on language preference and parents' place of birth. Among the findings of the study were: (1) Language associates with mathematics achievement, especially in tasks that require substantial amounts of language processing, as in the problem-solving section; (2)

Background factors that are directly or indirectly related to language proficiency also associate with scores on the problem-solving section. Lim concluded that "these findings suggest that bilingual students' success in problem-solving is inextricably interwoven with their level of proficiency in English and factors that relate to English proficiency. Greater exposure to the language of the classroom and the language of mathematics was recommended for limited English proficient students" (abstract, para. 1).

In his investigation of the predictive validity of selection measures and related variables used by the University Petroleum & Minerals (now KFUPM) in Saudi Arabia, Al-Doghan (1985) used high school total score (HSTS), admission test score (UPMAT), admission English, physics, mathematics and chemistry subtest scores, and the student's age (as first-stage variables); and preparatory GPA and preparatory English, mathematics, mechanical engineering, and system engineering scores (second-stage variables) as independent variables (predictors). The dependent variables (criteria of success) were preparatory GPA, freshman GPA, final GPA, and attrition status. The main validation study included 1,261 student records selected from files of applicants admitted in 1978/79. The cross-validation sample included 344 student records selected from files of applicants admitted in 1981. In this study English skill was found to be a good predictor only to a certain level, beyond which differences in English skill had no major influence on success.

In a study conducted by Sughayer (1989) to investigate the implication of language of instruction in science teaching and student achievement. In the study, there were two treatments, the first teaching science in Arabic, and the second in English. No significant difference in achievement for the language of teaching was found in this study.

Dakroub (2002) investigated the role of Arabic language literacy in the academic achievement of students in English middle school. Arab-American middle school students in a suburban middle school in Southeast Michigan were tested to determine their level of literacy in Arabic. 105 students met the requirements to be included in the

study. Raw scores from the Terra Nova standardized achievement test (CTB, McGraw-Hill, 1998) were compared with raw scores from an Arabic language literacy test to determine if there was a significant relationship between levels of literacy in the Arabic language and academic achievement in English reading, language and mathematics. Results from all the analyses confirmed a significant positive relationship between the achievement of Arab-American middle school students in English reading, language and mathematics and their level of literacy in the Arabic language. On measures of academic achievement in English reading, language and mathematics, participants who were classified as having high levels of literacy in the Arabic language outscored participants with low levels of Arabic language literacy .

3.3.7 Learning Styles

The current paradigm shift is going away from teaching and the teacher and toward learning and the learner. In this dispensation, the importance of understanding the best way an individual learns is increasingly becoming apparent. Educators have since realized that people are different and have different ways of doing things. The preferences, tendencies, and strategies that individuals exhibit while learning constitute what have come to be called *learning styles* (Thomson & Mascazine, 1997). People have different learning styles, and studies have shown that if individual learning style is accommodated in the teaching process, it results in an improvement in attitudes toward learning, increases in academic productivity and in academic achievement (Griggs, 1991). Individual learning style is a source of strengths and weakness for individual. If the presentation of a lesson coincides with a student's learning style, there is a tendency for the student to benefit tremendously from the lesson. Otherwise, this may negatively affect the learning process of the students. The knowledge of individual learning style is considered as an important area for personal academic competence and crucial for improvement of education (Kolb, 1984 & 1993; Griggs, 1991). In a mathematics classroom, the knowledge of students learning styles has a dual advantage; first, it helps students to understand and become aware of how they learn and the best way they study (metacognition). Studies have shown that students who know their personal learning styles often do apply such information with great success and enthusiasm (Griggs,

1991). The second advantage of knowing the students' learning style is that the knowledge helps the teachers in the preparation of their teaching strategies, lessons, and classroom activities that will maximize student learning process.

Review of literature on learning and understanding of mathematics reveals that numerous instruments have been developed over the last three decades to measure different types of learning styles. These instruments evolved from variety of conceptual orientations (Thomson & Mascazine 1997). However, Keefe (1987) identified the affective, cognitive, and physiological learning styles as three important factors embedded in the way individuals perceive, interact with, and respond to their learning environment. Curry (1987) in an attempt to provide a framework for the growing number and variety of conceptions of learning style theories, conceives of what Griggs (1991) called the "onion model". The so called "onion model" consists of four dimensions defined as follows:

1. *Personality dimensions:* These are the learning styles that address the influences of basic personalities on preferred approaches to acquiring and integrating information. This includes issues that deal with measures of extroversion/introversion, sensing/intuition, thinking/feeling, and judging/perception. Learning style models in this category include: Witkin's (1954) construct of field dependence/field independence and the Myers-Briggs Type Indicator (Myers, 1978) with dichotomous scales measuring extroversion versus introversion, sensing versus intuition, thinking versus feeling, and judging versus perception (Griggs 1991).

2. *Information processing:* The learning styles in this category focus on the individual's preferred intellectual approach to assimilating information. The most popular model in this category is Kolb's (1984) Experiential Learning Cycle which identifies four phases of information processing: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Also Honey & Mumford (1986) Learning Style Questionnaire and Schmeck's (1983) construct of cognitive complexity fall in this category.

3. *Social interaction:* The learning styles here look at how students interact in classroom settings. In this line of thought, Reichmann & Grasha (1974) identified six types of learners: independent, dependent, collaborative, competitive, participant, and avoidant.

4. *Instructional preference:* In some literature this class of learning style is called multidimensional because it addresses not only the individual's preferred approach to learning, but also the preferred environment most conducive for learning. Examples of learning styles in this category include the Human Information Processing Model by Keefe (1989) and the Learning Style Model of Dunn and Dunn (1978).

Although these models are similar in the sense that they all focus their attentions toward identifying and addressing individual differences in learning styles, there are important differences among the models. Griggs (1991) observed that "some models stress accommodation of individual style preferences while others stress flexibility and adaptation" (sec. 3, para. 5), also, "there is a range of quality among the assessment instruments that operationalize the various models and lack of a research base for some of the models" (sec. 3, para. 5).

Among the cognitive learning style instruments, Kolb's LSI has been characterized as most popular and perhaps the most controversial, and the one that has stimulated most academic discourse on the subject (Kinshuk, 1996). The Learning Style Questionnaire (LSQ) developed by Honey & Mumford (1986) is an attempt to address the "loopholes" in the Kolb's LSI. Although LSQ has been identified as the most suitable instrument for measuring learning style in the computer learning environment (Kinshuk, 1996), not much is known on the use of the instrument in the computer aided learning of mathematics environment.

Now we shall give a brief overview of these two learning styles models.

3.2.8.1 Kolb Learning Styles

Kolb developed his Learning Style Instrument (LSI) from his theory of Experiential Learning. According to Kolb (1984) the "process of experiential learning can be described as a four-stage cycle involving four adaptive learning modes – concrete experience, reflective observation, abstract conceptualization, and active experimentation" (p.40). These learning modes are of two dimensions. The first dimension is what Kolb called *prehension*, and consists of individual preferences for grasping and gathering information. The continuum of this dimension is from concrete experience on one end, and abstract conceptualization on the other. The second dimension consists of individual strategies for processing the information obtained. Kolb called this process *transformation*, and alluded that it ranges from active experimentation to reflective observation. From the two dialectically mismatched forms of prehension and transformation, Kolb came out with combinations of four different learning styles: convergent, divergent, assimilation and accommodative.

1. *Convergent:* The convergent learning style results from the dominance of abstract conceptualization and active experimentation. People with this learning style have strength in skills, and enjoy doing things such as problem-solving, decision making, and the practical application of ideas. The knowledge of individuals in this orientation is organized in a hypothetical-deductive manner which enables them to focus on specific problems. They would prefer to interact with technical tasks and problems rather than with social and interpersonal situations. People with a background in the physical sciences and professionals such as engineers and technical specialists tend to fall in this category. One major weakness of people with this learning style is the rush to make a decision which some time leads to wrong conclusion.

2. *Divergent:* The divergent learning style is the direct opposite of convergent. They emphasize concrete experimentation and experience over and above reflective observation. People with this learning style have imaginative ability and concern about value and meaning of new information. Also, they develop a perspective regarding topics by adapting the understanding of the whole, and investigation of the

relationships among elements that constitute a topic. They perform better in an observation and thinking situation rather than action and doing. People with background in liberal arts, humanities and professionals such as counselors, organizational development specialists, and personnel managers are most likely to fit in this style. The weaknesses of the divergent learning style include inability to make decisions, and they tend to get confused due to considerable alternatives at their disposal.

3. *Assimilation:* The assimilation learning style results from reflective observation and abstract conceptualization. People with this learning ability largely rely on inductive reasoning in constructing new knowledge and in integrating this new knowledge into their cognitive system. The main strength of people with this learning style is that they focus on ideas and concepts, and therefore have the ability to create theoretical models. Their concern is more on ideas and abstract concepts than in people. Ideas are judged based on their logic and accuracy rather than on their practical values. Individuals with backgrounds in basic science and mathematics tend to be assimilators. Similarly, professionals such as researchers and planners are more likely to be oriented toward the assimilation learning style. Among the weaknesses of this learning style is the fact that some theories refuse to come out with practical applications.

4. *Accommodative:* In accommodative learning style, the main learning abilities result from concrete experience and active experimentation, this is opposite to assimilation. Therefore, the greatest strength of this group lies in their implementations and execution of plans and tasks. People with accommodating orientations are concerned about action, conducting procedures, and being involved in new experiences. Should in case theory or plan conflict with reality, the accommodator will discard the plan or the theory. They enjoy taking risks and seeking opportunities. Their approach to solving problems is intuitive and using trial-and-error. Individuals with backgrounds in technical or practical fields tend to be accommodators. Among the weaknesses of this group is wasting too much time on meaningless activities.

3.2.8.2 Honey and Mumford's Learning Styles

The theoretical background of this learning style rest on Kolb model discussed above. As stated earlier, Kolb model considers learning as cyclic and revolving around four different experiences. People acquire knowledge and experiences through these four stages. However, experience has shown that most people develop preferences and liking to one stage over and above others in their learning process. These preferences are termed as their learning style. Building on this model, Honey and Mumford (1986) define the four extremes of learning styles as: activists, reflectors, theorists, and pragmatists.

1. *Activists:* Activists love novelty and tend to have an open-minded approach to learning. They involve themselves wholeheartedly and without bias in new experiences. They take risks through trying out things without planning. They look and like anything new. However, as the novelty disappears, they look for new experiences and get on with it. They use brainstorming techniques to solve problems and easily get bored with repetitive activities. They are exciting, vital and gregarious. The strengths of this style are in their open mindedness, self motivated and love for trying new experiences. The weaknesses include taking action without proper planning and adequate preparation, and lack of patience to pursue things to their logical conclusions; they easily lose motivation and interest.

2. *Reflectors:* Reflectors on the other hand, prefer to stand back and view experiences from a number of different perspectives, collecting data and taking the time to work towards an appropriate conclusion. They look before they leap. They study the situation thoroughly before taking any steps. They collect information about the new experience as well as the opinion of experts in that experience. They are slow in decision making; they would like to have the picture clear before they take decision. They enjoy observing other people in action. The strength of people with this learning style lies in their thoughtfulness before reaching a conclusion, spending a reasonable amount of thorough evaluation on new experience, which usually results to sound opinion and decision. The weaknesses include slow in decision making, and are afraid of failure so they are cautious and careful about taking risks.

3. *Theorists:* Theorists live in the world of ideas. They prefer to analyze, synthesize, and integrate new information into a systematic and logical theory. They are not happy until they get to the root of the problem and discover the principles behind it. They are objective in their approach. They synthesize facts and observation to reach a logical, structured conclusion. They rigidly reject subjective an ambiguous ideas and situations, also they do not go well with people that take decisions without theoretical underpinnings. The strengths of people with this learning style are that they are systematic theorists, enjoy research skills, and are objective thinkers. The weaknesses include lack of ability to handle subjective or uncertain situations.

4. *Pragmatists:* Pragmatists like theorists are keen on ideas. Nevertheless, pragmatists are keener to putting these ideas into practice. They would like to try and experiment with the new ideas, theories and techniques to see if they work in practice. They are open-minded and welcome any ideas that will help them to successfully execute their actions. They look for new ideas and discover their applications. They are interested in discussions on how to address problem. Nevertheless, they tend to be impatient with open-ended discussion that does not lead to making practical decision and problem solving. The strengths of people with this learning style include the fact that they are practical and realistic in their action. They know what they are looking for, and welcome any idea that will help them achieve that. Among the weaknesses are that they are less interested in experiences or ideas that have no practical application. They tend to spend less time on searching or thinking.

Many empirical studies have reported a significant relationship between students learning styles and their achievements in mathematics. Husch (2001) conducted a study with the aim of determining the relationship between learning style preferences, personality temperament types, and mathematics self-efficacy on the achievement and course completion rate. The participants of the study were college students enrolled in first and second semester calculus classes which utilized web-based materials at the University of Tennessee at Knoxville. The following research questions were explored. (1) How does student's achievement vary with learning style preferences? (2) How does student's achievement vary with temperaments? (3) How does student's achievement vary with mathematics self-efficacy? (4) How does student's achievement vary with

teaching method? A total of four classes were involved in the study. Five instruments were used to collect data from the students. The data collected included ACT mathematics scores, Myers-Briggs personality types, mathematics self-efficacy scores, and calculus test scores. Findings were significant for several dimensions of learning style and temperament with respect to both the calculus test and the Mathematics Self-Efficacy instruments. Students who were categorized as reflective learners on the Felder-Silverman Index of Learning Styles scored significantly higher on the calculus test and those students who were categorized as SPs (sensing and perceiving) on the Myers-Briggs Type Indicator scored significantly lower on the calculus test and the Mathematics Self-Efficacy Scale (MSES). Additionally, with one exception, the students who enrolled in the second semester calculus classes were visual rather than verbal learners.

In a similar study, Roark (1998) classified students as visual and non-visual learners. The purpose of the study was to see whether the visual group would score higher on standardized tests than those students that are classified as non-visual learners. The sample of the study was 33 visual and 33 non-visual adult learners in the adult basic educational program at Putnamville Correctional Facility as the sample group. The Vocational Learning Styles Inventory, Piney Mountain Press, Inc., was used to determine the learning style of each student in the study. The Test for Adult Basic Education (T.A.B.E.) was the standardized test administered. The mean scores were taken from both groups in the areas of vocabulary, comprehension, mathematics concepts, and mathematics computation. The result indicated that the visual learners group had higher mean scores than the non-visual learners group in all the areas assessed.

Geiser, Dunn, Deckinger, Denig, Sklar, Beasley & Nelson (2000) investigated the effects of two study strategies on mathematics achievement, studying, and attitudes. The participants in the study were one hundred and thirty (130) eighth-graders. Students were taught to use either traditional study strategies or learning-style-responsive study strategies when completing mathematics homework and studying for mathematics tests. Among the findings were that the students who applied learning-style-responsive strategies had significantly higher mathematics achievement and attitude scores than the students who applied traditional study strategies.

Wahl (2003) created 54 learning style projects for introductory college mathematics courses with the aim of understanding how students respond cognitively, emotionally, and motivationally to the learning style projects. These projects grew out of the need for learning style activities that could be implemented immediately and easily in introductory college mathematics courses and the need to document the effects of learning style projects on students' learning of mathematics. Each project focused around one mathematical concept from an introductory college mathematics course, and was designed for one or more learning style modalities (auditory, visual, or tactual/kinesthetic). Also, each one addressed a minimum of three of the five major learning systems (emotional, social, cognitive, physical, and reflective). Three main results emerged from the research. The first result was that students felt learning style projects help them understand the mathematical concepts better than concepts taught by lecture only. In particular, tactual/kinesthetic activities had the biggest cognitive impact because they clarified and illustrated the mathematical concepts. The second result was that students improved their attitudes towards mathematics. Students enjoyed tactual/kinaesthetic activities, and these activities helped them understand the relevance of the mathematics they learned. Students also enjoyed the social aspects of many of the collaborative activities. The third result was that students valued variety in classroom activities, including lecture.

In his study of the effects of hemisphericity and instructional strategies upon developmental college mathematics students, Bruno (1988) found that there is a significant difference between students' diagnosed hemisphericity and their learning style preferences. Specifically, simultaneous processors revealed a statistically significant correspondence (p<.0001) between selected elements and their hemisphericity. Based on this finding, Bruno reminded educators of the need to design mathematics materials for postsecondary remedial students which reflect their differences in hemispheric and learning styles.

Bonham (1989) investigated the effect of students' preferences for affiliation and independence on achievement and completion rate in a developmental mathematics course. The participants in the study were 72 entering freshmen at a four-year state

university enrolled in the developmental mathematics program. These students were randomly selected and assigned to one of three instructional strategies including lecture/discussion, teacher-guided small group discussion, and independent study. Students' preference for learning condition was measured by means of the 'Conditions' scale of the Canfield Learning Style Inventory. A statistically significant main effect (p <.05) for learning style preference upon achievement was found with higher scores for students with a strong preference for independence. Therefore, it does appear that a strong preference for independence is related to success in mathematics.

Bauer (1991) investigated the most effective way of teaching mathematics to identified junior high school Learning Disabled (LD) and Emotionally Handicapped (EH) students and the learning style characteristics unique to this population. The Learning Style Inventory (LSI) (Dunn, Dunn & Price, 1989) was administered to LD/EH (N = 75) and non-handicapped (N = 286) students. The results revealed that a statistically significant difference (p <.001) in mathematics achievement when a tactile/visual approach was used. However, no significant difference was found in mathematics achievement when instruction matched perceptual preference. A similar result was found by Aseeri (2000) when he investigated male eleventh grade students in Abha district in Saudi Arabia in order to discover their Piagetian cognitive level, and to determine whether differences among students exist based on their cognitive levels and their learning styles regarding their achievements in mathematics.

Cook (1997) investigated the relationships between and among mathematics anxiety level, perceptual learning style (audio, visual, tactile/kinesthetic), age, gender, and mathematics performance. The participants were 501 community college students taking remedial credit introductory algebra and college credit basic college algebra. The results revealed that the mathematics anxiety level was significantly correlated to one or more learning styles for all groups studied.

In a similar study, Raviotta (1988) investigated if the knowledge of one's individual learning style will increase one's academic achievement and enhance one's study orientation. The participants in the study were 77 high school students enrolled in a

second year mathematics class for low achievers. The experimental group, consisting of 41 students, received a full interpretation over three counseling sessions of their learning style based on results obtained from the Learning Style Inventory (LSI). The control group consisted of 36 students who received no learning style interpretations. The Mathematics component of the Comprehensive Tests of Basic Skills (CTBS) was administered to both the experimental and the control groups prior to the interpretation of the student's learning style and again after the completion of the study. A significance level of .05 was set for all comparisons. However, the F ratios computed for analysis of the two research questions did not show any statistically significant differences.

Jia (1994) examined the relationships of learning styles, attitudes toward computers, and student mathematics achievement in a mathematics course using a CAI lab. Participants in the study (N = 101) were volunteers from an undergraduate course in mathematics. Among the findings of this study was that the achievement scores were significantly higher for students having a concrete learning style than for students having an abstract learning style.

In a similar study Russell (1988) investigated the factors that predict achievement in individualized computer courses. Learning style was found to be the highest, followed by high school percentile, standardized mathematics scores, standardized reading scores, previous computer experience, college hours earned, and age. Also, Al-Badr (1993) found learning style to be one of the factors that contributed significantly to students' achievements in self-instruction sections of computer application software courses.

In another study, Parker (1989) examined whether geometry students with selected learning style indicators achieved better than others in classes that are supplemented with computer-assisted instruction (CAI), regardless of class placement. Learning styles data were provided via the Learning Style Profile and the geometry portion of the Sequential Test of Educational Progress Measured Achievement were utilized. Both tests were administered in the classroom by geometry instructors. One hundred and ninety-six (196) of ninth through twelfth grade students participated in the study. Statistically significant differences in achievement were found between the regular and

honors level classes, post-test achievement and spatial skill. The researcher concluded that (1) students in honors level geometry classes with supplemental CAI show significant achievement differences compared to students in regular classes, (2) variables maximizing predictability in post-test achievement were honors placement, pre-test achievement and spatial skill. The researcher gave the following pedagogical recommendations: Teacher should try to identify their students' spatial ability and mathematical profiles. This is important for instructional planning and teaching strategies. In addition, students' awareness of their profiles is critical for maximum geometry success.

Raiszadeh (1997) examined the relationship between students personality types, learning style preferences, and achievement in intermediate algebra. Three instruments were administered to 202 developmental, intermediate algebra students at a community college. Two of these instruments; the Myers Briggs Type Indicator (MBTI) and the Learning Style Inventory (LSI), were administered to students two months after the beginning of the semester. The Academic Assessment and Placement Program (AAPP) test was administered at the end of the semester. Although the study showed no significant relationships between the students' learning style preferences and their mathematics achievements, further analysis revealed that students with tactile preference achieved lower mathematics scores than their auditory and visual counterparts. In the same manner, it was found that students with intuition personality type achieved significantly higher mathematics scores than the students with sensing personality type.

3.4 Conclusion

In this chapter we reviewed both theoretical and empirical literature relevant to the selected variables (mathematics attitude, mathematics aptitude, computer attitude, computer ownership, computer prior experience, learning styles and proficiency in the language of instruction). Although studies are not conclusive on the role of the selected variables in students' achievements, most of the studies reviewed here indicated, directly or indirectly, the influence of the selected variables to students' achievements in

mathematics – the reason for the projection that the selected variables are potential predictors of success in pre-calculus algebra supplemented with a computer lab program. The next chapter describes the research design in this study.

CHAPTE R FOUR

Research Methodology

4.1 Introduction and Overview of the Study

The purpose of this study was to assess the extent to which the selected variables (mathematics attitude, mathematics aptitude, computer attitude, computer ownership, computer prior experience, learning styles and proficiency in the language of instruction) contribute to the success in the pre-calculus algebra course supplemented with computer aided learning program. This chapter discusses the research design and methodology of this study. The chapter consists of the following subheadings: Introduction, Target population, Sample, , Statistical hypothesis, Specification of the variables, Instrumentation, History of CAL in the preparatory year mathematics program at KFUPM, Vehicle of the study, Data collection, and Method of statistical analysis.

4.2 Target Population

The target population in this study was the preparatory year mathematics students at KFUPM. This population comprised of male students with an average age of 18 years, mostly fresh from high school. KFUPM is a highly competitive and selective institution within the Kingdom of Saudi Arabia. The majority of the students admitted at KFUPM are among 90th percentiles of the national high school final examinations. In addition, they are assumed to have passed with high score in the two admission tests known as RAM 1 and RAM 2, which are conducted throughout the Kingdom by KFUPM. Therefore, the newly admitted students are largely considered as the "cream" of the Saudi high schools graduates. Almost all of these students have Arabic as their first language as well as the language of instruction in their high schooling. Most of them have very little English background at the time of admission. A large number of the students comes from far distant and remote areas of the country, and so, are

accommodated on the campus. The language of instruction is changed to English, and the rigor of the program is far higher than what they were used to in the high schools.

In general, the transition stage from high school to university is one of the most decisive periods in a student's life. It is the time when these teenagers make up their minds about their future course. However, psychologically speaking, students at this age are fragile, indecisive, lack motivation and can easily be influenced by their peer group. Therefore, one can see that the preparatory year students are in a very delicate transition period of their lives - academically, socially, physically and linguistically.

4.3 Participants in the Study (Sample)

The participants in this study were the preparatory year students of King Fahd University of Petroleum & Minerals. At KFUPM, all the preparatory year students program take two compulsory pre-calculus algebra courses: MATH 001 and 002, (syllabus in Appendix III and IV), with the exception of those who have passed the promotion exams. New admissions are usually done at the beginning of the session (Fall semester). Students who successfully pass MATH 001 in the first semester take MATH 002 in the second semester (Spring). The students who fail MATH 001 in their first semester are allowed to repeat the course in the second semester. Similarly, those who fail MATH 002 in the second semester have a chance to repeat the course either in the summer or following Fall semester.

In both math courses, students are randomly distributed into various sections each ranging from 20 – 25 students per class. Each instructor is randomly assigned three sections to teach.

Based on this background, the sample of this study was students of MATH 002 and consisting of 6 randomly selected sections with approximate enrolment of 120 students. The researcher and two of his colleagues were the instructors of these classes (two sections per instructor). The placement of the students in the six sections was also random. As far as the students' background is concern, all of them had successfully

completed MATH 001, and most of them had passed the first English course, i.e. ENGL 001.

4.4 Research Statistical Hypotheses

Based on the result of the literature review conducted in the preceding chapter, our research statistical hypotheses for this study were as follow:

Hypothesis 1: There is a significant positive relationship between mathematics aptitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 2: There is a significant positive relationship between attitudes towards mathematics and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 3: There is a significant positive relationship between computer attitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 4: There is a significant relationship between computer ownership and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 5: There is a significant relationship between computer prior experience and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 6: There are significant differential effects of learning styles on achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 7: There is a significant relationship between proficiency in the language of instruction and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Hypothesis 8: The predictor variables (mathematics attitudes, computer attitudes, mathematics attitudes, computer ownership, proficiency in language of instruction, and learning styles) will contribute a significant portion of the variance in the achievement of the students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

4.5 Specification of the Variables (Dependent and Independent)

The variables in this study were classified into two categories: (1) independent variable (predictor), and (2) dependent variable.

4.5.1 Independent Variables

There are seven independent variables in this study. They are:

a) *Mathematics Attitudes:* This is the predisposition of students to mathematics at the beginning of the program. It was measured in the first week of classes in the experimental semester, and the instrument used was the revised version of the well known Aiken mathematics attitude scale (1979).

b) *Mathematics Aptitudes:* In this study, this refers students' performance in MATH 001. MATH 001 is a prerequisite for MATH 002 which is the criterion variable. The material of MATH 001 (Appendix V) is basically a review of the material that students completed in high school mathematics. However, its coverage at KFUPM is more rigorous and the exams more difficult than that of high school.

c) *Computer Attitude:* This is the predisposition of students to computers at the beginning of the program. It was measured in the first week of classes through a questionnaire developed by Loyd & Gressard (1984a).

d) *Computer Ownership:* Computer ownership here meant personal ownership of a computer either at home or at university hostel, and not the computers in the university labs. The question asked was "Do you have computer at home?"

e) *Computer Prior Experience:* This simply means the time period in which a student has been exposed to computers either in school or at home. Here, school refers to primary, middle, secondary school, or university. While the time period for home computer use refers to the interval in years: (a) more than 9 years, (b) 7 - 9 years (c) 4 – 6 years (d) 1 – 3 years (e) less than one year. The average of these two experiences determines the student's prior computer experience.

f) *Learning Styles:* These are the students learning preferences at the beginning of the program, and were measured in the first week of the classes by using Learning Styles Questionnaire (LSQ) developed by Honey & Mumford (1992, 1986).

g) *English Language Proficiency:* As stated earlier, most of the students have Arabic as their first language, and also as the medium of instruction up to their high school education. Therefore, the students are generally found weak in English at the time of admission to the university preparatory year program. In this study, the students' English proficiency was determined by the students' grade in the preparatory English I (ENGL 001). This is an aggregate of the students' performance in six English units: Listening, Vocabulary, Grammar, Reading, Writing and Oral. Due to the peculiar nature of language status of the students, it is believed that the trend in a student's performance in these exams show their level of comprehension and proficiency in the language.

4.5.2 Dependent Variables

The dependent variable in this study was the students' achievements in MATH 002 determine by the students final grade at the end of the experimental semester.

4.6 Instrumentation/Measurement

The questionnaires used in this study measured the independent variables as indicated above. Five major questionnaires were used to collect data for the following variables: mathematics attitude, learning styles, computer ownership, computer prior experience, and computer attitudes.

4.6.1 Measurement of Mathematics Attitudes

The Mathematics Attitude Scale by Aiken (1979), and revised in Aiken (2000) was used in this study for measuring the students' attitude towards mathematics. Lewis Aiken is a renowned psychometrician who has been associated with measurement of attitude towards mathematics for more than three decades. Many different scales for measuring attitude towards mathematics and science are due to him. Three of these scales (Aiken & Dreger, 1961; Aiken, 1974 & 1979) were reported in Taylor (1997). According to Taylor, all the three scales "are characterized by their brevity, simplicity, and as such are useful instruments for both the teacher and the researcher" (p.125). These tests are widely used and their psychometrics are intensively investigated. All the three Aiken Scales are on a 4-point Likert-type, with statements concerning mathematics that the students must agree or disagree with along a continuum from *Strongly Disagree* to *Strongly Agree.* We shall discuss each of these scales in more detail.

The scale proposed by Aiken & Dreger (1961) consists of 10 positive and 10 negative statements (20 questions in all). The scale was developed after questioning 310 college students. Shaw & Wright (1967) have stated that this scale has a satisfactory reliability and validity. The test–retest reliability coefficient of this scale has been reported to be 0.94 by the authors (Aiken & Dreger). Similarly, the factorial validity of the scale was investigated with 2538 high school students by Adwere-Boamah, Muller & Kahn (1986). They showed that the scale is two-dimensional (Enjoyment and Fear) with reliability coefficients .93 and .87 respectively for Enjoyment and Fear. These results are in line with the findings of an earlier study conducted by Silverman, Creswell, Vaughn, & Brown (1979). Recently, Wong (2001) translated the scale into Chinese. The translation was verified for correctness and language appropriateness. The Chinese version was administered to 91 lower-secondary students on two occasions, 18 days apart. The test–retest reliability coefficient was found to be 0.85.

The Aiken (1974) scale was developed after administering the questionnaire to 190 college students. The scale is purported to measure the Enjoyment and Value of mathematics. It consists of 11-items for Enjoyment and 10-items for Value. Here, Aiken

not only defined the scale, but also obtained some basic psychometric data on each scale. For instance, Aiken found the reliability coefficient of the Enjoyment and Value scales to be .95 and .85, respectively. To provide additional information concerning the reliability and discriminant validity of this scale, Watson (1983) administered the instrument to 287 first year Australian university students, and found .88 and .68 as the reliability coefficient for Enjoyment and Value respectively. Although, the reliability coefficient in her study was lower than the one initially obtained by the author (Aiken), she concluded that the result is acceptable. Moreover, her factor analysis revealed that enjoyment of mathematics and value of mathematics are two separate factors, thereby confirming the bi-dimensionality of the scale as originally suggested by the author. Furthermore, Watson found that "correlation analyses of E (enjoyment) and V (value) scales with each other and with other variables supported Aiken's contention that the scales measure different aspects of attitude toward mathematics" (Watson 1983:1253). Earlier, Nolen, Archambault & Greene (1976) examined the suggested two-factor structure of this scale with 96 elementary teachers, and found that the scale is more meaningful both psychologically and empirically if considered as a three-factor (enjoyment, general value, and personal value). They concluded that,

> While internal consistency estimates for the first two factors were only slightly improved by imposing the new structure, a meaningful third factor with an internal consistency of .78 emanated. Moreover, increases in item discrimination indices were found (Nolen *et al*., 1976, Abstract).

The third scale is also due to Aiken (1979), which was selected for this study. It was initially developed for Iranian high school students, age between 11 and 15. This instrument consists of 24 statements. In this scale, Aiken intended to measure four factors: Enjoyment, Motivation, Importance, and Freedom from Fear. It has been claimed that this scale has not been validated for adult students (Taylor, 1997). To address this problem, Taylor surveyed 430 students enrolled in a tertiary preparatory program. However, the result of the factorial validity of the scale was found to be (unlike the original assumptions of four factors) two dimensional (Enjoyment and Value) when used with adult students. The reliability coefficients of these two extracted factors (Enjoyment and Value) were found to be higher (.91 and .83 for Enjoyment and

Value, respectively) than the original coefficient reported by Aiken (.50 and .86, for Enjoyment and Value, respectively). In this study, the instrument was used inline with the latest finding in Taylor (1997) as a two-factor scale. It may be worthy to mention that the level of the students surveyed by Taylor matches with the participants in our study.

4.6.2 Measurement of Computer Attitudes

The measurement scale selected for this study was the computer attitude scale (CAS) developed by Loyd & Gressard (1984a). According to Nash & Moroz (1997), the Scale is one such measure of attitude towards computers which has been used extensively with college students and professional educators. For the extensity of the use of this instrument, one can see for instance various studies conducted by Loyd & Gressard (1984a, 1986), Kluver, Lam, Hoffman, Green, & Swearingen (1994), Bandalos & Benson (1990), Pope-Davis & Twing (1991), Bennett (1995), Busch (1995) and Park & Gamon (1995).

CAS is a Likert-type instrument originally consisting of thirty items, which later expanded to forty items by Loyd & Loyd (1985). Each set of ten questions represents a dimension. The four dimensions are as follows: computer anxiety, which assesses the fear while dealing with computers; computer confidence, which assesses the confidence in the ability of dealing with computers; computer liking, which assesses the enjoyment of dealing with computers; and computer usefulness, which assesses the perception of the proliferation of computers on future jobs. The CAS consists of statements such as "I would like learning with computers." The individuals indicate the degree to which they agree with the statement on a four-point scale, with "agree strongly" on one end and "disagree strongly" on the other. Each response is given a value of 1 to 4, with 4 indicting a more positive attitude towards computers.

According to Troutman (1991), the CAS was subjected to three validation studies, in which the participants were elementary, middle school, and secondary school teachers. The results indicate: (a) the scores of the three subscales are sufficiently stable, (b) the CAS has reasonable convergent validity; and (c) the CAS is sensitive to attitude changes

resulting from computer instruction and experience. In their validation study of the original CAS, which consists of three units (Computer Anxiety, Computer Confidence, Computer Liking), the authors (Gressard & Loyd, 1986) subjected the CAS and all of its three subscales to two validation studies. The first one was to examine the reliability and factorial validity of the subscales, while the second was aimed at the preprogram-post-program administration of the subscales. The results of these studies indicate that the "Computer Attitude Scale is a convenient, reliable and valid measure of computer attitudes, and that it can be confidently and effectively utilized in research and program evaluation context" (p.295). In the first study, the researchers reported a reliability coefficient of the three subscales and total as .89, .89, .89, and .95 for the Computer Anxiety, Computer Confidence, Computer Liking, and the Total Scale, respectively. Here, the three factors accounted for 54% of the total variation. In the second study, the authors concluded that "the analysis of differences in pre-program and post-program scores indicates that Computer Attitude Scale is sensitive to attitude changes resulting from computer instruction and experience" (p.301).

Later Loyd & Loyd (1985) expanded the original CAS from thirty items of three factors to forty items with four factors. The additional factor included therein was Computer Usefulness, which also has 10 items. Loyd & Loyd (1985) investigated the reliability, factorial validity, and differential validity of the new CAS together with all its four subscales (Computer Anxiety, Computer Confidence, Computer Liking, Computer Usefulness). The participants in their study were 114 teachers enrolled in computer staff development courses. The result of the study indicated that CAS is "reliable in measuring teachers' attitudes towards computers and effective in differentiating among teachers with different amounts of computer experience" (Loyd & Loyd, 1985:903). The reliability coefficients were found to be .90, .89, .89, and .82 for Computer Anxiety, Computer Confidence, Computer Liking subscales, while the Total Score was estimated as .95.

In his comparison of four computer attitude scales Woodrow (1991) found that the reliability coefficients of CAS and its subscales are high, with the overall reliability coefficient as 0.94. There are many other studies that attest to this high reliability of

CAS scale. Further discussions on the psychometric properties of the CAS were cited by Nash & Moroz (1997).

4.6.3 Computer Prior Experience

For the measure of students' prior computer experience, the following statements each with five choices were given to the students. They were asked to choose the one that coincides with their experience. They were:

1. I have been using computer at home for? And the options were:
    a) more than 9 years.
    b) 7-9 years.
    c) 4-6 years.
    d) 1-3 years.
    e) less than 1 year.
2. I started using computers in school since when I was in? With the options:
    a) primary.
    b) intermediary.
    c) secondary.
    d) university.

It might be noted that these questions were asked as an additional part of the CAS questionnaire.

4.6.4 Computer Ownership

Here, the question was: Do you have a computer at home? This question also was incorporated into the CAS questionnaire.

4.6.5 Learning Styles

The Learning Styles Questionnaire (LSQ) by Honey & Mumford (1992) was used to measure the learning style of the students at the beginning of the program. It was claimed that LSQ is the most widely used diagnostic of its kind in the UK (reported in

http://www.peterhoney.co.uk/). The theoretical background of this questionnaire emerges from the Kolb's Experiential Learning, where learning is considered as a cyclic and continuous phenomenon. The learning circle has four constituent stages each at the end point of the four quadrants of the circle. The four stages are: 1) Having an experience, 2) Reviewing the experience, 3) Concluding from the experience, and 4) Planning the next steps. The continuity of the learning process makes all the four stages interdependent. No stage makes sense, or is particularly useful in isolation from the others. However, there is no fixed starting point, so one can start anywhere on the cycle because each stage feeds into the next.

LSQ is designed to characterize four categories of people with different learning styles, which were named by the authors as: Activist, Reflector, Pragmatist, and Theorist. According to Honey & Mumford (1992):

Activists like to take direct action. They are enthusiastic and welcome new challenges and experiences. They are less interested in what has happened in the past as well as in putting things into a broader context. They are primarily interested in the here and now. They believe in the philosophy of "go, try things out and participate". They like to be the centre of attention. In summary, Activists like:

  a) to think and conclude with their own efforts
  b) to have short sessions
  c) to have ample variety
  d) the opportunity to initiate
  e) to participate and have fun.

Reflectors like to think about things in detail before taking any action. They take a thoughtful approach. They are good listeners and prefer to adopt a low profile. They are prepared to read and re-read. They welcome the opportunity to repeat a piece of learning. Thus, in summary, they like:

  a) to think before acting
  b) thorough preparation

c) to research and evaluate

d) to make decisions in their own time

e) to listen and observe.

Theorists like to see how things fit into an overall pattern. They are logical people who prefer a sequential approach to problems. They are analytical, pay great attention to details and tend to be perfectionists. Thus, in summary, they like:

a) concepts and models

b) to see the overall picture

c) to feel intellectually stretched

d) structure and clear objectives

e) logical presentation of ideas.

Pragmatists like to see how things work in practice. They enjoy experimenting with new ideas. They are practical, down to earth and like to solve problems. They appreciate the opportunity to try out what they have learned/are learning. Thus, they like:

a) to see the relevance of their work

b) to gain practical advantage from learning

c) credible role models

d) proven techniques

e) activities to be real.

Most of the instruments for measuring learning styles have a problem with the psychometric issues. However, "prior research in other cognate disciplines suggests that the LSQ may be preferable to Kolb's Learning Style Inventory (LSI) and Revised LSI" (Duff, 2000). Some of the advantages that LSQ has over LSI and its revised version are that it "focuses on observable behavior and has more convincing face validity" (Duff, 2000). LSQ has been subjected to many validation studies, with alpha coefficients for the instrument ranging from 0.52 to 0.71, which indicate modest internal consistency reliability (Duff, 2000). Based on his review of literature, Duff gave the tabulated summary of the prior psychometric evidence of LSQ in Table 1.

Table 1: Summary of internal consistency reliability estimates reported in previous research (Adopted from Duff, 2000)

Study	Subjects	N	Coefficient			
			Activist	Reflector	Theorist	Pragmatist
Allinson & Hayes (1988)	UK managers	127	0.58		0.74	
	African & Indian managers	40	0.71		0.63	
Sims *et al*. (1989)	US business students	270	0.68	0.68	0.78	0.75
Fung *et al*. (1993)	Hong Kong undergraduate students	381	0.39	0.42	0.33	0.31
Tepper *et al*. (1993)	US undergraduate students	227	0.75	0.76	0.67	0.52
De Ciantis & Kirton (1996)	UK & Eire managers	185	0.76	0.76	0.67	0.64

Table 2: Summary of results (Adopted from Duff, 2000)

Study	Investigation	Results
1.	Internal consistency reliability	Moderate (ranging from 0.52 to 0.76). High degree of missing data for a number of variables in the Pragmatist scale
	Construct validity	Poor. No confirmation of four-factor structure
	Gender and learning style	Moderate (Kappa coefficient = 0.40)
2.	Face validity	Satisfactory test-retest reliability (Pearson correlation coefficients 0.61-0.81) over 1 year. Satisfactory category stability (Kappa coefficient = 0.71)
3.	Temporal stability	
4.	Predictive validity (self-reported learning activity preference)	Weak. Statistically significant correlation between learning style score and learning activity subcategory for only one (of 4) learning activity subcategories.

In addition to this, very little is known about the reliability and replicability of the LSQ application in higher institution. To address this problem, Duff (2000) carried out four intensive studies of the reliability and replicability of the LSQ in higher institutions. The summary of Duff's findings in the four studies is given in Table 2.

The LSQ is a self-administered inventory consisting of 80 or 40 items, with which respondents are asked to agree or disagree. The vast majority of these items are behavioral. That is, they describe an action that someone might or might not take. Occasionally, an item probes a preference or belief rather than a manifest behavior. Examples of items include:

1. "On balance I talk more than I can listen" (*Activist*)
2. "I tend to discuss specific things with people rather than engaging in social discussion" (*Reflector*)
3. "I am keen on exploring the basic assumptions, principles and theories underpinning things and events" (*Theorist*)
4. "I can often see better, more practical ways to get things done" (*Pragmatist*).

4.7 Computer as a Cognitive Tool

Following Pea (1987), the computer in the teaching and learning of mathematics is used either as *amplifier* or *organizer*. As an *amplifier*, computers are used to improve the quality or speed of existing mathematical activities, while as an *organizer*, computers change the nature of the mathematics activities (Crowe & Zand, 2000). The most common use of the computers in mathematics is mainly on drills, practice and tutorials, which merely *amplifies* the mathematical activities. However, as the students grow intellectually, they indeed need more sophisticated tools that will not only *amplify* their mathematical activities, but also *organize* them for advance mathematical thinking. Hence, utilizing computers as a cognitive tool for human cognitive activity (Dörfler, 1993). Computer algebra systems (CAS) such as Drive, Maple, MATLAB, and Mathematica are the tools that are commonly utilized for this purpose (c.f. Hillel, 1993). CAS is a part of what Pea (1987) described as *cognitive technology*, and is defined simply as "any medium that helps transcend the limitations of the mind" (Pea, 1987:91).

Like any other computer program, studies in the use of CAS in teaching/learning of mathematics are inconclusive. However, studies have shown that an appropriate use of CAS has considerable potential to bring about structural changes in the students' cognitive activities. Rather than just amplifying students' capabilities, CAS has the potential to increase his inquisitiveness, interaction with variety of models of mathematical concepts, and also to improve his heuristic problem solving and investigative skills, hence, shifting the mathematical activity to a higher cognitive level (Payton, 1987; Ben-Zvi, 2000; Tall, 1991; Pea, 1991; Kaput, 1992; Hillel, 1993; Dörfler, 1993).

In the CAS mode:

1. Students work with reasoning while giving a command to computers on what to do. They create the mathematics and the computer provides immediate feedback to assist them in exploring and refining their knowledge.
2. As a command driven system, the computer forces students to communicate correctly and to know exactly which operation they want to perform.
3. Inspection of the underlying algorithm helps in understanding the nature of the operation.
4. Construction of new operations results in better conceptual understanding.
5. The computer handles the computation thereby helping the students to focus on concept development and strategic planning.
6. Students can do symbolic manipulation beyond their personal capabilities.
7. The students get into an experimental approach of dealing with mathematics problems, which can lead to conjecture, pattern finding, examples and counter examples.

   (c.f. Harding, 1987; Tall, 1991; McCoy, 1996; Crowe & Zand, 2000)

Many empirical studies have shown that the use of computer algebra system (CAS) in teaching mathematics can improve positively the students' attitude towards mathematics (Trout, 1993; Costner, 2002). Also the students that use CAS seem to have deeper conceptual understanding of mathematics as compared to those who did not use CAS

(Melin-Conejeros, 1994; Cooley, 1995). It has been found that CAS can promote a variety of problem-solving strategies and active students' participation in doing mathematics (Parks, 1995; Costner, 2002). Students in CAS condition demonstrated substantially higher mathematics achievement than those receiving traditional instruction (Trout, 1993; Campbell, 1994).

4.8 History of CAL in the Prep Year Math Program at KFUPM

The mathematics courses in the preparatory year mathematics program at King Fahd University of Petroleum & Minerals (KFUPM) have witnessed a metamorphosis in a quest for optimizing the use of the fourth hour (usually termed as CAL hour). This hour aims to engage the students in problem solving of the material covered in the preceding week. In the past, some of the strategies employed for this hour were: Recitation, Tutorial, Supervised Problem Solving and CAL. Among these the CAL program stands as a better option among all because of its flexibility and immediate feedback. However, though different software (both locally designed and imported) has been tried each has shown minimal success.

At the start of the academic year 2000-2001, the preparatory year mathematics program was restructured as a semi-independent unit. Prior to that, it was completely under the department of Mathematical Sciences. The new set-up makes the preparatory year mathematics program semi-autonomous with an appointed Coordinator who oversees the whole program. As a result of this change many new ideas and innovations have been introduced in the program to meet the challenges therein. It is under this dispensation that several task groups were formed including a CAL group. One of the tasks of the CAL group was to collect "Computer Software Packages from different sources, which include Online Testing relevant to the Course Material", and also to evaluate them with a view of adopting a suitable one for the preparatory year mathematics program. As said earlier, many software both local and imported software have been tried. This is, however the first time that a systematic approach that has a theoretical base was employed to make the selection of the "appropriate" software. Also, a classroom experiment was conducted before the software was finally adopted for

use. For a comprehensive summary of the process followed in this regard, we refer an interested reader to Yushau (2002a) and Yushau, Bokhari & Wessels (2004).

Nevertheless, it has been observed that the software selected and finally adopted still fall in the category of what Pea (1987) called *amplifyer*, concentrating more or less on drills, practice and tutorials. While this might still be useful for MATH 001 (first pre-calculus course at KFUPM), a need for more challenging and sophisticated tools such as Drive, Maple, MATHCAD, MATLAB, Mathematica was suggested for MATH 002 (Aufmann, 2000). The use of CAS in learning mathematics has been shown to increase students' thorough understanding of the topic concerned (Harding, 1987; McCoy, 1996). This is as a result of the fact that in the CAS mode, students work with reasoning to teach computer what to do. They create the mathematics and the computer provides immediate feedback to assist them in exploring and refining their knowledge.

4.9 The Vehicle of the Study

In view of the arguments given in the preceding section, two software programs were used as a vehicle for the study. They are: MATLAB and WebCT; the former as problem solving tool and the latter as an online course development and delivery tool. A brief overview of the two programs is given below.

4.9.1 MATLAB

The name MATLAB stands for *matrix laboratory*. It is an interactive system whose basic data element is an array that does not require dimensioning. This system allows one to solve several technical computing problems, especially those having matrix and vector formulations. Most of the time, the desired calculations are carried out in a fraction of a second on MATLAB, which otherwise might require a well-written program in a scalar non interactive language such as C or Fortran. MATLAB integrates computation, visualization, and programming into an user-friendly environment where problems and solutions are expressed in familiar mathematical notations. Typical uses of MATLAB include:

- Math and computation
- Algorithm development
- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development including graphical user interface building.

MATLAB is widely used as a part of teaching in many mathematics courses. As a matter of fact, MATLAB is now indispensable in some mathematics courses such as Numerical Analysis, Differential Equations and Linear Algebra. For a comprehensive survey on the universities that are using MATLAB in their mathematics courses one may see Crowe & Zand (2000). It may be noted that MATLAB is not widely used in the teaching of pre-calculus algebra courses.

Based on the Aufmann' recommendations (2000), a student manual concerning MATLAB was developed by the researcher and two of his colleagues as a special assignment under the KFUPM grant during the summer of 2002 (detail in Yushau, 2002b). The manual is divided into 11 weekly modules for lab activities that cover the syllabus of MATH 002 (Appendix I). Each module consists of the objective of the lesson, MATLAB commands, examples and exercises. A pilot study for the implementation of the manual in the class environment was jointly carried out by the researcher and another instructor. No major problem was faced in this regard either by the students or the instructors through out the semester. The study provided us an opportunity to take note of some minor problems faced, and update the manual accordingly.

4.9.2 WebCT

WebCT is one of the world leading online/e-learning educational platform systems for higher education. It provides more convenient and personalized learning options for students with expanded access to academic programs, and continuous improvement of course material. For the instructor, WebCT Campus Edition allows him to create an

interactive learning environment that brings instructors and students together in a virtual classroom. This online course management combines course development and delivery tools with a comprehensive course administration system. In WebCT, instructors have an option of creating their entire courses online or complement it with a classroom-based course. In particular, WebCT can be used to:

- provide course material that includes text, complex equations, images, video, and audio.
- evaluate students by quizzes and assignments.
- communicate with students via discussions, electronic mail, real-time chat sessions, and an interactive whiteboard.
- facilitate learning with the help of a searchable index, glossary, and image. database for each course .
- encourage student interaction with others by enabling them to create student. homepages and online presentations.
- share course contents with other designers and institutions.
- record, maintain, and communicate grades.
- enable student self-evaluations through self tests and progress tracking.
- obtain and analyze data that allows teachers to analyze the effectiveness of their courses.

In the study under consideration, WebCT was used to complement a classroom-based lecture, therefore making the course a *blended e-learning.* Some of the areas where WebCT was utilized in this study are as follows

- The text of the MATLAB manual was provided online, which was accessible by the MATH 002 students all the time on WebCT.
- Solutions of the exercises and exams were provided online in WebCT.
- Students submitted all their weekly assignments online through WebCT.
- Online discussion forums and e-mail communications were part of the program, and were through WebCT platform.
- All announcements were carried out online through WebCT.

4.10 Data Collection

The data required for this study were individual student's achievement on the criterion measure, and the data on the characteristics of the individual student in relationship to the selected variables (mathematics attitude, mathematics aptitude, computer attitude, computer ownership, computer prior experience, learning styles and proficiency in the language of instruction). Data on students' achievements were collected from grade rosters submitted at the end of the sampled semesters (winter, 2003-2004 session). Data on the characteristics of the students with regards to the selected variables were collected at the first week of the semester by using structured questionnaires for all selected variables (issues regarding the questionnaires have been discussed above) except mathematics aptitude and English language proficiency. For mathematics aptitude and English language proficiency, measurement was based on the students' performance in preparatory Math I (MATH 001) and preparatory English I (ENGL 001). From the literature, it has been shown that previous mathematics grades are better predictors of success than most standard aptitude examinations (Siglin & Edeburn, 1978; Begle, 1979; Al-Doghan, 1985; Bridgeman & Wendler, 1989; Hebert, 1997).

4.11 Data Analysis

Statistical methods were used to analyze the data. The techniques employed include simple and multiple correlation and regression analysis, the analysis of variance and t-test. The dependent variable for this study was the student's achievement which was measured by the end of experimenting semester grade of MATH 002. The independent variables were the selected variables (mathematics attitude, mathematics aptitude, computer attitude, computer prior experience and computer ownership, learning styles and English language proficiency).

The analysis involved the use of Pearson-product-moment-correlation to indicate whether there was a statistically significant relationship between a predictor and the criterion. The implementation of simple regression was intended to determine the effect of a single variable in students' achievements for both prediction and explanation of the

success in MATH 002. On the other hand, the multiple regression approach was utilized to maximize the information obtained in each predictor. This approach was also used to obtain accuracy in predicting success by using more than one variable in combination. A t-test was used to determine relationship between students' achievements and categorical variables with two factors (like computer ownership). Analysis of variance (ANOVA) was utilized for categorical variables with more than two factors. The result of this analysis enabled the falsification or upholding of research hypothesis.

The utility of the software MINITAB, Microsoft EXCEL and SAS were utilized for the analysis of our data.

4.12 Conclusion

In this chapter the research design of this study was elaborated and various components of the research were explained in detail. The sub-topics covered include: The Target population, Sample, Research Hypotheses, Specification of the Variables, Computer as a cognitive tool, History of CAL in the preparatory year mathematics program at KFUPM, the Vehicle of the Study, Data Collection and Data Analysis.

The next chapter presents the results of this study followed by some discussion.

CHAPTER FIVE

Results

5.1 Introduction

The purpose of this study was to examine the relationship between student's factors that are associated with achievement in the pre-calculus college algebra course supplemented with a computer lab program. The factors considered in this study were mathematics aptitudes, mathematics attitudes, prior computer experience, computer ownership, computer attitudes, learning styles, and proficiency in the language of instruction (which is English in this case).

The participants in the study were the MATH 002 students of the preparatory year program (spring of 2003-2004 session) at King Fahd University of Petroleum & Minerals. The participants underwent a full semester experiment of learning pre-calculus algebra supplemented with a comprehensive computer lab program.

There are eight variables in the study – one dependent and seven independent variables. The independent variables were: mathematics attitudes, mathematics aptitudes, prior computer experience, computer ownership, computer attitudes, learning styles, and proficiency in the language of instruction. The dependent variable consisted of the students' achievements in MATH 002 obtained at the end of the semester, and reflected by students final grades in the course.

 The instruments used in this study were the Mathematics Attitudes Scale by Aiken (1979), Honey & Mumford (1992) Learning Styles Questionnaire, and Computer Attitude Scale by Loyd & Gressard (1984a). Questions regarding computer ownership and computer prior experience were designed for this study.

Data on the independent variables were collected at the beginning of the experimental semester, while the data on the dependent variable were collected at the end of the

experimental semester. Instruments were administered to the students in the first week of the experimental semester, and students were given enough instruction of what was required of them to do. Most of the students returned the questionnaire the same week, while others took them up to the second week. As usual some others did not respond. Out of 120 students that participated in the experiment, only the data of 59 students' were included in this analysis. Others were not considered due to apparent inconsistency and anomalies in the data, incomplete information, and withdrawal from program.

Various statistical techniques were used in order to examine the relationships among the dependent variable and the independent variables. This provided us with enough information to either accept or reject our statistical hypotheses. The statistical packages used for the analysis of the data were mainly MINITAB and MS Excel.

In this chapter, the results of this study are reported followed by some discussions. Also, the statistical techniques used and the results of the analysis are explained. The findings and discussion are presented for each of the eight statistical hypotheses. The interpretations of the results provide evidence to support or refute the hypotheses in this study. Furthermore, statistical findings that are not directly related to the hypotheses but aid in understanding of the data are presented.

The chapter is divided into six sections. After the introduction, the second section discusses some basic psychometric properties of the scales used with respect to our data. The third section reports the finding of the study with regards to the eight statistical hypotheses. In the fourth section, a discussion and interpretation of the finding in relation to the statistical hypothesis and available literature were given. The fifth section presents additional findings that are not directly related to the research hypotheses, but add additional insight to the hypothesis testing results. And the last section is the conclusion.

5.2 Psychometric Properties of the Scales used

In section 4.6 the instruments used in this study were discussed. Also literatures on the psychometrics of these instruments were reviewed. Here, those results are extended with

additional psychometrics properties of those instruments with regards to the data

Table 3: Pearson correlation coefficient matrix between mathematics attitude scale and its two subscales.

	1	2	3
1. Math Attitudes (Total)			
2. Enjoyment	0.85*		
3. Value	0.91*	0.56*	

* $p < .05$

collected in this study. Table 3 and 4 present the correlation results between mathematics and computer attitudes scales and their subscales. The correlations are all found to be statistically significant ($p < .05$). The correlation on mathematics attitudes (Table 3) indicates that the subscale Value correlates more with the total scale ($r = 0.91$) compared to Enjoyment where $r = 0.85$. Similarly, in Table 4, the results show that computer confidence and computer liking contribute more to the scale in comparison to computer usefulness and anxiety. The correlation of the total scale and the subscales is high. However, it was relatively low between the subscales with highest (0.73) between Confidence and Liking.

Table 4: Pearson correlation coefficient matrix between computer attitude and its four subscales.

	1	2	3	4	5
1. Computer Attitudes (Total)					
2. Anxiety	0.76*				
3. Confidence	0.89*	0.53*			
4. Liking	0.83*	0.51*	0.73*		
5. Usefulness	0.78*	0.44*	0.62*	0.48*	

* $p < .05$

A summary of the means and standard deviations together with reliability coefficients (alpha) of all the three scales together with their subscales is presented in Table 5.

Table 5: Summary of the reliability coefficient of the three instruments used

Scale	Subscale	N	M	SD	Alpha
Mathematics attitudes		51	68.06	11.44	0.85
	Value	53	37.49	7.22	0.81
	Enjoyment	54	30.61	5.49	0.70
Computer attitudes		50	120.48	15.69	0.87
	Anxiety	54	28.87	4.52	0.56
	Confidence	59	30.49	5.46	0.74
	Liking	58	29.09	4.46	0.58
	Usefulness	56	31.17	4.92	0.68
Learning styles					
	Reflectors	54			0.58
	Activist	54			0.38
	Pragmatist	55			0.32
	Theorists	55			0.26

* Responses vary because of missing data

Table 6, presents a comparison of the alpha values computed in the present study with those reported in other relatively new studies (e.g., Taylor, 1997, Duff, 2002, Loyd & Loyd, 1985). As can be observed, the reliability coefficient in both mathematics attitudes and computer attitudes are relatively on the lower side in comparison with what was found in Taylor (1997) and Loyd & Loyd (1985). However, in general, the scores are acceptable. The most surprising result is the coefficient in the learning styles. As reported earlier, more than half of the data collected in this study were rejected due to apparent anomalies and inconsistency, and most of these happened in learning styles scale. It has been reported in Galligan (1993) that discrepancies in score may exist for students filling a survey in a language different from their first language due to language difficulty. Therefore, a possible explanation for the low alpha coefficients might be attributed to difficulty in English language comprehension. To avoid this problem, the researcher initially intended to take the project of translating the instruments, especially

the learning styles questionnaire, into Arabic. However, the author denied permission (see Appendix VI).

Table 6: Comparison of reliability coefficients of the present study with those reported by Taylor, Duff and Loyd & Loyd

Scale	Subscale	Alpha	
		Present Study	Other Studies
Mathematics attitudes (Taylor, 1997)			
	Value	.81	.83
	Enjoyment	.70	.91
Computer attitudes (Duff, 2000)			
	Anxiety	.56	.90
	Confidence	.74	.89
	Liking	.58	.89
	Usefulness	.64	.82
Learning styles (Loyd & Loyd, 1985)			
	Reflector	.26	.73
	Activist	.38	.71
	Pragmatist	.58	.55
	Theorists	.32	.64

5.3 Findings

In this section we present the findings in our study. The results are interpreted in relation to the evidence they provide concerning the support or lack of it to the statistical hypotheses that guided the research.

The dependent variable in this study is the students' achievements in MATH 002. The grade point average (GPA) of all students involved in this study was 2.53 out of 4. This is far more than the overall GPA of the students that took MATH 002 in that semester (2.24 out of 4) a difference of 0.29 to the advantage of the experimental class. We shall

not go further on this as the study is not meant for comparison, neither are we claiming that the good performance is purely due to the program. The distribution of the letter grades, frequency and percentage is given in Table 7.

Table 7: Frequency distribution (%)of students' letter grades and GPA scores

Grade	GPA score	N (%)
A +	4.00	9 (15)
A	3.75	4 (7)
B +	3.50	3 (5)
B	3.00	8 (14)
C +	2.50	13 (22)
C	2.00	11 (19)
D +	1.50	5 (8)
D	1.00	2 (3)
F	0.00	4 (7)

Among the seven independent variables for this study, some are continuous and others categorical. The means and standard deviations of the continuous variable, and the frequencies and percentages of the categorical variables are presented in Table 8. It is worth noting that in the computer attitude scale, the minimum point that one can obtain if he answers all the questions is 40, while the maximum point attainable is 160. Therefore, a student with a score of 100 or above is considered having positive attitude. Similarly, in the mathematics attitude scale, student that answered all the questions gets a minimum score of 24, while the maximum is 96. Hence a student with score 55 or above is considered having positive attitude toward mathematics.

It can be observed that the students' attitude towards mathematics and computer is positive. Also, on the average, the students have been using computer at home or in school for more than three years. Similarly, the percentage of computer owners is high (73%) compared to those who indicated that they do not have (27%). Furthermore, the dominant learning style among students was Reflectors and the least was the Activist.

We shall restate our eight statistical hypotheses as presented in Chapter 4, followed by presentation of the results of the finding in the this study.

Table 8: Means and standard deviations of the different variables

	Variable		
	Continuous		Categorical
	M	SD	N (%)
Achievement (MATH 002 result)	2.52/4	1.19	
Mathematics Aptitude (MATH 001 result)	2.67/4	0.81	
English proficiency (English 001 result)	2.73/4	0.72	
Computer Attitudes	118.5/160	16.51	
Mathematics Attitudes	68/96	11.66	
Computer Prior Experience	3 years	0.96	
Computer Ownership			
Yes			43 (73)
No			16 (27)
Learning Styles			
Activist			8 (14)
Pragmatist			11 (19)
Theorist			14 (24)
Reflector			26 (44)

Hypothesis 1: There is a significant positive relationship between mathematics aptitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Mathematics aptitude in this study was measured by student performance in MATH 001. From review of literature, we have seen that MATH 001 was found to be a better predictor of students' success in comparison to high school final grade (AL-Doghan, 1985), while high school final grade is shown to be a better predictor of success than most standardized aptitude test (Begle, 1979; Siglin & Edeburn, 1978; Bridgeman &

Wendler, 1989). To examine the relationship between mathematics aptitude and students' achievements, a simple linear regression was used. The result, presented in Table 9, indicates that the relationship between students' mathematics aptitude and their achievements is statistically significant at $p < .05$. This result is in support of our hypothesis.

Table 9: Validity coefficient and the predictor equation of mathematics aptitude and achievement

Predictor	B	SE	T	p
MATH 001	.65	0.18	3.59	0.001

Hypothesis 2: There is a significant positive relationship between attitudes towards mathematics and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Mathematics attitude was measured using the Aiken scale (1979). The scale has been found to be consisting of two factors (Value and Enjoyment) if used with adult students (Taylor, 1997). To test this hypothesis, we seek the correlation between the students' achievements and students' mathematics attitude using Pearson correlation coefficient. However, contrary to our assumption, the correlation found is low ($r = 0.01$, and $p = 0.93$), and hence did not support our hypothesis. The results are reported in Table 15.

Hypothesis 3: There is a significant positive relationship between computer attitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

This hypothesis was tested using the Pearson correlation coefficient in order to find the level of relationship between students' attitudes towards computer as measured by computer attitude scale (CAS) by Loyd & Gressard (1984a) and their achievements. The results presented in Table 16 show no significant correlation between achievement and computer attitudes ($r = -0.01$ and $p = .938$), hence the hypothesis is rejected.

Hypothesis 4: There is a significant relationship between computer ownership and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Ownership of computer in this study meant that the individual is in a personal possession of computer either at home or in the hostel. As shown in Table 8, 73% of the students indicated that they own personal computer. We examined the relationship between students' computer ownership and lack of it with students' achievements by using t-test technique. The result did not indicate any statistically significant ($t_{26} = 0.08$, p < .05) effect of computer ownership to students achievement. Therefore, the hypothesis is not supported by the result.

Hypothesis 5: There is a significant relationship between computer prior experience and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Computer Prior Experience was measured by the average of how long a student has been using computers at home and school. Students were categorized into five groups based on their computer prior experience: more than 9 years, 7 – 9 years, 4 – 6 years, 1 – 3 years, and less than 1 year. No student was found to have less than one year prior computer experience. Therefore, the last category was discarded, and the categories became four. Analysis of variance was used to examine if the level of students prior computer experience has any significant effect on their achievements.

Table 10: Means and standard deviation for the different computer experience

Prior experience (years)	N	M	SD
1 - 3	8	2.19	1.10
4 - 6	24	2.75	.92
7 - 9	16	2,47	1.26
> 9	11	2.41	1.20

Contrary to our hypothesis, the result indicates that there is no statistically significant

(F[3,58] = .64 ns) relationship between students' achievements and their computer prior experience. Therefore, the hypothesis is rejected.

Hypothesis 6: There are significant differential effects of learning styles on achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Learning Styles Questionnaire (LSQ) by Honey & Mumford (1992) was used in this study to measure students learning styles. LSQ was designed to characterize four categories of people with different learning styles, namely: Activist, Reflector, Pragmatist, and Theorist. A majority of the students (Table 8) were found to be reflectors while the highest achievers were Activist (Table 11). To analyze the relationship between students learning styles and their achievements, we employed analysis of variance (ANOVA), the result indicates no statistically significant relationship (F[3,58] = .75, ns) between students' achievements and their learning styles.

Table 11: Means and standard deviation for achievement by learning style

Prior experience (years)	N(%)	M	SD
Activist	8 (13)	3.03	0.43
Theorist	14 (24)	2.45	1.08
Pragmatist	11 (19)	2.30	1.41
Reflectors	26 (44)	2.53	1.09

Hypothesis 7: There is a significant relationship between proficiency in the language of instruction and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

Due to the peculiar nature of the participants in this study, English language proficiency was measured in a slightly informal way. The students' background was very weak in English. The only rigorous and comprehensive course they have taken in English language was ENGL 001. This course is comprehensive and contains all aspects of

language (Reading, Writing, Grammar, Listening, Vocabulary, and Oral). Consequently, in this study, students' performance in this course was used as proxy for the level of their English language proficiency. Students who obtained a letter grade of C+ or above were classified as high English language proficient, while those with less than C+ were considered to have low English language proficiency. To examine the relationship between students classified as high/low English language proficient and their achievements, we ran a t-test. The result indicated a statistically significant relationship ($t_{35} = 3.39$, p < .05) between the students' level of English language proficiency and their achievements. This led us to accept the hypothesis.

Hypothesis 8: The predictor variables (mathematics attitudes, computer attitudes, mathematics attitudes, computer ownership, proficiency in language of instruction, and learning styles) will contribute a significant portion of the variance in the achievement of the students enrolled in a pre-calculus algebra course supplemented with a computer lab program.

To examine the joint effect of the independent variables on the dependent variable, the data were analyzed by multiple regression, using as regressors: mathematics aptitudes, mathematics attitudes, computer attitudes, computer ownership, computer prior experience, learning styles, and English language proficiency. A full model of regression equation was created for this purpose:

Equation 1: Regression Equation Model.

$$y = b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_7 x_7 + b_8 x_8 + b_9 x_9 + b_{10} x_{10} +$$
$$b_{11} x_{11} + b_{12} x_{12} + b_{13} x_{13} + c \tag{1}$$

Where y = Achievement, x_1 = Mathematics Aptitude, x_2 = English Language Proficiency, x_3 = Mathematics Attitudes, x_4 = Computer Attitude, x_5 = Computer Prior Experience (1 – 3 years), x_6 = Computer Prior Experience (4 – 6 years), x_7 = Computer Prior Experience (7 – 9 years), x_8 = Computer Prior Experience (more than 9 years), x_9 = Learning style (Activist), x_{10} = Learning style (Reflector), x_{11} = Learning style (Theorist), x_{12} = Learning style (Pragmatist), and x_{13} = Computer Ownership.

It is worth noting that multiple regression is used in a most natural way when all the variables concerned are continuous. However, in this study, three of our independent variables are categorical in nature. These are: Learning styles, computer ownership, and computer prior experience. Hence, we did not include these variables directly in the regression model; rather each category is placed as a separate factor in the regression equation as dummy variable (c.f. Lea (2004)). For instance, learning styles is not considered in the regression equation per se, instead, the four variables: Activists, Reflectors, Theories and Pragmatist, were considered individually at their own right. Similarly, in Computer Prior experience only the four categories (1 -3 years, 4 – 6 years, 7 – 9 years, and more than 9 years) are included. The summary of the regression model is given in Table 12, while Table 13 provides the detailed results of the regression.

Table 12: Multiple regression model summary

Model	R	R-Square	R-Square(adj)	R-Sq(pred)	p
1	0.66	0.44	0.30	8.56%	0.005

The results in Table 12 show that the independent variables all together account for almost 44% of the total variance in the students' achievements (with R-Sq = 43.6% and R^2-Adjust = 30.4%). Only the effect of English language proficiency (t = 3.29, p = 0.002) and mathematics aptitude (t = 2.17, p = 0.04) were significant (Table 13). Nevertheless, the overall model is significant with F(58,11) = 3.40 and p = 0.005. Therefore, the hypothesis is accepted.

Furthermore, we ran different partial model of the regressions, where one of the independent variables was isolated at a time to determine its effect on the entire model. This is summarized in Table 14. The result indicates that English language proficiency accounts for about 13% of students' achievements. This is followed by learning styles with 7% and mathematics aptitude accounting for about 6%. Together, the three variables accounted for more than 40% of the students' achievements. On the other hand, English language proficiency and mathematics aptitude together accounted for more than 37% of students' achievements.

Table 13: Summary of the value of each coefficient with standard error, t-statistics and p-value

Predictors		B	Std. Error	t	p
Constant		-0.20	1.16	-0.17	0.87
Mathematics Aptitude		0.44	0.20	2.17	0.035**
English language proficiency		0.57	0.17	3.29	0.002**
Mathematics attitudes		0.005	0.012	0.39	0.70
Computer attitudes		-0.00001	0.009	-0.01	0.99
Computer ownerships		-0.030	0.34	-0.09	0.93
Prior compute experience					
	1 - 3 years	-0.47	0.40	-1.19	0.240
	4 – 6 years	*	*	*	*
	7 - 9 years	-0.57	0.34	-1.69	0.098
	More than 9 years	-0.20	0.36	-0.57	0.57
Learning styles					
	Reflectors	*	*	*	*
	Activist	0.63	0.42	1.50	0.14
	Pragmatist	-0.41	0.35	-1.18	0.24
	Theorists	-0.13	0.34	-0.38	0.70

*The modal class of categorical variables. For categorical variables, the coefficients for each level of the relevant variable is relative to the modal class

** $p < 0.05$.

It is worthwhile to describe the content of Table 14. The 1st column contains the model while the 2nd column describes the independent variables in that model. The third column tells us the independent variables missing in the model. The R-square column indicates the extent to which the independent variables explain the variation in the model. The 6th column explained the decrease in what the model accounted as a result of removal of that variable. The last two columns give the F and the p values of each model.

Table 14: Summary of regression analysis for achievement using the full model (all the independent variables) and restricted model

Model	Variables Included in Model	Variable(s) Eliminated from Model	R^2	Reduction in R^2	df	F	p
Full	1,2,3,4,5,6,7,8,9,10,11,12		.44		11,58	3.40	.005*
R - Model 1	2,3,4,5,6,7,8,9,10,11, 12	1	.38	.06	10,58	3.94	.006*
R - Model 2	1,3,4,5,6,7,8,9,10,11,12	2	.31	.13	10,58	2.12	.041*
R - Model 3	1,2,4,5,6,78,9,10,11,12	3	.43	.01	10,58	3.69	.001*
R - Model 4	1,2,3,5,6,78,9,10,11,12	4	.44	.00	10,58	3.72	.001*
R - Model 5	1,2,3,4,8,9,10,11, 12	5, 6, 7	.40	.04	8,58	4.10	.001*
R - Model 6	1,2,3,4,5,78,9,12	9,10,11	0.37	0.07	8,58	3.71	.002*
R - Model 7	1,2,3,4,5,6,7,8,9,10,11	12	.44	.00	10,58	3.71	.001*

Where 1= Mathematics Aptitude, 2 = English Language Proficiency, 3 = Mathematics Attitudes, 4 = Computer Attitude, 5 = Computer Prior Experience (1 – 3 years), 6 = Computer Prior Experience (7 – 9 years), 7 = Computer Prior Experience (more than 9 years), 9= Learning style (Activist), 10 = Learning style (Theorist), 11 = Learning style (Pragmatist), and 12 = Computer Ownership. * $p < 0.05$.

5.4 Discussion

In this section the statistical findings as presented in the previous section are discussed. The findings are also interpreted in terms of their contribution to the validity of the predictors used in estimating academic success, and are compared with other results available in the literature. Here, the eight hypotheses considered in this study are restated and examined one after the other in relation to the statistical finding.

Hypothesis one states that there is a significant positive relationship between mathematics aptitudes and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. From Table 9, a significant relationship was found ($B = 647$, $p = 0.001$) between students' achievements in MATH 002 and the students mathematics aptitude. In other words a one unit change in the students' mathematics aptitudes leads to a 0.65 change in their achievements. This result is not surprising if one considers the fact that MATH 001, which was used as a measure of students' aptitude was the last pre-calculus course the students took, and was a prerequisite to the criterion variable (MATH 002). The result corroborates with many studies in the literature (Tuli, 1980; Jamison, 1994; Kelly, 1999; Soares, 2001). Begle (1979) after his intensive review of literature on the critical variables in mathematics education found that "the best predictors of success in beginning algebra are measures of the student's previous success in mathematics, as measured by his grades in mathematics courses" (p.97). Begle concluded that "hardly does any other variable contribute significantly to the predictive power of previous mathematics achievement measure" (p.97). A similar remark was made by Kelly (1999) in his longitudinal study aimed at predicting mathematics performance of Grade 9 high school pupils in South Africa. In an early study conducted by AL-Doghan (1985), the preparatory mathematics (MATH 001 and 002) were found to have a high predictive validity for measuring the students GPA at King Fahd University of Petroleum & Minerals.

Hypothesis two states that there is a significant positive relationship between attitudes towards mathematics and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. Mathematics attitude is one of the

variables that have been intensively studied due to the beliefs of many educators that a strong relationship exists between student's attitudes toward mathematics and their achievements in mathematics (Aiken, 2000). As a matter of fact many empirical studies have found mathematics attitudes strongly correlated with mathematics achievement (Charles, 1987; Thorndike-Christ, 1991; Simich-Dudgeon, 1996; AL-Rwais, 2000). On the contrary, this study did not find any statistically significant (r = 0.012, and p = 0.93) relationship between students attitudes and their achievements (Table 15). This result was not expected though a similar result was reported by AL-Furaihi (2003), coincidently also from Saudi Arabia. In his study, Al-Furaihi investigated the relationship between students' attitude toward learning mathematics and mathematics achievement. The study was conducted in Riyadh, Saudi Arabia. However, the result does not seems to be Saudi specific as there is a study conducted in Saudi Arabia in which attitude toward learning mathematics was found to be the best predictor of students' achievements (AL-Rwais, 2000). However, we are unable to get enough convincing data that may substantiate the reason for the other coincidence.

Hypothesis three states that there is a significant positive relationship between computer attitudes and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. As shown in Table 8, the average of the computer attitude of the participants in this study was almost 75% of the total score (160) of the scale. This indicates that the participants had positive attitudes towards computers. Nevertheless, the scores did not show statistically significant correlation with the students' achievements as shown in Table 16. In fact the table indicated that correlation is more towards negative not only in the total but likewise in all the subscales except in computer anxiety. A number of studies conducted by various researchers that reported similar findings include Benson (1989), Wood (1991) and Wohlgehagen (1992). On the other hand, Marty (1985), Al-Rami (1990) and Wohlgehagen (1992) found computer attitude and achievement to be correlated significantly.

As can be observed from the 2nd and 3rd hypotheses, the participants in the study had a positive attitude towards computer and mathematics. This might have to do with the fact

that the participants were mostly among the Saudi Arabian high school science graduates at least in the 90th percentile in their respective schools. As a result they were expected to have a high positives attitude towards mathematics and highly curious towards innovation like computers. In addition, the participants had been using computers either at home or in school for more than 3 years. Another reason may be due to the fact that most of the participants were planning to do engineering or computer science related BS program at KFUPM.

Hypothesis four states that there is a significant relationship between computer ownership and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. As reported earlier, about 73% of the participants in this study indicated that they have personal computer as shown in Table 8. The result of the t-test revealed that the effect of computer ownership on students' achievements was not statistically significant (T = 0.08, p = 0.94). This is contrary to many studies that reported the existence of strong correlation between computer ownership and achievement (Brown *et al*., 1989; Taylor & Mounfield, 1991; Cates, 1992; Nash & Moroz, 1997). The only thing we can notice, even in this study is that computer owners had a higher mean as compared to non computer owners as shown by Table 8, but the difference is not statistically significant. There are some studies like (Nichols, 1992) that corroborated our finding. In fact, a strong negative correlation in this context was reported by Al-Badr (1993).

Hypothesis five states that there is a significant relationship between computer prior experience and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. As for the computer prior experience, results in Table 10 indicated that most of the students (over 80%) have been using computer at home or in school (on the average) for more than 3 years. This information is important as KFUPM is continuously updating and reviewing its curriculum with the aim of incorporating the current technological teaching aids in order to make the university in the 'state of the art'. Therefore, knowledge of students' background on this technology will go along way in informing the University the right direction to go on these changes. The data were analyzed using ANOVA to see if the level of students'

computer experience has any significant relationship with their achievements. The ANOVA result shows that the p-value is 0.59. This indicates that the differences in students' achievements across categories of computer prior experience are not statistically significant. This is contrary to the findings reported by Russell (1988), Howard (1990), and Nash & Moroz (1997), but coincides with results reported in Al-Badr (1993), and Barakzai (2003). As can be noticed from the row means of the different categories as shown in Table 10, students with least computer experience (1 – 3 years) had the least mean (2.19 out of 4), which was the assumption. However, it was surprising to note that, in other groups, the higher the computer experience the lower the mean. Students with computer experience from 4 – 6 years outperformed all other groups. This is contrary to our earlier assumption that more prior computer experience might yield higher achievement. A plausible interpretation to this unexpected outcome is that perhaps the class of students with computer experience from 4 – 6 years is still fresh and on the verge of appreciating the novelty of computers. On the other hand, the other class (1- 3 years) might be relatively new in the use of the technology, hence could not yet do much with it and appreciate it. For those with more than 7 years of computer prior experience, it might be that the novelty in the computer usage has faded with time.

Hypothesis six states that there is a significant relationship between learning styles and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. The dominant learning style in this study was found to be reflectors (Table 11) consisting of 44% of the students, followed by Theorist with 24%. In terms of performance, Activist outperform all other groups with mean of 3.03 out of 4, followed by Reflectors with 2.53 out of 4 (Table 11). The performance of Activist is not surprising since they are characterized as open-minded, not skeptical, and involve themselves fully without bias in new experiences. These qualities tend to make them enthusiastic about anything new, and are also happy to be occupied by immediate experiences (Honey & Mumford, 1992). We analyze the effect of different learning styles on students' achievements using analysis of variance (ANOVA). However, no statistically significant difference was found ($F_{(58,3)} = .75$, and $p = .53$) among the achievements of students categorized based on their learning styles. Here, our finding coincides with many other studies in the literature (Gawronski, 1972; Raviotta, 1988;

Aseeri, 2000; Briggs, 2003; Cezair, 2003; LaPrise, 2003). Some other studies reported students learning styles to be significantly correlated with their achievements (Vondrell, 1987; Russell, 1988; Bauer, 1991; Al-Badr, 1993; Raiszadeh, 1997; Ulubabova, 2003).

Hypothesis seven states that there is a significant relationship between proficiency in the language of instruction and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. The participants in this study were bilingual Arabs who on the average are weak in English language; the new language of instruction at KFUPM. In the case where the language of instruction and the students local language is different (Bilingual and Multilingual settings), variation of language does affect the understanding and achievements of students as reported by many studies available in the literature (discussed in section 3.2.7). Therefore, proficiency in the language of instruction (in this case English) was selected as one of the independent variable in this study. To test if the level of proficiency in English language affect students achievements, students were categorized into two: high proficient in English language and low proficient in English language. A t-test was utilized to examine the existence of the relationship. Result shows that students classified as high proficient in the English language out-performed those students classified as low English language proficient in terms of average performance in MATH 002. Similarly, the result indicated a significance difference between students classified as high/low English language proficiency ($p = 0.002$). This finding corroborated with many other empirical studies (Taole, 1981; Ferro, 1983; Al-Doghan, 1985; Cuervo, 1991; Maro, 1994; Han, 1998; Lim, 1998). There are some studies, which have reported contrary to our findings (Chan, 1982; Sughayer, 1989). It should be noted that the preparatory year where this study was conducted, is a place where students are at their developmental level of learning English skills. AL-Doghan (1985) found that among the four components of the admission selection exams for admission into KFUPM (Math, Physics, English, Chemistry), English component was the best single predictor of the preparatory year GPA. The findings in this study and that of AL-Doghan might be seen as an exception in Begle's (1979) conclusion that "hardly does any other variable contribute significantly to the predictive power of previous mathematics achievement measure" (p. 97). In both

studies, English language score had a higher predictive power than previous mathematics achievement.

Hypothesis eight states that the predictor variables (mathematics attitudes, computer attitudes, mathematics attitudes, computer ownership, proficiency in language of instruction, and learning styles) will contribute to a significant portion of the variance in the achievements of the students enrolled in a pre-calculus algebra course supplemented with a computer lab program. The result of the multiple regression as reported in Table 12 shows that the regression was a moderate fit. All the independent variables together accounted for almost 44% of the total variance in the students' achievements (with R-Sq = 43.6% and R-Sq (adjust) = 30.4%). However, removing only four cases of "outliers" (students who did very well in some courses and fail in others), the picture became completely different. The new model accounted for more that 57% of students' achievements (R-Sq = 57.3%, R-Sq (adj) = 46.4%), and the model became highly significant at p < 0.00005. In both cases, the factor with the highest coefficient is Activist followed respectively by English language proficiency and mathematics aptitude respectively. However, as reported earlier, only the effects of English Language Proficiency and Mathematics Aptitudes were statistically significant.

From the results of the partial models in Table 14, we noted that English language proficiency along account for about 13% of students' achievements. This is followed by Activist (learning styles) with 7% and mathematics aptitude accounting for nearly 6%. Altogether, the three variables accounted for more than 40% of the students' achievements. On the other hand, English language proficiency and mathematics aptitude collectively accounted for more than 37% of students' achievements.

As Table 13 indicates, students' achievements is positively related to English language proficiency, mathematics aptitude and mathematics attitudes. With other variable held constant, students' achievements increases by 0.57 with respect to English language proficiency, 0.44 with respect to mathematics aptitude, and 0.0047 with respect to mathematics attitudes. On the other hand, achievement is negatively correlated to computer attitudes, decreasing by 0.00010 as a result of computer attitudes. As for the

categorical variables, the reference point is the modal class. The modal class of computer ownership was class of students who owned computer. From Table 13, we can see that those students who do not own computer have a propensity to achieve lower than those who own computer, decreasing in achievement by 0.030. For the learning styles, Activist tended to have higher achievement than Reflectors (modal class), increasing by 0.635. However, the reverse is the case for the other learning styles. Pragmatist and Theorist appeared to perform less than Reflectors by 0.41 and 0.13 respectively. Similarly, all the categories of computer prior experience tended to achieve less relative to the modal class (computer experience of 4 – 6 years), decreasing by 0.47, 0.57 and 0.2 for 1 – 3 years, 6 – 7 years and more than 9 years respectively.

5.5 Additional Results

During the course of this analysis, some results were obtained that were not directly related to the hypotheses, but have tendency to shed some light on the overall result of the study. These results are presented in this section.

Table 15: Pearson correlation coefficient matrix between the dependent variable (MATH 002), mathematics attitude, and its two subscales.				
	1	2	3	4
1. MATH 002				
2. Math Attitudes (Total)	0.07	1.00		
3. Math Attitude (Enjoyment)	-.03	0.56*		
4. Math Attitude (Value)	0.01	0.85*	.91*	

$* p < .05$

The result in hypothesis 2 indicates, no significant relationship was found between mathematics attitude and achievement. Since the scale used in this study comprises of two factors, we went ahead to seek the correlation between students' achievements and mathematics attitudes in relation to the two subscales (Enjoyment and Value). The result indicated no significant relationship between students' achievements and mathematics attitude and its two subscales (Table 15). However, the result shows that perceptions of

the value of mathematics contribute more to the overall attitudes towards mathematics than that of enjoyment. A possible interpretation of this result is as follows: mathematics is a prerequisite for all science oriented programs regardless of the major the students intend to pursue. Therefore, students are fully aware of the value of mathematics with regards to their intended specializations regardless whether they enjoy doing mathematics or not.

Table 16: Pearson correlation coefficients between the dependent variable (MATH 002), and computer attitudes, and its four subscales.

	1	2	3	4	5	6
1. MATH 002						
2 Computer Attitudes (Total)	-.01					
3 Computer Attitude (Anxiety)	0.15	0.76*				
4 Computer Attitude (Confidence)	-.01	0.89*	0.53*			
5 Computer Attitude (Liking)	-.09	0.83*	0.51*	0.73*		
6 Computer Attitude (Usefulness)	-.10	0.78*	0.44*	0.62*	0.48*	

* $p < 0.05$

Table 17: Summary of the Pearson correlations between the dependent and independent variables.

	SA	ELP	CO	MAP	CE	CA	MA	LS
SA	1.00							
ELP	0.519**	1.00						
CO	0.010	0.150	1.00					
MAP	0.430 **	0.491**	0.062	1.00				
CE	-0.005	0.121	0.253	-0.054	1.00			
CA	-0.010	0.095	0.294	-0.036	0.099	1.00		
MA	0.012	-0.003	0.159	-0.082	0.011	0.425	1.00	
LS	0.001	0.050	0.211	-0.025	0.015	0.044	0.049	1.00

*SA = Students Achievement, ELP = English language Proficiency, MAP = Mathematics Aptitude, CE = Computer prior experience, CA = computer attitudes, MA = mathematics attitudes, CO = computer ownership and LS = learning styles

**cells with highest correlations.

A similar analysis was done with computer attitudes. Here, also all the subscales do not seem to have any significant correlation with students' mathematics achievement. From Table 16, computer confidence seems to contribute more towards student's attitudes than the other subscales.

To analyze the data further, we ran a multiple correlation to obtain the correlation of the achievement and the seven independent variables. The result is in Table 17.

Table 18: Summary of the stepwise regression model between all the dependent and independent variables				
Step	1	2	3	4
Constant	0.7003	0.4442	0.3039	-0.3314
ELP	0.69	0.71	0.73	0.56
T-Value	4.58	4.84	5.07	3.52
P-Value	0.000*	0.000	0.000	0.001
CPE2		0.47	0.48	0.48
T-Value		1.92	2.03	2.08
P-Value		0.060	0.047	0.042
LSA			0.68	0.77
T-Value			2.01	2.31
P-Value			0.050	0.025
MAP				0.39
T-Value				2.17
P-Value				0.035*
S	0.938	0.917	0.893	0.865
R-Sq	26.91	31.41	36.09	41.20
R-Sq(adj)	25.63	28.96	32.61	36.85
R-Sq(pred)	20.83	23.50	27.23	30.78

*significant at p = 0.5

**ELP= English Language Proficiency, CPE2 = Computer Prior Experience (4 – 6 years), LSA = Learning style (Activist), MAP = Mathematics Aptitude.

As can be observed, the variable that correlates more with mathematics achievement is English language proficiency having a correlation coefficient of 0.52. This is followed by mathematics aptitude with a moderate correlation coefficient of 0.43. Among the independent variables, English language proficiency strongly correlated with mathematics aptitude as measured by MATH 001 with a correlation coefficient of 0.49, followed by the correlation between computer attitudes and mathematics attitude (0.43).

It is interesting to note that all the variables that correlate more with students' achievements (English Language Proficiency and Mathematics Aptitude) are all part of the preparatory year program. This indicates the extent to which the components of the preparatory year program are linked.

Furthermore, a stepwise multiple-correlation approach was used to produce the maximum predictive power with a minimum number of variables. Here, only four variables survived, the results are presented in Table 18. Once again, the variables that contributed more significantly were English language proficiency as measure by ENGL 001, followed by mathematics aptitude as measured by MATH 001. Other variables that contributed in the model were Activist, in learning styles, and computer prior experience (3 -6 years only).

5.6 An Overview of the Results

In this chapter, the results for each research hypothesis were presented followed by some discussion. The participants in the study were 120 students of the preparatory year MATH 002 of King Fahd University of Petroleum & Minerals. Various statistical techniques were used to analyze the data. Pearson correlation coefficient was used to investigate the relationship between achievement and mathematics attitude, and computer attitude, while a t-test was utilized to investigate the effect of computer ownership and English language proficiency on students' achievements. On the other hand, analysis of variance was employed to see if different learning styles and computer prior experience have any effect on students' achievements. Simple regression analysis was used to find the relationship between students' mathematics aptitudes and their achievements, while multiple regression technique was utilized to investigate the joint

effect of all the independent variables on students' achievements.

The results of regression analysis showed statistically significant relationship between the selected independent variables and students' achievements (p = 0.005). The model accounted for about 44% of the total variance of students' achievements. As a matter of fact, removing four "outliers" (students who did very well in some courses and fail in others) cases raised the percentage to 57%. In both models, only the contribution of mathematics aptitude and English language proficiency were found to be statistically significant. All other variables did not show any statistically significant contribution. In particular, English Language proficiency alone was found to account for 13% of students' achievements, while mathematics aptitude account for additional 6%. On the other hand, while investigating the effect of mathematics aptitude on students' achievements, the result of simple linear regression revealed that the coefficient of mathematics aptitude was 0.64.

The t–test result has shown a significant difference in achievement between students classified as high and low English language proficient. On the other hand, no significant difference was found among students that owned personal computer and those who did not. A possible reason may be due to the fact that computer lab was available for students practice through out the day time in the whole semester.

The analysis of variance (ANOVA) result has shown no significant difference between students categorized on the basis of their learning styles (Activist, Reflectors, Theorist, and Pragmatists). A similar result was found among students categorized on the basis of their different computer prior experiences (more than 9 years, 7 – 9 years, 4 – 6 years, and 1 -3 years). The dominant learning style among the students was Reflectors (44%) and the least was Activist with only 14%. However, in terms of academic achievement, Activists outperformed all others, while the remaining three performed almost equally same.

In terms of computer prior experience, to our surprise, students with computer experience 4 - 6 years (41%) outperformed students with more than 7 years of computer prior experience (48%). However, as expected, students with least computer experience

(1 - 3 yeast) had the least achievement.

The attitudes of students towards mathematics and computer were found to be positive. This might have to do with the fact that the students were science orientated right from high school where mathematics is an integral and strong component, and that most of the students have been using computers either at home or in school for more than 3 years (86%). Another reason may be due to the fact that most of the students were planning to enter into engineering or computer related program at KFUPM. However, these positive attitudes did not produce statistically significantly effect on the students' achievements in this study

The next chapter (VI) presents the summary, conclusion, limitations of the study. Also recommendations for application and further research are enumerated.

CHAPTER SIX

Summary, Conclusion, Limitations and Recommendations

6.1 Introduction

This chapter presents the summary, conclusions and limitations of this study. In addition, recommendations with regard to the application and further research are outlined here. The chapter consists of six sections. After the introduction, the second section gives a summary of the findings in this study. The third section outlines the conclusions derived from the research, and the limitations are enumerated in the fourth section. The fifth section discusses some implications of the findings to educational practices. The last section suggests relevant areas for further research.

6.2 A Reflection on the Study

Many educational and corporate bodies are increasingly becoming selective in nature. The main reason is due to limited resources as everyone would like to optimize the meager resources available to them. As a result, for a person to be accepted for admission or employment, in most cases, the candidate will have to go through some selection process. In fact the process is to make sure that the candidate possesses some good qualities that can ensure his success in the program.

For instance, for a candidate to qualify for admission into KFUPM, the candidate must be among the best ten percent of all high school graduates of that year in the Kingdom of Saudi Arabia. In addition, he must pass two different entrance examinations (RAM 1 & 2) with outstanding performance. Not only that, after completion of the preparatory year program, a student must have a minimum of C grade in mathematics in order to join BS program in engineering, computer or physical sciences. Therefore, students' achievement in mathematics has remained the "critical filter" (Sells, 1973) for the

selection and placement of students to various science and engineering oriented programs at KFUPM, and in fact to almost all other higher institutions.

Consequently, mathematics achievement has been of great concern to both researchers and mathematics educators. This concern has resulted in research seeking to determine, for example, the factors that positively or negatively affect students' achievements in mathematics. In many instances, the factors are investigated based on mathematics teaching and learning in general. However, very few studies have, on the other hand, investigated the factors contributing to students' achievements in mathematics when learning takes place in a computer aided environment. With the pervasiveness of computers in education, studies in this direction become imperative. Several variables have been established and identified as predictors of students' success in mathematics (Pugh, 1969; Elgamal 1987; Blansett 1988; Eshenroder, 1987; Bridgeman & Wendler 1991; Shaughnessy, 1993; Armstrong, 1997; Buerman, 1998) and also in computer science (Bauer, Mehrens & Visonhaler, 1968; Huse 1987; Shaffer, 1990; Al-Badr, 1993). It was projection in this study that some of these variables that have been found to predict success in mathematics and in computer science are also very likely to influence success in the computer-aided learning of mathematics environment. After careful observations and intensive literature review, the following variables were identified and selected for this study. They were: mathematics aptitude, English language proficiency, mathematics attitudes, computer prior experience, computer ownership, computer attitudes, and learning styles.

The main purpose of this research was to investigate the extent to which these identified and selected variables (mathematics aptitude, English language proficiency, mathematics attitudes, computer prior experience, computer ownership, computer attitudes and learning styles) contribute to students' achievements in a pre-calculus algebra course supplemented with a computer lab program. The research is significant in several ways:

1. It will contribute to knowledge in an area that has not previously been thoroughly looked into.

2. It will contribute to knowledge that is useful for practical management.
3. It will reveal who stands to benefit most in computer-aided learning mathematics programs.
4. It will aid in the selection process of students for computer based mathematics learning.
5. It will provide useful data for the purpose of counselling activities.
6. It will provide knowledge useful for courseware developers.
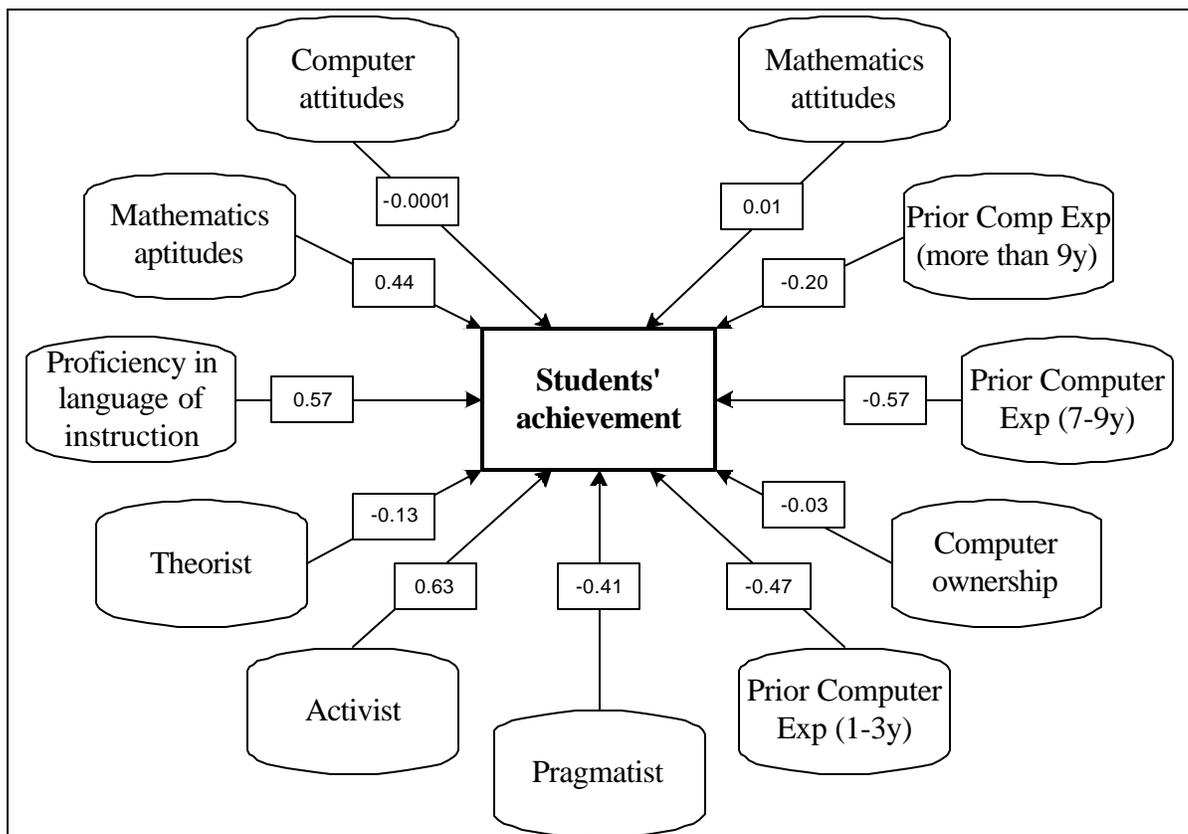
Figure 2: Coefficients of the selected variables in the multiple regression equation 1.

* Reflectors and computer prior experience (4 – 6 years) are the modal classes for learning style and computer prior experience, therefore, not reflected in the model as per the categorical data.

The participants in the study were MATH 002 (the second pre-calculus algebra course) students of the preparatory year program at King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia.

To collect data, a complete one semester experiment was carried out with 120 pre-calculus algebra students to investigate the role of the selected variables in students' achievements in the course. In the experimental semester, students were given a weekly lab that addressed the topics they had covered in the previous week. The software used for this purpose were mainly MATLAB and webCT; the former as a problem solving tool, and the latter as a course delivery and management tool. Students used MATLAB to solve problems and complete weekly homework. On the other hand, webCT was used for homework submission, access to additional course material, homework solution, and cyber discussion on mathematical issues. Prior to that, a complete student's manual for the course was developed by the researcher and his two colleagues under the Summer Special Assignment grant of King Fahd University of Petroleum & Minerals (see Appendix I).

The instruments used in the study were the Computer Attitude Scale by Loyd & Gressard (1984a), Mathematics Attitude Scale by Aiken (1979), and Learning Styles Questionnaire (LSQ) by Honey & Mumford (1986, 1992). The questionnaires for the two predictors, computer ownership and computer prior experience, were designed by the researcher. Data relating to the independent variables were collected at the beginning of the experimental semester (Spring, 2003-2004 academic session), while the data relating to the dependent variables, i.e., students' achievements in the course, were collected at the end of the experimental semester.

The instruments were administered to the students in the first week of the semester and were given up to one week to fill in and return the survey. Out of the 120 students that participated in the experiment, only the data of 59 were included in this analysis. The remaining were rejected due to missing information, anomalies in the data provided, withdrawal from the program and refusal to fill in the survey. The second part of the data, comprising of students' final grade in the course, were collected at the end of the

semester.

Data were analyzed using different kinds of statistical techniques. The software used were MINITAB and Microsoft Excel. SAS was also used to crosscheck results.

The following is a summary of the results as they relate to the eight statistical hypotheses that guided the research. Figure 2 presents a summary of the regression analysis, with the coefficient of each variable attached to it

1. Hypothesis one states that there is a significant positive relationship between mathematics aptitudes and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. Mathematics aptitude in this study was measured by students' achievements in MATH 001, which was the last pre-calculus algebra course the students took as well as a prerequisite for the criterion variable (MATH 002). Simple linear regression was used to examine the relationship between mathematics aptitude and achievement. Mathematics aptitude as measured by MATH 001 was found to be significantly correlated with students' achievements in pre-calculus algebra supplemented with a computer lab program. Therefore, the result is in support of our hypothesis.

2. Hypothesis two states that there is a significant positive relationship between attitudes towards mathematics and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. The attitude of students toward mathematics was found to be positive. This is not surprising since all the participants were "high achievers" in their respective previous high schools. In addition, they were from a science background, and they intended to study engineering or sciences. However, despite the positive attitude, no significant correlation was found between students' attitude and their achievements in pre-calculus algebra supplemented with a computer lab program. Consequently, the result is not in support of our hypothesis.

3. Hypothesis three states that there is a significant positive relationship between computer attitudes and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. The students' attitudes toward

computers were measured in this study using a computer attitude scale consisting of four subscales: computer anxiety, confidence, liking and usefulness. The total score of these four subscales is what determines individual attitudes towards the computer. Results have shown that the participants had positive attitudes towards the computer. However, the correlation coefficient between achievement and each of the computer attitude subscales, as well as the total scores, was not significantly different from zero, which indicated that there were no significant relationships between students' achievements in pre-calculus algebra supplemented with a computer lab program and the computer attitudes scale with its four subscales. Hence the result did not support the hypothesis.

4. Hypothesis four states that there is a significant relationship between computer ownership and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. About 73% of the participants in this study indicated that they had a personal computer. Nevertheless, the t-test result revealed that there is no significant difference in achievement in pre-calculus algebra supplemented with a computer lab program between students who own computers and those who do not. Hence, the hypothesis is not supported.

5. Hypothesis five states that there is a significant relationship between computer prior experience and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. In this study, computer prior experience was measured by how long a student had been using a computer both at school and at home. The students were categorized into four groups based on their years of computer prior experience: 1 -3 years, 4 – 6 years, 7 – 9 years, and more than 9 years. Students' computer prior experience was defined as the average of years he had been using computer both at home and at school. The result indicated that most of the students (85%), on average, had computer prior experience at home or school for more than three years. Analysis of the variance revealed that the achievement in pre-calculus algebra supplemented with a computer lab program is not significantly different among the four groups. Nevertheless, the result seems to indicate some more surprising trend in that the more years of computer experience the students had the less their achievements. However, the exception is on students with computer

prior experience of 1 – 3 years, who performed below all other categories. Since the result is not statistically significant, the hypothesis is not supported.

6. Hypothesis six states that there is a significant relationship between learning styles and achievements of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. Learning styles were measured in this study by the use of a learning styles questionnaire (LSQ) by Honey & Mumford (1992). The participants were classified into four groups according to the learning styles (Activist, Pragmatist, Theorist and Reflectors). The dominant learning style among the subject was Reflector (44%), and the group with the least number of students was Activist with 14%. In terms of performance, the Activist group was the highest among all the four groups, and the least was the Pragmatist group. However, the hypothesis is not supported since the result of the analysis of the variance revealed no statistically significant difference in achievement in pre-calculus algebra supplemented with a computer lab program among the four groups.

7. Hypothesis seven states that there is a significant relationship between proficiency in the language of instruction and achievement of students enrolled in a pre-calculus algebra course supplemented with a computer lab program. The participants in this study were bilingual with weak English backgrounds – the new language of instruction. As a result, proficiency in English language was selected as one of the independent variables to help us see the effect of the language of instruction in students' achievements in pre-calculus algebra supplemented with a computer lab program. Proficiency in English was measured by students' performance in ENGL 001. This course is an intensive language program comprising of subjects such as Listening, Reading, Writing, Vocabulary, Oral and Grammar. Students were categorized into two groups: low and high English language proficient. Students with grades of C+ and above were considered in this study as high English language proficient, while students with grades less that C+ were considered as low English proficient. The t-test result showed a statistically significant difference between the achievements of students categorized as high or low English language proficient. Students categorized as high English language proficient outperformed the low English proficient, and so the hypothesis was supported.

8. Hypothesis eight states that the predictor variables (mathematics attitudes, computer attitudes, mathematics attitudes, computer ownership, proficiency in language of instruction, and learning styles) will contribute a significant portion of the variance in the achievements of the students enrolled in a pre-calculus algebra course supplemented with a computer lab program. Multiple regression analysis was used to investigate this hypothesis. Several models were built to gather insight on the joint and individual contribution of the independent variables. One full model that comprised of all the independent variables and 6 restricted models were constructed. In the restricted models, one of the variables was missing. Each of the restricted models helped us to determine the contribution of each independent variable over and above others in the model. The result indicated that the full model, comprising all the independent variables, accounted for about 44% (R-square adjust = 31%) of the total variance of the students' achievements in pre-calculus algebra supplemented with a computer lab program. However, after removing only four cases of "outliers" (students who did very well in some courses and failed in others), the story became completely different. The new model accounted for more than 57% of students' achievements (R-Sq = 57.3%, R-Sq(adj) = 46.4%). In both cases, the factor with the highest coefficient is Activist (learning style) followed by English language proficiency and mathematics aptitude, respectively. However, as reported earlier, only the effects of English language proficiency and mathematics aptitudes were statistically significant. The two variables together accounted for more that 37% of the students' achievements. Although not all the variables play a significant role in the models. The models were all statistically significant at p = 0.05. Therefore, the results are in support of our hypothesis. A stepwise multiple regression approach was used to produce the maximum predictive power with a minimum number of variables. The only variables that survived here were: English language proficiency, mathematics aptitude, Activist learning style, and computer prior experience (4 -6 years only). A summary of the stepwise model is: p = 0.035, R-Sq = 41.2%, R-Sq(adj) = 36.85%.

6.3 Conclusions

Based on the findings of this study, the following conclusions are reached:

1. The achievements of students that participated in this experiment were above average when compared to all other students who took MATH 002 in the experimental semester (Spring, 2003 – 2004 academic session). Although our concern in this study is not making a comparison, the students' achievements indicated that a student can learn mathematics with a good computer-supplemented program without necessarily missing anything in the basic computational skills, on which all major exams were based.

2. The variables selected for this study emerged from the researcher's critical observation and intensive review of the literature. Not all the selected variables were found significantly predictive of academic success in this study. The predictive power varies. It was very low for mathematics attitude, computer ownership, computer attitude, and computer prior experience. Moderately low for some components of computer prior experience. However, it was moderate for mathematics aptitude, and moderately high for English language proficiency and Activist (learning style). As a result, five of the hypotheses were not supported by the findings in our study, while three were accepted beyond $p = .05$ level. The accepted hypotheses were those which claimed that mathematics aptitude, English language proficiency and the joint effect of all the independent variables have a significant positive relationship with the achievements of students enrolled in pre-calculus algebra supplemented with a computer-aided learning program.

3. English language proficiency was found to be the most statistically significant variable that highly correlated with students' achievements in this study. It accounted for about 13% of students' achievements in the regression model. Students classified as high English language proficient outperformed those classified as low English language proficient. The result corroborates many other studies in the area, and reemphasizes the significance of the language of instruction to students' comprehension and achievement in mathematics. The issue is more critical for bilingual students who are acquiring the language of instruction simultaneously

learning mathematics. The findings here do not in anyway contradict the conclusion of AL-Doghan (1985), where he found English language skills as a necessary but not sufficient variable for success at the KFUPM. It should be noted that this study was conducted at the preparatory year level. This is a year specifically meant for acquiring English as a new language of instruction. At this level, English was found to be a critical subject for students' progress (AL-Doghan, 1985). The results of the two studies, the present and that of Al-Doghan (1985) almost two decades apart, show the importance of English in students' achievements in the preparatory year at KFUPM in general, and in mathematics in particular.

4. In line with what was reported in both theoretical and empirical studies, this study also confirms that students' previous mathematics achievement is critical and has a high predictive power of students' achievements in the mathematics courses a student wishes to take in the future. To be more specific, our study concludes that students' achievements in MATH 001 were found to be strongly correlated with their achievement in MATH 002. Therefore, students' mathematics background is crucial, especially in a scientifically oriented university like KFUPM.

5. The findings of this study show that in predicting students' achievements previous mathematics grades is secondary to the students' level of proficiency in English language. This might be due to the fact that the participants are bilingual that are acquiring English. In any case, this is contrary to the high predictive power of the previous mathematics grades mostly reported in the literature (Begle, 1979). It was reported by AL-Doghan (1985) that an English skill was a very low or insignificant predictor of success for non-Saudi students compared to Saudis. However, the converse is the case in mathematics, where the predictive power of mathematics was found to be higher for non-Saudis as compared to Saudis. This is understandable since most of the non-Saudi students come from English medium schools and therefore, face no English language problem at KFUPM. On the other hand, Saudis come with mathematics background based on Arabic medium of instruction.

6. Although no significant difference in achievement was found among different learning styles, the significant contribution of the Activist (among the learning styles) in the general regression model indicates that learning style is a factor to to

be taking seriously. The performance of the Activist above all others is not surprising as they are characterized as open-minded, non skeptical and enthusiastic about anything new. Therefore, students with learning styles who are not opposed to new things and are open-minded are likely to benefit more by learning mathematics in a computer aided learning environment.

7. None of the factors related to attitudes (computer attitudes and mathematics attitudes) has shown any significant positive relationship to students' achievements. The result of the study also indicated that the participants had a positive attitude towards both mathematics and computers. The participants in this study were mostly in the 90 percentile of the Saudi Arabian high school graduates with science backgrounds, and therefore, were high achievers in their high school studies. So they were expected to have a high positive attitude towards mathematics and to be highly curious towards innovations like computers. The conclusion we draw from this is that for prediction purposes, attitudinal issues are of less relevance to a class of homogeneous students like the participants in this study. It might be more relevant to a heterogeneous class of students whose attitudes usually vary significantly.

8. The initial assumption was that students with personal computers will have more time to engage with mathematics problem solving and possibly gain more knowledge compared to those who do no have a personal computer. However, it appears that computer ownership correlates with students' achievements possibly in the case where access to a computer is difficult or most of the students do not own computers. In the case where most of the students own personal computers or computer labs are available to all students most of the time, then the effect of computer ownership might not be visible in students' achievements.

9. Most students have been using a computer either in their high school or at home, on average, for more than 3 years. This supports the claim that more students are coming to university these days fully or partially familiar with computers. As a result, supplementing the classroom with well tailored computer programs will not add any burden to the students; rather, it will provide them with an alternative way of solving problems, which will widen their mathematical horizon. Furthermore, the finding might be useful to other departments such as information and computer

sciences, management and information systems, etc. The knowledge that many students are coming with many years of computer experience will help them to streamline their programs accordingly.

10. The strong correlation found in this study among the preparatory year program courses (MATH 001, ENGL 001 and MATH 002) at King Fahd University of Petroleum & Minerals is an indication of the strength and connectivity of the program. This means that there is a need for more coordination and collaboration between the seemingly separate entities in the program for better students' performance.

6.4 Limitations of the Study

Some of the limitations of this study are detailed below:

1. The surveys selected by the researcher focused on the variables perceived by the researcher as significant to the study and were mostly based on the literature review. There are many other cognitive and non-cognitive students' variables that were not included in this study.

2. The samples of this study were the preparatory year students. These are bilingual students who have just completed high school but have not yet started their degree program due to a deficiency in the language of instruction. Different finding might result if the participants are English native speakers or if they have strong background in English.

3. The participants in the study were male and of Arab origin. The cultural diversity of the participants makes them have a difference worldview, and this might be reflected in the survey.

4. Success in mathematics is measured as a pass rate at the end of the experimental semester. No pre or post-test scores were analyzed for mathematics achievement or a change in knowledge level. Similarly, the major exams were based on the traditional way with only quizzes done with MATLAB.

5. The study is limited to the interpretation and conclusions drawn for a particular course in a particular cultural environment, and so cannot be generalized to other mathematics courses or other cultures.

6.5 Recommendations for Educational Implementation

Based on the findings of this research, as well as those of other prediction studies, the following recommendations are made for mathematics educators, administrators and courseware developers.

1. Science and engineering courses are gradually but surely becoming inseparable from technological developments. The students in technological institutions are in great need of early exposure to the power of technology in learning and solving mathematical problems Therefore, sciences and engineering universities should incorporate and expose their students to these technologies as early as possible. This is popularly known as 'catch them young'. This will make the students learn mathematics by active involvement with mathematical models using various software packages. In addition, it will allow them to tackle a wider range of mathematical problems from a different angle, consequently widening their mathematical horizon and enhancing their mathematical learning. However, technology should not be left to be an end in itself, but rather a means to an end.

2. Contrary to the thinking of skeptics about the use of technology in the teaching and learning of mathematics, students learning of mathematics with the aid of a computer, if carefully tailored and organized, will in no way endanger students' mathematical skills, understanding and achievement as is clearly shown in the findings of this study. Rather, such a program has all the potential of widening student's mathematical horizons.

3. For success of any computer based mathematics program, the teachers' attitudes towards the program is imperative. Mathematics teachers and professors should be made aware of the power of technology in the teaching and learning of mathematics. There is no way one can appreciate or participate positively in what he is not aware of or familiar with. Therefore, training programs should be organized to educate the

teachers to appreciate the difference that technology can make for them and their students during their teaching/learning process. In this regard, an intensive recommendation is given in Yushau (2004a).

4. As observed earlier by Yushau, Bokhari and Wessels (2004), the preparatory year mathematics courses at KFUPM have "witnessed a lot of metamorphosis in a quest for optimizing the fourth hour" (p.166). With this observation, we can restate our claim that among all other options and strategies tried in the pass "the CAL program stands as a better option among all because of its flexibility and immediate feedback" (p.167). The researcher's current experience strengthens the above conclusion, especially for MATH 002 students with whom he worked with for two semesters, one during pilot study and the other during the real experimental semester. However, we agree that a slightly different program is needed for MATH 001, but this is not an appropriate forum to get into this discussion.

5. For bilingual students, especially those acquiring the language of instruction at the same time as learning mathematics, the language issue is very critical and should be given special attention and consideration during curriculum development and the teaching and learning processes.

6. For homogenous students (high achievers or low achievers), attitudinal variables should not be included in this kind of study. It appears that those factors do not contribute positively or negatively to the achievements of students of these classes. Also, these factors should not be given a priority while counseling or selecting students for any computer based mathematics learning programs.

7. Most of the students are now coming to university and colleges with computer knowledge and experience. As a result, computer prior experience may not be a critical variable in a computer based mathematics learning environment.

8. Students' mathematics background is very crucial in learning mathematics in a computer aided learning environment. Therefore, it should be assessed before involving students in a computer based education program.

9. Cognitive variables seem to dominate students' achievements even in the computer aided learning environment. Therefore, courseware developers should pay more

attention to that in their courseware design and development. In addition, counselors also should pay attention to that while counseling students on this issue.

10. Software developers and counselors should be aware of the linguistics and subject-specific backgrounds of their end-users while designing their courses or counseling their clients. Therefore, findings in this study may help them modify their programs to suit individual differences.

6.6 Recommendations for Further Research

The following are recommendations for further research:

1. The preparatory year program at King Fahd University of Petroleum and Minerals prepares over 1200 students every academic year for entrance into different specialties. What is most peculiar among these students is the fact that almost all of them are Arabs who come from an Arabic medium of instruction. On arrival at the preparatory year, the language of instruction changes to English. To the best of this researcher's knowledge no research has been done on the implication of this language switch on students' understanding and achievement in mathematics. The researcher strongly believes that research in this direction will guide such institutions in many ways: curriculum review, instructional design, etc. Nevertheless, to get an informed and reliable result, the study should be longitudinal so that solid data can be collected for long time plan.

2. There seems to be a general complaint about the students' mathematics background. However, very little is known about what the students are coming to the preparatory year with in terms of mathematics background. Similarly, very little is known about what the preparatory year is actually preparing students with in terms of mathematics skills for various programs. Research is needed to ascertain the students' background on arrival as well as the contribution of the preparatory year mathematics program while departing. For instance, the basic knowledge of students can be assessed on arrival and after the preparatory year program. This can help in knowing approximately the contribution of the preparatory year mathematics program to students' mathematical knowledge. Also, the relationship between

preparatory year programs and first year achievement can also be explored in a similar manner. This will go a long way in providing data that can assist in the evaluation of the program, curriculum adjustment and detecting students' weakness and strengths.

3. As earlier observed, there seems to be a good correlation between various preparatory year programs. Therefore, research is needed to investigate the relationship between all the programs for the purpose of proposing a more holistic preparatory year program.

4. Learning styles describe the manner in which students receive and transform knowledge. KFUPM is a specialized university in the sense that all students that come to the university do so with the intention of studying engineering related courses. It is assumed that this class of students has a similar learning style. Therefore, comprehensive knowledge of student learning styles will help in counseling students or even in the selection process. For instance, the university is showing a lot of concern pertaining to the large percentage of students on probation. It might be possible that students of this class have a learning style that is not compatible with the program they are involved in.

5. This study might be replicated using a larger sample in order to verify the results. Other factors like high school achievement and entrance exam results might be included to reveal their roles in student success at the preparatory year level.

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APPENDICES

Appendix I: Students' Lab Manual Used for the study

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

COLLEGE OF SCIENCES
DEPARTMENT OF MATHEMATICAL SCIENCES
PREP-YEAR MATH PROGRAM

MATH 002

CAL MANUAL

Using

MATLAB
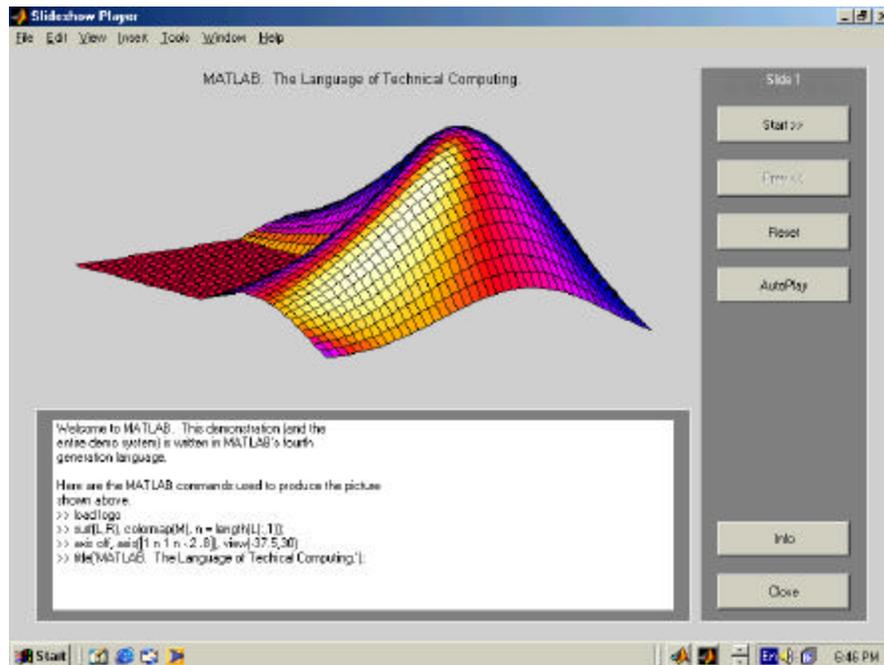
BY

Balarabe Yushau

Yaqoub Shehadeh

Mohammad Awad

TABLE OF CONTENTS

<div align="center">**Module 1**</div>

<div align="center"># Introduction To MATLAB</div>

This module will introduce you to a very powerful software called MATLAB. It is a very important tool for your future professional growth. In particular, the knowledge of this software will be of great help to you at whatever major you choose. MATLAB can do much more than you think, however, you will be introduced here only to the basic operations of the MATLAB. We encourage you to use your valuable time to explore more on the world of MATLAB at your free time. It is our hope that by the time you go through this module, you will be able to:

- login to MATLAB
- open a new work sheet (M-file)
- save your work sheet
- understand the MATLAB worksheet
- perform basic algebraic operations with MATLAB.

1.1 How to logon: We assume that you have attended many CAL classes in Math 001. In the same way you can log into MATLAB using the following steps:

- **Start** menu
- **Program**
- **MATLAB** (Click on it).

On clicking **MATLAB,** you will be prompted with a new window with the sign '>>', meaning that you are now in the MATLAB interactive **command mode.** On the MATLAB interactive command mode, you can type whatever you want MATLAB to do for you. If you write the commands correctly, the answer is ready by just pressing the **Enter** key.

1.2 Command line DEMOS: For instance, if you type **demo** in the command line,

\>>demo

a new window will appear
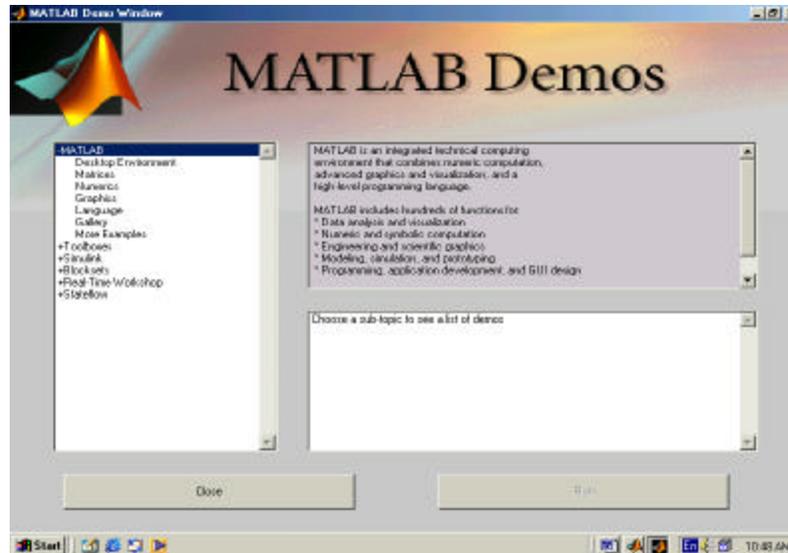
You can choose any topic of your choice to view how problems are solved on that topic using MATLAB. You are all encouraged to explore these demonstrations.

1.3 <u>Command line HELP</u>: If you need any help on any topic in MATLAB just type help in the command line and press enter. Example:

>> help

And immediately MATLAB will display all the help topics:

HELP topics:

MATLAB\general   - General purpose commands.

MATLAB\elmat   - Elementary matrices and matrix manipulation.

MATLAB\elfun   - Elementary math functions.

MATLAB\specfun   - Specialized math functions.

MATLAB\matfun   - Matrix functions – numerical linear algebra

If you know exactly the topic you are looking for help, you can type it in the command line directly (for instance, on elementary matrices and matrix manipulation, type *elmat*).

>> help elmat

Then MATLAB will display to you all the help topics on elementary matrices and matrix manipulation. Try a topic of your choice!

1.4 <u>MATLAB as Calculator:</u> I am sure you know how to use a calculator very well, so whatever you do with calculator, MATLAB can equally do the same and much more. For instance, the following notations are used in the MATLAB basic arithmetic operations;

Operation	Meaning
+	Addition
-	Subtraction
*	Multiplication
/	Division
^	Power or Exponent
.^	Element –by-element exponentiation
sqrt	Square root
abs	Absolute value

All these operations can be used with bracket '()'. Therefore, the **order of operations** we learnt in math 001 is very much relevant here.

Example: Use MATLAB to do the following:

a) $\sqrt{12} - 3(2+1) \div 2$

b) $2^4 + 16 \div 8 \times 3 - (5+1)$

c) $\left| -5 \right| - \left| -3 \right|$

In the command line, you will write:

(a) >>sqrt(12)-3*(2+1)/2

(b) >>2^4+16/8*3-(5+1)

(c) >>abs(-5)-abs(-3)

The moment you hit the **Enter** key, automatically MATLAB will give you the answer.

Note: *You must note the **order of operations** very well. As a reminder, they are listed below:*

1. *Quantities in brackets (starting with the inner most bracket)*
2. *Powers*

3. *Multiplication or division (from left to right)*
4. *Addition or Subtraction (from left to right)*

Thinking Corner: *Think about how did the MATLAB solve our previous examples. Write the order.*

Try these exercises using pencil and paper and check your answer using MATLAB.

$a)\ 64 \div 2^3 - 3^2 - (15 \div 5 \times 4 \div 2)$

$b)\ \dfrac{2}{3} + \dfrac{5}{3} \div \dfrac{5}{2} - \dfrac{3}{2}$

$c)\ \dfrac{9 \div (-5^2 + 5) \div (7 - 3^3)}{6 \div 3 - 2 + 0.04}$

Answers: a) -7,   b) -0.1667, and   c) 0.5625

1.5 <u>**How to Manage Your Worksheet:**</u> On top of the MATLAB interface window are the following:

1.5.1 *Menu bar:* This comprises of File, Edit, View, Web, Windows and Help

1.5.2 *Tool bar:* This comprises of things that are inside some of the items in the menu bar, but are used most frequently.

1.5.3 *How to create new M–File:* A new MATLAB sheet with extension '.m' is called M-file. To create M-File, choose:

- File menu
- *New*
- click on *M-file*

Then a new M-file worksheet is created.

However, *the symbol ">>" is NOT needed while working in M-file.*

1.5.4 *How to define a variable:* Variables names can contain up to 31 characters. Variable names must start with a letter, followed by any number of letters, digits or underscores. Punctuation characters (like, ?, %, and –(dash)) are not allowed.

Examples: xy3meet, func123, a5A4, m25b **are allowed**

           Best-buy, 5abc, %yui, @rihgt **are NOT allowed**

1.5.5 *How to Edit your worksheet:* Note that you cannot be able make major changes in the main MATLAB window. However, if you are in your worksheet (M-file) you can modify anything and be able to save the changes. Some basic editing commands in the main MATLAB window are as follows:

- **>> clear** means delete all variable
- **>>clear a b** means delete just variables *a* and *b*.
- **>>who** means show me all the variables.
- **>>clg** means clear last graph

1.5.6 *The use of some special Characters:* The following special characters are used in MATLAB:

Symbol	Usage
[ ]	Used to form vectors and matrices
( )	Used in the arithmetic operations
;	For end rows, and for suppressing printing
:	For subscripting and vector generation
,	Print the expression
%	Used for comment

1.5.7 *How to save your work:* After finishing your work and wish to save it somewhere, for instance in the floppy disk choose:

- **File,**
- **Save as** (give your file a suitable name)

Note (1) The **name of a file should not start with number,** and

(2) *You can only save your work if you are working in M-file*.

Exponential and Logarithmic Functions
and Their Graphs

Objectives:

If you go through this module carefully, you will be able to:

- evaluate exponential and logarithmic functions numerically using MATLAB,

- plot different types of exponential and logarithmic functions using MATLAB,

- use graphs to determine the zeros of exponential and logarithmic equations.

2.1 MATLAB Commands:

The following are some of the MATLAB commands that you need for the above objectives:

MATLAB command	Usage
inline	to define a function
plot	to graph a function
title	for a title of a graph
grid	for lines in the x and y axes
log10(x)	common logarithm of x
log(x)	natural logarithm 'ln' of x
ginput	to trace any point in a graph by mouse

2.2 Examples:

Example #1 Given that $f(x) = 3^x$ and $g(x) = e^x$. Evaluate each of the following:

$a) f(\boldsymbol{p}) \quad b) f[g(3)] \quad c) g(-\sqrt{15})$

Note: To obtain the answers for the above questions, follow the following steps carefully, as you will be using that in many other examples and exercises):

   Step 1: Open a new M-File (Go to the file menu, click New, then choose M-file)

   Step 2: Type in the following MATLAB commands in the new window:

   f=inline('3^x');

   g=inline('exp(x)');

The semicolon tells MATLAB to evaluate, but not to show the answer

f(pi)

f(g(3))

g(-sqrt(15))

Step 3: Then save your file with a name of your choice.

Now you have many ways to view your answers. Two of these ways are:

1. Go to the Debug menu, click on Run. Then go to the main MATLAB window to see your results.
2. Go to main MATLAB page, in the command prompt, write the name of the file and press Enter. You will get:

***Answer**: a) 31.5443,   b) 3.8303e+009,   and c) 0.0208*

Example #2 *Suppose that* $x = e^{2.1}$ *and* $y = \sqrt{3}^{\sqrt{2}}$, *then evaluate the following:*

a) $x^2 y$

b) $\dfrac{\sqrt{y}}{x}$

c) $(2x - y)^3$

Solution: (Follow the three steps of example 1)

x=exp(2.1);

y=(sqrt(3))^sqrt(2);

(x^2)*y

sqrt(y)/x

(2*x-y)^3

Answers : a) 145.0149,   b) 0.1806, and   (c) 2.8378e +003

## 2.3 How To Sketch Graphs Using MATLAB:

Example #3 Sketch the graph of $f(x) = 2^{-x} + 1$

Solution: (Follow the three steps of example 1)

x=-4:0.01:4;   %(starting point : increment : end point)

f=inline('2.^(-x)+1');
plot(x,f(x))
grid
title('Graph of $f(x)$')
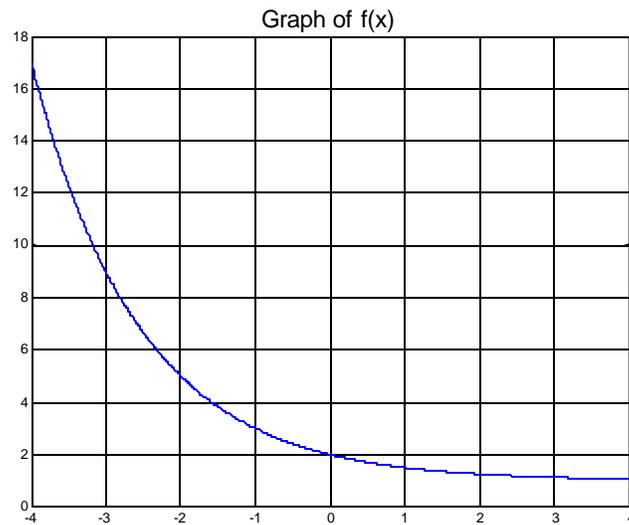
Graph of f(x)

Example #4 Graph $f(x) = -\log_2(5-3x)+3$

Solution: (Follow the three steps of example 1)

x=-10:.01:5/3;

f=inline('-log2(5-3*x)+3')

plot(x,f(x))

title('The graph of f(x)=-log2(5-3x)+3');

grid
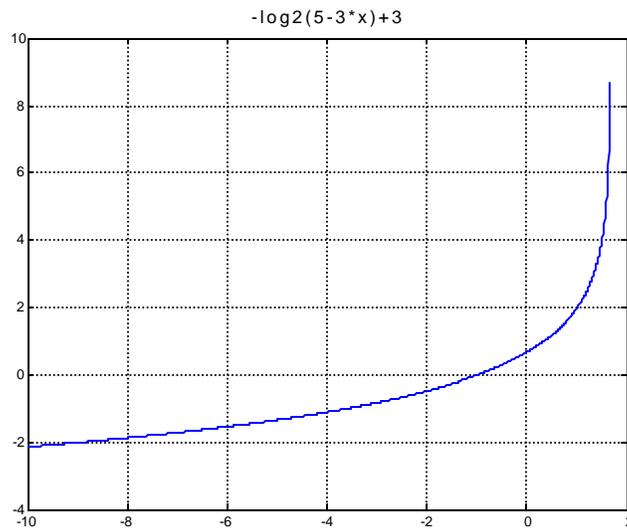
Example #5 Use MATLAB to determine the approximate zero of $f(x) = 2x - 2^x + 2$
to nearest hundredth.

Solution: (Follow the three steps of example 1)

x=-4:.01:4;

f=inline('2*x-2.^(x)+2');

plot(x,f(x))

grid

title('Graph of f (x) = 2x - 2^x + 2')

x=ginput(2)

Note: Using the graph below, we can get the approximate zeros by clicking on the x-intercept of the graph. With the help of the command "x=ginput(2)", MATLAB produces the x and y coordinates of the zeros.

```
   x          y
-0.6912    0.0029
 2.9954    0.0029
```

Answer: The approximate solutions are -0.6912 and 2.9954

Graph of $f(x) = 2x - 2^x + 2$
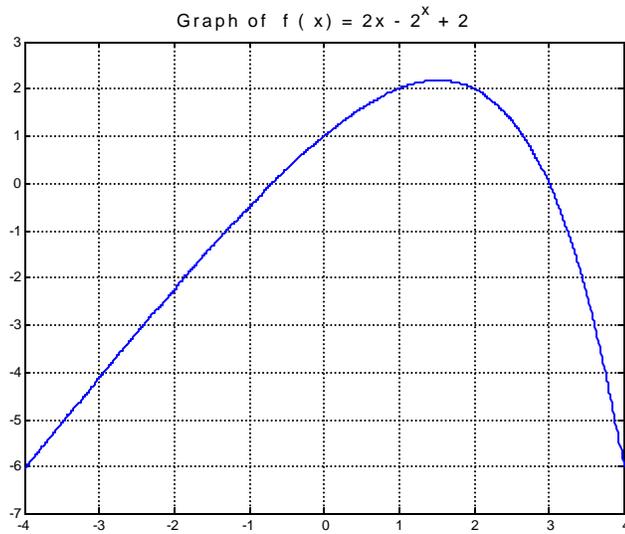
Example #6 Given the function $g(x) = \dfrac{\log x}{x}$

a) Sketch the graph of $g(x)$

b) Estimate the maximum value of $g(x)$.

c) What does $g(x)$ approach as $x \to \infty$?

Solution:

a) To sketch the graph, the following MATLAB commands are used.

```
x=0:1:200;                    %(for large x-value, like in this case, put increment =1)
g=inline('(log10(x))./x');
plot(x,g(x))
grid
title('The Graph of g(x)=(log10(x))/x')
```

Graph of g(x) =(log 10 (x))/ x)
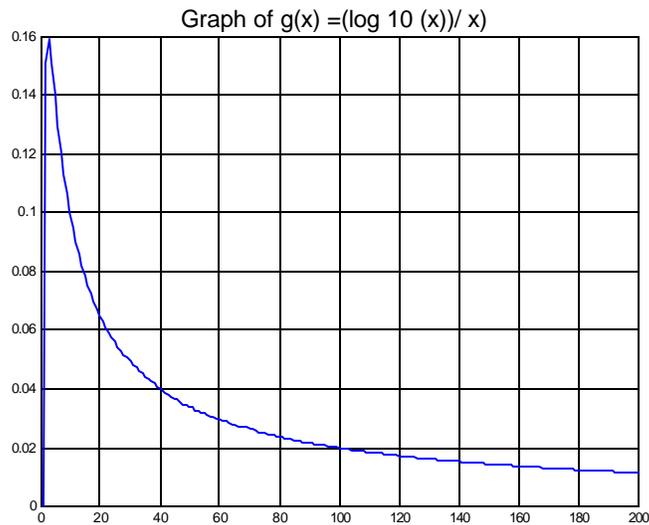
b) Using the graph, the approximate maximum value of the function is: 0.16.

c) As clearly shown in the graph, $g(x) \to 0, \ as \ x \to \infty$

Note: *If you need the exact value of the maximum, you can go to*

1. **Tool Menu**, *then select*
2. **Data Statistics**.

In the new window you will see the Maximum, Minimum, and other information about the graph.

2.4 Exercises:

Suppose that:

L_1 = **last one digit of your ID#,**
L_2 = **last two digits of your ID#, and**
L_3 = **last three digits of your ID#.**

(For example, if your ID# is 998765, then $L_1 = 5$, $L_2 = 65$, and $L_3 = 765$).

These symbols (L_1, L_2, and L_3) will be used in the exercises of all modules.

1. Use MATLAB to determine the zero(s) of $f(x) = \left(\dfrac{1}{2}\right)^{-x} - x - \dfrac{L_2}{L_1}$.

2. Given the function $g(x) = (L_2)x^{x-L_1}$.
   a. Sketch the graph of g
   b. Estimate the minimum value of g
   c. What does g approach as $x \to \infty$?

3. Graph $f(x) = (x - L_1)\log(x - L_1)$. Is $x = L_1$ a vertical asymptote? What is the minimum value of the function?

4. Sketch the graphs of the following:

Module 3

Exponential and Logarithmic Equations

<u>Objectives</u>:

By the end of this module, you will be able to gather more insight on the graph of exponential and logarithmic functions. We shall also see how to plot two graphs in the same plane.

3.1 <u>MATLAB Commands</u>:

In addition to the MATLAB commands that we learnt in our previous modules we have the following:

MATLAB Command	Usage
Legend	to differentiate between graphs

fzero(f,1.2)	to find the zero of f near 1.2
xlabel	for naming the x-axis
ylabel	for naming the y-axis

3.2 <u>Examples:</u>

Example #1 Graph $f(x) = -\log_3(x+4)^2$

Note: *MATLAB recognizes logarithms to base '10', base '2' and to base 'e'. Now to be able to draw the graph of the function in question (base 3), you must recall the change of base rule. It states:* $\log_a b = \dfrac{\log_c b}{\log_c a}$

Solution: **The process is the same as in our last module.**

x=-9:.01:1;

f=inline('-log((x+4).^2)/log(3)');   %(using change of base rule)

plot(x,f(x)), grid, xlabel('x'),ylabel('f(x)')

title('The graph of f(x)=-log3(x+4)^2')
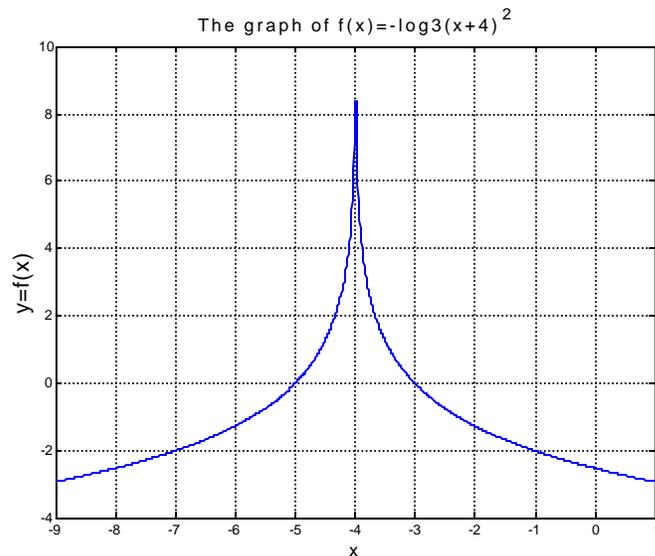
Example #2 *Use MATLAB to approximate the solution of the equation*

$2\log_3(2-3x) = 2x-1$ *by graphing techniques.*

Note: *In this case, we will graph each side of the equation as a separate function, where the intersection of the two graphs gives the solution.*

Solution :

x=-5:.01:2/3;

g=inline('2*log(2-3*x)/log(3)');

f=inline('2*x-1');

plot(x,g(x),'-',x,f(x),'-')

grid, legend('f','g'),

title('The graph of 2log2(2-3x) and 2x-1')

x=ginput(1), xlabel('x'),ylabel('f(x), g(x)')
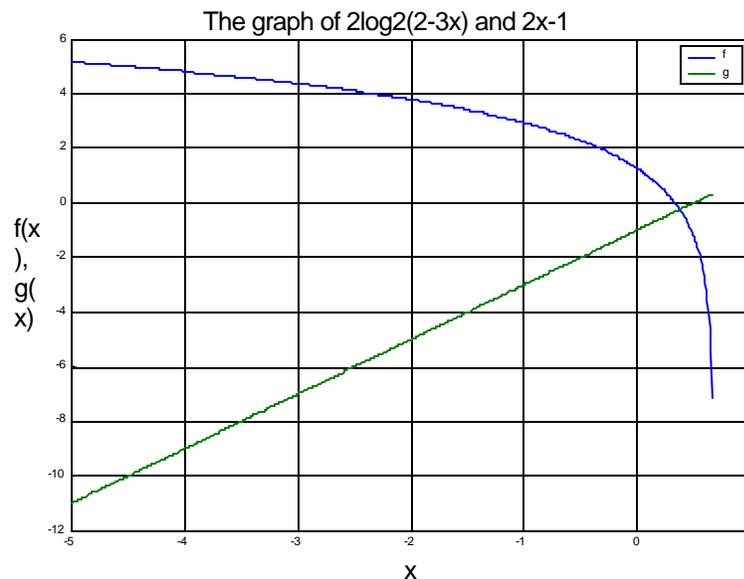
To illustrate the use of the MATLAB command "ginput" we can use the mouse and click at where the two graphs intersect. In the main MATLAB page we have (x, y) = (0.3848, -0.2368).

Answer: The approximate solution is x = 0.3848.

OR

Alternatively, to find the exact solution:

1. Use the equation $2\log_3(2-3x) - 2x + 1 = 0$

2. Type the following MATLAB commands,

>>f=inline('2*log(2-3*x)/log(3)-2*x+1')

>>fzero(f,.5)

Then the exact solution is 0.3758.

Example #3 **Use a MATLAB to approximate the solution of**

$\ln(8x+17) = \ln(98x-30) + 3$

Solution:

x=0:0.001:20;

f=inline('log(18*x+7)');

g=inline('log(98*x-30)+3');

plot(x,f(x),'-',x,g(x),'-')

grid

title('The graph of ln(18x+7) & ln(98x-30)+3')

legend('f','g')

xlabel('x'), ylabel('f(x), g(x)')

x=ginput(1)

> You can make the length of the interval small to make the intersection clear

The graph of ln(18x+7) & ln(98x-30)+3
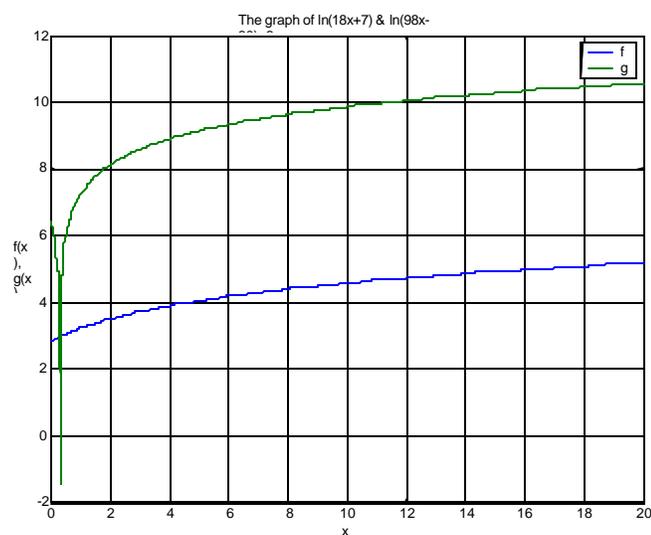
Answer: The solution is $x = 0.3159$

3.3 <u>Exercises:</u>

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Use a MATLAB Graph $g(x) = \left\| \log_{L_1} \left| 2x - L_2 + 50 \right| \right\|$

2. *Use a MATLAB to approximate the solution of the equation.*

   a) $2^{x+1} = x^2 - L_1$

   b) $\ln(2x+4) + \dfrac{1}{2}x = L_1$

   c) $\dfrac{e^x - e^{-x}}{2} = L_2 - L_1$

   d) $\log(5x-1) = 2 + L_1 + \log(x-2)$

3. If $M = \log_{\frac{1}{3}}\left(\dfrac{9^{-4}}{3}\right)$, $N = 4^{\frac{\log(2+L_1)^2}{\log 2}}$ Use MATLAB to evaluate

   a) $M + N$

   b) $M - N$

   c) MN^2

   d) $\dfrac{\sqrt{N}}{M}$

Module 4

Angles and Arcs

Objectives:

By the end of this module, you will be able to convert degrees to radians and radians to degrees using MATLAB. You will be also able to evaluate Trigonometric functions using MATLAB**.**

Note*: MATLAB recognizes radian measure for angles. Therefore, to evaluate any trigonometric function, we must first convert the angle measure to radians.*

4.1 MATLAB commands:

The following MATLAB commands will be used to evaluate trigonometric functions, and to convert angles into different measures.

MATLAB command	Usage
sin(x)	To evaluate the sine function of angle x
cos(x)	To evaluate the cosine function of angle x
tan(x)	To evaluate the tangent function of angle x
cot(x)	To evaluate the cotangent function of angle x
sec(x)	To evaluate the secant function of angle x
csc(x)	To evaluate the cosecant function of angle x
rat2deg(x)	radian measure degree measure
deg2rad	degree measure radian measure
deg2dms	degree measure DMS measure
dms2rad	DMS measure degree radian
dms2deg	DMS measure degree measure

4.2 Examples:

Example #1 Use MATLAB to convert the angle $224.282°$ to radian measure:

Solution:

The following two ways can be used here:

Method #1   >> deg2rad(224.282)

Method #2   >> 224.282***pi/180**

Answer: 3.9145

Example #2 Use MATLAB to convert $19°12'18''$ to degree decimal measure.

Solution

The following two ways can be used here:

Method #1   >> dms2deg(19,12,18)

Method #2   >> deg_min=12/60;

                   >>deg_sec=18/(60*60);

                   >>degree_decimal_measure=19+deg_min+deg_sec

degree_decimal_measure = 19.2050

Example #3 Use MATLAB to evaluate the following.

$a)$ $\sin 17°$ $b)$ $\sec \dfrac{3p}{7}$ $c)$ $\tan 8.2$

Solution:

>> sin(17*pi/180)

>> sec(3*pi/7)

>> tan(8.2)

Answers: a) 0.2924 b) 4.4940 c) -2.7737.

Example # 4 Find the length of an arc that subtends a central angle of 555 degrees in a circle of area 107 square meters.

Solution:

area=107

radius=sqrt(area/pi)

theta=555*pi/180

arc_length=radius*theta

Answer: arc_length = 56.5311

Example #5 Suppose that each tire on a car has a radius of 15 inches, and the tires are rotating at 500 revolutions per minute. Find the speed of the automobile to the nearest mile per hour.

Solution:

w=500*2*pi*60;   % (angular speed radian per hour)

r=15/(12*5280);   % (radius in mile)

v=r*w   % (linear speed)

Answer: The speed of the automobile is 44.6249 mph.

4.3 Exercises:

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Use MATLAB to convert $(L_2 + 5L_1 + 0.012L_3)^\circ$ to DMS.

2. Use MATLAB to convert $(3 + 5L_2)^\circ (7 + L_1)' (15 + L_1)''$ to degree decimal measure.

3. Evaluate the following using MATLAB

$a)$ $\cot(L_2 + 55L_1)^\circ$

$b)$ $\csc \dfrac{p(2 + L_1)}{11 + L_2}$

$c)$ $\sin(L_2 + L_1)^\circ + \cos^2(L_2 + L_1)^\circ$

4. Let $q = \dfrac{p(L_2 - 3L_1)}{29}$, then find x and y if $w(q) = p(x, y)$.

5. From a point 5(2+L_1) meters from the base of a tree, the angle of elevation to the top   of the tree is $(L_2 + 0.05L_3)°$. Find the height of the tree.

Module 5

Graphs of Trigonometric function

Objectives:

By the end of this module, you will be able to plot the graphs of trigonometric functions and related topics. Your knowledge of the previous module is very much relevant.

**Note** *that all the MATLAB commands we learnt before can be applied here.*

5.1 Examples:

**Example #1** Use MATLAB to graph the following functions:

$a) f(x) = \cos^2 x$ $\qquad\qquad$ $b) g(x) = \dfrac{1}{2}x \sin x$

$c) h(x) = -x + \cos x$ $\qquad\qquad$ $d) r(x) = \tan|x|$

$e) k(x) = (x+5)\sin\left(0.35x + \dfrac{P}{2}\right)$

Solution:

a)   x=-6:.01:6;
          f=inline('cos(x).^2');
          plot(x,f(x))
          grid, xlabel('x'),ylabel('f(x)')
          title('Graph of f(x)=cos^2(x)')

Graph of f(x)=cos²(x)
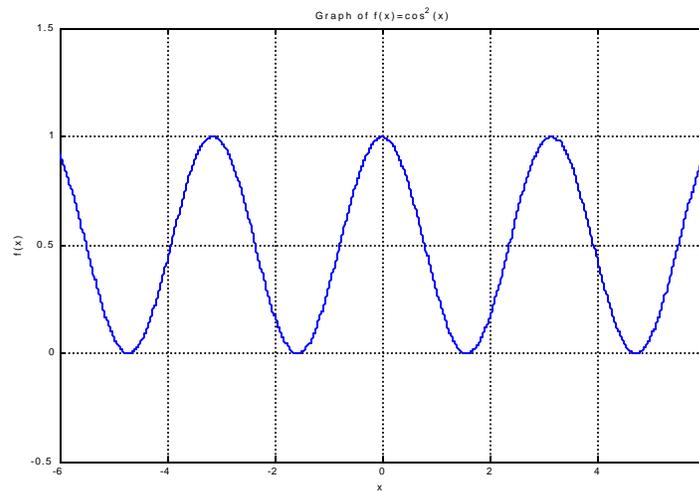
b)   x=-1:.01:20;

g=inline('1/2.*x.*sin(x)');

plot(x,g(x))

grid, xlabel('x') , ylabel('g(x)')

title('The graph of g(x)=(1/2)(x)sin(x)')

g(x)=(1/2)(x)sin(x)
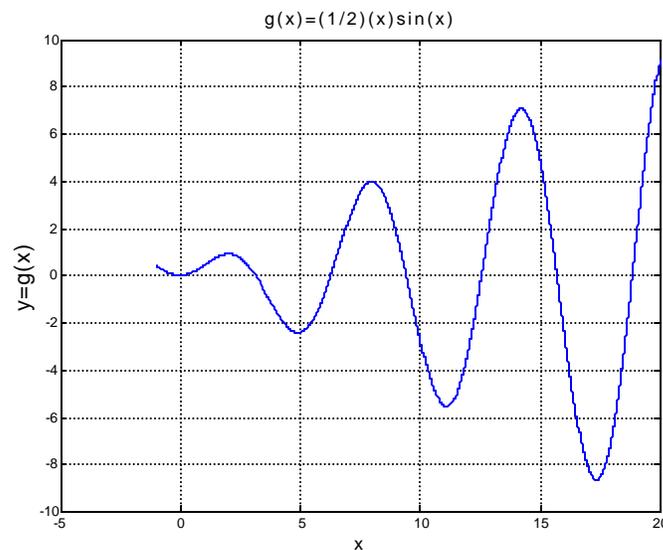
c)   x =-1:.01:20;

h=inline('-x+cos(x)');

plot(x,h(x))

grid , xlabel('x') , ylabel('h(x)')

title('The graph of h(x)=-x+cosx')

h(x)=-x+cosx
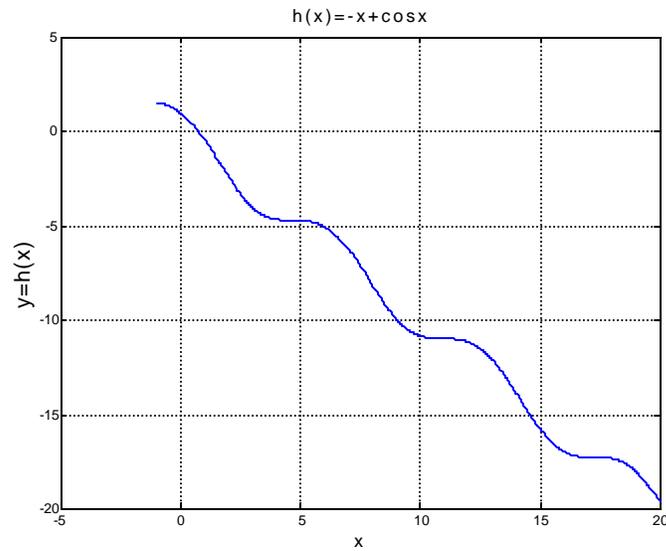
Note *that the functions in example 1(b) and 1(c) are not periodic.*

d)   x=-1.5*pi:.01:1.5*pi;

            r=inline('tan(abs(x))');

            plot(x,r(x))

             grid , xlabel('x') , ylabel('r(x)')

            title('The graph of r(x)=tan|x|')

r(x)=tan|x|
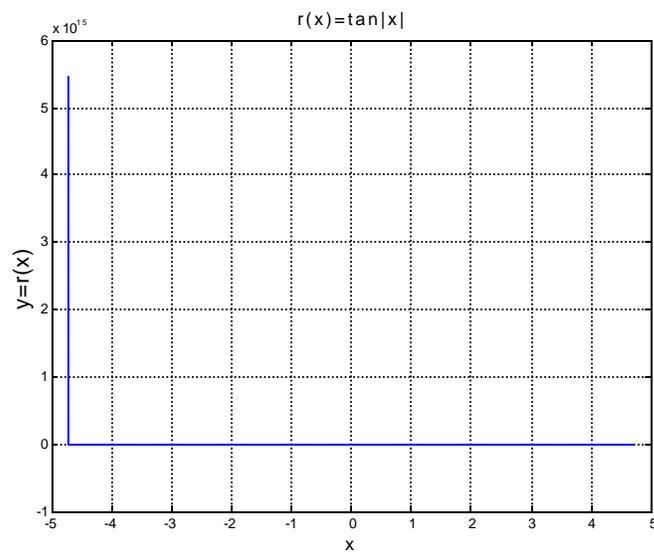
**Note:** *As you can see, the graph is not clear. To make it clear you have to change the range. To change the range:*

1. *Go to Edit Menu in the graph.*

2. *Click on Axis Properties*

3. *Change the range of y (example from -5 to 5)*

r(x)=tan|x|
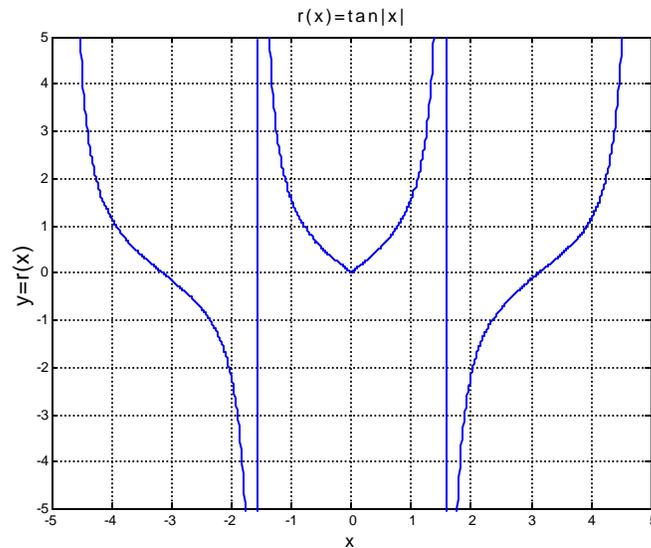
e)   x=-50:0.001:50;

f=inline('(x+5).*sin(0.35*x+pi/2)')

plot(x,f(x))

grid , xlabel('x') , ylabel('k(x)')

title('The graph of k(x)=(x+5)sin(0.35x+pi/2)')

$k(x)=(x+5)\sin(0.35x+pi/2)$
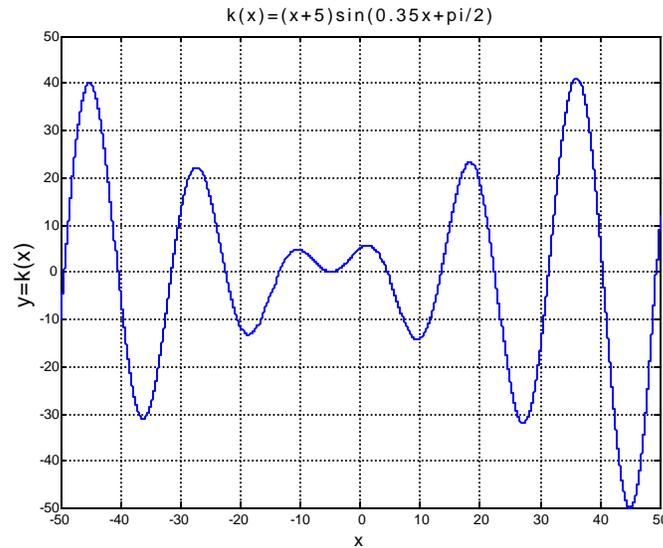
5.2 Exercises:

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Use MATLAB to graph the following functions.

$a)\ y = -L_1 x \cos L_2 x$

$b)\ y = (x + L_2)\sin\left(L_1 x + \dfrac{p}{2}\right)$

$c)\ y = \dfrac{\sin L_2 x}{L_2 x}$

$d)\ y = (2 + L_1)\sin x - \cos(2 + L_2) x$

2. Use MATLAB to graph the following functions.

$a)\ y = \dfrac{2}{1 + L_1}\sin\left(\dfrac{pL_2}{2} - \dfrac{4x}{3 + L_1}\right) - L_1$

$b)\ y = 3\tan\left((3 + L_1)px - 3\right) - 2 + L_1$

$c)\ y = \left| -\dfrac{20}{L_1 - 12}\sec\left(\dfrac{x}{3 + L_1} - \dfrac{p}{4 + L_1}\right) \right|$

3. Graph $y = (-2 + L_1)e^{\cos x}$. What are the maximum and the minimum value of y ?

4. Graph $y = (2 + L_1)^{\sin x}$. What are the maximum and the minimum value of y ?

Trigonometric Functions
(Evaluations and Equations)

<u>Objectives</u>:

By the end of this module, you are expected to be able to:

- graphically identify an equation that is Identity using MATLAB
- find solution of trigonometric equations using MATLAB.
- evaluate some trigonometric expressions.

6.1 <u>MATLAB commands</u>: The MATLAB commands of the inverse trigonometric functions are summarized in the following table:

MATLAB command	Function
asin(x)	$y = \sin^{-1} x = \arcsin x$
acos(x)	$y = \cos^{-1} x = \arccos x$
atan(x)	$y = \tan^{-1} x = \arctan x$
acot(x)	$y = \cot^{-1} x = \text{arccot } x$
asec(x)	$y = \sec^{-1} x = \text{arcsec } x$
acsc(x)	$y = \csc^{-1} x = \text{arccsc } x$

6.2 <u>Examples</u>

Example # 1 Use MATLAB to evaluate the following:

$$a)\ \cos 100^\circ \sin 40^\circ + \sin 100^\circ \sin(-50)^\circ$$

$$b)\ \frac{\tan {}^{5}\!p\!\!\!/\!\!_{8}}{3 - 3\tan^{2} {}^{5}\!p\!\!\!/\!\!_{8}}$$

$$c)\ \frac{\cot(-55)^\circ - \cot 80^\circ}{1 + \cot(-55)^\circ \cot 80^\circ}$$

Answers: a) -0.866,   b) 0.167, and c) -1

Example # 2 Find the exact value of the given expression.

$a)\ \cos\left(\sin^{-1}(-\tfrac{6}{23})\right)$

$b)\ \tan^{-1}\left(\cos\tfrac{\pi}{5}\right)$

$c)\ \sin\left(\cos^{-1}3\right)$

Solution

>> cos(asin(-6/23))

>> atan(cos(pi/5))

>>sin(acos3)

Answers: a) 0.9654,   b) 0.6802,   and   c) Undefined

Example # 3 Use MATLAB to verify which of the following is an identity:

$a)\ \sin2x = 2\cos x\sin x$

$b)\ \sin7x\cos2x - \cos7x\sin2x = \sin5x$

$c)\ \sin2x = 2\sin x$

Solution: One of the methods to verify whether an equation is an identity is by graphing techniques. Now, we graph each side of the equation on the same axes. If the two graphs coincide, then the equation is an identity. Otherwise, it is not.

a)   x=-pi:.001:pi;

f=inline('sin(2.*x)'); g=inline('2*sin(x).*cos(x)');

plot(x,f(x),'b+',x,g(x),'r-')

grid, legend('f+','g-'), xlabel('x'), ylabel('f(x), g(x)')

title('The graph of sin2x & 2cosxsinx'))

The graph of sin2x & 2cosxsinx
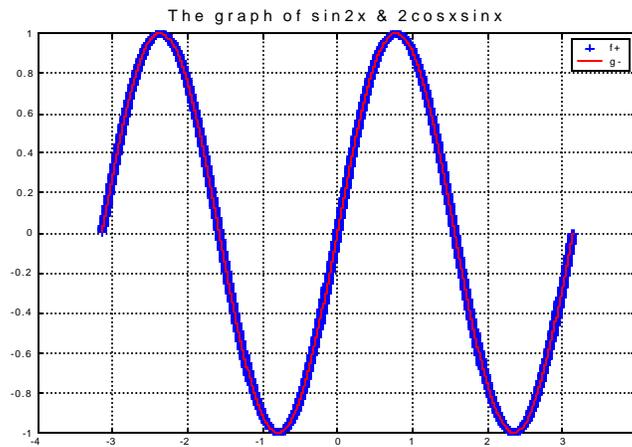
*Since both graphs coincide, then the equation is an Identity.*

b)   x=-pi:.001:pi;

f=inline('sin(7*x).*cos(2*x)-cos(7*x).*sin(2*x)');

g=inline('sin(5*x)');

plot(x,f(x),'go',x,g(x),'b:')

grid,legend('fo','g:'),xlabel('x'),ylabel('f(x), g(x)')

title('The graph of sin7xcos2x-cos7xsin2x & sin5x')

The graph of sin7xcos2x-cos7xsin2x & sin5x
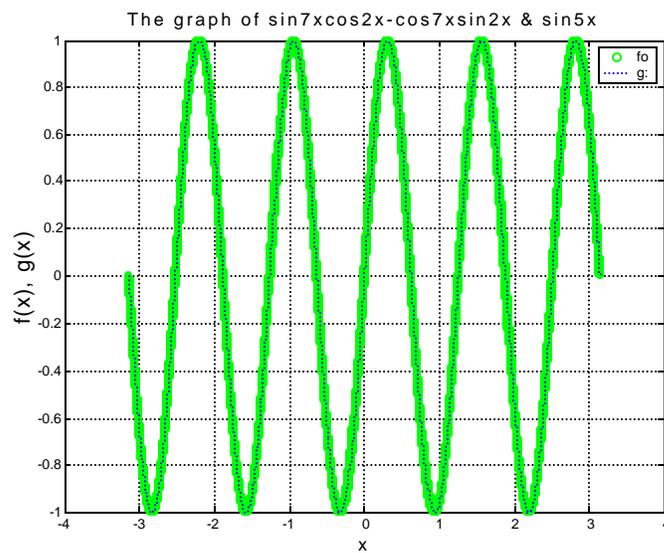
Since both graphs coincide, then the equation is an Identity.

c)   x=-pi:.001:pi;

        f=inline('sin(2.*x)'); g=inline('2*sin(x)');

        plot(x,f(x),'b+',x,g(x),'r-')

        grid,legend('f+','g-'),xlabel('x'),ylabel('f(x), g(x)')

        title('The graph of sin2x & 2sinx')
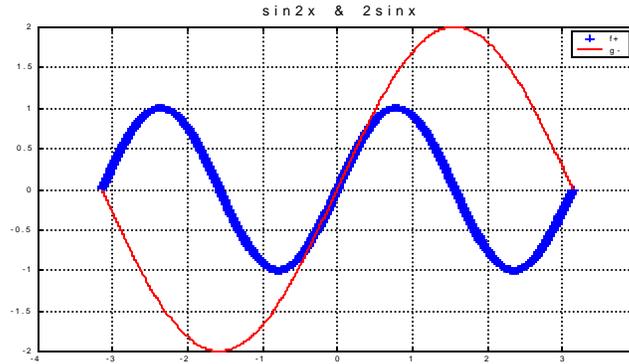
Since the two graphs are different, then the equation is NOT an Identity.

Example #4 Given $\cos A = -\dfrac{7}{25}$ in Quadrant III, and $\sin B = -\dfrac{12}{13}$ in Quadrant IV,

find

$a)\ \cos(A+B)$

$b)\ \sin\dfrac{A}{2}$

$c)\ \sin 2B$

$d)\ \tan\dfrac{A}{2}$

Solution:

A1=acos(-7/25);   %(A1 angle in Quadrant II)

Ar=pi-A1;   %(reference angle of A)

A=pi+Ar   %(angle in Quadranr III)

B=asin(-12/13)

a=cos(A+B)

b=sin(A/2)

c=sin(2*B)

d=tan(A/2)

Answers: a) -0.9938,   b) 0.8000,   c) -0.7101,   d) -1.333

Note *that for the previous example, you can also use the formulas of sum, difference, double, and half angles identities discussed in class. For instance, in Example 4(a):*

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

The MATLAB commands will be as follow:

cosA=-7/25;
sinA=-sqrt(1-(cosA)^2);
sinB=-12/13;
cosB=sqrt(1-(sinB)^2);
cosAplusB=cosA*cosB-sinA*sinB

Answer: cosAplusB = -0.9938

Remark: *For the next example, the method of finding zeros can be reviewed by referring to modules 3 (example 2 and exercise 2).*

Example #5 Use MATLAB to approximate the solution of the trigonometric equation.

$$3\cos^2 x + 5\cos x - 2 = 0, \quad 0 < x < 2\boldsymbol{p}$$

Solution

x=0:.001:2*pi;
f=inline('3*(cos(x)).^2+5*cos(x)-2');
plot(x,f(x)), xlabel('x'), ylabel('f(x)')
grid,x=ginput(2)
title('The graph of 3cos^2x + 5cosx - 2')

The graph is titled $3\cos^2 x + 5\cos x - 2$ with axes labeled x and $y=f(x)$.
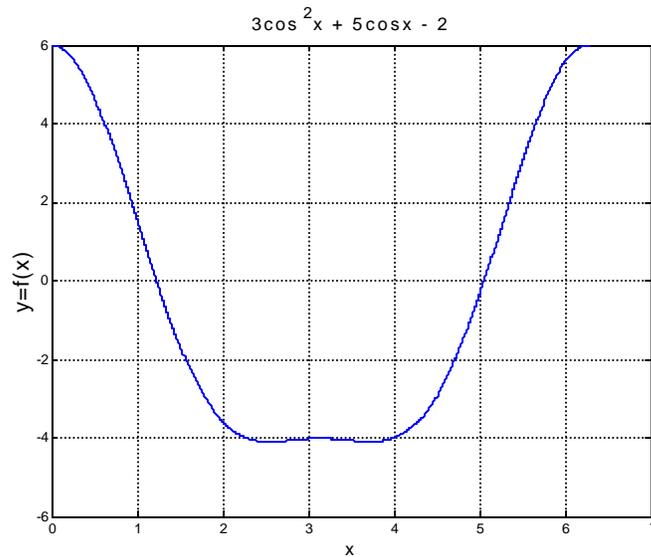
Answer: Using the mouse, the approximate solutions are: 1.2339   and 5.0565.

Note *that the above solutions are the x-intercepts of the graph*

         OR

To find the exact solutions, use the following MATLAB commands:

>>f=inline('3*(cos(x)).^2+5*cos(x)-2');

>> xzero=fzero(f,1)

>> xzero=fzero(f,5)

Therefore, the exact solutions are 1.2310 and   5.0522

Example #6 Use MATLAB to find the approximate and the exact solutions of the following equation

$$e^{\cos x} = 3^{\sin x}, \quad x \in [-6,6]$$

Solution:

x=-6:.01:6;

f=inline('exp(cos(x))-3.^sin(x)');   %(f(x)=exp(x)-3^(sinx))

plot(x,f(x))

grid, xlabel('x'), ylabel('f(x)')

title('The graph of f(x)')

x=ginput(4)
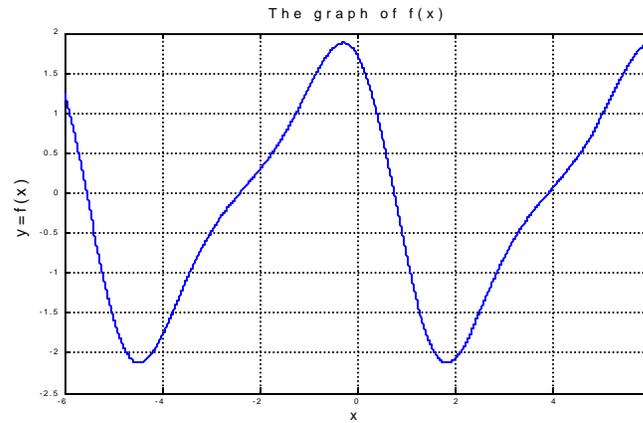
The graph of f(x)

OR

By drawing the two graphs separately in the same plane, we have:

x=-10:0.001:10;

f=inline('exp(cos(x))')   %(f(x)=exp(cos(x)))

g=inline('3.^(sin(x))')   %(g(x)=3^(sinx))

plot(x,f(x),x,g(x))

grid,x=ginput(4),xlabel('x'),ylabel('f(x), g(x)')

title('The graph of f(x) & g(x)')

The graph of f(x) & g(x)
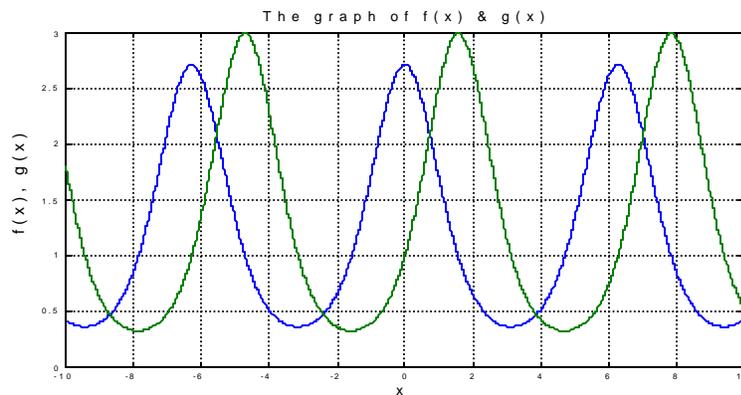
To find the exact solutions, use the following MATLAB commands:

>> f=inline('exp(cos(x))-3.^sin(x));

>> fzero(f,-5.5); fzero(f,-3); fzero(f,1); fzero(f,3)

Answers :

- From any of the two graphing techniques used above, using mouse, we can see that the approximate solutions are; -5.5069, -2.3733, 0.7604, and 3.8479

- The exact solutions are: -5.5447, -2.4031, 0.7384, and 3.8800

6.3 <u>Exercises:</u>

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Verify which of the following is an identity by two methods, using pencil and paper and MATLAB.

$a)\ 2\sin\dfrac{x}{2}\cos\dfrac{x}{2} = \sin x$

$b)\ \dfrac{\sin 2x}{1-\sin^2 x} = 2\cot x$

$c)\ \left(\cos\dfrac{x}{2} - \sin\dfrac{x}{2}\right)^2 = 1 + \sin x$

$d)\ \sin\left(\dfrac{p}{2} - x\right) = \cos x$

2. Approximate the solutions of the following equations using MATLAB

$a)\ 2\tan^2 x - \tan x + 2 - L_1 = 0, \qquad 0 \le x \le 2p$

$b)\ \sin 2x = \dfrac{3 + L_1}{x}, \qquad\qquad -4 \le x \le 4$

3. Find the exact value of the given expression.

$a)\ \cot^{-1}\left(\sin\dfrac{2p}{5 + L_1}\right)$

$b)\ \tan\left(\cos^{-1}\dfrac{1}{2 + L_1} + \tan^{-1}\dfrac{3p}{L_2}\right)$

$c)\ \cot\left(\sec^{-1}(L_2)\right)$

4. If $\sin A = \dfrac{-L_1 - 4}{5 + L_2}$, with A in quadrant III, and

$\cos B = \dfrac{-L_1 - 2}{6 + L_2}$ with B in quadrant III, find

$a)$ $\tan(A - B)$

$b)$ $\sin 2B$

$c)$ $\cos \dfrac{B}{2}$

$d)$ $\sin \dfrac{A}{2}$

Module 7

Vectors

Objectives:

If you follow this module carefully, by the end of it, in addition to knowing how to do some algebraic manipulations with vectors, you will be able also to find:

- magnitude of a vector
- the dot product of vectors
- angle between two vectors.
- x and y component of a vector
- the projection of one vector on another.

7.1 MATLAB Commands:

The following are the MATLAB commands for this module.

MATLAB Command	Usage
dot(u,v)	for dot product of u and v
norm(w)	for magnitude of the vector w
v(:,1)	horizontal component of v
v(:,2)	vertical component of v

7.2 Examples

Example #1 Let $v = i + 2j$ and $u = 4j + 3i$ be two vectors. Find

$a)\ \|v\|$

$b)\ v \cdot u$

$c)\ 2v + 3u$

$d)$ the scalar projection of u on

Solution:

v=[1 2];

u=[3 4];

mag_v=norm(v)

vdotu=dot(v,u)

2*v+3*u

proj = vdotu/mag_v   %(proj =(u.v)/||v||)

Answers: a) 2.2361,   b) 11,   c) 11 16,   and   d) 4.9193

Example #2 Given the vectors $v = -2i - 6\sqrt{3}\,j$, $u\langle -\sqrt{3}, -1 \rangle$

Find the magnitude and direction angle of the vector $\dfrac{v}{2} - \sqrt{3}u$

Solution:

v=[-2 -6*sqrt(3)];

u=[-sqrt(3) -1];

w=1/2*v-sqrt(3)*u;

mag_w=norm(w)

theta=atan(w(:,2)/w(:,1))   %($w(:,2)$ and $w(:,1)$ are the vertical and horizontal

                                    component of the vector w)

Answer:

Magnitude = 4, and direction angle is 300 degrees.

Example #3 Find the angle (in degrees) between the vectors $u = 3i - 2j$, $v = \langle -1, 7 \rangle$

Solution

u=[3 -2];

v=[-1 7];

d=dot(u,v);   % (dot product of u & v)

mag_v=norm(v);   % (magnitude of v)

mag_u=norm(u);   % (magnitude of u)

angle=acos(d/(nv*nu))   % (b=arccos(u.v/(||v||||u||)))

Alpha=rad2deg(angle)   % (Alpha is the angle between the vectors)

Answer: The angle is 131.8202 degrees.

7.3 Exercises:

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Given the vector $A = \langle -50 + L_2, 30 - L_1 \rangle$, find

a) the magnitude of A

b) the direction angle of A

c) a unit vector in the opposite direction of A.

2. Find the horizontal and vertical components of a vector v of magnitude $6(2 + L_1)$

and direction angle $\left(L_2 + 0.14L_3\right)^0$.

3. Let $u = (5 + L_1)i + (-33 + L_2)j, \quad v = \langle 41 - L_2, 3 + L_1 \rangle$, find the

   a) magnitude and direction angle of $\dfrac{1}{2}u - \dfrac{1}{3}v$

   b) scalar projection of u on v.

   c) angle between u and v.

Conic Sections
(Parabolas, Ellipses, and Hyperbolas)

Objectives:

By the end of this module, you will be able to know how to plot the graphs of Parabolas, Ellipses, Hyperbolas and Circles.

Note: *Since the graphs of Circles, Ellipses, Hyperbolas and horizontal parabolas do not represent functions, **MATLAB** could not sketch their graphs directly. The **trick** is to split the equation into two functions (by solving for y in terms of x), as we are going to see in some examples.*

8.1 Examples:

Example #1 Graph the following equations using MATLAB:

$a)$ $y = x^2 + 8x - 1$

$b)$ $x = -y^2 - 7y + 3$

Solution:

a)   x=-20:.001:12;

f=inline('x.^2+8*x-1');

plot(x,f(x)),xlabel('x'),ylabel('f(x)')

grid, title('The graph of y=x^2 + 8x -1')

The graph of $y = x^2 + 8x - 1$
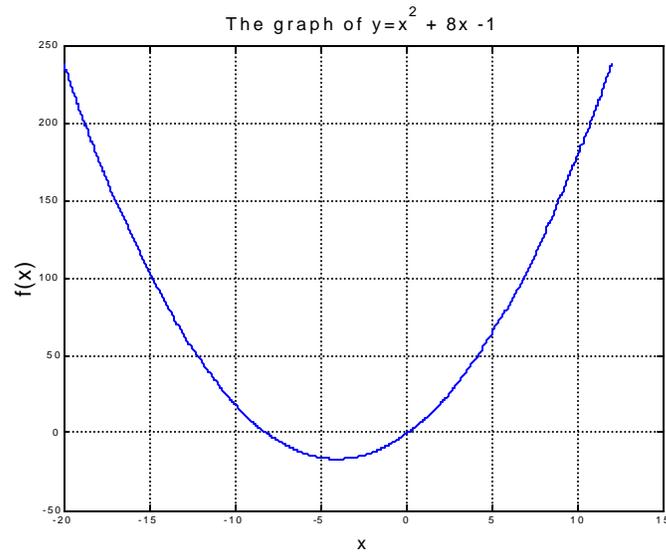
b) First, write the given equation as $y^2 + 7\ y - 3 + x = 0$, then solving for y in terms x gives:

$$y_1 = \frac{-7 + \sqrt{49 - 4(x - 3)}}{2},$$

$$y_2 = \frac{-7 - \sqrt{49 - 4(x - 3)}}{2}$$

We can graph the two functions as follows:

x=-20:.01:20;

y1=inline('(-7+sqrt(49-4*(x-3)))/2');

y2=inline('(-7-sqrt(49-4*(x-3)))/2');

plot(x,y1(x),'-',x,y2(x),'-')

grid, xlabel('x'),ylabel('y1, y2')

title('The graph of x= -y^2 - 7y + 3')

The graph of $x = -y^2 - 7y + 3$
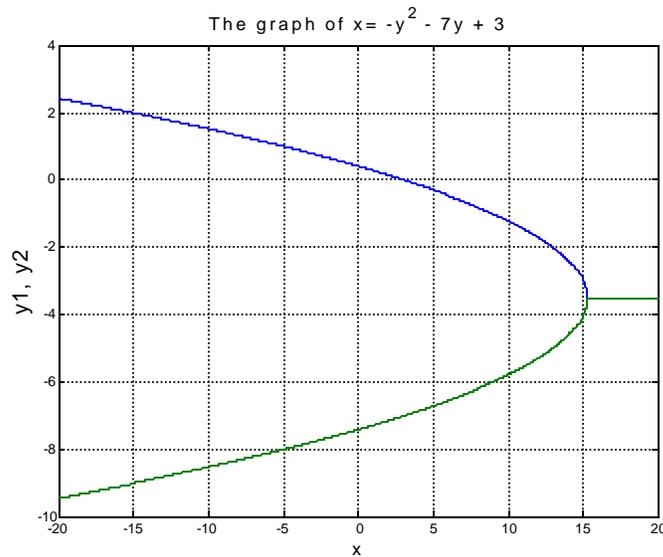
Example #2 **Use MATLAB to graph the following equations.**

a) $8x^2 + 25y^2 - 48x + 50y + 47 = 0$

b) $2x^2 - 9y^2 - 8x + 36y - 46 = 0$

Solution:

a) Solving the equation for y in terms of x gives:

$$y_1 = \frac{-50 + \sqrt{50^2 - 4(25)(8x^2 - 48x + 47)}}{50},$$

$$y_2 = \frac{-50 - \sqrt{50^2 - 4(25)(8x^2 - 48x + 47)}}{50}$$

x=-1:.001:8;

f=inline('(-50+sqrt(50^2-100*(8*x.^2-48*x+47)))/50');

g=inline('(-50-sqrt(50^2-100*(8*x.^2-48*x+47)))/50');

plot(x,f(x),'-',x,g(x),'-')

grid,xlabel('x'),ylabel('f(x), g(x)')

title('The graph of 8x^2 + 25y^2 -48x +50y +47')

The graph of $8x^2 + 25y^2 - 48x + 50y + 47$
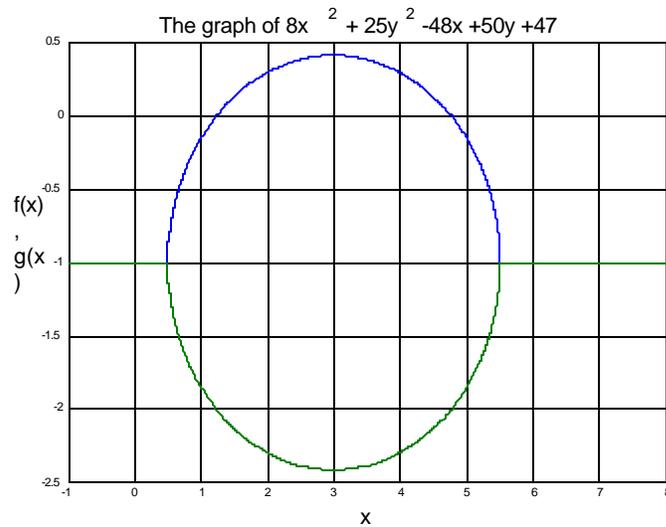
b) Solving the equation for y in terms of x gives:

$$y_1 = \frac{-36 + \sqrt{36^2 - 4(-9)(2x^2 - 8x - 46)}}{-18},$$

$$y_2 = \frac{-36 - \sqrt{36^2 - 4(-9)(2x^2 - 8x - 46)}}{-18}$$

x=-8:.001:12;

f=inline('(-36+sqrt(36^2+36*(2*x.^2-8*x-46)))/-18');

g=inline('(-36-sqrt(36^2+36*(2*x.^2-8*x-46)))/-18');

plot(x,f(x),'-',x,g(x),'-'),xlabel('x'),ylabel('f(x), g(x)')

grid, title('The graph of 2x^2 - 9y^2 - 8x + 36y - 46')

The graph of $2x^2 - 9y^2 - 8x + 36y - 46$
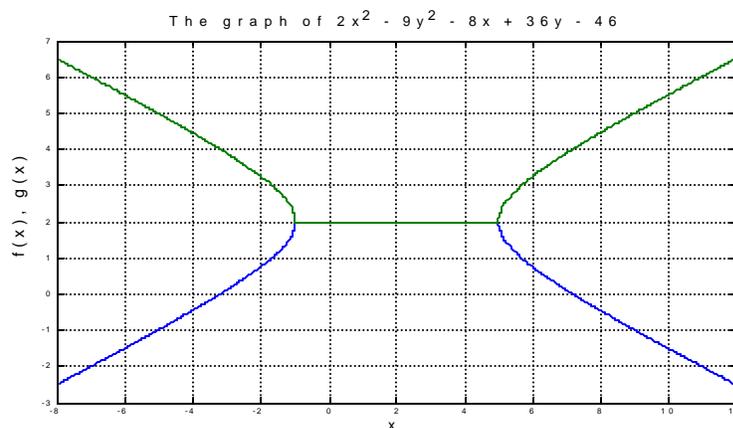
8.2 Exercises:

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Use MATLAB to graph the following equations.

   a) $y = -2L_1x^2 + x - L_2 + 40$

   b) $x = y^2 - (L_2 - 5L_1)y + 1$

2. Use MATLAB to graph the following equations

   a) $L_2x^2 + (L_1 + 12)y^2 - L_1x + (L_2 - 15)y - L3 = 0$

   b) $L_1x^2 - (L_1 + 17)y^2 + (L_2 - 4)x + (L_2 + 30)y - (L_3 - 25) = 0$

   c) $x^2 + y^2 - (L_1 + 3)x + (L_2 - 30)y - (L_2L_1 + 18) = 0$

Systems of Equations
(Linear and Nonlinear)

Objectives:

By the end of this module, you will see the power of MATLAB in solving system of equations. You will also be able to know how to easily find the inverse of any nonsingular square matrix.

9.1 MATLAB Commands:

The following are the MATLAB commands for this module.

MATLAB command	Usage
[ ]	for creating a new matrix
A'	to find the transpose of the matrix A
inv(A)	to find the inverse of the matrix A
X=A\B	to solve the linear system $AX=B$ using $X = A^{-1}B$

In MATLAB, a matrix is created using a rectangular array of numbers surrounded by square brackets []. The elements in each row are separated by **blanks** or **commas**. A **semicolon** indicates the end of each row, except the last row.

For instance the command

>> A=[1 2 3; 4 5 6; 7 8 9]   **OR**   >> A=[1,2,3; 4,5,6; 7,8,9]

produces the same matrix:

$$A = \begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{matrix}$$

Similarly, the commands

>>B=[1 2 3 4], C= B'

gives the row matrix B, and the column matrix C which is the transpose of B:

$$B = 1 \quad 2 \quad 3 \quad 4 \qquad\qquad C = \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \end{matrix}$$

Note that the next module discusses more on matrices.

9.2 Examples:

Example #1 Use MATLAB to solve the following linear systems.

a)
$$\begin{cases} \sqrt{2}\,x + \ y \ = 2.3 \\ 3x + \sqrt{5}\,y = 4 \end{cases}$$

b)
$$\begin{cases} 2.2x + \ 4\,y - 0.5z = 1.2 \\ 10x + \sqrt{3}\,y + \ 3z \ = 2.3 \\ 3x + 20\,y + 3.3\,z = 4 \end{cases}$$

c)
$$\begin{cases} 8x - 4\,y = 16 \\ -y + 2x = 4 \end{cases}$$

Using MATLAB, one can use many different ways to solve any given linear system of equations. One method is used in example 1(a), and the second method is presented in example 1(b).

Solution:

a)   A=[sqrt(2) 1; 3 sqrt(5)];

       B=[2.3;4];

       x=inv(A)*B

Answer: x = 7.0432

                    -7.6606

Then the solution is (7.0432, -7.6606)

b)   A=[2.2 4 -.5; 10 sqrt(3) 3; 3 20 3.3]

B=[1.2; 2.3; 4]

x=A\B

                    0.2143

Answer: x =   0.1760

                   -0.0492

Then the solution is (0.2143, 0.1760, -0.0492)

c)   A=[8 -4; 2 -1]

B=[16;4]

x=inv(A)*B

Answer: Warning: Matrix is singular to working precision.   x =   Inf

                                                        Inf

Note: *From this warning message in part (c), we can conclude that:*

- *the matrix A is singular,*
- *the determinant of A is zero,*
- *A has NO inverse,*
- the system is dependent, and so it has **infinitely many solutions**.

Since the system is dependent, this indicates that the two straight lines coincides.
This can be verified by graphing techniques.

Example #2 Use MATLAB to solve the following nonlinear systems.

a) $\begin{cases} y = x^2 + 2x - 4 \\ y = x - 1 \end{cases}$

b) $\begin{cases} y = 2x^2 - x - 1 \\ y = x^2 - 4 \end{cases}$

Solution:

For solving nonlinear systems, graphing technique is one of the most powerful methods in addition to the normal algebraic methods.

a)   x=-3:.001:2;

      f=inline('x.^2+2*x-4');g=inline('x-1');

      plot(x,f(x),'-',x,g(x),'-')

      grid, title('The graph of y = x^2 + 2x - 4 & y = x - 1')

      xlabel('x'),ylabel('f(x), g(x)')

      x=ginput(2)

The graph of $y = x^2 + 2x - 4$ & $y = x - 1$
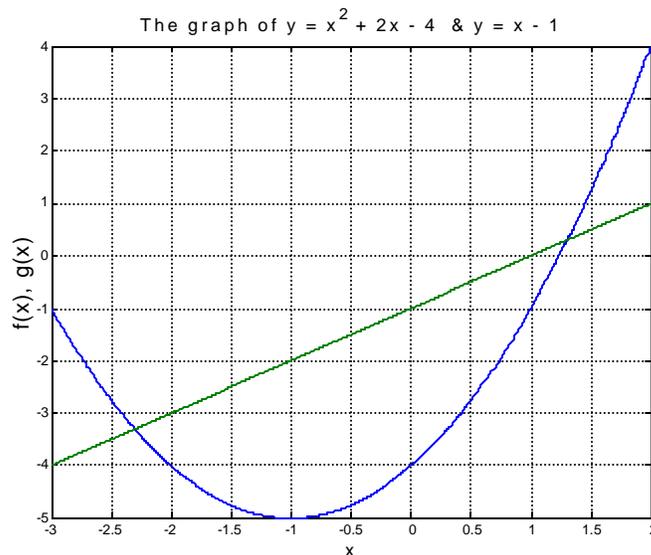
Answer: The solutions are the of intersections of the two graphs. That is (-2.3028, -3.03028) and (1.3028,0.3028)

b)   x=-10:.001:10;

      f=inline('2*x.^2-x-1');

      g=inline('x.^2-4');

      plot(x,f(x),'-',x,g(x),'-'),xlabel('x'),ylabel('f(x), g(x)')

      grid, title('The graph of y = 2x^2 - x - 1 & y = x^2 - 4')

The graph of $y = 2x^2 - x - 1$ & $y = x^2 - 4$
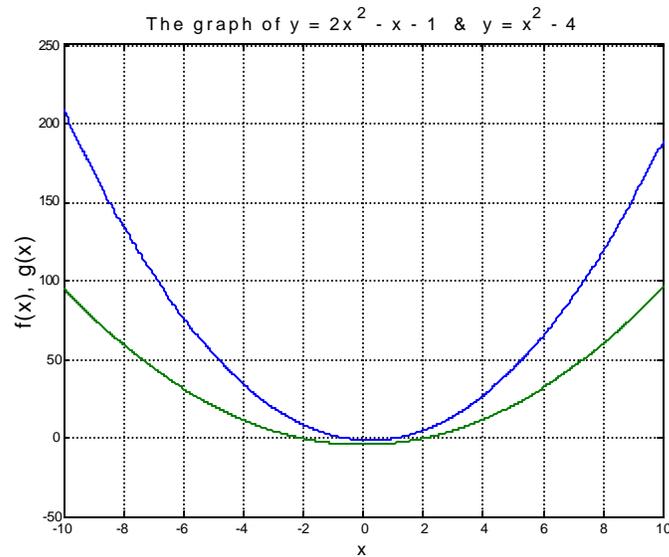
Answer: Since there is no intersection between the two graphs, then the system is inconsistent (no solution)

Example # 3 Approximate the real solution of each system of equations

a) $\begin{cases} y = \log_2 x \\ y = x - 3 \end{cases}$

b) $\begin{cases} y = \sqrt{x} \\ y = \dfrac{1}{x-1} \end{cases}$

Solution

a) x=0:.01:10;

   f=inline('log2(x)');

   g=inline('x-3');

   plot(x,f(x),'-',x,g(x),'-')

   legend('f','g'),xlabel('x'),ylabel('f(x), g(x)')

   grid , title('The graph of y = log2(x) & y = x - 3')

   x=ginput(2)

The graph of y = log2(x) & y = x - 3
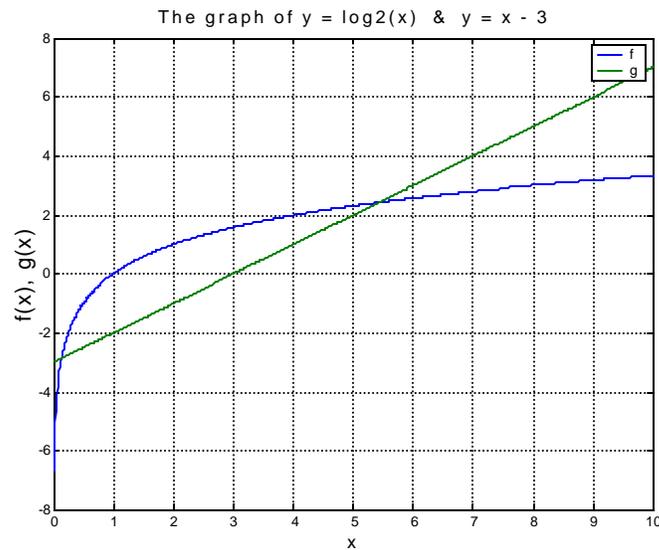
Answer: The solutions are (0.1498, -2.8304) and (5.4493, 2.4561).

b)   x=0:.1:10;

f= inline('sqrt(x)');

g=inline('1./(x-1)');

plot(x,f(x),'-',x,g(x),'-')

legend('f','g'),xlabel('x'),ylabel('f(x), g(x)')

 grid, title('The graph of y =sqrt(x) & y= 1/(x-1)')

x=ginput(1)

The graph of y =sqrt(x) & y= 1/(x-1)
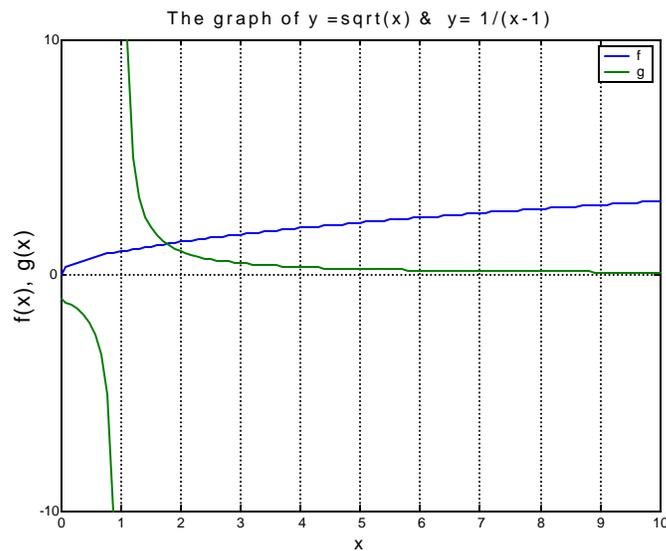
Answer: The solution is (1.7629, 1.31584).

Example #4 Find a polynomial of degree 2 that passes through the points (-2, -3), (1, -1), and (3,17).

Solution:

Since the polynomial has degree 2, then $f(x) = ax^2 + bx + c$. Now substituting the coordinates of each point in $f(x)$ will yield the following linear system:

$$\begin{cases} -3 = 4a - 2b + c \\ -1 = a + b + c \\ 17 = 9a + 3b + c \end{cases}$$

To solve this linear system using MATLAB, we have:

A=[4 -2 1; 1 1 1; 9 3 1]
B=[-3;-1;17]
x=A\B

Answer: x = 1.6667

                         2.3333

                        -5.0000

Then the polynomial is $f(x) = 1.667x^2 + 2.3333x - 5$

9.3 Exercises:

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Solve the following system of equations

a)
$$\begin{cases} \sqrt{2+L_1}\,x + 3L_2y = 5.2 \\ 2.6x + \sqrt{5L_2}\,y = -3.6 \end{cases}$$

b)
$$\begin{cases} L_1x + 3y - 4z - w = 21 \\ -3x + 2y + 3z + 2w = L_2 \\ 3x - L_1y - 7z + 12w = 10 \\ 2y + 34z - L_2w = -5 \end{cases}$$

c)
$$\begin{cases} 3x + L_1y - 2z - 5w + 3r = -3 \\ 3x + 8y + 3z - L_2w - 9r = 8 \\ x - 10y + 4w + L_1r = 0 \\ 4x + 11y + 2z - 4w = -L_2 \\ x - 8z + w - 10r = 15 \end{cases}$$

2. Solve the following systems by graphing method,

a)
$$\begin{cases} y = 2x^2 - x - L_3 + 20L_2 \\ y = (2 + L_1)x \end{cases}$$

b)
$$\begin{cases} y = 2x^2 - 1 - L_1 \\ x = y^2 + y + L_2 - 8L_1 \end{cases}.$$

3. Approximate the real solution of the following system of equations:

a)
$$\begin{cases} y = |x| - L_1 \\ y = (L_2)^{-x^2} \end{cases}$$

b) $\begin{cases} y = \dfrac{2+L_1}{x+1} - 3 \\ \\ y = \dfrac{x}{x-5-L_1} \end{cases}$ for $x \in (-10,10)$

c) $\begin{cases} y = \ln(x-L_1) \\ y = -x+L_2 \end{cases}$

4. Find a polynomial that passes through the points
   $(-0.2,2), (L_1, 0.13L_2), (0.1,20),$ and $(5,0.02)$.

Module 10

Matrices
(Algebra, Inverse and Determinant)

Objectives:

MATLAB is short form of **MAT**rices **LAB**oratory. Therefore, in this section you will see how to work with all sort of algebraic operations on matrices using MATLAB. In fact, this is what MATLAB specializes in.

10.1 MATLAB Commands: In addition to the commands we learnt in previous module, we have the following:

MATLAB command	Usage
A*B	to multiply the matrices A and B
det(A)	to evaluate the determinant of A
I=eye(3)	to construct the 3x3 identity matrix
A(n,:)	to show row n of the matrix A
A(:,n)	to show column n of the matrix A
A'	to find the transpose of the matrix A
rrefmovie(A)	step-by-step row reduced echelon form
rref(A)	direct answer row reduced echelon form

10.2 Examples:

Example #1 Consider the matrix A=[1 2 3; 4 5 6; 7 8 9] . With the matrix A so defined, you can ask MATLAB to give you any row or column of the matrix A. The command is:

```
>> r3=A(3,:)              %(show me row 3 of the matrix A)
   r3 = 7    8    9
```

```
>> c2=A(:,2)              %(show me column 2 of the matrix A)


       2
c2 =   5
       8
```

>> A=1:9   %(Create a vector A with components from 1 to 9)

>> B=8-A   %(Create a vector B with component 8-A)

Answer: A = 1   2   3   4   5   6   7   8   9

                   B = 7   6   5   4   3   2   1   0   -1

The **transpose** of a matrix A is a new matrix B in which the rows of the matrix A are the columns of the matrix B. For instance, if you want to get the transpose of the matrix A above, just give the command:

>> A'

            1   4   7

Answer: 2   5   8

            3   6   9

Example #2

If $A = \begin{bmatrix} 2 & 3 & -1 & 6 \\ 0 & 5 & 12 & 3 \\ 15 & 6 & 4 & -5 \\ 6 & 2 & -3 & 6 \end{bmatrix}$, and $B = \begin{bmatrix} -6 & 13 & 25 & 64 \\ 35 & 95 & 36 & 5 \\ -25 & -36 & 40 & 2 \\ -6 & 20 & 56 & 4 \end{bmatrix}$, find

a) $3A - 2B$

b) $AB - 3A^2$

c) $A + B - 2I_4$

d) A^{-1}

e) $|B|$

Solution

A=[2 3 -1 6; 0 5 12 3; 15 6 4 -5; 6 2 -3 6];

B=[-6 13 25 64; 35 95 36 5; -25 -36 40 2; -6 20 56 4];

3*A-2*B

A*B-3*A^2

A+B-2*eye(4)

inv(A)

det(B)

Answers:

$$
a) \begin{array}{rrrr} 18 & -17 & -53 & -110 \\ -70 & -175 & -36 & -1 \\ 95 & 90 & -68 & -19 \\ 30 & -34 & -121 & 10 \end{array}
\qquad
b) \begin{array}{rrrr} 7 & 386 & 418 & -21 \\ -737 & -206 & 531 & 142 \\ -130 & 254 & 207 & 804 \\ 64 & 430 & 474 & 133 \end{array}
\qquad
c) \begin{array}{rrrr} 6 & 16 & 24 & 70 \\ 35 & 98 & 48 & 8) \\ -10 & -30 & 42 & -3 \\ 0 & 22 & 53 & 8 \end{array}
$$

$$
d) \begin{array}{rrrr} -0.2126 & 0.0302 & 0.0120 & 0.2076 \\ 0.5987 & -0.1003 & 0.1047 & -0.4613 \\ -0.2246 & 0.1105 & -0.0284 & 0.1458 \\ -0.0992 & 0.0585 & -0.0611 & 0.1858 \end{array}
\qquad
e) \ 892956
$$

Example #3. Obtain the row reduce echelon form of the following matrices:

$$
a)\ A = \begin{bmatrix} 2 & 3 & -1 & 6 \\ 0 & 5 & 12 & 3 \\ 15 & 6 & 4 & -5 \\ 6 & 2 & -3 & 6 \end{bmatrix}
\qquad
b) = \begin{bmatrix} 2 & 6 & 36 & 21 & 14 & 35 \\ 2 & 6 & 52 & 48 & 34 & 35 \\ -6 & 36 & 45 & 84 & 74 & -6 \\ 25 & 6 & 3 & 4 & 36 & 25 \\ 0 & 36 & 0 & 23 & 3 & 25 \end{bmatrix}
$$

Solution: You can obtain the row reduced echelon form of a matrix using MATLAB by two ways; directly, and step-by-step. We are going to use the two methods in this example.

a) The command for *direct method* is:

>> A=[2 3 -1 6; 0 5 12 3; 15 6 4 -5; 6 2 -3 6]; rref(A)

Answer:

$$\begin{array}{cccc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{array}$$

b) The command for the *step-by-step* method is

>> A=[2 6 36 21 14 35; 2 6 52 48 34 35; -6 36 45 84 74 -6; 25 6 3 4 36 25;

0 36 023 3 25]; rrefmovie(A)

Continue pressing **Enter** (or any key) till your matrix is finally reduced to echelon form. This is the step-by-step method.

Answer:

$$\begin{array}{cccccc} 1 & 0 & 1 & 0 & 0 & -1/3 \\ 0 & 1 & -2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1/3 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{array}$$

What is your conclusion?

Example # 4 Solve the following system of equations

$$\begin{cases} x + 5z = 20 \\ 2x + y - z = -3 \\ 7x + 3y + z = 2 \end{cases}$$ using row reduced echelon form.

Solution:

Here, matrix A is the augmented matrix of the system, therefore,

>> A=[1 0 7 20;2 1 -1 -3;7 3 1 2];

>> rref(A)

Answer: 1   0   0   -1

               0   1   0   2

               0   0   1   3

Therefore, the solution is (-1, 2, 3).

10.3 Exercises:

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Given that

$$A = \begin{bmatrix} L_1 & -6 & 30 & 25 \\ 0 & L_2 & 36 & -58 \\ 36 & 2 & -5 & 6 \\ 5 & -41 & 19 & 45 \end{bmatrix}, \quad B = \begin{bmatrix} 2 & 6 & 3 & 5 \\ 3 & 2 & 5 & 6 \\ 25 & L_2 & 15 & 8 \\ 2 & 3 & L_1 & 3 \end{bmatrix}, \quad C = \begin{bmatrix} 2 & 6 & 36 & 21 & 14 \\ 2 & 6 & L_2 & 48 & 34 \\ -6 & 36 & 45 & 84 & 74 \\ 0 & 36 & 0 & 23 & L_1 \end{bmatrix},$$

Find

$a)\ AC, \qquad b)\ 3A-4B, \qquad c)\ \dfrac{2}{3}A^2 + CB$

$d)\ A^{-1}, \qquad e)\ |B|, \qquad\qquad f)\ CC^T - B^2 + 8I_4$

$g)$ the row reduced echelon form of the matrices A, B and C.

2. Given $A = \begin{bmatrix} L_1 & -100 & 3 \\ 80 & 0.4\,L_2 & 70 \\ -65 & 0 & 0.029L_3 \end{bmatrix}, \quad B = 5A^2 - A$

Find a matrix D satisfying the following equation $-B^T + (2 + L_1)D = A^{-1}B$

Review and Self Evaluation

Objectives:

This module will give us the summary of all that we have learnt in this course. It will comprise of three parts:

- Summary of MATLAB commands
- Practice Test, and
- Self Evaluation Test

Note: *All the MATLAB commands that we used are summarized into one page. See Appendix 1.*

11.1 Practice Test:

We shall present in this section seven completely solved examples. If you follow them carefully they should serve as a summary of all the modules.

Example # 1. Evaluate the following:

$a)\ \left(\log_5 16\right)\left(\log_2 \sqrt{5}\right) + 25^{\frac{\log \sqrt{5}}{\log 5}}$

$b)\ \sec\left(\dfrac{3p}{10}\right) + \cot^2 30^0 - \sin 20$

$c)\ \cos\left(\tan^{-1}\dfrac{5}{12} - \sin^{-1}\left(-\dfrac{4}{5}\right)\right)$

Solution:

\>> (log(16)/log(5))*(log2(sqrt(5)))+25^(log10(sqrt(5))/log10(5))

\>> sec(3*pi/10)+(cot(30*pi/180))^2-sin(20)

\>> cos(atan(5/12)-asin(-4/5))

Answers: a) 7,   b) 3.7884, and   c) 0.2462

Example # 2. Given the $-3x^2 - 4x + 1 = -\log_8(4+x)$, find the

a) approximate solutions.

b) exact solutions.

Solution:

a)   x=-4:.1:4;

        f=inline('-3*x.^2-4*x+1');

        g=inline('-(log(4+x))./log(8)');

        plot(x,f(x),'-',x,g(x),'-')

        grid, title(' The graph of f(x) and g(x)')

        legend('f','g'),xlabel('x'),ylabel('f(x), g(x)')

        x=ginput(2)
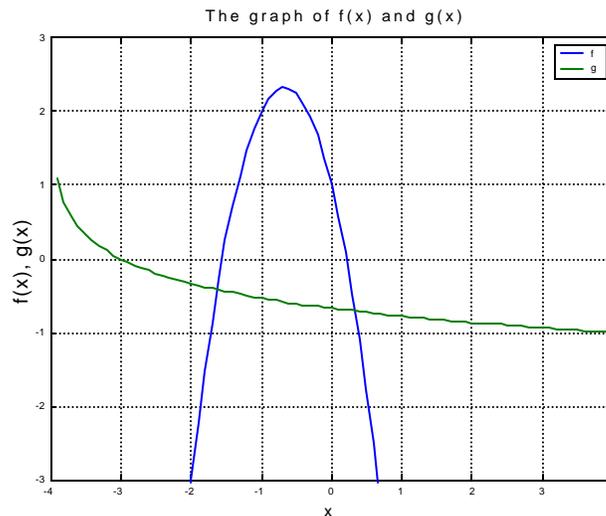
x	y
-1.6129	-0.4298
0.3410	-0.6579

Answer: The approximate solutions are **–1.6129** and **0.3410**

b) To find the exact solutions, use the following MATLAB commands:

\>> f=inline('-3*x.^2-4*x+1+(log(4+x))./log(8)');fzero(f,2)

\>> fzero(f,-1.5)

\>> fzero(f,.5)

Answer: The exact solutions are **-1.6240** and **0.3398**

3. Given the $-5x-4=-3^{x+1}$, find

 a) the approximate solutions.

 b) find the exact solutions

Solution:

a)   x=-2:.1:2;

          f=inline('-5*x-4');

          g=inline('-3.^(x+1)');

          plot(x,f(x),'-',x,g(x),'-')

           grid , title('The graph of f(x) & g(x)')

          legend('f','g'),xlabel('x'),ylabel('f(x), g(x)')

          x=ginput(2)
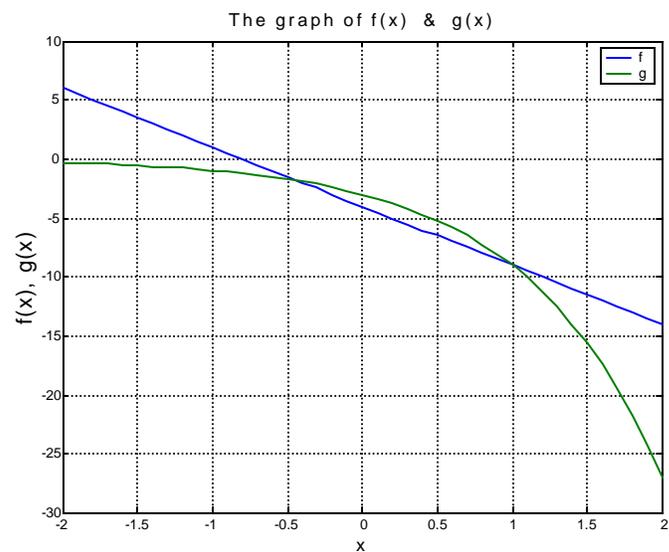
       x   y

  -0.4009 -1.8713

   1.0092 -9.1228

Answer: The approximate solutions are **-.4009 and 1.0092**

b)   f=inline('-5*x-4-(-3.^(x+1))');
        fzero(f,-.5)
        fzero(f,1)

Answer: The exact solutions are -0.4230 and 1.

4. Approximate the solutions of the equation

$$2\cos 3x - \sin 2x = |x - 1|$$

Solution:

x=0:.1:2*pi ;
f=inline('2*cos(3*x)-sin(2*x)');
g=inline('abs(x-1)');
plot(x,f(x),'-',x,g(x),'-')
grid , title(' The graph of f(x) and g(x)')
legend('f','g'),xlabel('x'),ylabel('f(x), g(x)')
x=ginput(3)
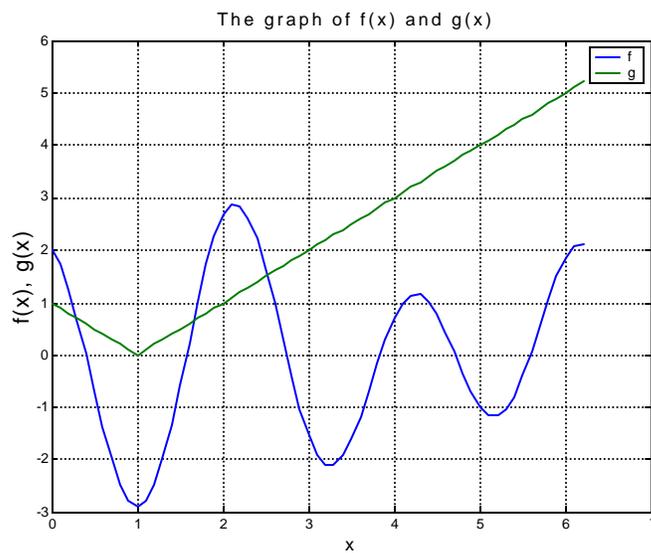
x	y
0.2823	0.7237
1.6532	0.6447
2.5242	1.4868

Answer: The approximate solutions are **0.2823 , 1.6532 , and 2.5242**

5. Let $v = \langle 2, -5 \rangle$, $w = \langle -3, 7 \rangle$, $u = 3i + 5j$, find

a) the direction angle of the vector *3v - 2w*.

b) $proj_v(7u + 11j)$

Solution:

v=[2 -5];
w=[-3 7];
u=[3 5];
za=3*v-2*w;
tb=7*u+[0 11];
a_theta=atan(za(:,2)/za(:,1))
% (tan(theta)=(vertical component / horizontal component)
theta=a_theta*180/pi
b_Proj=dot(v,tb)/norm(v)

Answer a) The direction angle 3v-2w is 292.4794 of degree

b) The scalar projection of 7u+11j on v is –34.9107

6. Solve the following nonlinear system of equations by graphing technique

$$\begin{cases} -2x^2 + 3x + 6 = 0 \\ 16y^2 + 9x^2 - 96y - 36x + 36 = 0 \end{cases}$$

Solution:

x=-3:.1:7;

f=inline('-2*x.^2+3*x+6');

y1=inline('(96+sqrt(96^2-4*16*(9*x.^2-36*x+36)))/32');

y2=inline('(96-sqrt(96^2-4*16*(9*x.^2-36*x+36)))/32');

plot(x,f(x),'-',x,y1(x),'-',x,y2(x),'-')

grid, title('The graph of f(x), y1(x), and y2(x)')

legend('f','y1','y2'),xlabel('x'),ylabel('f(x), y1(x), y2(x)')

x=ginput(4)
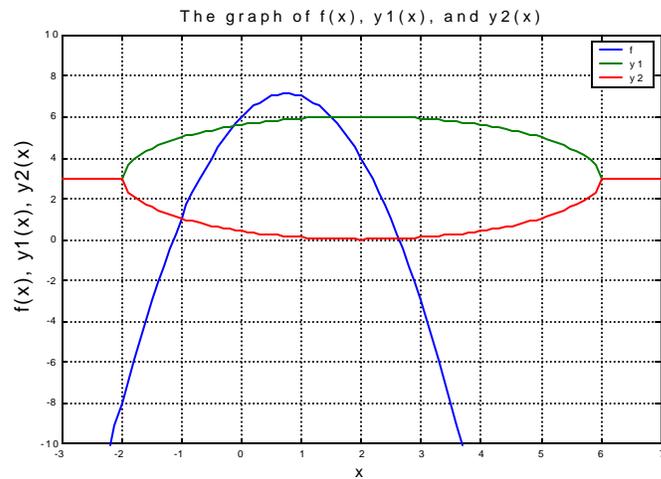
x	y
-1.0069	0.9649
-0.1313	5.6433
1.5276	5.9942
2.6336	0.0292

The solutions are (-1.006, 0.964), (-0.131, 5.643), (1.52,5.994), and (2.6336,0.0292).

7. Consider the system

$$\begin{cases} 2x - 2.1y + 7z = \cos^{-1}\dfrac{1}{3} \\ \dfrac{1}{2}x + y - z = 3.2 \\ 4.5x + 8y - 11z = -2.5 \end{cases}$$

a) Use matrices to find the solutions of the system.

b) If the coefficient matrix of the above system is A, then evaluate $A^2 - 5A + |A|I_3$

a)　　　　>> A=[2 -2.1 7; 1/2 1 -1; 4.5 8 -11]

>> B=[acos(1/3);3.2;-2.5]

>> x=inv(A)*B

Answer:　　x = 　-9.8135

　　　　　　　　15.8378

　　　　　　　　7.7311

Then the solution is (-9.8135, 15.8378, 7.7311).

b)　　　　>> A^2-5*A+det(A)*eye(3)

Answer:

　12.8500　60.2000　-95.9000

　-5.5000　-24.6500　18.5000

　-59.0000 -129.4500　187.9000

11.2 <u>Self Evaluation Test</u>:

The following seven problems are for your self-evaluation. If you have any difficult with any question, you are advised to go back and revised the relevant module, then come back to the question.

Let L_1, L_2 and L_3 be as defined in Exercises of module 2.

1. Evaluate the following:

a) $\log_{L_1}\left(\sqrt{e}\right)^{\ln 4}+\left(\sqrt[3]{e^{-1}}\right)^{\ln 8}$

b) $\cos 905^0+\cot^2 905^0$

c) Find the degree measure of the angle $\tan^{-1}\dfrac{1}{2+L_1}+\tan^{-1}\dfrac{1}{L_2}$

2. Given that $\cot A=\dfrac{5+L_2}{3}$, $A\in I_Q$ and $\csc B=-5+L_2$, $B\in QIV$, find

a) $\tan(2A-3B)$

b) $\sec\dfrac{A}{2}$

c) $\sin(B+2B)$

3. Estimate the solutions of the equation $-4\ln(x+L_1)=\left(\dfrac{L_2}{100}\right)^{x-1}-10$.

4. Use MATLAB to approximate the solution of the equation

$$3\cot^2 x-2\cot x=(2+L_1)\sin x \quad \text{for} \quad -5\le x\le 5$$

5. Let $v=(2+L_1)i-2j$, $u=\left\langle 2,\dfrac{L_2}{5+L_1}\right\rangle$, $w=3j-(L_1)i$, find the degree measure

of the angle between the vectors $w-2v$ and $u+2v$

6. Use MATLAB to solve the following nonlinear system:

$$\begin{cases} 2x^2 + L_2x - 8y^2 + L_1y - L_3 = 0 \\ y^2 + x^2 + L_1y + L_2x = 0 \end{cases}$$

7. Consider the system

$$\begin{cases} -x + y + z = L_1 \\ 10x - 20y + 30z = \dfrac{L_2}{10} \\ 8x + 7y - 6z = \dfrac{L_3}{100} \end{cases}$$

a) use matrices inverse method to solve the system.

b) find the matrix N such that $CC^T - (4 + L_1)N = |C^{-1}|.I_3$ where C is the coefficient matrix of the above system.

References:

1. Aufmann, et al. 2002, **Colledge Algebra & Trigonometry**, 4th edition. Houghton Mifflin Company, Boston.

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3. Hanselman, D & Littlefield, B. 1998, **Mastering MATLAB 5: A Comprehensive Tutorial and Reference**. Prentice Hall, Upper Saddle River, New Jersey 07458.

4. Loughlin K F & Abul-Hamayel (Ed). 2001, **CHE 325 Chemical Engineering Computing Laboratory Manual**, 6th Edition KFUPM, Dhahran.

5. Mechanical Engineering Department, ME 413: System Dynamics and Control, **Introduction to MATLAB**, KFUPM, Dhahran.

Summary of MATLAB commands

MATLAB Command	Usage
+	Addition
-	Subtraction
*	Multiplication
.*	Element - by - element multiplication
/	Division
^	Power or Exponent
.^	Element –by-element exponentiation
sqrt	Square root
abs	Absolute value
[ ]	to form vectors and matrices
( )	for the arithmetic operations
;	For end rows, and for suppressing printing
:	For subscripting and vector generation
,	Print the expression
%	Used for comment
y	Yellow (color)
m	Magenta (color)
c	Cyan (color)
r	Red (color)
g	Green (color)
b	Blue (color)
w	White (color)
k	Black (color)
.	Point (for grid of graph)
O	Circle (for grid of graph)
X	X-mark (for grid of graph)
+	Plus (for grid of graph)
-	Solid (for grid of graph)
*	Star (for grid of graph)
:	Doted (for grid of graph)
-.	Dashdot (for grid of graph)
--	Dashed (for grid of graph)
inline	to define a function
plot	to graph a function
title	for a title of a graph
grid	for lines in the x and y axes
$\log 10(x)$	common logarithm of x

$\log(x)$	natural logarithm 'ln' of x

ginput	to trace any point in a graph by mouse
Legend	to differentiate between graphs
fzero(f,a)	to find the zero of f near a
xlabel	for naming the x-axis
ylabel	for naming the y-axis
sin(x)	to evaluate the sine function of angle x
cos(x)	to evaluate the cosine function of angle x
tan(x)	to evaluate the tangent function of angle x
cot(x)	to evaluate the cotangent function of angle x
sec(x)	to evaluate the secant function of angle x
csc(x)	to evaluate the cosecant function of angle x
asin(x)	$y = \sin^{-1} x = \arcsin x$
acos(x)	$y = \cos^{-1} x = \arccos x$
atan(x)	$y = \tan^{-1} x = \arctan x$
acot(x)	$y = \cot^{-1} x = \text{arccot } x$
asec(x)	$y = \sec^{-1} x = \text{arcsec } x$
acsc(x)	$y = \csc^{-1} x = \text{arccsc } x$
dot(u,v)	for dot product of the vectors u and v
norm(w)	for magnitude of the vector w
rat2deg	radian measure degree measure
deg2rad	degree measure radian measure
deg2dms	degree measure DMS measure
dms2rad	DMS measure degree radian
dms2deg	DMS measure degree measure
A'	to find the transpose of the matrix A
inv(A)	to find the inverse of the matrix A
X=A\B	to solve the linear system $AX=B$ using $X = A^{-1}B$
A*B	to multiply the matrices A and B
det(A)	to evaluate the determinant of A
I=eye(n)	to construct the nxn identity matrix
A(n,:)	to show row n of the matrix A
A(:,n)	to show column n of the matrix A
A'	to find the transpose of the matrix A
rrefmovie(A)	step-by-step row reduced echelon form
rref(A)	direct answer row reduced echelon form
clear	clear worksheet
clg	clear graph
NaN	not a number

Appendix II: Lab Syllabus for Pre-Calculus II (MATH 002)

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
College of Sciences, Prep-Year Math Program
MATLAB CAL SYLLABUS
MATH 002 (032)

Pre-Requisite	MATH 001
Textbook	College Algebra & Trigonometry by Aufmann/Barker/Nation, 4th Edition, Houghton Mifflin, (2002)
Software	MATLAB version 6.1

WK	Date	Topic
1	Feb. 14-18	**No CAL This Week**
2	Feb. 21-25	Introduction to MATLAB
3	Feb. 28-Mar. 3	Exponential and Logarithmic Function and Their Graphs
4	March 6-10	More on Graphs Exponential and Logarithmic
5	March 13-17	Exponential and Logarithmic Equations
6	March 20-24	Graphs of Trigonometric Functions
7	March 27-31	More on Graphs of Trigonometric Functions
8	April 3-7	**No CAL This Week**
9	April 10-14	Trigonometric Functions (Evaluations and Equations)
10	April 17-21	Trigonometric Functions (Evaluations and Equations) - Continues
11	May 24-28	Vectors
12	May 1-5	Conic Sections (Parabolas, Ellipses, and Hyperbolas)
13	May 8-12	Systems of Equations
14	May 15-19	Matrices
15	May 22-25	Review and Self Evaluation

Appendix III: Syllabus for Pre-Calculus II (MATH 002)

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
College of Sciences, Prep-Year Math Program
MATH 002 SYLLABUS
TERM 032

Pre-Requisite	MATH 001
Textbook	College Algebra with Trigonometry by Aufmann/Barker/Nation, 4th Edition, Houghton Mifflin, (2002)
Objectives	The students are expected to develop the comprehension of the course material in English, improve their computational skills and demonstrate writing ability of solutions with logical steps. An emphasis will be given to the understanding of the statement of problem and the mathematical terminology. The medium of instruction will be strictly English from the first <u>day of classes.</u> The course primarily aims at the development of critical thinking among the students through the mathematical concepts studied at the <u>High School level.</u> Word problems will be an important part of the course. MATH 001 will be regarded as a base of this course.

Week #	Date	Text Sections	Topic	Homework Problems
1	Feb. 14-18	4.2	Exponential Functions and Their Graph	32,37,43,63,81,86
		4.3	Logarithmic Functions and Their Graphs	27,40,47,55,72,77
2	Feb. 21-25	4.4	Properties of Logarithmic	7,14,28,38,46,72,76
		4.5	Exponential & Logarithmic Equations	6,16,28,44,78,79
3	Feb. 28-Mar. 3	5.1	Angles and Arcs	10,13,33,47,60,69,72,87
		5.2	Trigonometric Functions of Acute Angles	4,8,17,22,33,42,54,59,73
4	Mar. 6-10	5.3	Trigonometric Functions of Any Angle	5,12,22,29,44,64,68,77,86
		5.4	Trigonometric Functions of Real Numbers	11,15,38,46,55,82,85,93,98
5	Mar. 13-17	5.5	Graphs of Sine and Cosine Functions	5,14,29,50,59,62,79,83
		5.6	Graph of Other Trigonometric Functions	3,15,24,40,44,50,66
6	Mar. 20-24	5.7	Graphing Techniques	8,15,24,29,44,62,92
		6.1	Verification of Trigonometric Identities	11,19,31,54,67
7	Mar. 27-31	6.2	Sum, Difference and Co-function Identities	5,10,15,22,29,33,40,67,80
MIDTERM EXAM SATURDAY APRIL 3 (4.2 - 6.2)			
8	Apr. 3-7	6.3	Double and Half Angle Identities	4,8,11,22,32,41,52,60,77,92
		6.4*	Only Functions of the form $f(x) = a \sin x + b \cos x$	6,99,101
9	Apr. 10-14	6.5	Inverse Trigonometric Functions	16,23,35,53,63,68,78
10	Apr. 17-21	6.6	Trigonometric Equations	13,20,30,42,49,68,78
		7.3	Vectors	4,10,12,19,29,34,48,56,64,76
11	Apr. 24-28	8.1	Parabolas	7,13,16,29,33,54
		8.2	Ellipses	5,14,25,36,39,44,49,72
12	May 1-5	8.3	Hyperbolas	5,10,24,34,38,45,50,65
		9.1	Systems of Linear Equations in Two Variables	4,12,17,40,48,60
13	May 8-12	9.3	Nonlinear systems of Equations	4,11,15,31,46,49
		10.1	Gaussian Elimination Method	7,16,24,28,52,54
14	May 15-19	10.2	The Algebra of Matrices	5,14,23,27,29,36,68
		10.3	The Inverse of a Matrix	3,8,16,22,39
15	May 22-25	10.4	Determinants	8,11,26,29,36,46,50,61
	May 26	**Review**	**Last Day of Classes**	

Appendix IV: Syllabus for MATH 001 (Used to measure students mathematics aptitude)

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
College of Sciences, Prep-Year Math Program
MATH 001 SYLLABUS
TERM 032

Pre-Requisite	HIGH SCHOOL ALGEBRA
Textbook	College Algebra & Trigonometry by Aufmann /Barker/Nation, 4th Edition, Houghton Mifflin, (2002)
Objectives	The students are expected: to comprehend the material of this course. to improve their computational skills in basic Algebra and Trigonometry to demonstrate their writing ability in Mathematics with logical steps. Please note that the medium of instruction will be strictly ENGLISH from the first day of classes.

Week #	Date	Text Sections	Topic	Homework Problems
1	Feb. 14-18	P-1	The Real Number System	1,6,11,24,30,36,42,58,73
2	Feb. 21-25	P-2	Intervals, Absolute Value and Distance	2,6,14,20,21,35,44,57,60,69,78,86,100
		P.3	Integer and Rational Number Exponents	
3	Feb. 28-Mar. 3	P-3	Integer and Rational Number Exponents	8,20,42,48,54,85,90,103,111,122,127, 135
		P-4	Polynomials	15,20,33,46,52,61,67,82
4	Mar. 6-10	P-5	Factoring	7,18,25,36,44,53,57,74,83
		P-6	Rational Expressions	6,14,19,36,56,62,70
5	Mar. 13-17	1.1	Linear Equations	3,11,20,26,34,36,44,52,55,70,76
			Formulas and Applications (Examples #1 and #2) and (table 1.1**) ONLY	2,8,15,20,23,25
6	Mar. 20-24	1.3	Quadratic Equations	9,12,18,31,36,38,45,62,74,80,06,109,123
7	Mar. 27-31	1.4	Other Types of Equations	8,12,21,24,30,36,40,44,58,67
		1.5	Inequalities	7,16,19,28,34,43,62,70,86,92,96,97
MIDTERM EXAM THURSDAY APRIL 1 (Chapter P- 1.5)				
8	Apr. 3-7	2.1	A Two-Dimensional Coordinate System and Graphs	15,22,29,38,43,54,65,73,84,91,106
9	Apr. 10-14	2.2	Introduction to Functions	7,9,18,21,38,39,43,49,92,
10	Apr. 17-21	2.3	Linear Functions	10,14,25,37,49,67,70,84,87
		2.4	Quadratic Functions	6,12,16,26,30,44,73,77,81
11	Apr. 24-28	2.5	Properties of Graphs	4,11,15,20,25,30,38,42,51,56,59,78
		2.6	The Algebra of Functions	5,9,25,36,47,62,75,76
12	May 1-5	3.1	Polynomial and Synthetic Divisions	4,16,21,34,43,49,59,61,70,72,75
		3.2	Polynomial Functions	5,9,37,41,46,56,64
13	May 8-12	3.3	Zeros of Polynomial Functions	4,9,17,26,37,45,76
14	May 15-19	3.4	The Fundamental Theorem of Algebra	8,20,41,46,47,57,67
		3.5	Rational Functions and Their Graphs	4,5,18,25,32,35,41,44,54,69
15	May 22-25	4.1	Inverse Functions	4,8,12,28,38,41,54,65,67
	May 26	**Review**	**Last Day of Classes**	

Appendix V: Syllabus for Preparatory English I (Used to measure English language proficiency)

Preparatory English I (ENGL
Description

Teacher 1: ………………….………………. (Office: ….….); **Teacher 2:** ………..………..

Texts: Listening (I & II), Reading (Textbook I & II, Activity I & II), Vocabulary (I & II), Grammar (Ora
Longman Dictionary of Contemporary
English

Course Schedule (Semester 032)

Week	Dates	Listening	Reading	Vocabulary	
1	14 - 18 Feb	Unit 1 Lesson 1 - 3	Texts 1A - 1B		Ur in
2	21 - 25 Feb	Unit 1 Lesson 4 - 8	Texts 1C - 2A	Orientation 1	Ur &
3	28 Feb - 3 Mar	Unit 2 Lesson 9 - 12	Texts 2A - 2B	Orientation 2	Ur
4	6 - 10 Mar	Unit 2 Lesson 13 - 16	Texts 2C - 2D	Chemistry 1	Ur ge
5	13 - 17 Mar	Unit 3 Lesson 17 - 20	Texts 2E - 3A	Chemistry 2	Ur pr
6	20 - 24 Mar	Unit 3 Lesson 21 - 23	Texts 3A - 3B	Chemistry 3	ex
7	27 - 31 Mar	Unit 3 Lesson 24 - 26	Text 3C	Mathematics 1	Ur cu &
8	3 - 7 Apr	(EP)	(EP)	Mathematics 2 (EP)	de
		MID-SEMESTER EXAMINATIONS (5,			
9	10 - 14 Apr	Unit 3 Lesson 27 - 31	Texts 3D - 3F		Ur ac
10	17 - 21 Apr	Unit 3 Lesson 32 & Unit 4 Lesson 33 - 34	Text 4A	Mechanics 1	Ur is
11	24 - 28 Apr	Unit 4 Lesson 35 - 38	Texts 4B - 4C	Mechanics 2	ob
12	1 - 5 May	Unit 4 Lesson 39 - 42	Texts 4D - 5A	Mechanics 3	Ur pr Ur
13	8 - 12 May	Unit 5 Lesson 43 - 46	Texts 5A - 5C	Electricity 1	ch Ur
14	15 - 19 May	Unit 5 Lesson 47 - 49	Texts 5C - 5E	Electricity 2	mc
15	22 - 26 May	Unit 5 Lesson 50 review	Texts 5E - 5F review	Electricity 3	Ur to
16		FINAL EXAMINATIONS			

RS: 12.03

Appendix VI: Permission letters and other correspondences with authors of the instruments used.