FACTORS INFLUENCING CALCULUS COURSE

SUCCESS AMONG FRESHMEN

ENGINEERING STUDENTS



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**DEDICATION**

This dissertation is dedicated to my parents

Renelice and Rodgers Mwavita for the way they modeled faith in God in their daily lives.

'Kwa Imani, yote yawezekana.'

To my sisters, Sophie and Pendo, this one is for you too.

# ACKNOWLEDGEMENTS

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**CHAPTER ONE**

**Introduction**

Engineering programs in America have several core courses that freshman engineering students take before they can be accepted as engineering majors. Calculus is one of these courses. Calculus provides the foundation for understanding higher-level science, mathematics, and engineering courses (Gainen & Willemsen, 1995). Further, Sorby and Hamlin (2001) have pointed out that calculus is the starting point in mathematics instruction for many engineering programs. Success in calculus is therefore imperative for freshman engineering students. Calculus provides the mathematical background and foundation for future engineering courses. The importance of succeeding in first year calculus among freshman engineering students has been emphasized in several studies (Gainen & Willemsen, 1995). Due to poor performance in calculus among freshman students in the last ten years, the undergraduate calculus course has attracted an unprecedented level of national interest (Bonsangue & Drew 1995). Many of the freshman engineering students fail to meet the minimum grade criterion of A, B, or C in their calculus course (Seymour & Hewitt, 1997). Thus, researchers have conducted several studies to determine factors that cause low performance in calculus among college students.  As such, several interventions have been used to modify performance. These interventions have focused on specific areas that are believed to be linked to calculus success at the college level.

## Academic background characteristics

Struggles with mathematics courses at the junior and high school level often lead to an overall weak background in calculus and may contribute to performance difficulties among freshman engineering students. One of the academic background characteristics that has been examined by researchers is the role of prior mathematics preparation in relationship to calculus performance. Wang and Goldschmidt (2000) examined the effects of mathematics courses taken by students at the junior and high school level. This study reported that the number of mathematics courses taken at the junior and high school level plays a prominent role in higher level mathematics achievement (Wang & Goldschmidt, 2000). In a recent study, Ma (2001) examined the impact of mathematics course work and subsequent mathematical attainment of $7^{th}$ to $12^{th}$ grade students. This study showed that students exposed to advanced mathematics courses at the middle and junior high school level had high mathematics achievement in subsequent years. The results of this study are supported by previous research done using nationally representative data that high school students who take more mathematics courses perform better in standardized tests of mathematics achievement (Gamoran, 1987; Hoffer et al. 1995; Rock & Pollack, 1995).

Other academic background characteristics that have been found to be an indication of the level of mathematics ability of many freshman engineering students have been high school GPA, and ACT scores. Wilhite et al. (1998) examined high school calculus and other variables with respect to achievement in a first-semester college calculus course among college students at the University of Arkansas. They found that both high school GPA and ACT mathematics score were strong predictors of college

calculus course grade. Further, Edge and Friedberg (1984) at Illinois State University, identified factors affecting achievement in the first course in calculus. Among the variables that they used to predict success (i.e. grades A, B, or C) was ACT scores. The analysis showed that the ACT math score was the best predictor of success (Edge & Friedberg 1984). Moreover, colleges and universities continue to use standardized predictive tests, such as ACT in their admission criteria. Other studies have indicated that students with high ACT scores have typically done well in college level courses (Noeth, Cruce, & Harmston, 2003).

Researchers have also examined the impact of high school GPA on calculus achievement. In a study conducted at the University of California, Davis among engineering students, students graduating with engineering degrees came more academically prepared for college work and had higher high school GPAs (Lucas, 2003). These findings are consistent with prior research that has shown that high school GPA is a predictor of calculus performance at the college level (Wilhite, 1998).

Despite the fact that these two academic background indicators are widely used as criteria for college admission, studies have also shown that both high school GPA and ACT scores fail to represent all students, especially women and minorities. For example, Sedlacek (1989) showed that ACT correlates well with freshman grades for Caucasian students in general, but reported lower correlations for nonwhite students. As a result of the shortcomings of these indicators, some students are neglected. To alleviate the potential problem of neglecting able students, several intervention programs have been incorporated in colleges. These programs focus on able students who have relatively lower GPA and ACT scores.

## Intervention programs

Among the most widely recognized intervention programs in college mathematics is the calculus workshop model that was originally developed to serve under-represented students at the University of California, Berkeley by Uri Treisman in the late 1970s (Treisman, 1985). The Berkeley model, known as the Emerging Scholars Program (ESP), has been adapted in mathematics courses at several major universities (Selvin, 1992). Today, these programs are intentionally serving both diverse and inclusive student populations (Asera, 2001). These programs provide mathematics workshops designed to identify and build on student strengths for those students arriving at college with gaps in their mathematical backgrounds. Besides addressing the mathematical background issue, these programs also addressed the study skills factors, taking notes, doing assignments, studying for a test, using the available resources, working in groups, and emphasizing attendance and planning (Asera, 2001).

Another aspect of involvement in ESP programs is the impact the program has on academic patterns and self-perceptions (Bonsangue & Drew, 1995). ESP provides a safe environment for students to collaborate, study and even gain effective study skill in calculus (Asera, 2001). These particular factors have been found to influence students' performance at the college level.

Allen (2001) at the University of Missouri in Rolla determined the impact of the "Summer Bridge Program" on calculus performance among engineering freshmen. Students who enrolled in the Summer Bridge Program performed significantly higher in college calculus as compared to their counterparts who did not attend the summer program (Allen, 2001). The Summer Bridge Program was created specifically to address

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inadequate high school preparation. The selection criteria included students' academic success in high school, interest in engineering, and ACT score, recommendations from high school counselors, math or science teachers. The program was 7-weeks long. The goals of the summer program were: 1) to enhance and strengthen students' academic preparation in mathematics, chemistry and English; 2) to familiarize students with the resources of the engineering departments and university; and 3) to build students into community that supports each other academically, socially, and emotionally. This is accomplished by academic advising, clustering in math and science courses, and study skills seminars, such as stress and time management. Depending on their high school math background and their scores on Missouri Mathematics Placement Test (MMPT), students are placed into algebra, trigonometry or calculus courses. These students are in class five hours per day, Monday through Friday. The MMPT is used to measure the effect of the Summer Bridge Program on the math skills of the students. After participation in the summer program, many students subsequently achieve higher post MMPT scores enabling them to enroll in higher level mathematics courses. Essentially, Allen (2001) reports that students who participate in the summer program fare better than their non-Summer Bridge Program counterparts in calculus. The results from the Summer Bridge Program on students' calculus performance are consistent with studies conducted by other researchers (Bonsangue & Drew, 1995; Moreno & Muller, 1999; Prather, 1996).

It is clear that mathematics academic background plays a major role in calculus achievement (Seymour & Hewitt, 1997). Specifically, mathematics course work taken at the junior and high school levels (Ma, 2001), high school GPA (Lucas, 2003), and standardized tests such as ACT (Noeth, Cruce, & Harmston, 2003) all contribute to

success in calculus. At the same time, college studying experiences do appear to impact student performance. The Emerging Scholars Programs and Summer Bridge Programs have shown that student engagement such as study patterns is also essential for students. When students are aware of, and use the help seeking resources available to them, they appear to do well.

## The Problem

Calculus is a core required course for all incoming engineering freshman students at a large Midwestern university. The students enroll in calculus in their first semester of their freshman year. This course is taught by the Mathematics department faculty. The course is a four-hour-credit class. In order to proceed in the engineering program, freshman engineering students must obtain an "A", "B", or "C" grade in the first calculus course.

The College of Engineering Architecture and Technology at this university had observed that the number of freshman engineering students with grades "A", "B", or "C" in calculus was declining at an alarming rate. As a result, faculty members of the College of Engineering Architecture and Technology conducted a study that examined student pass grades of "A", "B", or "C" in the calculus course as influenced by the number of credit hours in the course. For example, a course listed as 2145 is five-credit-hours while 2144, is four-credit hours. The results of this study indicated that as the number of credit hours in a course increased, student success tended to decline.

As a result, and in collaboration with the Mathematics department, the College of Engineering, Architecture and Technology revised the basic calculus series from two five-credit courses to three courses of four, three, and three credit hours. The first full

implementation of the new calculus sequence took place in 2002. Data collected by the College have not been conclusive. However, preliminary analysis of the data indicated that success rate in the new course was less than the previous course (i.e. the five-credit calculus course). Since this new calculus course has not increased the calculus success rate among freshman engineering students, a close examination of the factors that influence success among freshmen engineering students has become necessary.

## Purpose of the Study

The purpose of this study is to examine the theoretical path model of expectancy-value variables that predict calculus success among freshmen engineering students. This study examined eight variables. These were total number of mathematics courses taken at junior high and high school levels, ACT composite score, ACT math score, high school GPA, utility value (valuing of calculus), student class engagement habits, help-seeking behaviors, and self-regulated learning. These factors were examined under the expectancy-value theory. Specifically, the study was guided by the following questions.

### Research questions

1. Are the theoretical expectancy variables (total number of mathematics courses taken at junior high and high school level, ACT composite, ACT math, HSGPA) significantly related? In other words, do these variables represent the "expectancy" construct?

2. Are the theoretical value variables (utility value, class engagement, help-seeking behavior, self-regulated learning) significantly related? In other words, do these four variables represent the "value" construct?

3. Is the theoretical expectancy-value model supported by these data?

These questions are based on the expectancy-value model that guided this study. This model provides a theoretical ground to examine all eight variables together and their impact on calculus success.

## Expectancy and Value

The questions posed in this study are each linked to a theoretical factor believed to affect entry-level student success in calculus. These factors are expectancy and value. Freshmen engineering students participating in this study will respond to survey items developed around the theoretical factors. The theoretical factors are fully developed in Chapter 2, review of literature. A brief explanation of each factor follows here, along with a description of the intended variables for each factor.

Value-related variables

Value factors identified in this study are; utility value, class engagement, student's help-seeking behavior and self-regulated learning. These variables are also believed to directly affect success in a first-year calculus course. The relationship between valuing calculus and success in the calculus course will be assessed through the use of nine Likert-type modified scaled items based developed by Schau's (1995) *Student's Attitude Toward Statistics for Engineering*, value subscale (SATS-E). These items are based on Eccles et al. (1983) expectancy-value theory. A total score will be developed for each student, with this score expressing student perception of the value of calculus.

Class engagement refers to involvement and participation in a subject matter by students. This entails working on class work outside the classroom or participating inside the class. Students' activities such as doing class assignments, studying before class

and/or exam, are indicators of class engagement. These class engagement activities will be assessed and related to student performance in calculus.

Help-seeking behavior refers to use of academic resources that are available to all students. This factor is divided into three components; a) use of instructor time, b) use of review sessions designed for calculus students, and c) use of the university Resource Center. These three utilization variables will be assessed and related to student performance in calculus.

Self-regulated learning will be measured through the use of Bandura's (1996) self-regulated learning subscale from his *Multidimensional Scales of Perceived Self-Efficacy*. A composite store to the eleven-item subscale will be determined for each student, and this total score will serve as the measure of self-regulated learning for the participating first-year freshmen.

Expectancy- related variables

This factor serves to identify those characteristics of freshmen engineering students believed to directly affect success in a first-year calculus course. Variables used to measure this factor will include number of mathematics course work taken at both the a) junior and high school levels, and prior academic achievement, as determined by c) high school GPA, c) student ACT composite and ACT math scores. Thus four variables will be assessed for the expectancy factor in this study.

The first expectancy variable is the total number of mathematics courses taken at junior high and high school levels. This variable refers to the sum of mathematics courses taken from $8^{th}$ grade to $12^{th}$ grade. The relationship between total number of mathematics

courses taken at junior high and high school levels and students' calculus performance will be assessed.

ACT composite score and ACT math score are the second and third expectancy variables respectively. A relationship between each variable with calculus performance among freshmen engineering students will be assessed. High school GPA (HSGPA) is the fourth expectancy variable. The relation between calculus success and high school GPA will be assessed.

### Definition of Terms

1. Calculus Success: College calculus achievement measured by end of semester's grade for the Calculus 2144 course, consists of A, B, or C grades.

2. Self-regulation: refers to student activities such as planning, monitoring, and regulating, measured as one variable by the eleven item subscale of Bandura's (1986) *Multidimensional Scales of Perceived Self-Efficacy* (MSPSE) survey.

3. Value: refers to the perceived usefulness or worth of Calculus 2144, measured as one variable by the nine item subscale of the Schau (1995) *SATS-E* survey instrument which is based on Eccles et al. (1983) expectancy-value theory.

### Significance of the Study

The available research indicates that there is a need for the identification of factors that contribute to the successful completion of calculus among freshman engineering students. This is because many of the freshman engineering students who fail calculus in their first semester most likely drop out of the program. This indication is echoed by many studies performed in engineering programs around the country (Moreno & Muller, 1999; Seymour & Hewitt, 1997; Shuman, Delaney, Wolfe, Scalise &

Besterfield-Sacre, 1998; Wong & Eide, 1997). Furthermore, knowledge of the factors will assist engineering program advisors to better advise students, and notice student problems before it is too late.

Further, the Mathematics department will be able to pace the presentation of material, and take into consideration student factors that enhance understanding of the subject matter, which leads to success in the course. All in all, the information that will be obtained from this study will aid in identifying key factors that may improve performance in entry-level calculus among freshman engineering students. Both the College of Engineering and the Mathematics department at this large Midwestern University will benefit from the study's results.

## Limitations of the Study

The following limitations are identified;

1. This study will include freshman engineering students at one university; therefore, the results may not be generalizable to all higher education institutions.

2. Only freshman engineering students who had enrolled in Calculus 2144 in fall 2002 and spring 2003 will be included in this study.

3. The sample of the engineering students used in this study was not randomly selected.

4. This study is an example among many that attempt to find factors affecting calculus achievement among engineering students, in an effort to predict engineering students' success in calculus. As such, the results are by no means to be considered definitive. This investigation is merely an attempt to offer insight

into the possible need for further research in this area. Even if this approach

appears to identify factors contributing to accurate estimation of student success, a

much larger body of evidence for the factors cited here would be needed before

this approach could be used with confidence.

## Organization of the study

This chapter has provided the background and foundation of this study. Two

theoretical factors that impact calculus success among college students have been

identified. These factors are expectancy and value and are briefly discussed under the

expectancy-value framework. A total of eight variables that are believed to impact

calculus success are identified under this frame work. These are utility value, class

engagement, help-seeking behavior, and self-regulated learning, total number of

mathematics courses taken at junior high and high school levels, ACT composite

score, ACT math score, and high school GPA. Utility, class engagement, help-

seeking behavior, and self-regulated learning are identified as value-related variables.

Total number of mathematics courses taken at junior high and high school level, ACT

composite score, ACT math score, and high school GPA are identified as expectancy-

related variables. The chapter provides the significance of this study, definition of

terms, and limitations. Chapter II provides the theoretical model and review of the

literature related to these two factors. In Chapter III, the method used in this study is

presented. While, results of the analyses are presented in Chapter IV. Finally, Chapter

V presents a summary of the study, discussion, implications of the findings and

recommendations.

# CHAPTER TWO

## Review of the literature

This chapter presents a review of the literature relevant to the study. The first section will present the theoretical framework of this study. This framework is based on expectancy-value theory. An overview of this theory will be reviewed. The next section will focus on eight research variables believed to affect entry-level college student success in calculus. These variables are divided into two categories of the expectancy-value model that directly influence academic achievement; expectancies and values. Under expectancies, total number of mathematics courses taken at junior high and high school levels, ACT composite score, ACT math score, and high school GPA are discussed. Utility value, class engagement, help seeking behavior, and self-regulated learning are all discussed under the value category.

**Theoretical Framework**

Expectancy-value theory, developed by Eccles et al. (1983), guides this study. The model presented in this study is based on an extensive review and synthesis of the literature which simultaneously recognizes the influence of the two factors with four variables for each factor that seem to influence calculus success among freshmen engineering students. The two factors; expectancy and value are independent (Eccles et al., 1983). Each factor; expectancy and value directly influences achievement or success as shown in Figure 1.  Prior students' experiences, abilities and competencies are believed to influence expectancies for success on tasks. At the same time, values placed on tasks directly influence the actions taken to achieve success. These actions include planning and executing the plans, which are indicators of self-regulation. In addition, actions may include class preparation, time on task, and participation, which are the indicators of class engagement. Finally, help seeking behaviors also provide an indicator of actions taken by students to achieve success.

A theoretical model for the current study was developed to provide a framework in which these two factors can be examined together. Figure 1 shows how the expectancy and value theoretical factors identified in this study work together. These factors are assessed with variables that are divided into value-related and expectancy-related areas.

Figure 1

Theoretical model based on Expectancy-Value Theory

**Expectancy-Related Variables**

Total math courses taken
ACT composite
ACT math
High school GPA

Variables all related

**Achievement**

Calculus Success

**Value-Related Variables**
Utility value
Self-regulated learning
Classroom engagement
Help seeking behavior

Variables all related
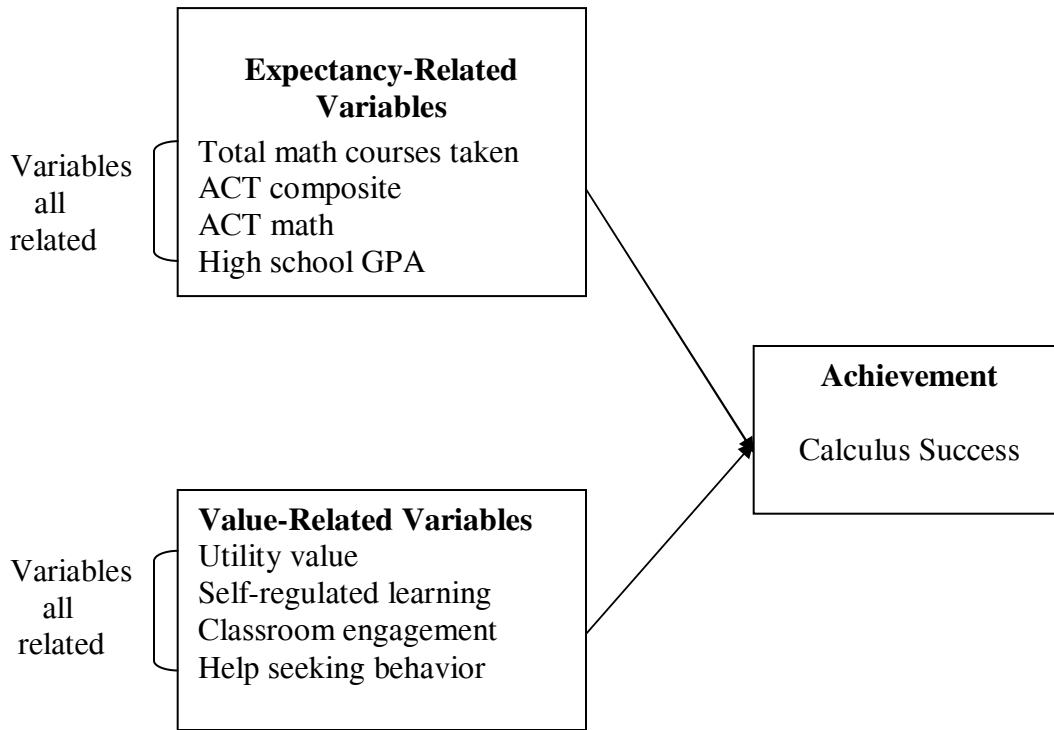
**Expectancy-value theory**

Among psychological theories of motivation, expectancy-value theory has been one of the most important views on the nature of achievement motivation (Wigfield, 1994). This theory posits that individuals' expectancies for success and the value they have for succeeding are important determinants of their motivation to perform different tasks (Wigfield, 1994). One of the recent models of expectancy-value theory is that of Eccles et al. (1983). This model was developed as a framework to understanding early adolescents and adolescents' performance in the mathematics achievement domain (Wigfield, 1994). Eccles et al. (1983) proposed that children's' achievement performance and choice of achievement tasks were most directly predicted by their expectancies for success on those tasks and the subjective value they attach to success on those tasks. In

addition, they contend that expectancies and values are most directly determined by other achievement-related beliefs, including achievement goals, and self-schemata, and beliefs about ability and competence.

The expectancy-value model of achievement posits that individuals' expectancies for success and the value they have for succeeding are important determinants of their motivation to perform different tasks, and their choices of which tasks to pursue (Wigfield and Eccles, 2001). Eccles et al., (1983) posit that these two constructs; expectancy and values are independent. A crucial factor influencing achievement is the task value component. Wigfield and Eccles (2001) identify four components of task value. They are attainment, intrinsic interest, extrinsic utility, and cost value components. This present study will focus on the extrinsic utility value and its relation to academic achievement.

**Value-related variables**

The value related factor identified in this study will be measured with four variables; are utility value, students' self-regulated learning (SRL), classroom engagement, and help seeking behavior. According to Eccles et al., (1983) model, value has four components. These are attainment, interest, utility, and cost (Wigfield & Eccles, 2002). The value category of Eccles et al. (1983) expectancy-value model captures these four variables. Three of the four theoretical variables examined in this study are captured by the cost component of the value construct. These are self-regulated learning, help-seeking behavior, and classroom engagement. It is hypothesized that these three variables strongly correlated with each other. On the other hand utility value correlates significantly with self-regulated learning and classroom engagement. All in all, the four

theoretical variables capture the value construct. Therefore, it is expected that if students value a task, they are likely to engage in activities that enhance achievement and or success on the task. Activities for this study that impact achievement are self-regulation, classroom engagement, and students' help seeking behaviors.

This section of the review will focus on extrinsic utility value, self-regulated learning, classroom engagement, and students' help-seeking behaviors.

<u>Utility value</u>

Jacobs & Eccles (2000) define utility value as the usefulness of the task for individuals in terms of their future goals. They argue that a task can have positive value to an individual because it facilitates important future goals, even if s/he is not interested in the task for its own sake. For instance, an engineering student may not be interested in calculus, but because s/he wishes to become an engineer, the calculus course has a high utility value for them. In one sense, this component captures the extrinsic reasons for engaging in a task (Jacobs & Eccles, 2000).

Research on values has identified achievement –related indicators. For example, Eccles and Wigfield (1995) identified interest, usefulness, and importance to doing well on a task as indicators of values. Ryan and Deci (2000) reported the same indicators. In studies of achievement values, individuals typically rate particular domains, such as science or math, in terms of interests, usefulness, or how important it is that they do well (Eccles & Wigfield, 1995). Values have been found to predict achievement (Berndt & Miller, 1990).

The expectancy-value model of achievement posits that individuals' expectancies for success and the value they have for succeeding are important determinants of their

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motivation to perform different tasks, and their choices of which tasks to pursue (Wigfield and Eccles, 2002). Hence one crucial factor influencing achievement is the task value component. Eccles and Wigfield (2002) identify the utility component of task value influencing achievement behavior. According to them, utility value refers to the usefulness of the task for individuals in terms of their future goals, including their career goals. Calculus among engineering students renders itself clearly to the utility value aspect of the expectancy-value model. Calculus, in the present study is taught by the mathematics department hence there may be a tendency for students to wonder about the value of the subject.

Besterfield-Sacre, Atman, and Shuman (1998) studied engineering student attitude and proposed a need to evaluate students' attitudes toward the engineering program such as the courses and or curriculum. In addition, Sorge (2001) investigated the impact of engineering students' attitudes on statistics performance in a large comprehensive university. She discussed the need to investigate the relationship of value and achievement among engineering students' courses. The study had shown that values, specifically utility values, influenced the engineering students in their performance on a statistics course (Sorge, 2001).

Since the early 1950's, values have been recognized as impacting achievement (Atkinson, 1957). Early value scales were designed to measure both values and expectancies. In the past two decades, value scales have evolved. As such, many value scales mirror those early value scales. For example, Rokeach (1973, 1979, and 1983) developed value scales that assess general human values. Rokeach's (1979) view values as standards or criteria to guide judgment, choice, attitude, evaluation, argument,

exhortation, rationalization, and one might add, attribution of causality" (p. 2). In this case, value scale measures the clusters of values that are correlated to political opinions, involvement, racism, altruism and religious activity (Rokeach, 1973, 1980). On the other hand, Feather (1975, 1979& 1982) describes values as general, stable beliefs about what goals and ways of behaving are desirable, and also as the standards or criteria used by individuals to evaluate behavior. Feather's (1971) value instrument involves ranking of values on the terminal and instrumental values scales.

More recently scales to measure components of utility value that are theorized to impact achievement have been developed. For example, Schau, Stevens, Dauphinee, Del Vecchio (1995) developed the Students Attitude Toward Statistics for Engineering (SATS-E). Schau's et al. (1995) value scale was developed specifically for engineering students. This values subscale was developed to capture the utility value factor, a variable examined by this study. It is clear that the Value subscale of SATS-E has Expectancy-value theory as its foundation. This well developed and tested subscale will be used in this study. According to Eccles et al. (1983), worth, importance, and usefulness of a task are indicators of utility value. Wigfield & Eccles (2000) posit that students with high utility values put effort into tasks, in turn they become successful. As such, in this study the impact of utility on the value calculus course is examined.

In conclusion, literature presented here provides a basis to incorporate values as variable to be explored by this study. Utility value of a course or subject tends to influence achievement. Studies have shown that students who see the value of the course tend to perform higher compared to those students who have value the course less.

<u>Self-Regulated Learning</u>

According to social cognitive theory, self-regulation is viewed as an interaction of personal, behavioral, and environmental processes (Bandura, 1986). In essence, it entails behavioral skills of self-managing environmental contingencies, and knowledge and sense of personal agency to enact this skill in relevant contexts (Zimmerman, 2000). Zimmerman (2000) explains that self-regulation incorporates thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals.

In the past two decades, a number of researchers have investigated the effects of self-regulation on students' academic achievement (Schunk & Zimmerman, 1997). This research has consistently demonstrated the importance of self-regulated learning to academic achievement. Self-regulated learning has also been demonstrated to be a significant predictor of achievement track (high or low) (Zimmerman & Martniez-Pons, 1986), college student's assignment to developmental/remedial or regular college admission (Ley & Young, 1998), and college student's academic success (Zimmerman, Bandura, & Martinez-Pons, 1992). Thus, the significance of self-regulated learning to academic settings and performance has been fairly established.

According to Bandura (1997), self-regulated learning capabilities are linked to achievement. As such educational researchers have linked self-regulation to achievement in classroom settings (Miller, 2000). Zimmerman (1994) posits that research on self-regulated learning continues to identify attributes and strategies used by effective self-regulated learners. For example, Pintrich and De Groot (1990) examined individual differences in a number of self-regulated learning strategies among students (e.g., rehearsal, persistence, comprehension monitoring). Research studies on academic

learning show that students who are able to regulate their own learning in the face of many distractions and difficulties in classrooms perform and learn better than students who lack self-regulatory capabilities (Pintrich, 2000).

Given the importance of self-regulating learning in general, and more specifically within classroom settings, it is interesting that there is very limited empirical research focused on self-regulated learning among engineering students. The impact of self-regulated learning on calculus success among freshmen engineering students has not been studied. Given that self-regulated learning has been found to be domain-specific (Miller, 2000), the current study examined the impact of self-regulated learning among freshmen engineering students on calculus success.

There are many different models of self-regulated learning that propose different constructs and mechanisms, but they do share some basic assumptions about learning and regulation. Pintrich (2000) identifies four assumptions that these models have in common. First, all models view learners as active participants in the learning process. Secondly, all models assume that learners can monitor, control, and regulate certain aspects of their own cognition, motivation, and behavior as well as some features of their environments. Thirdly, all models assume that there is some type criterion or standard against which comparisons are made in order to assess whether the process should continue as is or if some type of change is necessary. Finally, all models assume that self-regulatory activities are mediators between personal and contextual characteristics such as achievement or performance.

These four self-regulated learning model assumptions identify key indicators of self-regulated learning strategies. These are organization, concentrating, participating,

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identifying and using available resources to enhance achievement. All four indicators of self-regulated learning strategies are examined in this study. Since calculus course work involves completing assigned problems, students enrolled in the class are expected to plan and work on the problems outside the classroom. However, students do face various distractions while in college. There are many activities in college besides academics. For example, sports, parties, and social life in general. These extracurricular activities may come in the way of students' academic work and jeopardize their performance. However, according to research on self-regulated learning, students who exercise self-regulated learning strategies in the midst of all distractions are more likely to succeed in their academic endeavors (Pintrich, 2000).

This study used Bandura's (1989) *Multidimensional Scales of Perceived Self-Efficacy* (MSPSE). This scale was designed to measure student's perceived capability to use various self-regulated strategies; organizing school work, participating in class discussions by taking notes, concentrating on subjects by studying and completion of assignments, and even using the help resources when in need of assistance. Research indicates that organizing is an important study activity (DiVesta & Moreno, 1993). Organizing materials may be broadly described as transforming and "rearranging instructional materials to improve learning, for example, 'I make an outline before I write my paper" (Zimmerman & Martinez-Pons, 1986, p. 618). Organizing was strongly associated with achievement in several studies. For example, Zimmerman and Martinez-Pons (1988) reported that organizing strategies are strongly related to achievement among middle school students. In addition organizing strategies were found to be strong contributors in explaining the difference between advanced track and lower track high

school students (Zimmerman & Martinez-Pons, 1986). At the college level, organizing strategies predicted regular admission and underprepared college student group classification (Ley & Young, 1998).

Successful learners make efforts to determine or arrange a place where a task is to be completed (Trawick & Corno, 1995). Structuring the environment relates to a learner's ability to cope effectively with disturbances, a crucial part of self-regulation process (Corno, 1994). In a confirmatory study among 100 college students managing distractions was a first order factor contributing to self-regulation (Orange, 1999). The ability to concentrate on schoolwork in midst of distractions is a vital self-regulated learning strategy. Gagne (1985) showed that environmental structuring enables learners to eliminate or decrease distractions and to attend to learning. Before learners can pay attention they must have an environment that allows, if not encourages, them to focus attention on the learning task at hand (Ley & Young, 2001). Expert learners have knowledge about the optimal study conditions for meeting demands of the task (Ertmer & Newby, 1996). These learners ask themselves, "When and where do I study best? How supportive is the learning environment?" (Ertmer & Newby, 1996, p. 20). Evidence from studies in which learners have recalled their usual study practices suggests that academically stronger learners use environmental structuring more than do academically weaker learners (Ley & Young, 1998).

Review of self-regulated learning has investigated the presence of SRL skills and documented their impact on academic achievement. This literature indicates the importance of SRL in academic achievement. These studies strongly support the notion that effort expended organizing, concentrating, participating, and managing distractions

while involved in academic work influences achievement. These four identified aspects are indicators of self-regulated learning strategies. The current study examined the effect of self-regulated learning on calculus success among freshmen engineering students.

<u>Classroom academic engagement</u>

Academic engagement is a term often used to describe active involvement, commitment, and attention as opposed to apathy and lack of interest (Newmann, Wehlage, & Lamborn, 1992). Researchers of academic engagement identify certain indicators of engagement. For example, Singh, Granville and Dika (2002) consider doing homework, coming prepared for classes, regular attendance, not skipping classes as a reflection of student engagement. In addition, Connell and Klem (2004) identify time students spend on work, intensity of concentration and effort, tendency to stay on task, and propensity to initiate action when given an opportunity as indicators of academic engagement.

Research on academic engagement links higher levels of engagement in school to improved performance (Connell & Klem, 2004). For example, Finn (1993) found that student engagement is a robust predictor of student achievement and behavior. In addition, Wasserstein (1995) asserts that highly engaged students are intrinsically motivated to learn and thus perform at higher levels than low engaged students. In addition, Guthrie and Anderson (1999) contend that engaged students are good learners. Skinner, Wellborn, and Connell (1990) investigated predictors of achievement in grade school students and determined that engagement mediated the effects of students' beliefs about learning on school achievement. It is clear that time, participation, and preparations are key indicators of academic engagement.

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Time on task has been identified as an indicator of class engagement. For example, Ficham, Hokoda, and Sanders (1989) showed that time on task influences achievement. Time on task in this study was measured by the time students spend doing work. In fact, students who did more work than required performed at higher levels. Nymstrand and Gamoran (1991) document similar results that suggest substantive engagement behavior in class work produces higher scores on achievement measures. In addition Boekaerts, Pintrich and Zeidner (2000) note that engaged students spend time on their work and use self-regulation strategies to study. In a study to examine the effect of engagement and achievement related outcomes, Marks (2000) reported a positive correlation between engagement and grades. In addition, Finn and Rock (1997) document large significant differences on engagement measures between students classified as academically successful and non-academically successful. This study showed students that exhibit high class engagement behaviors perform higher on academic measures. Thus time spent doing class work is an indication of the level of academic engagement. These studies suggest that the more time one spends on doing class work the likely they are to succeed.

Although learning involves cognitive processes that take place within each individual, motivation to learn also depends on the student's active involvement in the classroom. Active classroom participation is one of the indicators of academic class engagement. Greenwood, Delquadri, and Hall (1984) identify classroom behaviors such as participating in tasks, writing notes in class, reading silently, asking and answering questions as indicators as indicators of classroom engagement. These indicators have been found to impact academic achievement (Gettinger & Seibert, 2002). Other

researchers such as Linnenbrink and Pintrich have termed them as enablers to academic achievement. These researchers therefore suggest that these classroom behaviors identified are relevant measures of students' class participation, subsequently a measure of academic engagement. Given that class engagement influences performance, any form of engagement is important. A link of class participation is suggested to be an influence on academic performance.

Academic activities done prior to class are indicators of preparation. These activities provide an indication of how one is engaged in a class. These activities are studying the textbook, reviewing class notes, reading a head, doing homework before class to name just a few. Researchers contend that students who prepare before class tend to perform well in class. For example, Newman (1981) identified student participation in school as one characteristic students' involvement and engagement. Ficham, Hokoda, and Sanders (1989) showed that students who prepared by studying and doing extra academic work outside the class outperformed their counterparts. Further, students who engage in these academic activities outside the classroom tend to increase their comprehension and learning of new materials (Hancock & Betts, 2002). Academic activities outside the class are a clear indication of student academic engagement. Academically disengaged students tend to be lazy and bored (Dowson & McInerney, 2001). Further, they tend to avoid work resulting to poor class performance.

Despite some encouraging results linking academic engagement and achievement, there has been limited research on this topic at the college level. Handlesman, Briggs, Sullivan, and Towler contend that  engagement studies at the college level have focused on major projects such as the National Survey of Student Engagement (NSSE) at Indiana

University (NSSE; 2000, 2002). The NSSE assesses how an institution's programs and practices produce desired effect on students' activities, experiences, and outcomes. Thus, the survey measures engagement as a global quality that students have in relation to elements such as level of academic challenge and supportive campus environments. The focus of NSSE is on active learning and other educational experiences and does not focus on individual courses; rather it assesses students' overall perception.

Given that the focus of this study is to explore factors that influence success in a calculus course among engineering freshman students, research indicates academic engagement should serve as a factor. In conclusion, the research reviewed shows that class engagement is correlated with higher achievement. Further the literature identifies time on task activities such as doing homework, studying, participating in class, and doing more work than required work outside the class as indicators of student engagement. Since little research has been done on the impact of student engagement behaviors on calculus among engineering students, there is evidence from a variety of studies to suggest that engagement behaviors may positively influence achievement.

Help-Seeking Behaviors

Help seeking is a way of regulating the social environment to promote learning (Schunk, 2000). Help seeking behavior incorporates strategies students use in seeking assistance when they encounter difficulties. Theory on academic help seeking among students treats help seeking behavior as an adaptive strategy for coping with difficulty and promoting mastery (Butler & Neumann, 1995). In addition, research on help seeking posits help seeking as an important self-regulatory strategy that contributes to student learning (Newman, 1994).

A help-seeking model was originally presented by Nelson-LeGall (1981). This model identified is a task analysis of the help seeking process, and it is comprised of five steps. These steps are:

1. Become aware of need for help.

2. Decide to seek help.

3. Identify potential helper(s).

4. Use strategies to elicit help.

5. Evaluate help-seeking episode

In this model, a learner first must become aware that the task is difficult or that s/he is stuck and is in need of help. In the next step, learners must consider all available information and decide whether to seek help. Once a decision is made to ask for help, a suitable helper must be found. In the next step, the request for help must be expressed in a suitable way. This step is influenced by students' knowledge and skills of discourse (Newman, 1998a); the request must match the task demands. When students have received help, they must decide on what the degree of help that is useful to address their difficulties. If it does not help them, they must request further help, or they may even need to identify a new helper. The first three steps of this model will be used for this study. The last two steps are beyond the scope of the present study. In the following section, literature on help seeking behavior and achievement is reviewed in the light of the identified three steps of the help-seeking model.

Being aware of need for assistance when students encounter situations in which there is some discrepancy between the demands made and their ability to meet them is the first step in the helping seeking model. In addition, when students monitor their

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academic performance, show awareness of difficulty they cannot overcome on their own, and exhibit the wherewithal and self-determination to remedy that difficulty by requesting assistance from a more knowledgeable individual, they are exhibiting awareness of need for help (Newman, 2002). This step is foundational for the help seeking strategy. Newman (2002) contends that help seeking can avert possible failure, maintain engagement, lead to task success, and increase the likelihood of long-term mastery and autonomous learning. These studies suggest that for a student to be aware of a need for help, s/he must be faced with a difficulty in the subject area. The ability to assess task difficulty, monitor task progress, and evaluate one's own comprehension and knowledge are major metacognitive functions (Newman, 1998a). However, another way to assess the need for help is through feedback. When students get feedback on their academic work, they are able to assess whether they need help or not.

After assessing the need for help, the second step is to make a decision to seek help. In this step, learners must consider all available information and decide whether to seek help. Puustinen (1998) assumed that efficient self-regulated learners first question themselves, seeking the right answer or solution to the task at hand before deciding to ask for help. Ryan and Pintrich (1998) consider this step crucial in the help seeking process. There are several learner- related factors that have an effect on this decision. For example, learners may not ask for help out of fear that they will receive less credit for a successful outcome (Nelson-LeGall, 1981) or that the instructor or fellow students will view them as incompetent (Ryan, Pintrich, & Midgley, 2001). One motivation to seeking assistance is performance. Karabenick (2003) has shown that students who adopt mastery

goals (a focus on learning and self-improvement) are more likely decide to engage in help seeking.

Once the decision has been made to seek assistance, a suitable helper must be found. In classroom contexts, an instructor or fellow student might serve this role. The criterion for choosing the helper appears to differ by age (Aleven, et al., 2003). For example, Nelson-LeGall (1981) contend that perceived competence of the helper and his or her expected sensitivity to the needs of the learner may play a key role in selecting a helper. Nonetheless, students at the college level have a choice of helpers. These range from their fellow students, learning resource centers, teaching assistants, review sessions, and instructors.

Asking for help has been found to correlate significantly with self-regulated learning strategies (Newman, 1994). When students monitor their academic performance, show awareness of difficulty they cannot overcome on their own, and exhibit an effort to remedy that difficulty by requesting assistance from a more knowledgeable individual, they are exhibiting self-regulated learning strategy (Newman, 2002). Zimmerman (1990) also observed that self-regulated learning employs extraordinary effort in achieving task. This effort according to Bandura (1993) is predicated by ability of the students. Students with low ability on a task, and with high self-regulated learning strategies are bound to seek for help; where as those with low self-regulated learning skills may avoid seeking-help (Ryan, Pintrich, & Midgley, 2001). As such, studies have shown that help-seeking is an important self-regulatory strategy that contributes to student learning (Karabenick & Sharma, 1994; Newman, 1994).

Studies on help-seeking among engineering students are limited despite the fact that help-seeking may be beneficial to students. Most work has been done on advising, study skills, and curriculum integration. Treisman's (1985) Emerging Scholars Programs have been established in many colleges of engineering. These programs have become sources of assistance and community among students, and have thus encouraged help-seeking behavior.

Asera's (2003) review of Emerging Scholars Programs (ESPs) posits that these programs have become a major source of help to students in need of help. Students who realize that the task at hand is beyond their ability attend these programs to get assistance. In fact several studies have pointed out that students who attend these programs to get assistance do perform higher than their counterparts. For example, Allen (2001) at the University of Missouri, Rolla showed that engineering students who attended the ESP program had higher calculus grades than the non ESP participants.

Calculus has been identified as one of the challenging courses among college students (Gainen & Willemsen, 1995). In calculus class, students are provided with home work problems, quizzes and exams. After given assignments, quizzes or tests, students receive feedback. This feedback provides an assessment for the student. In fact, most of the universities and colleges have developed programs to provide assistance to students who realize a need for help in this subject area.

Taken together these studies suggest help-seeking is an important factor that facilitates learning. Students are prone to face difficulties especially, in calculus. The availability of help resources to students when they face difficulties is crucial. This present study identifies instructors, teaching assistants, Mathematics Learning Resource

Center, review sessions, and study groups as helpful resources. The fact that these resources are available to students leads to an evaluation of the use in the form of their help seeking behaviors of students.

## Expectancy-related factors

The expectancy related factor identified by this study are the total number of mathematics courses taken at junior high and high school level, ACT composite scores, ACT mathematics scores, and high school GPA. The literature will review each of these four variables as it relates to college entry level calculus course success.

<u>Number of mathematics courses</u>

There are a number of indicators of academic background characteristics. These indicators are believed to impact mathematics achievement. For example, mathematics curriculum structure, prior mathematics achievement as measured by GPA, the average of the highest course completed at the junior high and high school level, overall school achievement and the course work rigor. One crucial indicator of background characteristics is the total number of mathematics courses taken at junior high and high school level (Ma, 2000).

Research in the mid 80s and 90s posits that course taking behavior influences achievement. Bryk, Lee, and Smith (1990) studied high school organization and its effects on teachers and students. Among several factors identified was curricular organization in schools in terms of courses that students take. This has powerful effects on academic achievement. For instance students who are exposed to many mathematics courses earlier in junior high school tend to perform well in their subsequent mathematics courses (Ma, 2000). Further, the principal determinant of student achievement is course

taking (Bryk, Lee, & Smith, 1990). Lee, Chow-Hoy, Burkam, Geverdt and Smerdon (1998) examined mathematics courses students take, whether students are in public, independent or Catholic schools, and low ability versus high ability in mathematics in relationship to mathematics achievement among high school students. Among the findings, the number of mathematics courses taken by students influenced mathematics achievement in all three groups of students (public, Catholic, independent).  They concluded that mathematics courses students take prior to high school strongly influences mathematics achievement at high school level.

Raizen and Jones (1985) express similar views from their preliminary review of indicators of pre-college education in science and mathematics. In this study, they identified the number of mathematics courses students take as a vital indicator of school input. This variable shows a dimension of opportunity to learn mathematics as well as course content. Cool and Keith (1991) examined ability, time spent on homework, motivation, and academic coursework as they influence learning. They performed a path analysis on High School and Beyond data to examine the effects of these variables on the academic achievement of high school seniors. This study reports a strong direct effect of academic coursework on student achievement. In addition, Smith and Walker (1988) document that differences in mathematics proficiency among students can be explained by differences in course taking behavior. Males and females perform equally well if they have equivalent course taking backgrounds.

Additional research studies continue to confirm the relationship between number of mathematics courses taken with students' achievement. In a study to determine factors that influence high school achievement, Chaney, Burgdorf and Atash (1997) analyzed

1990 National Assessment of Educational Progress (NAEP) and the 1990 High School

Transcript Study data. They compared students' course taking patterns with their NAEP

achievement scores and with schools' graduation requirements. They reported that

student's course taking patterns not only influenced graduation but also achievement. In

1995, Hoffer, Rasinski and More analyzed data from the National Education

Longitudinal Study (NELS), which controlled for student background characteristics such

as race. Their findings report a positive relationship between the total number of

mathematics courses completed and gains in achievement test scores from 8 grade to 12

grade. These findings are supported by Lee, Croninger, and Smith (1997) who

investigated how the organization of mathematics curriculum in the U. S. high schools

affects how much students learn in that subject. They used data on background and

academic proficiency of 3, 056 high school seniors in 123 public high schools from the

1990 National Assessment of Educational Progress (NAEP) in mathematics. They

investigated average course work in mathematics courses (in Carnegie units), variability

in academic course-taking in mathematics, proportions of graduates who follow an

academic or college-preparatory program, variability of graduates in an academic

program, proportion of mathematics courses taken that are academic, and average ninth-

grade GPA. The results indicate that students are advantaged by attending schools where

they take more academic mathematics courses. These results support prior findings in this

area, e.g., Rasinski and More (1995). Therefore, from these studies, it is clearly indicted

that the numbers of mathematics courses students take at the junior high and high school

level correlates positively with mathematics achievement.

As students progress from junior high to high school, they encounter more opportunities to take more mathematics courses. Meyer (1998) reported that as students take more mathematics courses their mathematics achievement gains increases. This study suggests that as students advance from junior high to high school, they encounter opportunities to enroll in more mathematics courses. Another study to investigate the impact of mathematics course taking on student achievement conducted used the 1999 NAEP data. In this study, Campbell, Hombo, and Mazzeo (2000) report that the type of mathematics courses students take impacts their performance. Among high school students, they report that students who continuously enroll in progressively more mathematics courses through out high school score highly on a mathematics achievement test. A similar study was conducted among eighth grade students using data from the 1992 National Assessment of Educational Progress (NAEP) in mathematics for the nation and the states. In this study, the researchers examined the mathematics course taking patterns of eighth grade students and the impact on mathematics achievement. Type of course and whether or not they were taking mathematics that particular year were the variables of interest. This study found that students who had enrolled in pre-algebra and algebra had higher proficiency scores than students taking only eighth grade mathematics (NAEP Facts, 1996). Similarly, Ma's (2000) study used six waves of data (grades 7-12) from the Longitudinal Study of American Youth. This research examined the effects of advanced mathematics course work on subsequent achievement in, and attitude toward, mathematics, with partial adjustment for student background characteristics. Results showed that in the early grades of high school, algebra courses and every advanced mathematics course significantly affected mathematics achievement. These findings are

supported by earlier studies that used the same NELS data. In addition, Lee, Croninger and Smith (1998) examined the effects of math course taking at the lower grades and achievement. Their findings suggested that schools that offered courses higher than algebra and more high –end offerings (especially calculus), their students progressed farther in the mathematics curriculum. Further, their average achievement in mathematics was higher compared to students who did not receive the advance mathematics offering.

The findings of these studies have encouraged an increase mathematics offering in both junior high and high schools. According to Campbell, Jolly, Hoey, and Perlman (2002), the number of eighth grade students taking Algebra has increased. Hence, the more eighth grade students take Algebra, the more likely they will take calculus in high school, according to Gamoran and Hannigan (2000). At the high school level, nearly two-thirds of 17 year olds report taking Algebra II, Precalculus and/or calculus (Campbell, Jolly, Hoey, & Perlman, 2002). As a result, NAEP mathematics achievement scores among high school students have been on the increase.

Noeth, Cruce, and Harmston (2003) conducted a survey among high school students intending to major in engineering. They report that high school students planning to major in engineering at the college level take more advanced mathematics courses. Out of 52,112 students planning to major in engineering, 56 percent took calculus high whereas all students took Algebra 1, Algebra 2, and geometry. Further, 67.7 percent took of those planning to major in engineering trigonometry, and another 62.9 percent taking another advanced math course beyond Algebra II.

Number of mathematics courses taken at the junior high and high school levels appears to have a strong correlation with mathematics achievement scores. These studies

have shown that advanced mathematics courses are an indicator of student's mathematic academic background. Besides, these studies indicate an increase in advanced mathematics course taking patterns among students, especially students planning to join engineering majors in colleges. Another important aspect revealed by these studies is that students who take advanced mathematics courses continue to enroll in progressively more advanced mathematics courses. Thus, students who take more and advanced mathematics courses during their junior high and high school levels not only perform higher in the mathematics, but also develop deep conceptual understanding.

In summary, the literature has shown that both number of mathematics courses taken by students at the junior high and high school levels are very important academic background characteristics for calculus achievement.

ACT scores

Another indicator of academic background aptitude is the ACT score. ACT score primarily measures educational achievement in college-preparatory courses (ACT, 1997). Thus various studies have used ACT scores as an academic background indicator. For example, Edge and Friedberg (1984) examined factors affecting achievement in first calculus course among freshman students at Illinois State University. They examined the predictive power of several academic variables such as ACT scores, SAT scores, high school GPA, high school rank, and placement scores. This study reported that among variables such as high school rank, Algebra skills and concepts, ACT math scores were the best predictors of first year calculus success. Students with high ACT math scores were predicted to receive higher grades in the course. In addition, Wilhite, Windham, and Munday, (1998) included ACT math scores, high school rank, age and high school

mathematics achievement as academic achievement predictors in first year calculus course among college freshman. Their findings showed ACT math score to be a stronger predictor of calculus success. Similarly, Allen (2001) examined the impact of pre-entry characteristics of ACT math score and high school percentile rank on first semester college GPA among freshman engineering students. He reported that 28.6 percent of the variance in first-semester college GPA could be attributed to ACT math scores and high school percentile rank. In another study examining high school GPA and ACT scores in predicting college academic success, Noble and Sawyer (2002) analyzed of the 1996-97 ACT data comprised of 219,435 first year students from 301 postsecondary institutions. The results of their analysis suggest that ACT score and high school GPA jointly are more accurate in predicting first year college GPA. The use of ACT scores in predicting success in first year calculus is also demonstrated in Dougherty and Cooley (2003) study The inclusion of the ACT scores, specifically the composite and math scores for the present study is clearly indicated by the literature reviewed. Further, at the present institution, ACT scores and high school GPA are criteria used for admission in the engineering program. The use of ACT scores is certainly an indicator of students' academic background and thus serves as an important variable in this study.

High school GPA

High school GPA is an indicator of student's high school performance (Dougherty & Cooley, 2003). In addition, high school GPA has been used to predict students' college performance. For example, Beecher and Fischer (1999) analyzed high school courses and GPA as predictors of college success among 409 students at Utah Valley State College. High school GPA was reported to be the most powerful predictor of

success and thus retention. Similarly, Miceri (2001) found that high school GPA had a stronger relationship to student outcomes than test scores from analyzing nine years of data from over 15, 000 students at the University of South Florida. Several studies have considered high school GPA as an indicator of mathematics or calculus performance in college. For example, Dougherty and Cooley (2003) used high school GPA to predict calculus performance among engineering students at Colorado University.

Research studies on engineering students have continued to examine the impact of high school GPA on calculus achievement, college success, persistence and retention in the engineering program. For instance, in a study investigating the predictive effects of high school calculus and other variables on achievement in first semester college calculus courses among college freshman students, Wilhite, Windham, and Munday (1998) examined high school GPA, high school rank, ACT scores, and age. Their analyses report that high school GPA was among the strong predictors of calculus achievement in the set of variables. Students who had high GPA performed well in their first college calculus course. Similarly, Perkins (2002) examined academic aptitude variables, SAT scores, high school GPA, high school rank, and high school grades in mathematics courses, mathematics placement scores and their impact on persistence in the engineering program among freshman engineering students. Among the variables reported to be significant in predicting success, thus persistence in the program, was high school GPA. In another study at the University of California, Davis, Frye-Lucas (2003) identified high school GPA as an educational background indicator. The impact of high school GPA on calculus success among African-American freshman engineering students was examined. The results show high school GPA and number of high school mathematics courses were

strong predictors of student outcomes in first year calculus. More recently, Dougherty and Cooley (2003) predicted student performance in freshman calculus. They report that high school GPA was a strong predictor of calculus performance. Students with high high school GPA's tended to pass the first calculus course.

These studies all suggest that high school GPA can be a measure of academic background. In fact, Bonsangue and Drew (1995) posit that high school GPA provides a measure of precollege achievement as well as academic expthe Universityre. Hence the current study plans to examine the impact of high school GPA on calculus.

Academic background characteristics play a crucial role in achievement. Literature reviewed identified indicators of academic background believed to influence calculus achievement at the college level. These are the number of mathematics of courses students take at the junior high and high school levels. Such courses are believed to provide the conceptual understanding and foundation to more advanced mathematics courses such as calculus at the college level. In addition, the expthe Universityre to many and advanced courses at the pre-college level is believed to influence students' attitude toward mathematics. As students enroll in more mathematics courses, they appear more likely to positively perceive mathematics. This perception can influence performance in the long run.

In conclusion this study will examine the number of mathematics courses taken at the junior high and high school. In addition, high school GPA and ACT composite and ACT math scores will be examined to determine their influence on first year calculus course success among freshman engineering students.

**Chapter Summary**

This chapter outlines eight variables affecting calculus success among freshman engineering students. Taken together these variables are based on strong theoretical foundation from the Eccles et al. (1983) expectancy-value model. Expectancy and value are independent of each other (Eccles et al., 1983). Within this model, utility valuing of calculus, self-regulated learning, classroom academic engagement, and student's help-seeking behavior are identified as a value-related factors. The review discussed how each indicator influences achievement. In addition, academic background characteristics are identified as an expectancy-related factor. The chapter reviewed four variables of academic background characteristics. The four are the number of mathematics courses taken at junior high and high school levels together, ACT composite score, ACT math score, and high school GPA. Studies reviewed suggested that the number of mathematics courses taken at junior high and high school levels, high school GPA, and ACT composite scores and mathematics sub scores are good indicators of students' mathematics background characteristics.

In conclusion, this literature review has provided a basis for exploring these eight variables and their impact on calculus achievement among freshman engineering students at one large Midwestern university. The expectancy-value theory provides a theoretical framework for uniting these factors. Table 1 summarizes the factors, corresponding variables, and corresponding variable indices identified in this study.

Table 1

Theoretical Factors with correspond variables for the study

| Factor | Variable | Index |
|---|---|---|
| Expectancy | 1. Total number of mathematics courses taken at junior and high school levels. | Sum of math courses taken |
| | 2. ACT composite score | ACT composite |
| | 3. ACT math subscores | ACT math |
| | 4. High school GPA | HSGPA |
| Value | 1. Utility value | SATS-E score |
| | 2. Self-regulated learning | MSPSE-score |
| | 3. Classroom engagement | Engineering Survey score |
| | 4. Help-seeking behaviors | Engineering Survey score |

## CHAPTER THREE

### Research Method

The purpose of this study was to examine the theoretical path model of expectancy-value variables that predict calculus success among freshmen engineering students. This study examined eight variables. These were total number of mathematics courses taken at junior high and high school levels, ACT composite score, ACT math score, high school GPA, utility value (valuing of calculus), student class engagement habits, help-seeking behaviors, and self-regulated learning. These factors were examined under the expectancy-value theory. The study was guided by the following questions.

### Research questions

1. Are the theoretical expectancy variables (total number of mathematics courses taken at junior high and high school level, ACT composite, ACT math, HSGPA) significantly related? In other words, do these variables represent the "expectancy" construct?

2. Are the theoretical value variables (utility value, class engagement, help-seeking behavior, self-regulated learning) significantly related? In other words, do these four variables represent the "value" construct?

3. Is the theoretical expectancy-value model supported by these data?

To answer these three research questions, this chapter is divided into five sections. The first section provides the background information. The second section describes the sample used in the study. The third section describes the measures used. Section four reviews the variables used in the study, and describe the procedures used to collect the data. The fifth section provides a description of the statistical analyses used to analyze the data obtained.

**Background**

The setting of the study was the College of Engineering, at a large Midwestern university. The target population of this study was all freshmen-engineering students enrolled in one entry-level calculus course during Fall 2002 and Spring 2003 semesters. The Dean's office of the College of Engineering Architecture and Technology at this university, through their Student Assessment Specialist and Student Information Services, compiled a list of all freshman engineering students enrolled during the targeted time frame. In the compiled list, both telephone contacts of the students and their parents were included. A total of 512 students were identified. The contact information was vital for this study. Data collection was done through the administration of the instrument via telephone. Since the list contained all the students during the proposed time frame, all students on the list were contacted. An Institutional Review Board approval was obtained to collect data (See Appendix A). An implied consent statement (see Appendix B) was used to solicit each student's participation. Only students who were eighteen or older in age were contacted by the BSR to participate in the study, therefore parents were not contacted. Participation was solely voluntarily. The Bureau for Social Research (BSR) at

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the large Midwestern university performed the telephone survey. The Engineering telephone survey was used to collect data from the participants (see Appendix C).

Prior to administering the Engineering Survey, the BSR selected fifteen interviewers. The interviewers were selected based on their communication and data collection skills. They received training specifically for the collection of data for this study. A step by step procedure that was used in selecting, training of interviewers, how the data were collected is provided in Appendix D. To maintain confidentiality, the fifteen interviewers signed a confidentiality statement (See Appendix E). A common script was used by all interviewers (see Appendix F). A list of frequently asked questions was provided to all interviewers to assist in answering questions from the participants (see Appendix G).

### Sample

The initial sample for this study consisted of 512 students. However, 77 students were eliminated because the contact telephone was not a working number or a wrong number. One student had a physical/ language problem, 124 had a working number but did not avail themselves to participate in the survey, and 15 students refused to participate. Thus, 295 students were included in this study. The sample represents 68% of the total 434 students with working telephone numbers.

Out of the 295 students, 20.3% were female (n = 60) and 79.7% were male (n = 235). Eighty percent (n = 237) of the students were Euro-American, 7.1 % Native Americans (n= 21), with 1.7% African Americans (n = 5), Hispanic (n = 5), and Asian American (n =5) each. International students (n = 20) accounted for the remaining 6.8 %. According to National Science Foundation Engineering indicators, the average number of

engineering students enrolled in engineering programs in America is 80 % are male and 20% are female (NSF, 2004). Of the engineering students enrolled, 15.5 % represents all the minorities (NSF, 2004). Thus, the student sample in this study mirrors the national average of students enrolled in engineering programs. Therefore, this sample is representative of the population of engineering students taking calculus.

## Procedures

The BSR obtained the Engineering Survey data and constructed an initial data file. The researcher then matched the BSR databank participants with the archived student database to compile the final databank used in the analysis. Table 2 provides the factors, variables, and source of each of the items source used in this study.

Table 2

Factors, variables, and items sources

| Factors | Variables | Source |
|---------|-----------|--------|
| Expectancy Survey | 1. Number of math courses taken at junior and high school | 11 items from Engineering |
| | 2. ACT composite | 1 item from student database |
| | 3. ACT math | 1 item from student database |
| | 4. High school GPA | 1 item from student database |
| - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - |
| Value | 1. Utility Value | 9 items from Engineering Survey  modified SATS-E |
| | 2. Class engagement | 11 items from Engineering Survey |
| | 3.  Help-seeking | 5 items from Engineering Survey |
| | 4.  Self-regulated learning | 9 items from Engineering Survey |

<u>File manipulation</u>

A code book providing all the items used in the study was created. The code book

contained name, the type (string or numerical), width, label, label name, and scale of each

variable collected for this study. In addition, missing numbers were identified. Appendix H shows a section of the code book constructed for this study.

After a code book was created, the researcher computed new variables from existing variables. Five new variables had to be created. These were composite scores of utility value, class engagement, help-seeking behavior, and self-regulated learning. SPSS for windows version 12.0 was used to calculate composite scores for each of the five variables. Number of mathematics courses taken at junior and high school level was computed by summing up the 11 items identified in the Engineering Survey. Utility value variable was computed by summing up the 9 items from collected from Engineering Survey. Class engagement variable was computed by summing up the 11 items from the Engineering Survey that assessed this variable. Help-seeking behavior was computed by summing the 5 items from the Engineering Survey used to assess this variable. Finally, self-regulated learning variable was computed by summing up the 9 items from the Engineering Survey used to assess this variable. All five variables were added to the data file.

The next step, the researcher recoded existing variables to new variables. The variables that were recoded were gender, race, calculus course grade, and country of origin. All these variables were strings and hence were recoded to numeric format. For example "Female" was recoded to "1" and "Male" to "2". Finally the researcher ran frequencies on all variables to detect data entry problems.

**Measures**

<u>Telephone survey</u>

      The measure developed for this study is known as the Engineering Survey (see Appendix C). Table 3 provides the factors, variables, and the range of scores for each variable used from the Engineering Survey. It should be noted that not all Engineering Survey items were used in this study. Of the 58 engineering survey items, 47 items were selected for use by the researcher in the current study.

Table 3

Factors, variables, and variables score range

| Factor | Variables | Score range |
|---|---|---|
| Expectancy | Total number of math courses taken at junior and high school | 1 to 11 |
| | ACT composite | 1 to 36 |
| | ACT math | 1 to 36 |
| | High school GPA | 1 to 4 |
| Value | Utility value | 9 to 63 |
| | Class engagement | 11 to 77 |
| | Help-seeking | 5 to 35 |
| | Self-regulated learning | 11 to 77 |

Archived Student Database

Student's gender, ethnicity, ACT composite score, ACT math score, high school GPA and calculus course grade were obtained from student database archived data maintained by the university. Data from the student database and Engineering Survey were merged by the researcher to create a databank used in the analysis.

<u>Research Variables</u>

Table 2 provides the factors, variables, and the source of items assessing each variable. Two sources were used to assess the variables in this study. These sources were the Engineering Survey, which assessed number of mathematics courses taken at the junior high and high school level, utility value, classroom engagement, help-seeking behavior, and self-regulated learning. The student database at the large Midwestern university provided ACT composite scores, ACT math scores, and high school GPA.

<u>Dependent variable</u>

The dependent variable in this study was calculus success. This variable was scaled from 5 to 1. An "A" grade = 5, "B" grade = 4, "C" grade = 3, "D" = 2, "F" = 1. This variable was obtained from the SIS archived data.

<u>Independent variables</u>

A total of eight research variables representing the expectancy-value factors were examined with regard to calculus success in this study. Four variables of students' academic background represented expectancy. These are number of mathematics courses taken at junior and high school levels, ACT composite score, ACT math score, and high school GPA. Four other variables, utility value, class engagement, help-seeking, and self-regulated learning, represented value. These variables are shown in Table 3.

<u>Scales for variables</u>

The first variable cited in Table 2, the number of mathematics courses taken at junior high and high school level was a sum of all the mathematics courses a student took during those years as reported by the student. For example, if a student took Algebra I in eighth grade, pre-calculus in ninth grade, trigonometry and calculus in tenth grade, AP calculus in eleventh grade and geometry in twelfth grade, their score on this variable was

six. Scale scores on this variable ranged from 1 to 11. A high score on this variable means the student took many mathematics courses at the junior and high school level.

ACT composite and ACT math score were obtained from the SIS archived data. ACT scores are standardized measures that range from 1 to 36. ACT scores assess college readiness (ACT, 2004). College readiness refers to level of preparation a student needs to be ready to enroll and succeed without remediation in a credit-bearing course in college (ACT, 2004). As such, ACT scores are indicators of educational background experiences of students. A high score on this variable means the student was ready for college education (ACT, 2004).

High school GPA is a measure of student's success in high school. High school GPA is a measure of student's academic performance (Noble & Sawyer, 2002). Both high school GPA and ACT scores have been effective in predicting success of first –year college GPA (Noble & Sawyer, 2002). Despite issues such as grade inflations, high school GPA is used as one of the many college admission criteria (Noble & Sawyer, 2002). High school GPA ranged from 1 to 4. A high score on this variable indicated a higher high school performance. These four variables are identified as expectancy related variables.

The next four variables were considered value-related factor. The first one was utility value. Utility value (valuing of calculus) variable was assessed using Schau's (1995) modified SATS-E. Replacing the term "statistics" with "calculus" in all the nine items did the modification on this subscale. For example instead of, "Statistics is worthless." the modification to this statement was "Calculus is worthless." This scale was designed to measure student's perceived worthiness of calculus. The subscale has 9

items. Students responded to items rated according to a 7-point Likert-type scale. For example, "Calculus is worthless." With choices "1" = "strongly disagree" to "7" = "strongly agree". A composite score across the 9 items was used as the measure of utility value in this study. The scores ranged from 15 to 62, with higher scores indicating greater perception of utility value of calculus to the student.

Other researchers have used this subscale. For example, Sorge (2001) used the subscale to assess the value of statistics among engineering students and reported a Cronbach's alpha reliability estimate value of .78. This estimate suggests reasonable internal consistency reliability. More recently, Hilton, Schau, and Olsen (2004) investigated the attitude of college students toward statistics using the value subscale and reported a Cronbach's alpha coefficient of .68. In the current study, coefficient alpha estimated for this modified value subscale was .73. This suggests reasonable internal consistency reliability for this student sample.

The next value related variable assessed was class engagement. This variable was assessed with a total of 11 items. One item used a 4-point Likert-type scale. The question was, "How many notes did you take?" The choices were "1 = none", "2 = occasionally recorded important concepts", "3 = recorded a summary of each lecture", and "4 = recorded everything the instructor wrote on the board or showed on the screen." Three items used a 5 –point Likert-type scale. These items were, for example, "How often did you read the textbook sections before class that corresponded to that day's lecture?" Choices were "1"= "never" to "5" = "always". Another example item is, "How much time did you spend reviewing your notes when working on homework problems?" The response choices ranged from "1" = "never" to "5" = "more that 1 hour and a half". Four

items were rated on 6-point Likert-type scale. These items inquired how much time

students spent preparing for different tasks for class, for example, "What percentage of

the time did you attempt your homework problems within the week they were assigned?"

The response choices ranged from "1" = "never" to "6" = "90 to 100% of the time."

Finally three items on this variable were scored along a 8-point Likert-type scale. These

items inquired on how much time students spent in studying before exams, for example,

"How many hours did you spend studying for your first major exam?" The choices

ranged from "1" = "0" to "8" = "more than 10 hours." A composite score across all the

11 items served as the variable score. The composite score for class engagement ranged

from 11 to 77. A higher composite score on the variable indicated more class engagement

while a low score indicated a little class engagement by the student.

Third value related variable was student's help-seeking behavior. This variable

was assessed in the same manner as class engagement. Five items were used to assess this

variable. Each item measured the number of times the student sought help or used the

available resources while enrolled in the calculus course. For example, "How many times

did you contact your instructor for help during office hours?" Choices were "1" = "0" to

"7" = "more than 10 times". Students responded to all five items according to a 7-point

Likert-type scale, with higher scores indicating higher help-seeking behavior. The score

range for this help-seeking variable was 5 to 35.

Self-regulated learning was the fourth value related variable. This variable was

assessed with Bandura's (1989) self-regulated learning (SRL) subscale from his

*Multidimensional Scales of Perceived Self-Efficacy*. This scale was designed to measure a

student's perceived capability to use various self-regulated strategies. The subscale has

11 items. Students responded to items rated along a 7-point Likert-type scale. For example, "How well can you complete your homework assignments by posted deadlines?" With choices "1" = "not well at all" to "7" = "very well". A composite score across the 11 items was used as a measure of self-regulated learning. The scores ranged from 11 to 77, with higher scores indicating greater capability perceptions for self-regulating learning.

Studies that have used this scale have reported on the internal consistency reliability of the subscale. For example, Miller (2000) reported alpha coefficient estimates of .90 (English) and .93 (Math) with a sample of junior and high school students, while Williams and Hellman (2004) reported an alpha coefficient of .79 while assessing the self-regulated learning strategies of a sample of college students studying online. These values suggest a reasonable level of reliability. In the current study, coefficient alpha for the SRL scale was .74, which suggested a reasonable level of reliability for this student sample.

**Data analysis plan**

Data were analyzed using SPSS version12 for windows. Univariate descriptive statistics were obtained to analyze the data distribution and to ensure accuracy of data entry. Bivariate correlations for all variables in the study were also obtained. Data analysis proceeded in two phases to answer the research questions of the study.

<u>Phase I</u>

This phase of the analysis responded to research question one and two. The questions were:

1.  Are the theoretical expectancy variables (total number of mathematics courses taken at junior high and high school level, ACT composite, ACT math, HSGPA) significantly related? In other words, do these variables represent the "expectancy" construct?

2.  Are the theoretical value variables (utility value, class engagement, help-seeking behavior, self-regulated learning) significantly related? In other words, do these four variables represent the "value" construct?

To answer research question one, bivariate correlations for the four expectancy variables were obtained. The pattern of significant correlations among variables was noted. Similarly, to answer research question two, bivariate correlations for the four value variables were obtained. The pattern of significant correlations among these variables was noted.

<u>Phase II</u>

This phase of the analysis responded to research question three which was:

3.  Is the theoretical expectancy-value model supported by these data?

A path analysis was conducted to answer this research question. Stage and Nora (2004) describe a path diagram as an illustration wherein the variables are identified and arrows from variables are drawn to other variables to indicate theoretically based causal relationships. The independent variables are called exogenous variables. Exogenous variables in a path model are those variables with no explicit causes (no arrows going to

them, other than the measurement error term). The dependent variables are called endogenous variables. Endogenous variables, then, are those which do have incoming arrows. Endogenous variables include intervening causal variables and dependents. Intervening endogenous variables have both incoming and outgoing causal arrows in the path diagram.

Figure 2 provides a path diagram used to guide the analysis. In this study, calculus course grade was the dependent (endogenous) variable. Calculus had incoming arrows only. The independent (exogenous) variables were the total number of mathematics courses taken at junior high and high school level, ACT composite score, ACT math, high school GPA, utility value, class engagement, help-seeking behavior, and self-regulated learning. All eight variables had outgoing arrows only. A full, standard multiple regression was conducted to assess theoretical fit of the model.

Figure 2

Prediction diagram of the full theoretical model
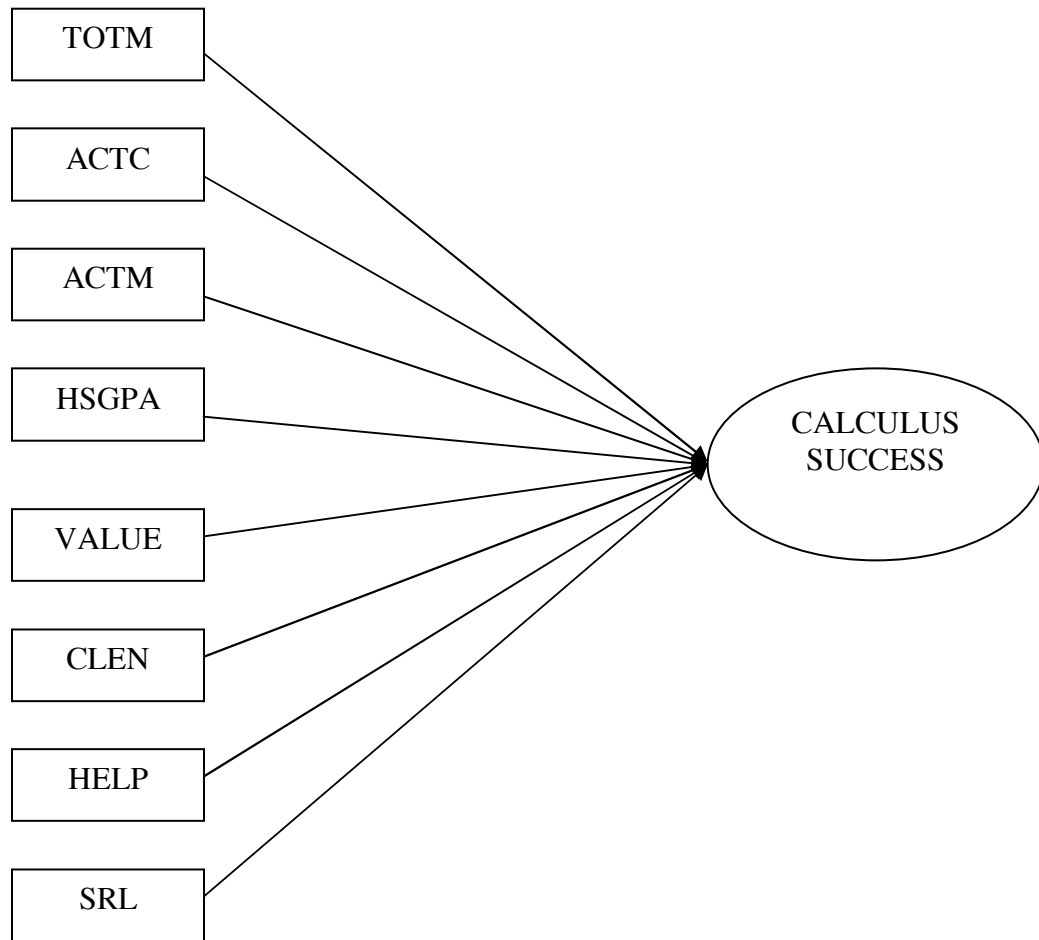
**Chapter summary**

This chapter has described background information about the study, the sample, measures, variables, procedures, and data analysis plan for the study. Freshmen engineering students enrolled in calculus in the Fall 2002 and Spring 2003 semesters were the target students. Two primary sources of data were used. Data collected from Student database at the large Midwestern university and the telephone-administered Engineering Survey were the two sources. A detailed procedure of how the study was conducted and a discussion of the data analysis plan were provided. The data analysis was divided into two phases. Phase one of data analysis focused on first and second research questions while phase two focused on presenting and testing the theoretical model proposed by this study. The results of data analysis are presented in chapter IV.

# CHAPTER FOUR

## Results

This chapter presents descriptive statistics describing the sample and presents the results from the statistical tests for the research questions proposed in this study. The first section reports the descriptive statistics for the variables used in the study. Next, the results from the statistical tests are presented including the outcome of each research question.

## Descriptive statistics

Univariate descriptive statistics were determined for all the variables used in the study. Expectancy and values are equally important in expectancy-value motivational theory (Eccles, et al., 1983). Accordingly, expectancy and value were assessed as two separate constructs. Table 4 presents the means, standard deviations, and minimum and maximum score values obtained by the students in the study, and possible score range values for each of the variables. The variables are divided into expectancy and value constructs.

Table 4

Descriptive statistics for variables: Total number of participants, mean score, standard deviation, minimum and maximum values and range of possible scores

| Factor | Variable | N | Mean | SD | Min. - Max. | Range |
|--------|----------|---|------|-----|-------------|-------|
| Dependent Variable | Calculus grade | 243 | 3.51 | 1.40 | 1 - 5 | 1 – 5 |
| Expectancy | Total math courses | 293 | 5.42 | 1.42 | 1 - 9 | 1 - 11 |
| | ACT composite | 261 | 26.10 | 4.15 | 14 - 35 | 1 - 36 |
| | ACT math | 261 | 26.70 | 3.99 | 14- 36 | 1 - 36 |
| | HSGPA | 261 | 3.58 | .43 | 1.83 - 4 | 1 – 4 |
| Value | Utility Value | 289 | 43.29 | 8.04 | 15 - 62 | 9 - 63 |
| | Class engagement | 275 | 40.91 | 9.32 | 17 - 64 | 11 - 77 |
| | Help-seeking | 293 | 13.73 | 6.10 | 5 - 33 | 5 - 35 |
| | Self-regulated learning | 293 | 55.96 | 8.22 | 29 - 72 | 11 – 77 |

Students averaged a calculus course grade of B (calculus grade = 3.51). Standard deviation of the calculus course grade among the freshmen engineering students who participated in this study was 1.40. Figure 3 provides a histogram distribution of calculus course grades. The histogram shows that the distribution of calculus grades was negatively skewed (skewness measure = -.507). This is typical of students in majoring in engineering. Students in engineering majors tend to do very well in prior mathematics

courses (Noeth & Harmston, 2003) as such they tend to do well on mathematics courses

offered in college.

Figure 3

Calculus course grades distribution



Skewness = -.507
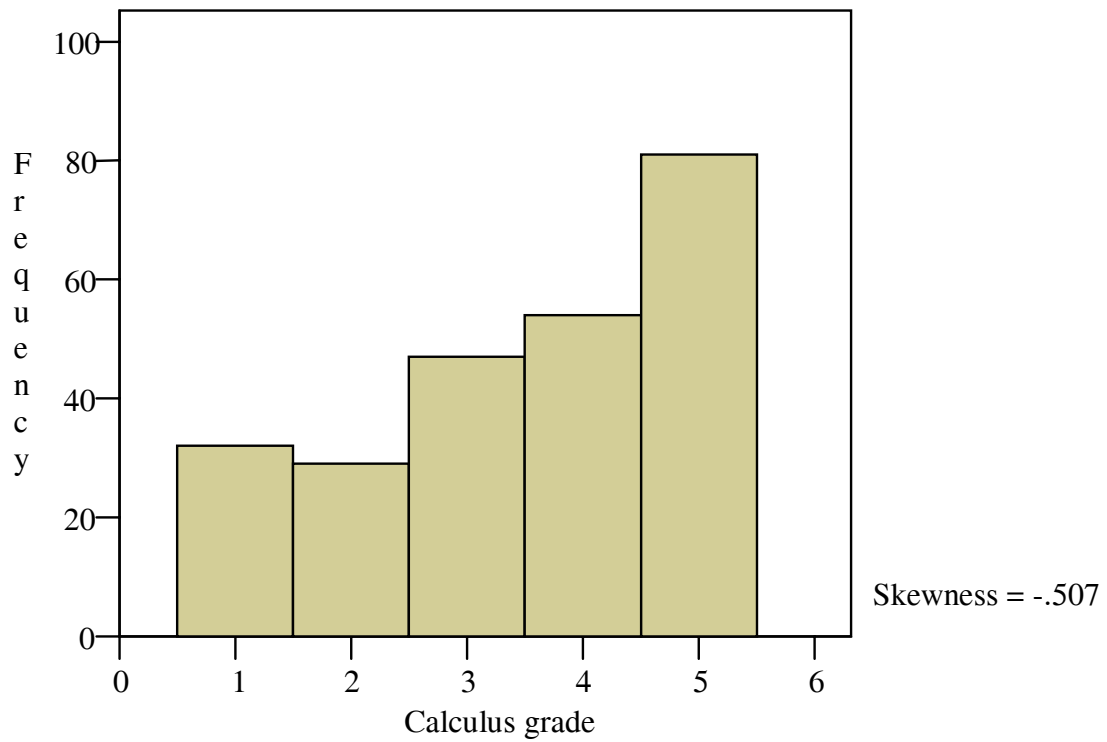
The average total math courses taken at junior high and high school level by the students in this study was five mathematics courses. The standard deviation was 1.42 suggesting that the student sample in this study was homogenous on this variable. Figure 4 shows the distribution of total math courses taken at junior and high school level of the sample used in this study. The distribution appears to be approaching a normal distribution on this variable. The skewness value for this variable's distribution was .142.

Figure 4

Total number of math courses taken distribution



Skeweness = .142
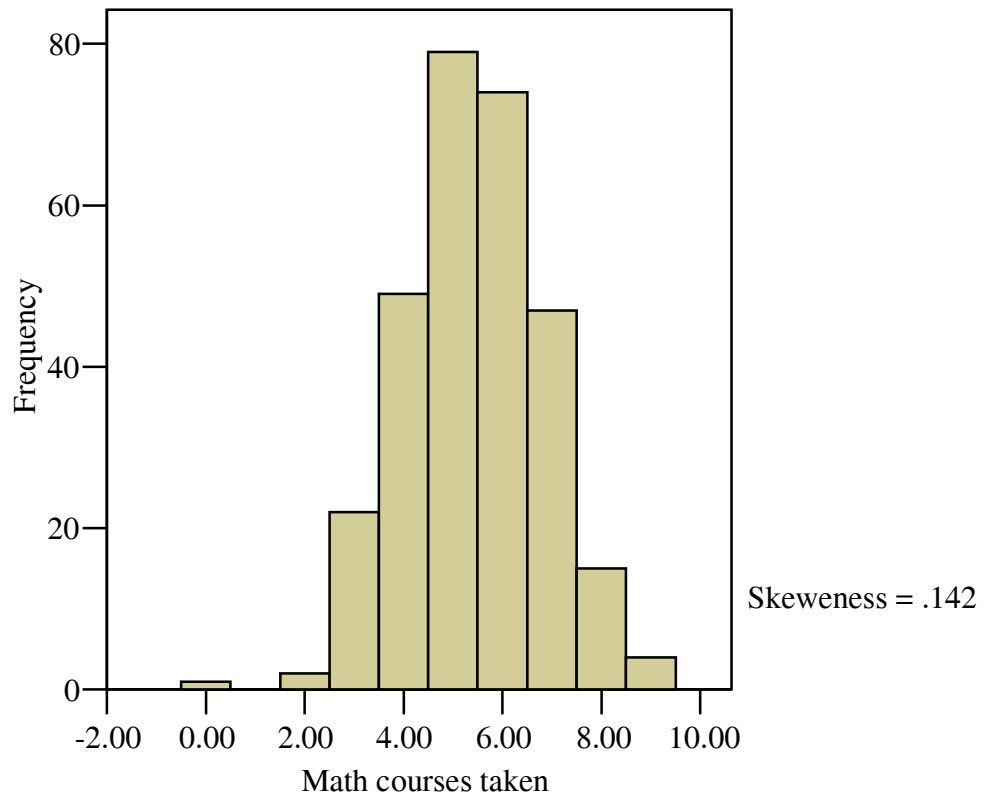
The mean ACT composite score was 26.10 with a standard deviation of 4.15.

Figure 5 provides the distribution for the ACT composite variable. The measure

distribution for this measure was slightly negatively skewed (skewness = -.242), with

majority of the students' scores on the higher end as expected of engineering students.

Figure 5

ACT composite distribution



Skewness = -.242
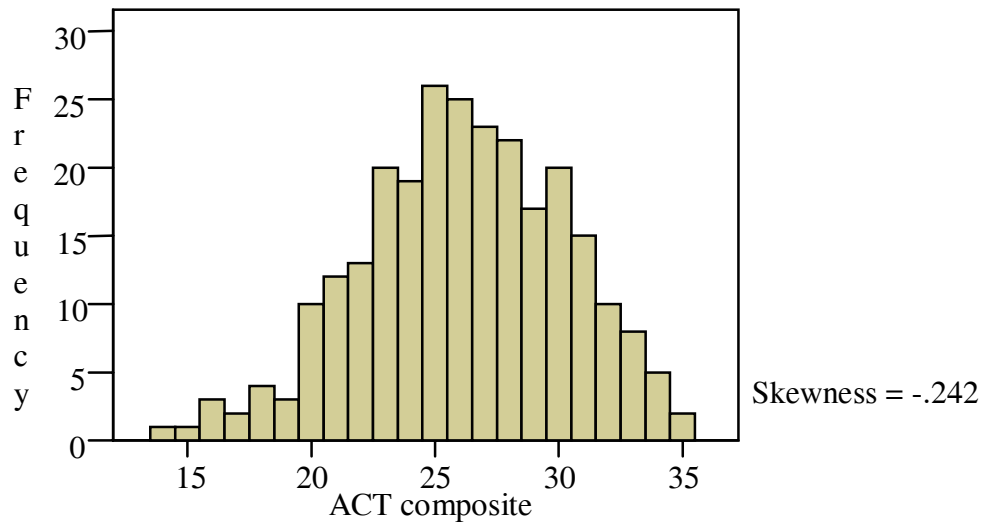
Similarly, the mean ACT math score of the students in this study was 26.70 and standard deviation of 3.99. Figure 6 provides the ACT math distribution for the sample used in the study. The distribution shows that the ACT math variable was negatively skewed (skewness = -.373). This is typical of students majoring in engineering. These students normally have high scores on both the ACT composite and ACT mathematics. The ACT composite mean and ACT math mean for the sample used in this study were found to be above the national average of 20.9 (ACT composite) and 20.8 (ACT math) of students majoring in engineering according to ACT 2004 report (ACT, 2004).

Figure 6

ACT math distribution



Skewness= -.373
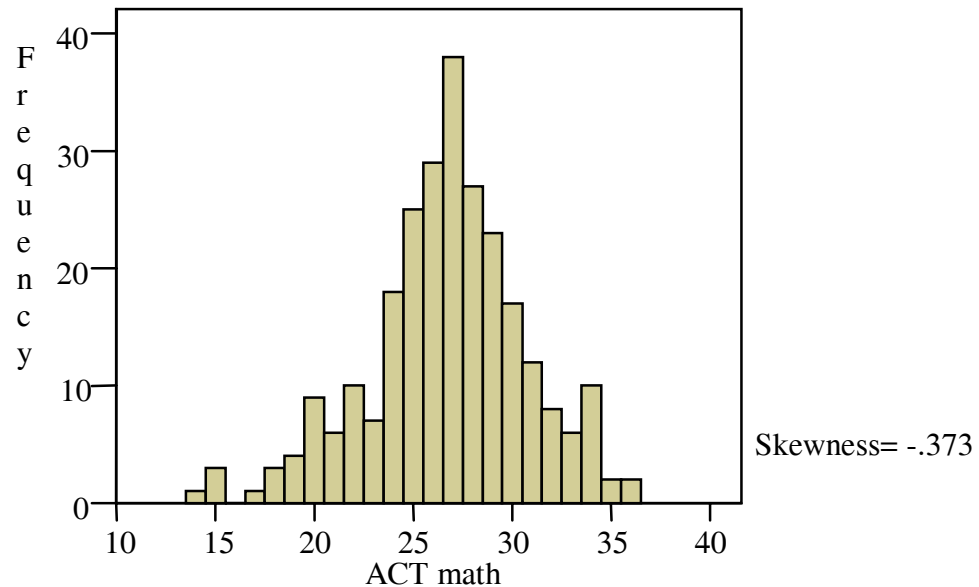
The average high school GPA was 3.58 implying students in this study had an average high school GPA of B. The standard deviation was .43 suggesting a homogenous sample. Figure 7 provides the distribution of high school GPA variable. The distribution on this variable was negatively skewed (skewness = -1.055). This is because high school GPA often suffers from grade inflation (Hardy, 1997; Ziomek & Svec, 1995). Grade inflation occurs when a student receives a grade for course work unwarranted by the level of work or achievement demonstrated (Stone, 1995). Inflating grades has, in part, been a response to fears that stringent grading would damage the student's self-concept (Edwards, 2000). Thus, there has been an increase in reported grades unaccompanied by higher student achievement (Stone, 1995). The awarding of higher grades to students causes a negatively skewed distribution. At the same time, students who major in engineering tend to have very high school GPA. As such, the negative skewness of this variable just like ACT composite and ACT math is expected.

Figure 7

High school GPA distribution (N = 190)
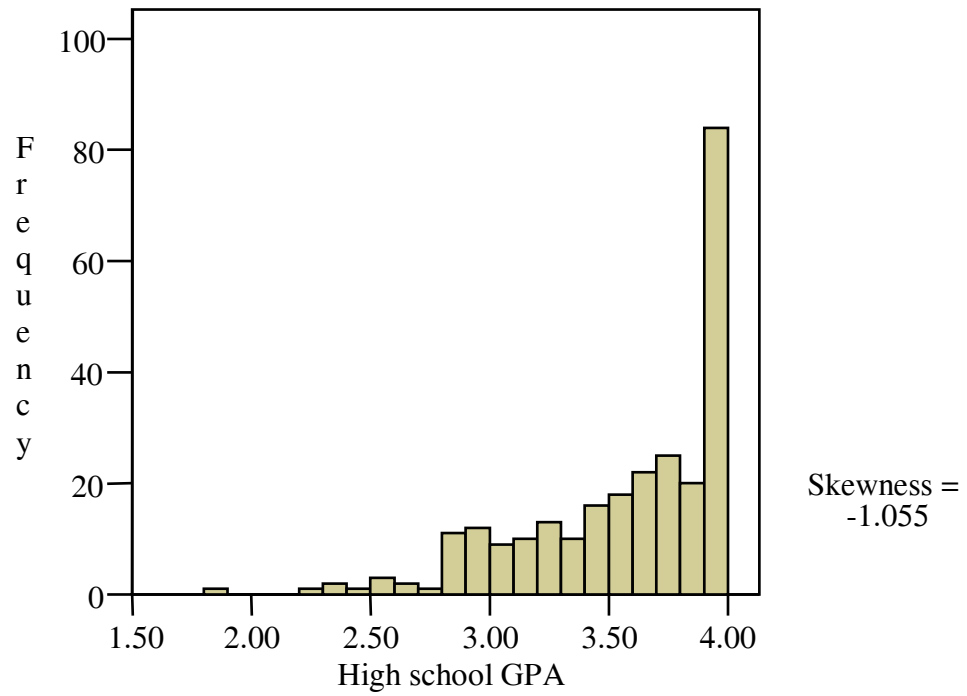
Utility value mean score was 43.29 with a standard deviation of 8.04. Figure 8

provides the distribution of student scores for this variable. The distribution for this

measure was slightly negatively skewed (skewness = -.563). Students in this study were

fairly spread out along the utility value scale. However, the mean score suggests that, on

the average, students valued calculus moderately.

Figure 8

Utility value distribution (N = 190)
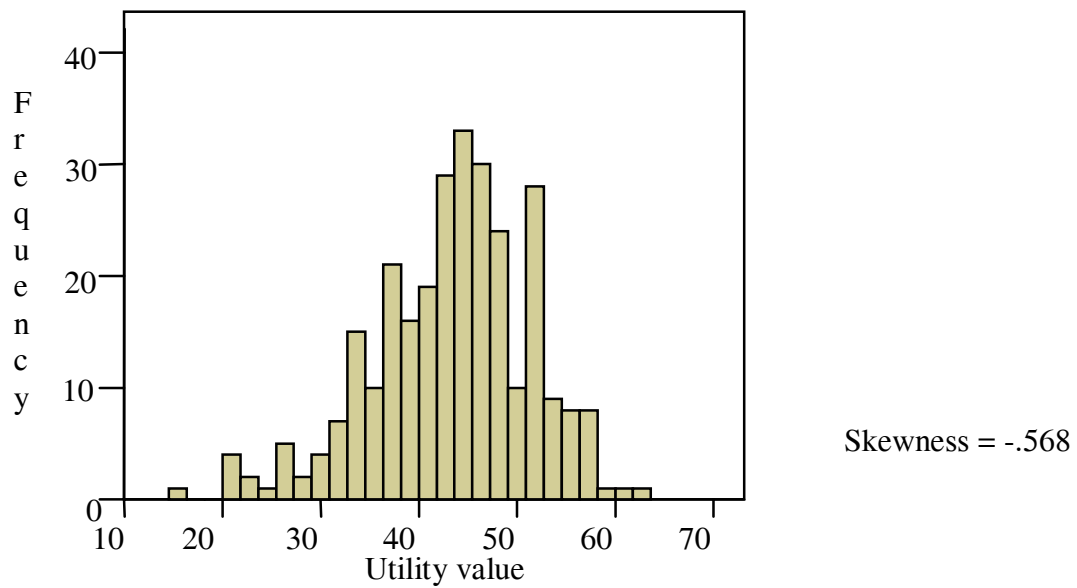


Skewness = -.568

The class engagement score mean was 40.91 with a standard deviation of 9.32.

Figure 9 presents the score distribution of this variable. The skewness value of this

variable was -.201, a relatively small negative value. Scores on this variable were fairly

spread out; however, the mean score suggested that students on the average engaged in

class engagement activities moderately.

Figure 9

Class engagement distribution
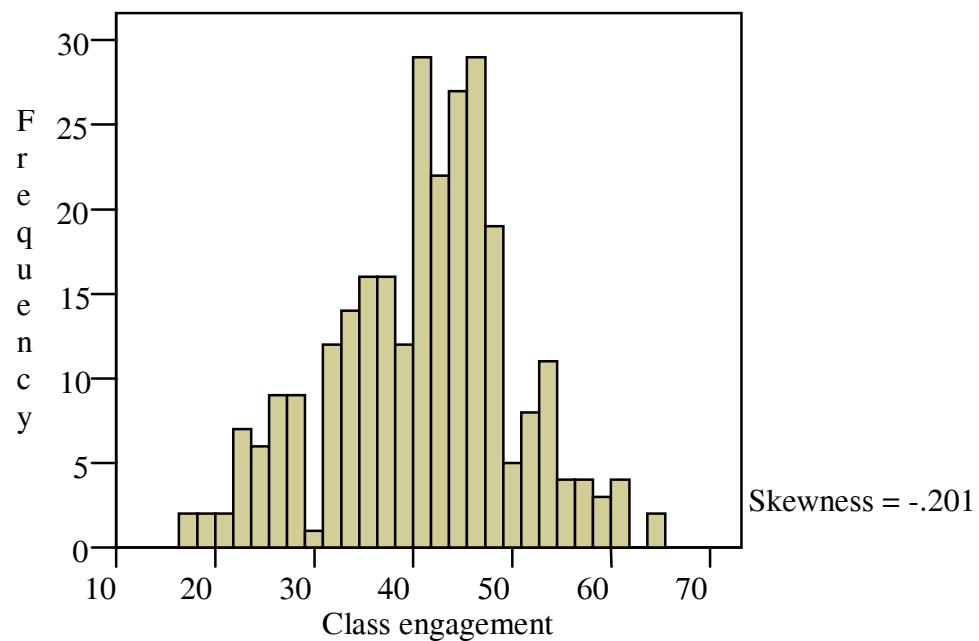
Skewness = -.201

Help-seeking behavior variable had a mean of 13.73 and standard deviation of

6.10. Figure 10 provides the distribution of this variable. The distribution of this variable

was positively skewed (skewness = .837) suggesting that a majority of the students had

low scores on the variable. The scores on this variable were fairly spread out (SD = 6.10).

The mean of 13.73 suggested that on the average, students tended to seek help very few

times.

Figure 10

Help-seeking distribution



Skewness = .837
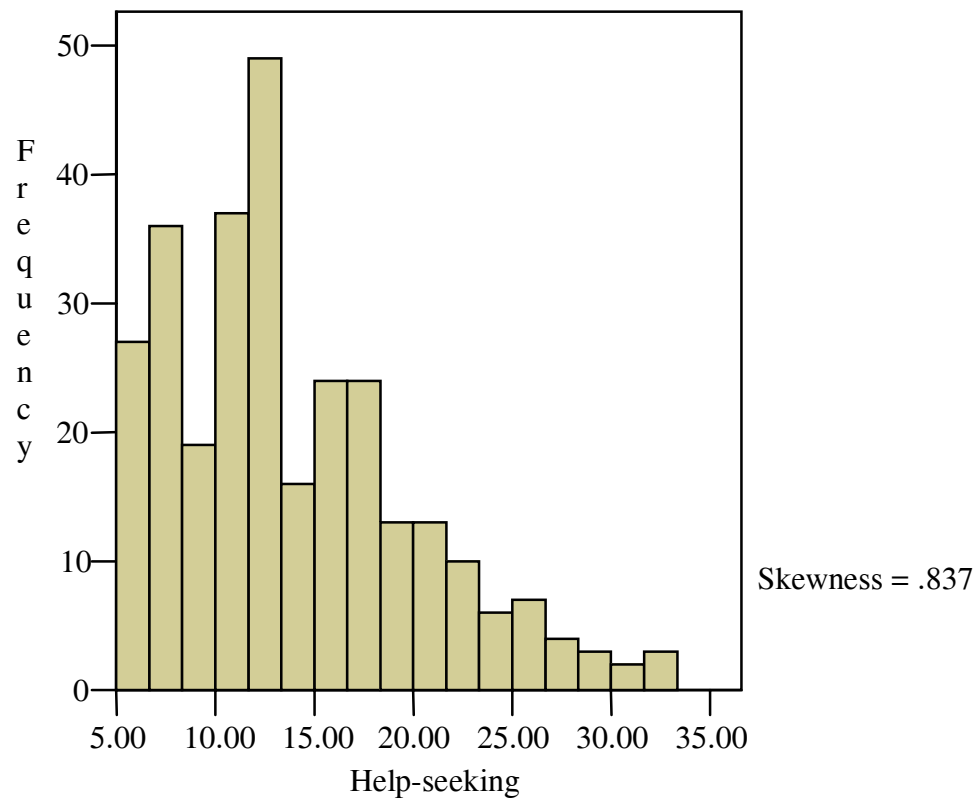
Finally, students scored relatively high on self-regulated learning scale with an average of 55.96 and standard deviation of 8.22. Figure 11 provides the distribution of the scores on this variable. The distribution on this variable was found to be slightly negatively skewed (skewness = -.568). Most of the students in the sample tended to score on the higher end of the scale on this variable. However, scores on this variable were fairly spread out (SD = 8.22). The mean score suggests that on the average students tended to view themselves as having relatively high self-regulated learning skills.

Figure 11

Self-regulated learning distribution
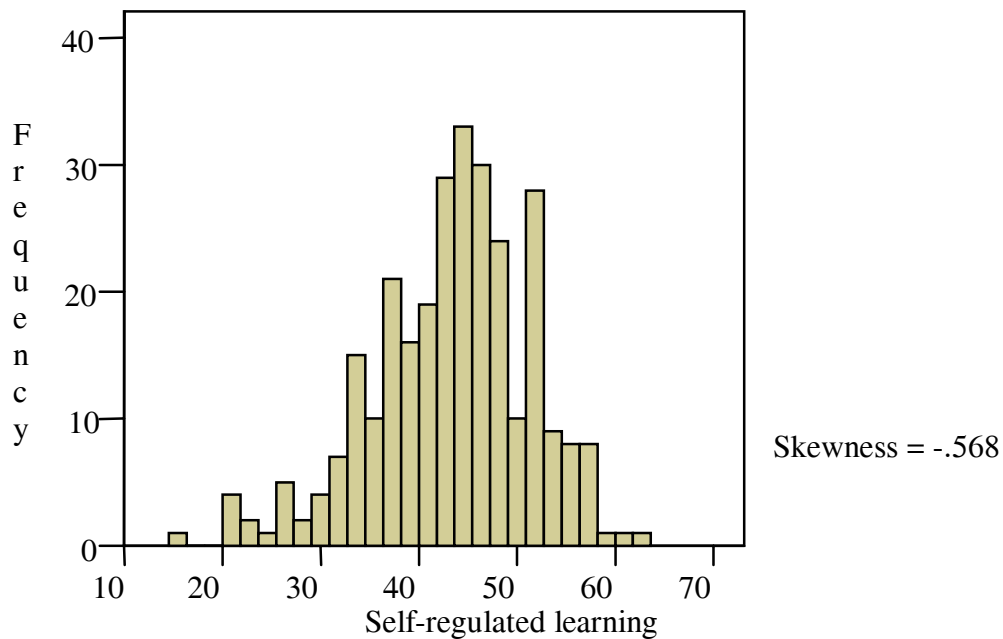


Skewness = -.568

**Summary**

Examination of the distributions of these nine variables indicated that they were within a reasonable measure of skewness. The skewness statistic value for each variable's distribution was within the ±1, an acceptable range for low skewness (de Vaus, 2002). It was concluded that all the distributions were symmetrical and thus the normality assumption for the parametric analyses conducted in this study was apparently met. Therefore, multiple regression was deemed an appropriate data analytic technique for this dataset.

**Analyses**

This section of this chapter provides the analyses and results for each of the three research questions examined in this study. Research question one was analyzed first followed by research question two and finally research question three.

Convergent and Divergent validity

Convergent validity is achieved when variables that theoretically should be related are in reality related (Nunnally, & Bernstein, 1994); consequently, significant correlations between variables for a construct indicate convergence. On the other hand, discriminant (divergent) validity is achieved when variables that should theoretically not be related are in reality not related (Nunnally & Bernstein, 1994). Consequently, weak or non-significant correlations are observed across the variables for two constructs indicating lack of convergence, hence divergence. Correlation coefficients have been used to establish both convergent and divergent validity. For example, Talaga and Beehr (1995) used correlation coefficients to assess convergence of retirement variables. In their study, Talaga and Beehr (1995) examined Pearson correlation coefficients for statistical

significance to establish convergence among three retirement variables. Significant

correlation coefficients (r) of the variable of interests ranged from .11 to .83 (Talaga &

Beehr, 1995). Since the intercorrelations coefficients among the three retirement

variables reached statistical significance, Talaga and Beehr (1995) concluded that the

variables converged to one construct, thus establishing construct validity. Most recently,

Caldwell, Rudolph, Troop-Gordon and Kim (2004) used Pearson bivariate correlations

coefficients on six constructs of self-worth and social disengagement by assessing for

both convergent and divergent validity among the variables of interest. They assessed the

Pearson bivariate correlation coefficients among the variables for statistical significance.

Variables that were expected to correlate were note and so were the variables that were

not expected to correlate.  Two constructs were identified (self-worth and disengagement)

using this method. Significant and non-significant correlations between variables together

established convergent and divergent validity of the two constructs. They reported

significant correlations ranging from .10 to .24, stating that these correlations were

moderate in size (Caldwell, et al., 2004). Thus, this study used Pearson correlation

coefficient to establish both convergent and divergent validity.

Are the theoretical expectancy variables (total number of mathematics courses taken at junior high and high school level, ACT composite, ACT math, HSGPA) significantly related? In other words, do these variables represent the "expectancy" construct?

To answer this research question, Pearson correlation coefficients between the theoretical "expectancy" variables were examined. Correlation coefficients indicate the strength of relationship between variables and can range between +1 to -1 in magnitude (Pedahzur, 1997). The closer the coefficient is to +1 or -1, the stronger the relationship. If the sign is positive, the relationship between the variables is positive, indicating that high scores on the one variable tend to go with high scores on the other variable. If the sign is negative, the relationship is negative, indicating that high scores on the one variable tend to go with low scores on the other variable. Coefficients that are at or near .00 indicate that no relationship exists between the variables involved. In this study, all Pearson coefficients were assessed for statistical significance.

Correlation coefficients are also used to check for construct validity (Nunnally & Bernstein, 1994). A construct refers to something that exists theoretically but is not directly observable (Vogt, 1999). Thus, construct validity refers to the extent to which variables measure the constructs of interest (Vogt, 1999). In order to establish construct validity, both convergent and discriminant, validity may be used (Nunnally & Bernstein, 1994).

<u>Expectancy construct</u>

Table 5 presents the correlation matrix of the four expectancy variables.

Table 5

Bivariate correlations among the four expectancy variables (N = 190)

| Variable | TOTM | ACTC | ACTM | HSGPA |
|----------|------|------|------|-------|
| TOTM | - | | | |
| ACTC | .252** | - | | |
| ACTM | .284** | .840** | - | |
| HSGPA | .234** | .470** | .455** | - |

Note. TOTM = total number mathematics courses taken at junior high and high school levels; ACTC = ACT composite score; ACTM = ACT math score; HSGPA = High school GPA;
**p < .01

All intercorrelations between the expectancy variables were statistically significant at the .01 level. The direction of the relationship was positive in all intercorrelations. It should be noted that ACT math and ACT composite had the highest intercorrelation coefficient (r = .840). The total number of mathematics courses taken at junior high and high school level (TOTM), ACT composite (ACTC), ACT math (ACTM), and high school GPA (HSGPA) were significantly correlated. The amount of variance ($r^2$) that these four variables shared ranged from 5.5% to 71%. Although these variables were not perfectly correlated, they were moderately related to each other, with the average correlation being .42. Gall, Borg, and Gall (2003) contend that, since many factors influence the behavior patterns and personal characteristics in educational research, correlations in the range of .20 to .40 might be all that one should expect to find in the relationships between variables studied by educational researchers. Thus,

examining the intercorrelations of these four variables, and using Gall et al., (2003)

argument, it was concluded that the four theoretical expectancy variables converged to

measure the "expectancy" construct. Thus, convergent validity was established.

<u>Research question two</u>

Are the theoretical value variables (utility value, class engagement, help-seeking

behavior, self-regulated learning) significantly related? In other words, do these four

variables represent the "value" construct?

<u>Value construct</u>

To answer this research question Pearson correlations between the theoretical

"value" variables were examined. Table 6 presents the correlation matrix of the four

value variables.

Table 6

Bivariate correlations among the four value variables (N = 190)

| Variable | VAL | CLENG | HELP | SRL |
|---|---|---|---|---|
| VAL | - | | | |
| CLENG | -.123* | - | | |
| HELP | -.083 | .344** | - | |
| SRL | .196** | .280** | .156** | - |

VAL = utility value; CLENG = class engagement; HELP = help-seeking behavior; SRL = self-regulated learning.
*p < .05; **p < .01

Correlations between the value variables were examined for statistical

significance. All but one of coefficients reached statistical significance. The amount of

common variance shared ($r^2$) between all of the six correlations ranged from .7% to 12%.

It should be noted that help-seeking and utility value correlation was not statistically significant. Common variance shared, without this correlation, was calculated and the new value $r^2$ ranged from 1.5% to 12%. The average statistically significant correlation of the value-related variables was .22, meeting Gall's et al. (2003) correlation criteria among variables in educational research (i.e., $.2 \leq r \leq 4$). With an exception of one correlation, all five intercorrelations were statistically significant. The average correlation was found to be .22 relatively weak but within acceptable range (Gall et al., 2003). Accordingly, these variables appeared to converge to the value construct. These results suggest that, on the average, the expectancy set of variables shared approximately 18% of the variance, whereas the value set shared approximately 5% of the common variance.

Intercorrelations across constructs

After assessing each set of variable set (expectancy and value) for convergent validity, the next step of the analysis assessed divergent validity. Divergent validity was assessed by examining the correlations of variables across the two constructs; expectancy and value. In this step, it was expected that variables that theoretically should not be correlated would not correlate. Table 7 provides cross-construct variable correlations.

Table 7

Bivariate correlation matrix for the expectancy-value variables in the study (N = 190)

| Variable | TOTM | ACTC | ACTM | HSGPA | VAL | CLENG | HELP | SRL |
|---|---|---|---|---|---|---|---|---|
| TOTM | - | | | | | | | |
| ACTC | .252** | - | | | | | | |
| ACTM | .284** | .840** | - | | | | | |
| HSGPA | .234** | .470** | .455** | - | | | | |
| VAL | .043 | .041 | .013 | -.066 | - | | | |
| CLENG | -.073 | -.133* | -.197** | -.045 | -.123* | - | | |
| HELP | -.083 | -.245** | -.312** | -.136* | -.083 | .344** | - | |
| SRL | -.001 | -.023 | -.088 | .049 | .196** | .280** | .156** | - |

Note. TOTM = total number mathematics courses taken at junior high and high school levels; ACTC = ACT composite score; ACTM = ACT math score; HSGPA = High school GPA; VAL = utility value; CLENG = class engagement; HELP = help-seeking behavior; SRL = self-regulated learning.
$*p < .05; **p < .01$

As noted previously, the four expectancy variables and the four value variables were expected to be significantly intercorrelated, demonstrating construct convergence. On the other hand, cross-construct intercorrelations were expected to below or statistically non-significant. Examination of intercorrelations presented in Table 7 revealed that, as anticipated, that the six bivariate correlations among the four expectancy variables were statistically significant. Further, the four value variables also tended to be significantly related. The block of bivariate correlations between the two validity triangles represent the cross-construct variable correlations typically assessed for divergent validity. There are sixteen cross-construct variable correlations in this study.

Out of these sixteen correlations, only five coefficients reached statistical significance. It should be noted that three of these five significant values included variables correlated with help-seeking behaviors. The common variance shared among these cross-factor variables ranged from .0001% to 9.7%. Further, the average r-squared value was 1.6%. The average cross-construct correlation was .032, a value that is below the acceptable range of .20 to .40 for expected correlations among variables in educational research (Gall et al., 2003). In light of these results, these cross-construct intercorrelations did not converge to a construct. The variables that were expected to correlate, did correlate (expectancy and value) and the variables that were expected to not correlate (cross-construct variables), indeed did not tend to correlate. Consequently, it was concluded that both convergent and discriminant validity were demonstrated among the expectancy-value variables.

In conclusion, these results showed that the four expectancy variables were intercorrelated, and the four value variables tended to be intercorrelated. These findings suggest that the eight theoretical variables measured two separate and distinct constructs. The intercorrelations among the variables within their specific construct suggest convergent validity. Only five out of sixteen cross-construct variable correlations coefficients reached statistical significance. The value of the cross-construct variable correlations suggested that discriminant validity was achieved for the variables. These results tend to suggest that the eight theoretical variables measure two theoretically separate constructs; expectancy and value.

<u>Research question three</u>

Is the theoretical expectancy-value model supported by these data?

Figure 12 was used to guide the analysis that answered this research question. A standard multiple regression analysis was conducted with calculus course grade as the dependent variable (criterion), and total number of mathematics courses taken at junior and high school level, ACT composite, ACT math, high school GPA, utility value, class engagement, help-seeking, and self-regulated learning serving as independent (predictor) variables. Table 8 summarizes the regression results where calculus course grade was regressed on the set of expectancy and value predictors. This regression analysis was conducted to assess the two equally important theoretical constructs; expectancy and value.

Figure 12

Full theoretical prediction model (N = 190)
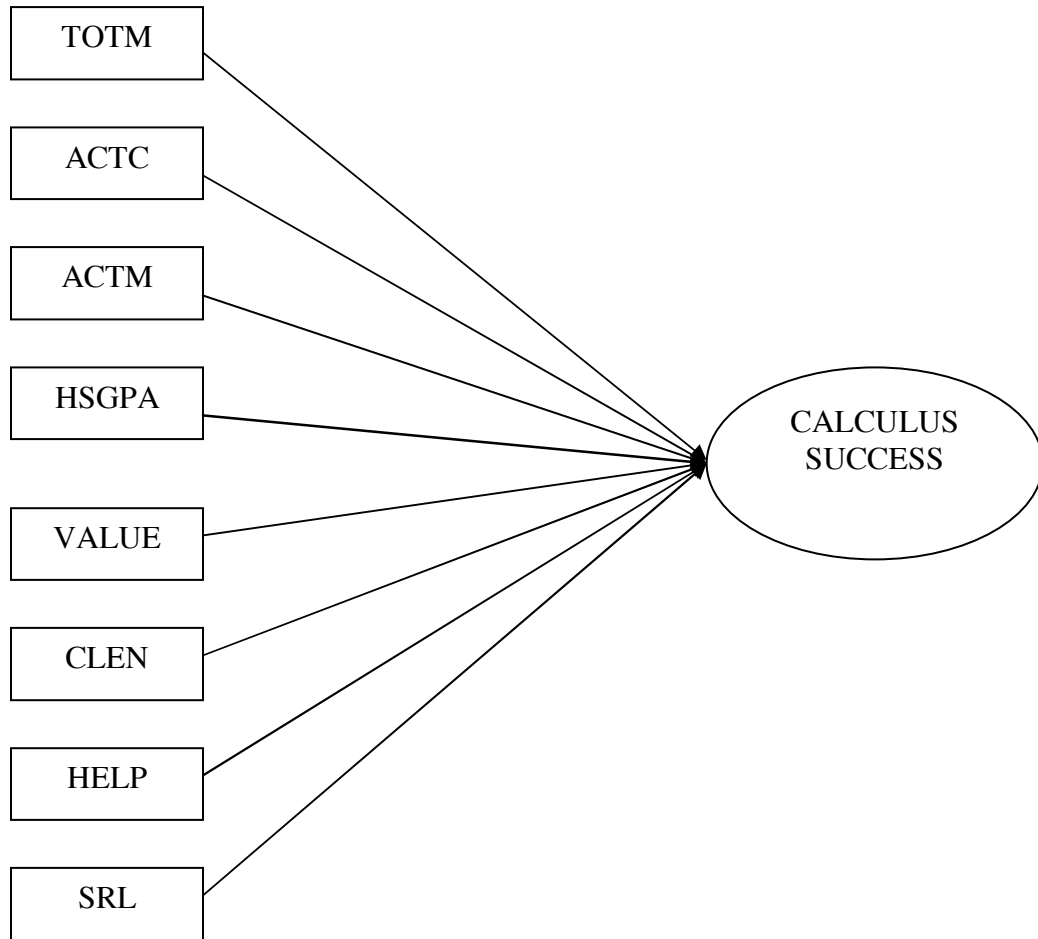


Note. TOTM = total number mathematics courses taken at junior high and high school levels; ACTC = ACT composite score; ACTM = ACT math score; HSGPA = High school GPA; VAL = utility value; CLENG = class engagement; HELP = help-seeking behavior; SRL = self-regulated learning.

Results indicated that, taken together, the eight theoretical expectancy-value variables accounted for 40.3% (where R = .634) of the variability in calculus success among freshmen engineering students, a statistically significant amount ($F_{(4, 189)}$ = 15.245; p = .000). Each individual predictor in the analysis was assessed for statistical significance. This was done by assessing the partial regression coefficients associated by each predictor by use of t-tests. Accordingly, high school GPA (t = 5.764; p =. 000), utility value (t = 2.240; p = .026), and help-seeking (t = -2.982; p = .003) variables significantly predicted calculus success. All significant predictors were compared. As a result, among the three significant predictors, high school GPA was found to be the strongest predictor of calculus, followed by help-seeking behavior, and finally utility value.

Table 8

Regression analysis of all eight variables (N = 190)

| Variable | b-weight | t | p-value |
|---|---|---|---|
| **Expectancy** | | | |
| TOTM | -.039 | -.603 | .547 |
| ACTC | .039 | 1.127 | .261 |
| ACTM | .050 | 1.321 | .188 |
| HSGPA | 1.350 | 5.764 | .000 |
| - - - - - - - | - - - - - - - | - - - - - - - | - - - - - |
| **Value** | | | |
| VAL | .023 | 2.240 | .026 |
| CLEN | -.003 | -.038 | .970 |
| HELP | -.043 | -2.982 | .003 |
| SRL | .023 | .846 | .399 |

$R^2$ = .403 F (8, 181) = 15.245; p= .000
Note. TOTM = total number mathematics courses taken at junior high and high school levels; ACTC = ACT composite score; ACTM = ACT math score; HSGPA = High school GPA; VAL = utility value; CLENG = class engagement; HELP = help-seeking behavior; SRL = self-regulated learning.

The correlation between ACT math and ACT composite was found to be .84 (see Table 5). This value was high and suggested a possibility of multicollinearity existing between the two variables (Tacq, 1997). Multicollinearity, a problem that is caused by high correlations between predictors in multiple regression analysis, affects the estimation of regression statistics (Pedhazur, 1997). Thus, a closer examination of the

two variables was warranted. Several approaches have been suggested to deal with highly

correlated predictors in regression analysis. According to Pedhazur (1997), variables that

are highly correlated should be "deleted one at a time so that the effect of the deletion on

the sizes and tests of significance for the *b*'s for the remaining variables may be noted"

(p. 202). Following Pedhazur (1997), two multiple regressions were conducted; one with

ACT math deleted and a second with ACT composite deleted. Table 9 summarizes the

regression analysis with ACT math deleted among the eight theoretical variables.

Table 9

Regression analysis with ACT math deleted (N = 190)

| Variable | Beta Weight | t | p-value |
|----------|-------------|------|---------|
| Expectancy | | | |
| TOTM | -.029 | -.504 | .615 |
| ACTC | .227 | 3.364 | .001 |
| HSGPA | .394 | 5.850 | .001 |
| Value | | | |
| VAL | .130 | 2.150 | .033 |
| CLEN | -.008 | -.121 | .904 |
| HELP | -.216 | -3.265 | .001 |
| SRL | .049 | .771 | .442 |

$R^2$ = .397 F (7, 182) = 17.101; p= .000

Note. TOTM = total number mathematics courses taken at junior high and high school levels; ACTC = ACT composite score; ACTM = ACT math score; HSGPA = High school GPA; VAL = utility value; CLENG = class engagement; HELP = help-seeking behavior; SRL = self-regulated learning.

Deleting the ACT math predictor resulted in ACT composite reaching statistical significance (t = 3.364, p = .001) as a predictor. The size of the beta weight for the help-seeking variable slightly increased (i.e., from -2.982 to -3.265). However, for all non-significant variables, the slight decrease or increase of their respective beta weights was attributed to chance. At the same time, $R^2$ reduced from .403(with all eight variables) to .397 (ACT math deleted), a reduction of .006, less than 1%, a very small amount.

Multiple regression analysis with ACT composite deleted was then performed to observe the changes in beta weights and statistical tests of significance of each variable entered in the analysis.

Table 10 summarizes the regression analysis with ACT composite removed from the eight theoretical variables.

Table 10

Regression analysis with ACT composite deleted (N = 190)

| Variable | Beta Weight | t | p-value |
|---|---|---|---|
| Expectancy | | | |
| TOTM | -.035 | -.606 | .545 |
| ACTM | .232 | 3.438 | .000 |
| HSGPA | .406 | 6.202 | .000 |
| - - - - - - - - - - - - - - - - - - - | | | |
| Value | | | |
| VAL | .142 | 2.359 | .019 |
| CLEN | -.006 | -.087 | -.931 |
| HELP | -.200 | -2.961 | .003 |
| SRL | .052 | .830 | .407 |

$R^2$ = .398 F (7, 182) = 17.152; p= .000
Note. TOTM = total number mathematics courses taken at junior high and high school levels; ACTC = ACT composite score; ACTM = ACT math score; HSGPA = High school GPA; VAL = utility value; CLENG = class engagement; HELP = help-seeking behavior; SRL = self-regulated learning.

Deleting the ACT composite predictor resulted in ACT math reaching statistical significance (t = 3.438, p= .000). The beta value for ACTM (.232) was larger than ACTM composite's (.227) shown in Table 9. With ACT composite deleted, the beta weight magnitude for high school GPA increased from the full model value .338 to .406. The beta weight for the utility value variable also increased from the full model value.135 to .142. Self-regulated learning's beta weight decreased slightly and still did not reach statistical significance and is thus not interpretable. At the same time, $R^2$ was reduced from .403 (with all eight variables) to .398 (ACT composite deleted), a reduction of .005 or .5%. Thus, when deleting ACT math, the reduction of $R^2$ was higher (.6%) than that of deleting ACT composite (.5%). Based on these findings and the fact that math has been linked as a "critical filter" course for engineering students (Ganinen & Willemsen, 1995; Seymour & Hewitt, 1997), in this study, ACT math was selected to be entered in the regression analysis rather than ACT composite.

The final analysis that was selected included high school GPA, ACT math, utility value, and help-seeking behavior. Calculus course success was regressed on these four predictors. Table 11 summarizes the regression analysis with the four selected variables.

Table 11

Regression analysis with the four selected variables (N = 203)

| Variable | Beta Weight | t | p-value |
|---|---|---|---|
| Expectancy | | | |
| ACTM | .209 | 3.438 | .000 |
| HSGPA | .430 | 7.024 | .000 |
| - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - | | | |
| Value | | | |
| VAL | .166 | 3.001 | .003 |
| HELP | -.169 | -2.897 | .004 |

$R^2 = .400$ F (4, 198) = 33.042; p= .000
Note. ACTM = ACT math score; HSGPA = High school GPA; VAL = utility value; HELP = help-seeking behavior;

From Table 11, high school GPA (HSGPA), ACT math (ACTM), utility value (VAL), and help-seeking (HELP) behavior were statistically significant predictors of calculus success, as measured by the calculus course grade. These four predictors included two that were expectancy variables (HSGPA and ACT math), and two are value variables (VAL and HELP). Figure 13 provides the reduced and final path diagram model of the four expectancy-value variables predicting calculus success among freshmen engineering students in the large Midwestern university.

Figure 13

Reduced prediction model (N = 203)
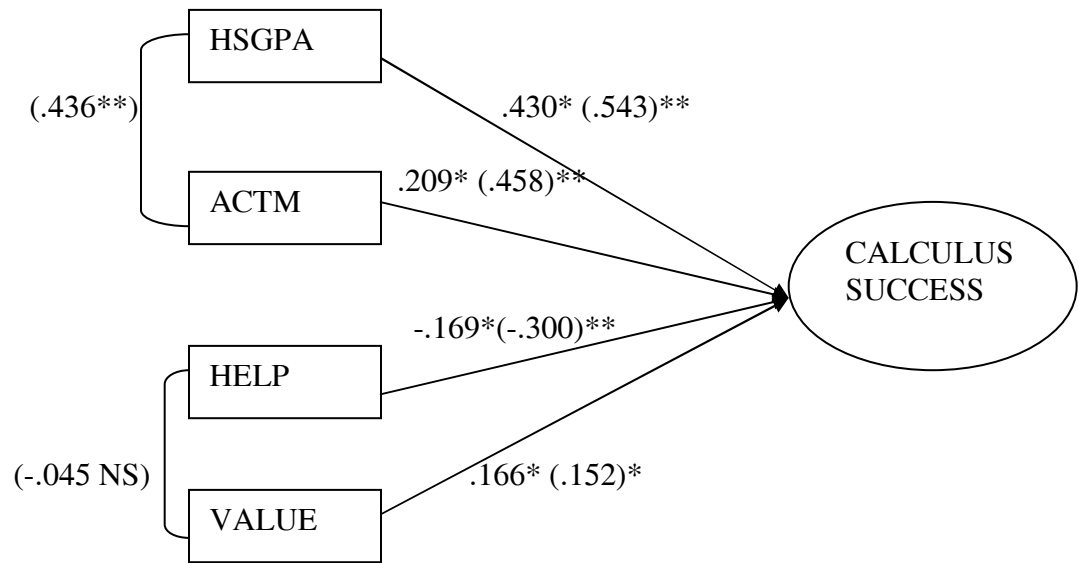


*p < .05; **p < .01

Note. Values in parenthesis = correlation coefficients; values outside parenthesis = standardized beta; ACTM = ACT math score; HSGPA = High school GPA; VAL = utility value; HELP = help-seeking behavior;

High school GPA, ACT math, and utility value were all positively related to calculus success as indicated by the beta-weights on the directional arrows in the model. Help-seeking behavior, on the other hand, was negatively related to calculus success, thus implying that higher help-seeking behavior predicted less t calculus success.

## Chapter Summary

This chapter presented the results of the data analysis for the study. Three research questions were addressed. Correlation matrices were used to assess research questions one and two. The results showed that total mathematics courses taken at junior high and high school level, ACT composite, ACT math, and high school GPA were correlated. It was therefore concluded that these variables measured the same theoretical construct – "expectancy". Utility value, class engagement, and self-regulated learning tended to be correlated and converged as "value".

A full theoretical model with all eight expectancy-value variables predicting calculus success was tested. A reduced model with statistically significant paths was estimated. Two expectancy variables (HSGPA &ACT math) and two value variables (HELP & VALUE) were found to be statistically significant predictors of calculus success among freshmen engineering students in this study. Taken together, these variables accounted for 40% of the variability in calculus success. In the final reduced and final model, high school GPA was the strongest predictor of calculus success, followed by ACT math, help-seeking behavior, and then utility value. Discussions, recommendations, and conclusions for the study are presented in Chapter V.

**CHAPTER FIVE**

**Discussion**

This chapter discusses theoretical implications, recommendations for practice, recommendations for future research and conclusion. The discussion of the theoretical implications is organized into the following areas, expectancy and value variables in relationship with the expectancy-value theory, and in relationship with calculus success. The reason for this organization is to first discuss the common themes found in the results from the hypotheses regarding the relationship between the eight theoretical expectancy-value variables and their respective constructs (i.e., expectancy and value). Next, the research findings for the third hypothesis are discussed in relationship with calculus success among freshmen engineering students by comparing the results with the theoretical support provided by the literature. Recommendations for practice and suggestions for future studies are presented are presented next. Finally, the conclusions are presented.

**Theoretical Implications**

The purpose of this research was to examine the theoretical model of the expectancy-value variables that predict calculus success among freshmen engineering students. This study examined eight variables. These were total number of mathematics courses taken at junior high and high school level, ACT composite score, ACT math

score, high school GPA, utility value, class engagement, help-seeking behavior, and self-regulated learning. These variables were examined under the expectancy-value theory of motivation. Three research questions guided were examined in this study. These questions were:

1. Are the theoretical expectancy variables (total number of mathematics courses taken at junior high and high school level, ACT composite, ACT math, HSGPA) significantly related? In other words, do these variables represent the "expectancy" construct?

2. Are the theoretical value variables (utility value, class engagement, help-seeking behavior, self-regulated learning) significantly related? In other words, do these four variables represent the "value" construct?

3. Is the theoretical expectancy-value model supported by these data?

Expectancy

Research question one investigated whether the four theoretical expectancy variables were intercorrelated, thus measuring the "expectancy" construct. The four theoretical expectancy variables were, total number of math courses taken at junior high and high school levels, ACT composite, ACT math, and high school GPA. The results indicated that these variables were indeed strongly correlated establishing convergent validity. Since this study was guided by the expectancy-value theory of motivation, this finding was vital. The four theoretical expectancy variables measured "expectancy" construct in reality.

This finding reinforces the expectancies for success literature advanced by expectancy-value model proponents such as Atkinson (1957) and Eccles et al., (1983).

Literature on expectancy-value model identifies prior achievement behaviors such as student's prior success as measures of expectancy construct (Wigfield, 1994). In this study, prior student's success variables were examined and they all converged to "expectancy" construct supporting the existing literature.

Overall, this study contributes not only confirmation of a previously supported relationship between the four theoretical expectancy variables and the expectancy construct; it also focuses attention on the college level students, specifically engineering students. This is relevant because most of the research on expectancy under the expectancy-value theory of motivation has been mainly with children during early elementary and adolescents (Eccles & Wigfield, 1995; Eccles et al., 1993). In addition, motivation research among engineering students has been limited (Willemsen, 1995). The specific population of freshmen engineering students provides the researcher to partition and isolate new factors associated with success in calculus course. This study strengthened the support of the relationship between the theoretical expectancy variables and the expectancy construct, and it provides a starting point for additional studies on expectancies variables.

Value

The second research question investigated whether the four theoretical value variables measure the "value" construct. The four theoretical value variables investigated in this study were; utility value, class engagement, help-seeking, and self-regulated learning. Results from this study showed that all but one of the six correlations was statistically significant suggesting that these four variables converged to one construct of

"value". This finding suggested that the four theoretical value variables measure the "value" construct in reality.

Literature on values contends that importance, usefulness of the task, cost, and attainment of task are major components of values (Eccles et al., 1983). These components together provide the value construct that directly influences success and or achievement. In addition, the value construct in the expectancy-value model of achievement motivation is equally important in directly influencing achievement as the expectancy construct (Eccles et al., 1983). The four theoretical value variables examined in this study represented the value construct. This finding provides support to a more specific of value definition (Wigfield & Eccles, 2000).

Values have been identified as a key component in the Eccles et al., (1983) expectancy-value model of motivation and achievement. Values have been found to influence achievement. For example, Wigfield et al., (1992) found that values impact achievement in mathematics. This study found out that utility value, class engagement, help-seeking behavior and self-regulated learning measure the "value" construct the second construct in the expectancy-value model of motivation.

This study contributes not only confirmation of previously supported studies that posit a relationship between theoretical value-related variables with the value construct (Eccles, et al., 1983), but it also focuses on college students' value variables. This is relevant because in order to expand knowledge of values in relationship with the expectancy-value achievement motivation model, having a foundation established with a specific population (freshmen engineering students) facilitates the control of variability whereby new value variables can be identified. The specific population helps the

researcher partition and isolated new value factors associated with calculus success. Thus, this study strengthened the relationship between theoretical value variables and the value construct, and it also provides a foundation for additional studies under the expectancy-value achievement motivational theory.

Expectancy-Value model

This research found support for the expectancy-value model. Both expectancy and value variables predicted calculus success among freshmen engineering students, supporting Eccles' (1984) assertion that expectancies and values are integral to achievement or success. In the regression analysis performed, high school GPA (expectancy variable) was the strongest predictor followed by help-seeking behavior (value variable), utility value (value variable) ACT math (expectancy variable) respectively. ACT composite was the fifth overall predictor. Self-regulated learning and total number of mathematics courses taken at junior and high school levels were the weakest predictors in the set.

Research on number of mathematics courses taken at junior and high school level has been found to influence mathematics achievement in successive years (Lee, Chow-Hoy, Burkam, Geverdt, & Smerdon, 1998). However, other researchers observe that although, the number of mathematics may play an important role in mathematics achievement, the type of mathematics course taken by students is very vital (Gamoran & Hannigan, 2000). The findings from this study showed that number of mathematics courses taken at both junior and high school did not significantly influence calculus course success among freshmen engineering students at this large Midwestern university. This finding is contrary to Lee et al., (1998) however, is consistent with studies on the

type of mathematics courses taken at junior and high school levels. For example, Jones (1987) reported that students who had taken calculus at in grade 12 achieved better in mathematics that did those who had not taken calculus regardless of prior mathematics ability. In addition, Adelman, (1999) contends that taking specific courses beyond the Algebra II more than doubles the odds of a student succeeding at the college level. Thus, prior mathematics courses that provide the basic foundation for college calculus are essential for students who plan to enroll in engineering majors. This study shows that it is not just the number of mathematics courses taken at junior and high school but also the specific mathematics courses taken at both levels are crucial in influencing calculus course success among freshmen engineering students.

ACT composite and ACT math scores each influenced calculus achievement. However, findings from this study indicated that when these two variables were included in the regression analysis, their impact on calculus success was not statistically significant. ACT composite was found to have a slightly lower impact than ACT math on calculus achievement. Thus ACT math was retained in the analysis. The finding of this study after retaining only ACT math in the analysis was consistent with prior research on achievement. For example, Edge and Friedberg (1984) found that ACT math score was a significant predictor of calculus achievement among freshmen college students. In another study by Wilhite, Windham, and Munday (1998), noted that ACT math score was a strong predictor in fist year calculus course among college freshmen. More recently, Allen (2001) reported that ACT math score was a good predictor of success among freshmen engineering students. Thus, this study's finding in terms of ACT math as a predictor of calculus course success is supported by previous studies.

High school GPA was found to be a stronger predictor of calculus success among freshmen engineering students in this study. This finding is consistent with previous research. One study by Edge and Friedman (1984), found that high school GPA influenced calculus performance among freshmen college students. In one study by Perkins (2002), found out that high school GPA was a stronger predictor of calculus success among college students. Similarly, Frye-Lucas (2003) identified high school GPA to influence calculus achievement among freshmen college students. This study not only identified high school GPA as a predictor of calculus success among freshmen engineering students, but also found this variable to be the strongest among all eight theoretical variables.

Among the four values related variables, utility value and help seeking behavior were found to be significant predictors of calculus course success among freshmen engineering students. On the other hand, classroom engagement and self-regulated learning were not statistically significant predictors.

Pintrich and Schunk (1996) posit that values are positively correlated with actual achievement. This study not only found that values are positively correlated to calculus success but also predicted calculus success among freshmen engineering students. Students who valued calculus tended to perform higher than their counterparts who did not value the subject matter. This finding supports research on values and achievement motivation in the expectancy-value theory of motivation. For instance, Eccles et al., (1983) posit that utility value impacts achievement. In addition, Deci and Ryan (1985) noted that usefulness of a task motivates students to do well.

Classroom engagement behavior was not found to be statistical significant predictor of calculus course success among freshmen engineering students in this study. Classroom engagement on the other hand was not a statistical significant predictor of calculus course success. This finding is contrary to literature on engagement that posits student engagement is a robust predictor of student achievement (Finn & Rock, 1997). The fact that classroom engagement was not statistical significant predictor of calculus course success may be due to classroom engagement being subsumed by the other value-related variables. In addition, research on engagement contends that engagement is a multidimensional construct that encompasses behavior, emotion, and cognition (Fredricks et al., 2004). The vast majority of studies test the impact of single type of engagement and a single outcome of interest, such as the correlation between behavioral engagement and achievement (Fredricks et al., 2004). Classroom engagement was assessed as a multidimensional construct. It is possible that specific type of engagement (behavioral, emotional or cognitive) was significant but could not be captured in this study.

Studies on class engagement posit that for an engaged learner, the joy of learning inspires persistence to accomplish the desired goals even in the face of difficulty (Schletchy, 2002). Basically, it is assumed that engaged students have the skills to work with others and know how to transfer knowledge to solve problems creatively (Jones, Valdez, Nowakowski, & Rasmussen, 1994). Despite the fact that classroom engagement was not a statistical significant predictor of calculus achievement among freshmen engineering students in this study, more studies may be needed before conclusions are made. In this study, classroom engagement correlated significantly with utility value, self-regulated learning, and help-seeking behavior. Thus, there is all likelihood that this

particular variable was subsumed in the other value-related variables. Studies have shown that if a student values a subject, then they will be engaged and do whatever it takes to be successful (Assor, Kaplan, & Roth, 2002).

Help-seeking behavior was a statistical significant predictor of calculus course success. Help-seeking has been identified as an adaptive strategy for coping with difficulty and promoting mastery (Newman, 1991). This study found that help-seeking behavior to be negatively related to calculus course success. Thus, as help-seeking behavior of students increase, it is expected that the calculus course success to decrease. This finding suggests that freshmen engineering students, who are successful in calculus course, tend to exhibit less help-seeking behaviors. There are two possible explanations to this finding. The first explanation may be due to the fact that freshmen engineering students have had a strong calculus background, thus, capable of doing well with minimum help. The second explanation emanates from help-seeking literature. Help-seeking behavior may be avoided because it is experienced as dependency (Butler & Neuman, 1995). This state may conflict both with personal autonomy needs, which Deci and Ryan (1987) see as the major component of intrinsic motivation. Closely related to the state autonomy is the perception help-seeking has on people. Studies have shown that people are reluctant to seek help when the need for help is construed as evidence of low ability, and thus threatening to one's self-esteem (e. g., Shapiro, 1983). Students need to have a nurturing and safe classroom environment that encourages students to seek assistance when they encounter difficulties.

Studies have shown that students with learning goals seek help when they encounter difficulties thus increase their competence on the task (Dweck, 1988).

Classroom that emphasizes mastery of knowledge facilitates learning goals among students facilitating help-seeking behavior (Newman, 2002). On the other hand, performance goal orientation classroom emphasizes good grades and looking good among pears (Newman, 2002). Thus, students with performance goal orientation tend to avoid seeking help when they encounter difficulties (Newman, 2002). Clearly, help-seeking behavior is influenced by classroom environment. The role of teacher or instructor and peers in the classroom may facilitate help-seeking behavior or help-avoidance behavior among students.

All in all help seeking was found to be a significant predictor of calculus course success consistent with studies that view help-seeking behavior as an important self-regulatory strategy that contributes to student learning and achievement (Newman, 1994; Zimmerman & Martinez-Pons, 1988).

Self-regulated learning was not statistically significant in predicting calculus course success among freshmen engineering students in this study. Despite this finding, literature on self-regulated learning suggests the contrary. For example, Schunk and Zimmerman (1997) posit that self-regulated learning impacts students' academic achievement. In addition, Zimmerman and Martinez-Pons (1986), found out that self-regulated learning strategies to be predictive of test performance. It is likely that self-regulated learning was also subsumed in the other value-related variables such as classroom engagement and help-seeking behavior. Thus, before any conclusions are made about the role of self-regulated learning and calculus course success, more research is needed.

**Implications for practice**

Gainen (1995) contends that calculus is one of the gateway courses among engineering students. In fact, most engineering programs in America require freshmen engineering majors to enroll in calculus during their first year (Sorby, 2001). Research on calculus performance among freshmen engineering students has indicated that a most of them fail to meet the passing criteria. For example, Seymour and Hewitt (1997) posit that between 40 to 60 percent of science, mathematics, and engineering students with higher than average abilities are lost within their first college mathematics course. Responding to this claim, this study explored factors that influence freshmen engineering to pass entry level calculus course. The findings of the present study provide faculty members in engineering programs and mathematics critical factors to pay attention to when admitting or advising students.

The first implications of this study for educational practice have to do with the importance of the expectancy-value variables in calculus achievement. The results of this study showed that both expectancy and value variables have significant effect on achievement behavior. This finding suggests that students' expectancies for success predict calculus course success. Specifically, high school GPA and ACT math were significant predictors of calculus course success among freshmen engineering students. In fact, studies have demonstrated that expectancies are predictors of achievement (Eccles et al., 1983). Thus, colleges of engineering may pay a closer attention to measures of prior achievement closely related to calculus. This study identified high school GPA and ACT math score. The findings of this study suggest that students with high scores on these two variables are likely to do well in entry level calculus course. Prior successes tend to

enhance competency beliefs among students which in turn influence expectancies for success (Eccles et al., 1983). Thus, admission criteria to engineering programs may consider using these two expectancy variables.

Another implication relates to students' experiences and activities related to the calculus course. Once a student is in college, value-related variables play a pivotal role in influencing achievement. Students, who value a subject, tend to be highly engaged, exercise self-regulated learning strategies, and thus seek assistance when they encounter difficulties (Newman, 2002). In light of the present findings, value-related variables do impact calculus course success. Specifically, in this study, both utility value and help-seeking behavior were found to be significant predictors of calculus course success among freshmen engineering students. Thus enhancing students' value of calculus for their present and future goals is important. Increase in students' perceived value of calculus motivates students to set higher processes goals (Bandura, 1986), thus, they become engaged in the course and in turn use self-regulated learning skills to succeed in the course (Zimmerman & Martinez-Pons, 1990). Not only should the faculty members show and reinforce the value of calculus, but also there is a need to emphasize learning goal orientation among students. Learning goals facilitate help-seeking behavior a self-regulated learning strategy important for students when they face difficulties on a task.

## Recommendation for future research

The expectancy-value theory of motivation has provided a theoretical model of assessing various motivational factors that influence achievement. This model was tested and supported in this study. Since, the eight theoretical expectancy-value variables investigated in this study accounted for 40% of variance in calculus course success, there

is a need to explore other possible variables. It is evident that this model may be used to identify other expectancy-value variables not investigated in this study.

Further research on classroom engagement and self-regulated learning among freshmen engineering students is needed before any conclusions are made about their impact on calculus course success.

The inclusion of a qualitative component such as focus groups to identify students' perceptions regarding important factors or variables that contribute to their calculus course success could provide and explanation for the variance that was not accounted for in this study.

Replication of this study with other groups of subject (such as students enrolled in calculus course in Spring 2004; Fall 2004) would be needed to validate this study.

## Conclusion

The influence of expectancy-value variables on calculus course success among freshmen engineering students provides understanding of motivational factors that are associated with achievement. Literature on expectancy-value theory of motivation contends that expectancy and value are two independent constructs that influence achievement (Eccles et al., 1983). The purpose of this study was to examine eight theoretical expectancy-value variables believed to influence calculus course success among freshmen engineering students in a large Midwestern university.

Three research questions guided this study. The first research question examined whether the four theoretical expectancy variables (Total number of mathematics courses taken at junior and high school level, ACT composite, ACT math, and high school GPA) measured the 'expectancy' construct. Bivariate correlations among the four variables

were statistically significant. This indicated that these four variables were intercorrelated and therefore converging to one construct of expectancy.

Research question two examined whether the four theoretical value variables (utility value, class engagement, help-seeking behavior, and self-regulated learning) measured the 'value' construct. Most of the bivariate correlations were statistically significant. This indicated that these four variables were intercorrelated and therefore converging to one construct of value.

The third research question tested a theoretical path model that involved all eight theoretical expectancy-value variables in predicting calculus. Four variables (high school GPA, ACT math, utility value, and help-seeking behavior) were statistically significant predictors of calculus course success among freshmen engineering students.

In conclusion, since most of the expectancy-value research has been done among elementary and high school students, this study provides support for the expectancy-value motivational theory in examining possible factors that influence calculus course success among college students. Results from this study may assist faculty members from college of engineering and mathematics departments to pay close attention to expectancy-value variables as predictors of achievement.

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*grade inflation.* ACT Research Report Services. Iowa City: American College

Testing Program.

# Appendix A

## Institutional Review Board

Date:   Tuesday, September 02, 2003                    IRB Application No   EG042

Proposal Title:    CEAT Survey of Factors Influencing Student Performance in MATH 2144 (Calculus I) course

Principal
Investigator(s):

| Steven Langstraat | Mwarumba Mwavita | David R Thompson |
|---|---|---|
| 201 ATRC | 152d Physical Science | 201G ATRC |
| Stillwater, OK  74078 | Stillwater, OK  74078 | Stillwater, OK  74078 |

Reviewed and
Processed as:     Expedited

Approval Status Recommended by Reviewer(s):  Approved

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Dear PI :

Your IRB application referenced above has been approved for one calendar year.  Please make note of the expiration date indicated above.  It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved.  Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year.  This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly.  Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved projects are subject to monitoring by the IRB.  If you have questions about the IRB procedures or need any assistance from the Board, please contact Sharon Bacher, the Executive Secretary to the IRB, in 415 Whitehurst (phone: 405-744-5700, sbacher@okstate.edu).

Sincerely,

Carol Olson

Carol Olson, Chair
Institutional Review Board

**Appendix B**

**Engineering Survey of Factors Influencing Student Performance in MATH 2144
(Calculus I)**
Implied Assent Statement

Hello, my name is _____ and I'm calling from 's
Bureau for Social Research in Stillwater.  We are doing a survey on behalf of the
University and The College of Engineering.

THE UNIVERSITY and College of Engineering are continuously improving its
programs and services so that students have the best opportunity for academic success.
 Part of this process is asking for feed back from former and current students.

You have been selected to participate in a telephone survey because of your past
enrollment at THE UNIVERSITY in MATH 2144 Calculus I. Participation in this survey
is completely voluntary, and your responses are confidential.

The survey takes about fifteen minutes to complete, and if there are any questions
you do not wish to answer, you may ask to skip them.

Your response to this survey will be kept in strict confidentiality. The results from
this study will be presented in reports, professional conferences, and or dissertation with
**no** identification of participants. You can withdraw from the interview at anytime without
penalty.

Could you take a moment to answer a few questions about your educational
experiences at THE UNIVERSITY?

INTERVIEWER:    SELECT 1 TO CONTINUE WITH INTERVIEW,
                PRESS (CTRL + END) IF NOT AVAILABLE.

# Engineering Survey of Factors Influencing Student Performance in MATH 2144 (Calculus I)

**The first questions focus on your <u>junior and high school math experience</u>.  For each junior or high school math class I read, please tell me in which grade you had the course.**

1. **Tell me, in what grade did you take Algebra I?**
   **Was it in…?**
   ☐ 8<sup>th</sup> grade
   ☐ 9<sup>th</sup> grade
   ☐ 10<sup>th</sup> grade
   ☐ 11<sup>th</sup> grad
   ☐ 12<sup>th</sup> grade
   ☐ Never took it.

2. **Geometry?**
   **Was it in…?**
   ☐ 8<sup>th</sup> grade
   ☐ 9<sup>th</sup> grade
   ☐ 10<sup>th</sup> grade
   ☐ 11<sup>th</sup> grade
   ☐ 12<sup>th</sup> grade
   ☐ Never took it

3. **Algebra II?**
   **Was it in…?**
   ☐ 8<sup>th</sup> grade
   ☐ 9<sup>th</sup> grade
   ☐ 10<sup>th</sup> grade
   ☐ 11<sup>th</sup> grade
   ☐ 12<sup>th</sup> grade
   ☐ Never took it

4. **Algebra III (or Math Analysis)?**
   **Was it in…?**
   ☐ 8<sup>th</sup> grade
   ☐ 9<sup>th</sup> grade
   ☐ 10<sup>th</sup> grade
   ☐ 11<sup>th</sup> grade
   ☐ 12<sup>th</sup> grade
   ☐ Never took it

5. **Trigonometry?**
   **Was it in…?**
   ☐ 8<sup>th</sup> grade
   ☐ 9<sup>th</sup> grade
   ☐ 10<sup>th</sup> grade
   ☐ 11<sup>th</sup> grade

☐ 12<sup>th</sup> grade

☐ $12^{th}$ grade
☐ Never took it

**6.** **Pre-Calculus?**
**Was it in…?**
☐ $8^{th}$ grade
☐ $9^{th}$ grade
☐ $10^{th}$ grade
☐ $11^{th}$ grade
☐ $12^{th}$ grade
☐ Never took it

**7.** **Calculus?**
**Was it in…?**
☐ $8^{th}$ grade
☐ $9^{th}$ grade
☐ $10^{th}$ grade
☐ $11^{th}$ grade
☐ $12^{th}$ grade
☐ Never took it

**8.** **Advanced Placement Calculus – AB?**
**Was it in…?**
☐ $8^{th}$ grade
☐ $9^{th}$ grade
☐ $10^{th}$ grade
☐ $11^{th}$ grade
☐ $12^{th}$ grade
☐ Never took it

**9.** **Advanced Placement Calculus – BC?**
**Was it in…?**
☐ $8^{th}$ grade
☐ $9^{th}$ grade
☐ $10^{th}$ grade
☐ $11^{th}$ grade
☐ $12^{th}$ grade
☐ Never took it

**10.** **Statistics?**
**Was it in…?**
☐ $8^{th}$ grade
☐ $9^{th}$ grade
☐ $10^{th}$ grade
☐ $11^{th}$ grade
☐ $12^{th}$ grade
☐ Never took it

**11.** **Advanced Placement Statistics?**
**Was it in…?**
☐ $8^{th}$ grade
☐ $9^{th}$ grade
☐ $10^{th}$ grade
☐ $11^{th}$ grade

☐ 12th grade
☐ Never took it

**The next questions also focus on your <u>junior and high school math experience.</u>
For these questions, chose the response that BEST describes your situation.**

1.  (skip if never had HS algebra) How would you rate your **high school ALGEBRA** learning experience in preparation for **MATH 2144 ("Calculus I")**? Would you rate your learning experience as …
    ( Poor )          ( Fair )          ( Good )                    ( Excellent )

2.  (skip if never had HS calculus) How would you rate your **high school CALCULUS** learning experience in preparation for **MATH 2144 ("Calculus I")**? Would you rate your learning experience as …
    ( Poor )          ( Fair )          ( Good )                    ( Excellent )

3.  Was your High school schedule …
    ( Block Schedule )                    ( Regular Schedule )

4.  In high school how much time **OUTSIDE class** per week did you devote to doing **MATH** homework? Would you say you devoted …
    ( None )    ( 1minute – 1hour )    ( 61minutes – 2 hours )    ( 121minutes – 3 hours )    ( 181minutes – 4 hours )
    ( > 4 hours)

5.  (skip if never had HS algebra II) In your **ALGEBRA II** class, did you cover …
    (Less than ½ of the **MATH** textbook. )                    (½ of the **MATH** textbook but less than ¾. )
    (¾ of the **MATH** textbook, but less than the entire book. )      (The entire **MATH** textbook. )

**The next set of questions focus on your MATH 2144 "CALCULUS I" <u>experience at</u>**

**<u>the University.</u>  Chose the response that BEST describes your situation.**

6.  How many times did you **miss MATH 2144** "**CALCULUS I"** class last semester? Would you say you missed …
    ( 0 times )          ( 1-2 )    ( 3-4 )    ( 5-6 )    ( 7-8 )    ( 9-10 )          ( More than 10 )

7.  How often did you **READ** the textbook sections **BEFORE** class that corresponded to that day's lecture? Would you say …
    ( Never )          ( Rarely )          ( Sometimes )    ( Often )          ( Always )

8.  What percentage of the assigned problems did **you** do? Would you say …
    ( 0% - Never did them )    ( 1 - 50% )          ( 51 - 69% )          ( 70 - 79% )      ( 80 - 89% )
    ( 90 - 100% )

9.  What percentage of the time did you **attempt** your homework problems **within the week** they were assigned? Would you say…
    ( 0% - Never ) ( 1 - 50% of the time ) ( 51 - 69% of the time ) ( 70 - 79% of the time ) ( 80 - 89% of the time ) (
    90 - 100% of the time )

10. What percentage of the homework problems did you **COMPLETE BEFORE** the next **class session**? Would you say …

( 0% - Never ) ( 1 - 50% of the time ) ( 51 - 69% of the time ) ( 70 - 79% of the time ) ( 80 - 89% of the time ) ( 90 - 100% of the time )

11. What percentage of the homework problems did you **COMPLETE BEFORE** the next **test/exam**? Would you say …
( 0% - Never ) ( 1 - 50% of the time ) ( 51 - 69% of the time ) ( 70 - 79% of the time ) ( 80 - 89% of the time ) ( 90 - 100% of the time )

12. How many times did you contact your **instructor** for help during **office hours**? Would you say it was …
( 0 )     ( 1-2 )    ( 3-4 )    ( 5-6 )    ( 7-8 )    ( 9-10 )    ( More than 10 )

13. How many times did you contact your **instructor** for help by **e-mail** or **on-line** open group discussion? Would you say it was…
( 0 )     ( 1-2 )    ( 3-4 )    ( 5-6 )    ( 7-8 )    ( 9-10 )    ( More than 10 )

14. How many times did you **ask questions DURING** class? Would you say it was …
( 0 )     ( 1-2 )    ( 3-4 )    ( 5-6 )    ( 7-8 )    ( 9-10 )    ( More than 10 )

15. How many times did you **RECEIVE** help or **attended review sessions** during the semester? Would you say it was …
( 0 )     ( 1-2 )    ( 3-4 )    ( 5-6 )    ( 7-8 )    ( 9-10 )    ( More than 10 )

16. How many times did you go to the **Math Learning Resource Center** for additional instruction? Was it…
( 0 )     ( 1-2 )    ( 3-4 )    ( 5-6 )    ( 7-8 )    ( 9-10 )    ( More than 10 )

17. How much time did you spend **studying** the assigned sections **before** you started the homework problems?  Was it ….
( Never studied )          ( 1- 30 minutes ) ( 31minutes – 1hour )      ( 61 minutes – 1 ½ hours )  ( More than 1 ½ hours )

18. How many notes did you take?  Would you say you took….
( None )          (Occasionally recorded important concepts. )               ( Recorded a summary of each lecture. )
( Recorded everything the instructor wrote on the board or showed on the screen.)

19. How much time did you spend **reviewing your notes** when working on the homework problems?  Was it ….
( Never reviewed )          ( 1- 30 minutes ) ( 31minutes – 1hour )      ( 61 minutes – 1 ½ hours )  ( More than 1 ½ hours )

20. How many **hours** did you spend studying for your **first** major exam?  Would say you spent …
( 0 )    ( Less than one hour )    ( 1-2 )      ( 3-4 )        ( 5-6 )   ( 7-8 )  ( 9-10 )
( More than 10 )

21. How many **hours** did you spend studying for your **second** major exam?  Would say you spent …
( 0 )    ( Less than one hour )    ( 1-2 )      ( 3-4 )        ( 5-6 )   ( 7-8 )  ( 9-10 )
( More than 10 )

22.  How many **hours** did you spend studying for your **final** exam?  Would say you spent …
( 0 )    ( Less than one hour )    ( 1-2 )      ( 3-4 )        ( 5-6 )   ( 7-8 )  ( 9-10 )
( More than 10 )

23. (Mark all that apply question)

Now I'd like to know **how** your **MATH 2144 "Calculus I"** homework problems were handled. I'll list several ways, and you can say 'yes' or 'no' to each. Were your homework problems ...

 (Never turned in. )
( Turned in but not graded. )
( Discussed in the class. )
(Graded, returned, but not included in course grade. )
( Graded, returned, and included in course grade. )
(Contributed to the course grade. )
( Not turned in, but we were **quizzed** over exact or similar problems for H.W. grade. )
(
Other_____
_____)

24. Did you experience difficulty in learning the concepts and skills in Math 2144?
( Yes )          ( No )
**(if 24 is answered "Yes" then GO TO 25, otherwise GO TO 26)**

25. **At what point** during the semester did you realize your difficulty? Would you say …
 ( After the first assigned homework. )      ( After the first quiz. )
 ( After the midterm exam. )              ( After the final exam. )
 (
Other_____
__)

26. How confident were you that most of your homework assignments were completed **correctly**? Would you say…
( never )                          ( on less than 50% of the problems )
( on  50 – 75% of the problems )    ( on 76 – 90% of the problems )
( on 91 to 100% of the problems )

27. Please tell us how you knew your homework problems were done correctly?

_____
_____

_____
_____

**Using a 1 to 7 scale where 1 is "not well at all" and 7 is "very well, please describe your UNIVERSITY experiences related to homework, study skills, and classroom instruction.**

1) How well can you complete your homework assignments by the posted deadlines?

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Not well at all                 Not too well               Pretty well

     Very well

2) How well can you study when there are other interesting things to do?

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Not well at all                 Not too well               Pretty well

     Very well

3) How well can you concentrate on school subjects?

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Not well at all                 Not too well               Pretty well

     Very well

4) How well can you take class notes of instruction?

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Not well at all                 Not too well               Pretty well

     Very well

5) How well can you use the library to get information for class assignments?

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Not well at all                 Not too well               Pretty well

     Very well

6) How well can you plan your school work?

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Not well at all                 Not too well               Pretty well

     Very well

7) How well can you organize your school work?

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Not well at all                 Not too well               Pretty well

     Very well

8)  How well can you remember information presented in class and textbooks?

1               2               3               4               5               6
7
Not well at all                         Not too well                    Pretty well
        Very well

9)  How well can you arrange a place to study without distractions?

1               2               3               4               5               6
7
Not well at all                         Not too well                    Pretty well
        Very well

10) How well can you motivate yourself to do school work?

1               2               3               4               5               6
7
Not well at all                         Not too well                    Pretty well
        Very well

11) How well can you participate in class discussions?

1               2               3               4               5               6
7
Not well at all                         Not too well                    Pretty well
        Very well

**We are almost finished. Using a 1 to 7 scale where 1 is "strongly disagree" and 7 is "strongly agree", please tell me the number that BEST describes your <u>opinion</u> about MATH 2144 – Calculus I.**

12) Calculus is worthless.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
7

Strongly Disagree          Somewhat Disagree          Somewhat Agree

     Strongly Agree

13) Calculus should be a required part of your professional education.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
7

Strongly Disagree          Somewhat Disagree          Somewhat Agree

     Strongly Agree

14) Calculus skills will make you more employable.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
7

Strongly Disagree          Somewhat Disagree          Somewhat Agree

     Strongly Agree

15) Calculus is **NOT** useful to the typical Engineering professional.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
7

Strongly Disagree          Somewhat Disagree          Somewhat Agree

     Strongly Agree

16) Calculus thinking is **NOT** applicable in your life outside your future job employment.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
7

Strongly Disagree          Somewhat Disagree          Somewhat Agree

     Strongly Agree

17) **YOU** use Calculus in your everyday life.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
7

Strongly Disagree          Somewhat Disagree          Somewhat Agree

     Strongly Agree

18) Calculus conclusions are **RARELY** presented in everyday life.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
7

Strongly Disagree          Somewhat Disagree          Somewhat Agree

     Strongly Agree

19) **YOU** will have **NO** application for Calculus in your future profession.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Strongly Disagree                    Somewhat Disagree                    Somewhat Agree
    Strongly Agree

20) Calculus is irrelevant in your life.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

7

Strongly Disagree                    Somewhat Disagree                    Somewhat Agree
    Strongly Agree


21a) Would you be willing to participate in a follow – up  focus group to discuss and elaborate further on your experience in **Math 2144** in the coming two weeks? (Yes)          (No – if no go to "Thank" screen)

21b) **If Yes**:  You may be contacted via telephone or email with information about these focus groups about 2 weeks after this interview. (Then go to "Thank" screen")

## Appendix D
## BSR STEP BY STEP PROCEDURE

The "CEAT MATH 2144" study was a survey of students at the Large Midwesten University who had taken College Calculus I (MATH 2144) during the Fall 2002 semester and/orSpring 2003 semester. Data collection was conducted between September 3 and September 12, 2003 by the Bureau for Social Research at The Large Midwestern University. Computer Assisted Telephone Interviewing (CATI) was the data collection technology used for this project.

### Interviewer Selection

Interviewers were students at . They were selected for their communication and data collection skills, trained for this project, and supervised closely during all their work. Many interviewers had worked at the BSR previous semesters on other projects.

### Training of Interviewers

Training of the interviewers at the BSR was conducted in three phases. Phases one and two applied only for new interviewers, while phase three applied to all interviewers. In the first phase, new interviewers were required to attend an initial training session during which they were given basic instructions/guidance in survey interviewing. During the second phase, new interviewers attended a second training session which began with a written test over material covered in phase one, as well as content from the interviewer training manual. Then new interviewers were given instructions on using the CATI software. In the third phase, all interviewers attended a training session which covered survey protocol and policies for this project and the actual survey questionnaire was reviewed item by item. Following the project-specific training session, each interviewer had a practice session on the computer with a supervisor or other BSR staff members. All new interviewers had to pass an oral competency practice interview.

As an employment requirement, all interviewers were required to read and sign a statement of professional ethics that contains explicit guidelines about appropriate interviewer behavior and protection of confidential respondent information.

Fifteen (15) interviewers collected data for this survey. Many interviewers had worked at the BSR previous semesters on other projects.

### Computer Assisted Telephone Interviews

This project used the Ci3 for Windows system (from Sawtooth Software, Inc.) for authoring the interview script for the computer program. Once programmed, the

interview script was uploaded to the interviewing software, WinCATI version 4.2 (from Sawtooth Technologies, Inc.).

To conduct interviews using Computer Assisted Telephone Interviewing (CATI) software, each interviewer uses a personal computer, which displays survey questions on the computer screen one at a time in the proper order. The interviewer wears a telephone headset and has both hands free for entering responses into the computer via the keyboard. Responses are entered as numbers, such as "1" for yes and "2" for no.

Ci3 and WinCATI allow the computer to skip specified questions based on respondents' answers to previous questions. This eliminates asking certain questions that are not applicable to respondents. It also improves the quality of the data collected.

**Supervision**

Interviews were supervised throughout the data collection process. Supervisory responsibilities include monitoring interviews, responding to interviewer questions, reviewing call back appointments for the next day, and running reports on interviewer productivity.

**Operations**

Interviews were conducted by telephone from the phone bank located at the BSR. The interviewing was organized into evening shifts Monday through Thursday and an afternoon shift on Friday. The majority of interviewing took place in the evening.

Telephone numbers (contact records) to be called were assigned a priority code automatically by the CATI system. The priority code was based on the outcome (or disposition) of the most recent call attempt. Attempts that resulted in the target respondent asking to be called back at a later day/time received the highest priority code. Attempts that resulted in answering machines, no answers, and busy signals received lower priority codes. The disposition of each attempt was recorded and stored in the CATI system. Interviewers were instructed to review the call history of previous attempts prior to making calls. Each telephone number in the sample was called until it had been attempted at least 12 times without success or until data collection ended on September 12, 2003.

After each call attempt, the software allowed the interviewer to type a message describing the outcome of the attempt in a "message box". Interviewers were instructed to record any pertinent information about the call in this box. For example, interviewers could indicate relevant information about respondents who refused to participate in the interview, or they could record information pertaining to scheduling future interview appointments. When a target respondent refused participation, interviewers were instructed to indicate the respondent's reason for declining participation in the interview, the points used by the interviewer to encourage participation, and the point at which the introductory script was terminated. In many instances, target respondents who declined

participation were called again in hopes of gaining their cooperation. Once a target respondent refused the interview twice, their phone number was not attempted again.

Interviewers who set call back appointments were instructed to record the specific date and time of the scheduled appointment, the name of the target respondent (if determined), and whether the appointment was definite or indefinite. The computer prompted the interviewer to enter the call back date and time using a computer calendar and clock function. These call back appointments were then stored by the CATI system until the appropriate date and time.

Open-ended responses were typed, verbatim, directly into the computer using a text box on the computer screen. In addition, interviewers could record special notes or comments about the interview in a "notes" field using the computer's function keys.

For each call made, the CATI system recorded the date, time, and disposition of the call as well as the interviewer identification number. Completed interviews were recorded directly into the CATI system and stored on a BSR file server. Each completed interview was assigned a unique respondent number. The data files were backed up at the end of the day automatically by the CATI software.

**Answering Machine Messages**

The sample for this study included many students with answering machines. Interviewers were instructed to leave a message stating they were calling from the Bureau for Social Research at the Large Midwestern University, and they would be calling back. Interviewers gave a local number (or toll-free number, if needed) and stated the respondent could call the BSR to participate in the study.

**Appendix E**
**Bureau for Social Research**

**Staff Confidentiality Agreement**

The Bureau for Social Research was created to support and facilitate social and behavioral science research at and beyond. Our research projects sometimes ask sensitive and confidential information from research participants. Truthful and accurate respondent information is critical to the accuracy of results and procedures.

As a result, the nature of the information collected by staff working for the Bureau for Social Research requires a commitment of confidentiality to protect research participants' rights to privacy. Frequently a commitment of confidentiality is a prerequisite to facilitate participation by respondents in research projects. Therefore, we have made, and will continue to offer, a commitment of confidentiality to respondents and research sponsors. Because unauthorized breaches of that confidentiality would violate assurances we have given that are essential to obtaining truthful and accurate information, thereby impinging on our ability to produce accurate and reliable products, unauthorized disclthe Universityre of research information would result in a greater harm than benefit to the public interest. As a result, the Bureau for Social Research requests that each employee read and sign the following confidentiality agreement as a condition of employment.

I HEREBY AGREE NOT TO RELEASE THE FOLLOWING PRIVILEDGED INFORMATION TO ANY NON-BUREAU PERSONNEL WITHOUT PROPER AUTHORIZATION FROM A DULY AUTHORIZED EMPLOYEE OR AGENT OF THE BUREAU FOR SOCIAL RESEARCH:

1. Information leading to the identification of study participants.
2. Questionnaire forms, questions and materials,
3. Individual participant responses and research results, and
4. Unpublished tabulations of research results.

I FURTHER AGREE:

5. To refrain from discussing material relating to individual respondents with persons other than project staff, and
6. To see that information is released only to authorized personnel.

I understand that violation of this agreement would result in dismissal and could result in civil action.

| | |
|---|---|
| Signed | Date |

| | |
|---|---|
| Witness | Date |

**BSR INTERVIEW SCRIPT**

```
CATI ON
COL 112
HIGHCOL 79
HELPBTN ON
OPNENTER ON
SQN RIGHT


LIST QB23LIST
1. Never turned in
2. Turned in, but not graded
3. Discussed in the class
4. Graded, returned, but NOT included in course grade
5. Graded, returned, AND included in course grade
6. Contributed to the course grade
7. Not turned in, but QUIZZED over exact/similar problems for H.W.
grade
8. Other
ENDLIST


Q:HELLO1
T: 1 1
     Hello, my name is _____ and I'm calling from Oklahoma State
University's Bureau for Social Research. We are conducting an interview
on behalf of the University and the College of Engineering,
Architecture
and Technology [ or CEAT].
     THE UNIVERSITY and CEAT are continuously improving their programs
and services
so that students have the best opportunity for academic success. Part
of
this process is asking for feedback from former and current students.
     *ENTER '1' to continue
T:15 1 1
     Hello, my name is _____ and I'm calling from Oklahoma State
University's Bureau for Social Research. We spoke with _____
previously
regarding a math survey. I'm calling now to finish that interview.
     *ENTER '1' to restart
I:
COL 121 21
COL 121 25
NUM 1 1


Q:HELLO2
T: 1 1
     You have been selected to participate in a telephone interview
because of your past enrollment at THE UNIVERSITY in College Calculus I
(MATH 2144).
Participation in this survey is completely voluntary, and your
responses
are confidential.
     This interview takes about 15 minutes to complete, and if there
are
```

any questions you do not wish to answer, you may skip them. Would this be
a good time to answer a few questions about your educational experience
at THE UNIVERSITY?
        *IWER: SELECT 1 TO CONTINUE,
               PRESS (CTRL+END) IF NOT AVAILABLE.
I:
COL 121 9
COL 121 10
NUM 1 1
QAL Notqal
INTDATE = SYSDATE
INTTIME = SYSTIME
CMDI ATTNUM "NumberOfAttempt"
CMDI RECNUM "RecordNumber"
CMDI IWERID "CurrentInterviewerID"


Q:QA1  *****************************
T: 5 4
To begin, I would like to ask some questions that focus on your junior
high (or middle school) and high school math experience(s). For each
high school math class I read, please tell me in which grade you had
the course.

Tell me, in what grade did you take Algebra I? Was it in...?
T: 12 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 12 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF


Q:QA2  *****************************
T: 5 4
Geometry? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade

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```
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF


Q:QA3   *****************************
T: 5 4
Algebra II? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF


Q:QA4   *****************************
T: 5 4
Algebra III (or Math Analysis)? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
```

```
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Algebra III (or Math Analysis) are math courses offered after Algebra
II,
for those who don't want to take Trigonometry or Pre-Calculus.
ENDHELP

Q:QA5   *****************************
T: 5 4
Trigonometry? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF

Q:QA6   *****************************
T: 5 4
Pre-Calculus? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
```

```
ENDIF


Q:QA7   ******************************
T: 5 4
Calculus? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF


Q:QA8   ******************************
T: 5 4
Advanced Placement Calculus - AB? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Advance Placement Calculus AB is the High School-offered college
equivalent of Calculus I
ENDHELP


Q:QA9   ******************************
T: 5 4
```

Advanced Placement Calculus - BC? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Advance Placement Calculus BC is the High School-offered college
equivalent of Calculus II
ENDHELP

Q:QA10   ******************************
T: 5 4
Statistics? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade
4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF

Q:QA11   ******************************
T: 5 4
Advanced Placement Statistics? Was it in...?
T: 10 4
1. 8th grade
2. 9th grade
3. 10th grade

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4. 11th grade
5. 12th grade
6. Never took it
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF

Q:QB1
T: 5 4
The next questions also focus on your junior high (or middle
school) and high school math experience(s). For these questions,
choose the response that BEST describes your situation.

Overall, how would you rate your HIGH SCHOOL ALGEBRA learning
experience in preparation for College Calculus I (MATH 2144)?
Would you rate your learning experience as...
T: 13 4
1. Poor
2. Fair
3. Good
4. Excellent
[5. INVALID RESPONSE]
[6. INVALID RESPONSE]
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
IF (QA1 = 6)
 IF (QA3 = 6)
  IF (QA4 = 6)
    SKP
  ENDIF
 ENDIF
ENDIF
LOC 13 9 1
HLA .3
NUM 1 9
IF (ANS > 4)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF

Q:QB2
T: 5 4
Overall, how would you rate your HIGH SCHOOL CALCULUS learning

experience in preparation for College Calculus I (MATH 2144)? Would
you rate your learning experience as...
T: 10 4
1. Poor
2. Fair
3. Good
4. Excellent
[5. INVALID RESPONSE]
[6. INVALID RESPONSE]
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
IF (QA7 = 6)
 IF (QA8 = 6)
  IF (QA9 = 6)
   SKP
  ENDIF
 ENDIF
ENDIF
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 4)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF

Q:QB3
T: 5 4
Was your High school schedule...
T: 10 4
1. Block Schedule
2. Regular Schedule
[3. INVALID RESPONSE]
[4. INVALID RESPONSE]
[5. INVALID RESPONSE]
[6. INVALID RESPONSE]
[7. INVALID RESPONSE]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 2)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Block scheduling is generally when H.S. courses are completed in 18
weeks
instead of 36 weeks.

If respondent reports "both", then ask how a majority of their math
classes were scheduled. If a majority were block, then choose block.
ENDHELP

Q:QB4
T: 5 4
In high school how much time OUTSIDE CLASS per week did you devote to
doing MATH homework? Would you say you devoted...
T: 10 4
1. None
2. 1 hour or less (1 to 60 min)
3. 1 to two hours (61 to 120 min)
4. 2 to three hours (121 to 180 min)
5. 3 to four hours (181 to 240 min)
6. More than 4 hours
[7. INVALID ANSWER]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF

Q:QB5
T: 5 4
In your ALGEBRA II class, did you cover...
T: 10 4
1. Less than ½ of the MATH textbook.
2. ½ of the MATH textbook but less than ¾.
3. ¾ of the MATH textbook, but less than the entire book.
4. The entire MATH textbook.
[5. INVALID ANSWER]
[6. INVALID ANSWER]
[7. INVALID ANSWER]
8. DON'T KNOW
9. REFUSED
I:
IF (QA3 = 6) SKP
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 4)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF

Q:QB6
T: 5 4

The next set of questions focus on your College Calculus I
experience at THE UNIVERSITY. Excluding the current semester,
choose the response that BEST describes your situation
during the most recent semester you were enrolled in Math 2144.

When you took College Calculus I (MATH 2144), how many times would you
say you missed class?
T: 13 4
1. 0 times
2. 1-2
3. 3-4
4. 5-6
5. 7-8
6. 9-10
7. More than 10
8. DON'T KNOW
9. REFUSED
I:
LOC 13 9 1
HLA .3
NUM 1 9
H:
Refer to the most recent semester in which they took the course.
ENDHELP

Q:QB7
T: 5 4
How often did you READ the textbook sections BEFORE class that
corresponded to that day's lecture?  Would you say...
T: 10 4
1. Never
2. Rarely
3. Sometimes
4. Often
5. Always
[6. INVALID ANSWER]
[7. INVALID ANSWER]
8. DON'T KNOW
9. REFUSED
I:
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 5)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Refer to the most recent semester in which they took the course.
ENDHELP

Q:QB8
T: 5 4
What percentage of the assigned problems did YOU do?

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```
        *IWER: Do not read response options unless probing
T: 10 4
[1. 0% – Never did them]
[2. 1 – 50%]
[3. 51 – 69%]
[4. 70 – 79%]
[5. 80 – 89%]
[6. 90 – 100%]
[7. INVALID ANSWER]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 7
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Refer to the most recent semester in which they took the course.

"do" – Include both those attempted and those completed.

       Refers only to those done outside of class (not problems
        assigned to be worked on during class).
ENDHELP

Q:QB9
T: 5 4
What percentage of the time did you ATTEMPT your homework problems
WITHIN THE WEEK they were assigned?

        *IWER: Do not read response options unless probing
T: 10 4
[1. 0% – Never]
[2. 1 – 50% of the time]
[3. 51 – 69% of the time]
[4. 70 – 79% of the time]
[5. 80 – 89% of the time]
[6. 90 – 100% of the time]
[7. INVALID ANSWER]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
```

ENDIF
H:
Refer to the most recent semester in which they took the course.
ENDHELP

Q:QB10
T: 5 4
What percentage of the homework problems did you COMPLETE BEFORE the
next CLASS SESSION?

        *IWER: Do not read response options unless probing
T: 10 4
[1. 0% – Never]
[2. 1 – 50% of the time]
[3. 51 – 69% of the time]
[4. 70 – 79% of the time]
[5. 80 – 89% of the time]
[6. 90 – 100% of the time]
[7. INVALID ANSWER]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3
NUM 1 9
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Refer to the most recent semester in which they took the course.
ENDHELP

Q:QB11
T: 5 4
What percentage of the homework problems did you COMPLETE BEFORE the
next TEST or EXAM?

        *IWER: Do not read response options unless probing
T: 10 4
[1. 0% – Never]
[2. 1  – 50% of the time]
[3. 51 – 69% of the time]
[4. 70 – 79% of the time]
[5. 80 – 89% of the time]
[6. 90 – 100% of the time]
[7. INVALID ANSWER]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3
NUM 1 9

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```
IF (ANS > 6)
  IF (ANS < 8)
    BEEP
    REASK
  ENDIF
ENDIF
H:
Refer to the most recent semester in which they took the course.
ENDHELP

Q:QB12
T: 5 4
How many times did you contact your INSTRUCTOR for help during OFFICE
HOURS?

       *IWER: Do not read response options unless probing
T: 10 4
[1. 0]
[2. 1-2]
[3. 3-4]
[4. 5-6]
[5. 7-8]
[6. 9-10]
[7. More than 10]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3
NUM 1 9
H:
Refer to the most recent semester in which they took the course.

This would include TA's.

Appointments count.
ENDHELP

Q:QB13
T: 5 4
How many times did you contact your INSTRUCTOR for help by E-MAIL or
ON-LINE open group discussion?

       *IWER: Do not read response options unless probing
T: 10 4
[1. 0]
[2. 1-2]
[3. 3-4]
[4. 5-6]
[5. 7-8]
[6. 9-10]
[7. More than 10]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
```

LOC 10 9 1
HLA .3
NUM 1 9
H:
Refer to the most recent semester in which they took the course.

On-line open group discussion is active communication such as in
a chat room or instant reply messaging.

This includes TA's.
ENDHELP

Q:QB14
T: 5 4
How many times did you ASK QUESTIONS IN class during
the semester?

        *IWER: Do not read response options unless probing
T: 10 4
[1. 0]
[2. 1-2]
[3. 3-4]
[4. 5-6]
[5. 7-8]
[6. 9-10]
[7. More than 10]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3
NUM 1 9
H:
Refer to the most recent semester in which they took the course.
ENDHELP

Q:QB15
T: 5 4
How many times did you RECEIVE help or ATTEND REVIEW SESSIONS during
the semester?

        *IWER: Do not read response options unless probing
T: 10 4
[1. 0]
[2. 1-2]
[3. 3-4]
[4. 5-6]
[5. 7-8]
[6. 9-10]
[7. More than 10]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3

NUM 1 9
H:
Refer to the most recent semester in which they took the course.

Does not include receiving help during office hours.

Does not include receiving help during class.

Does include help from classmates, TAs, tutors, and instructors AS
LONG AS it was a structured setting and not a social event.
ENDHELP

Q:QB16
T: 5 4
How many times did you go to the MATH LEARNING RESOURCE CENTER (MLRC)
for additional instruction?

        *IWER: Do not read response options unless probing
T: 10 4
[1. 0]
[2. 1-2]
[3. 3-4]
[4. 5-6]
[5. 7-8]
[6. 9-10]
[7. More than 10]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3
NUM 1 9
H:
Refer to the most recent semester in which they took the course.
ENDHELP

Q:QB17
T: 5 4
How much time did you spend STUDYING the assigned sections BEFORE YOU
started the homework problems?

        *IWER: Do not read response options unless probing
T: 10 4
[1. Never studied]
[2. Half-hour or less (1 – 30 minutes)]
[3. Half-hour to 1 hour (31 minutes – 60 min)]
[4. One hour to 1 ½ hours (61 minutes – 90 min)]
[5. More than 1 ½ hours (91 minutes or more)]
[6. INVALID ANSWER]
[7. INVALID ANSWER]
[8. DON'T KNOW]
[9. REFUSED]
I:
COL 121 8
LOC 10 9 1
HLA .3

```
NUM 1 9
IF (ANS > 5)
```

## Appendix G
## Frequently Asked Questions

Following are some commonly asked questions and the necessary information to provide an answer in your own words.

*"I've never heard of your organization"* or *"Where did you say you were from?"*

> Bureau for Social Research –
> Provides resources and services for assisting social science research
> - Assists in research done by THE UNIVERSITY faculty and other public and private organizations

**Client**
> College of Engineering, at the Large Midwestern University.

*"What is this about?"*

> Calling College of Engineering students who enrolled in MATH 2144 Calculus I course in either Fall 2002 or Spring 2003.

**Survey questions regarding**

- Your Math preparation in High school
  Your experience in MATH 2144 Calculus I course at THE UNIVERSITY

*"Who will see this information?"*

> The information is coded (turned into numbers) and then statistically analyzed
> Results will be summarized and then given to the College of Engineering at the Large Midwestern Univeristy.
> - Survey results used to assess students' services and needs in MATH 2144 Calculus I course
> - Results will be used in reports, conference presentations and doctoral dissertation without identifying subjects involved in the study
>   Identifying information, such as phone number, is kept separate from the interview in a confidential file
>   Identifying information will be destroyed when study is complete

*"How did you get my telephone number?"*

> List of phone numbers:

**Contact information**

*For questions regarding the survey, contact:*
Steven Langstraat –      Assessment Specialist –
                 (405) 744-5140
Dr. David R. Thompson – Associate Dean for Instruction and Extension,
                  (405) 744-5140
Mwarumba Mwavita-Evaluator –(405) 744-4637

# Appendix H

Engineering Survey Codebook

Variable Name:  respnum$
Variable Label:  Respondent Number
Values:   Range

Variable Name:  QA1
Variable Label:  Tell me, in what grade did you take Algebra I?  Was it in…?
Values:  1 = 8th grade
          2 = 9th grade
          3 = 10th grade
          4 = 11th grade
          5 = 12th grade
          6 = Never took it
          7 = Before 8th grade
          8 = DON'T KNOW
          9 = REFUSED

Variable Name:  QA2
Variable Label:  Geometry? Was it in...?
Values:  1 = 8th grade
          2 = 9th grade
          3 = 10th grade
          4 = 11th grade
          5 = 12th grade
          6 = Never took it
          7 = Before 8th grade
          8 = DON'T KNOW
          9 = REFUSED

Variable Name:  QA3
Variable Label:  Algebra II? Was it in...?
Values:  1 = 8th grade
          2 = 9th grade
          3 = 10th grade
          4 = 11th grade
          5 = 12th grade
          6 = Never took it
          7 = Before 8th grade
          8 = DON'T KNOW
          9 = REFUSED

Variable Name:  QA4
Variable Label:  Algebra III (or Math Analysis)? Was it in...?
Values:  1 = 8th grade
        2 = 9th grade
        3 = 10th grade
        4 = 11th grade
        5 = 12th grade
        6 = Never took it
        8 = DON'T KNOW
        9 = REFUSED

Variable Name:  QA5
Variable Label:  Trigonometry? Was it in...?
Values:  1 = 8th grade
        2 = 9th grade
        3 = 10th grade
        4 = 11th grade
        5 = 12th grade
        6 = Never took it
        7 = Before 8th grade
        8 = DON'T KNOW
        9 = REFUSED

Variable Name:  QA6
Variable Label:  Pre-Calculus? Was it in...?
Values:  1 = 8th grade
        2 = 9th grade
        3 = 10th grade
        4 = 11th grade
        5 = 12th grade
        6 = Never took it
        7 = Before 8th grade
        8 = DON'T KNOW
        9 = REFUSED

Variable Name:  QA7
Variable Label:  Calculus? Was it in...?
Values:  1 = 8th grade
        2 = 9th grade
        3 = 10th grade
        4 = 11th grade
        5 = 12th grade
        6 = Never took it
        8 = DON'T KNOW
        9 = REFUSED

Variable Name:  QA8
Variable Label:  Advanced Placement Calculus - AB? Was it in...?
Values:  1 = 8th grade
       2 = 9th grade
       3 = 10th grade
       4 = 11th grade
       5 = 12th grade
       6 = Never took it
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QA9
Variable Label:  Advanced Placement Calculus - BC? Was it in...?
Values:  1 = 8th grade
       2 = 9th grade
       3 = 10th grade
       4 = 11th grade
       5 = 12th grade
       6 = Never took it
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QA10
Variable Label:  Statistics? Was it in...?
Values:  1 = 8th grade
       2 = 9th grade
       3 = 10th grade
       4 = 11th grade
       5 = 12th grade
       6 = Never took it
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QA11
Variable Label:  Advanced Placement Statistics? Was it in...?
Values:  1 = 8th grade
       2 = 9th grade
       3 = 10th grade
       4 = 11th grade
       5 = 12th grade
       6 = Never took it
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QB1
Variable Label:  Overall, how would you rate your HIGH SCHOOL ALGEBRA learning
         experience in preparation for College Calculus I (MATH 2144)?  Would you
         rate your learning experience as...
Values:  1 = Poor
         2 = Fair
         3 = Good
         4 = Excellent
         8 = DON'T KNOW
         9 = REFUSED
IF (QA1 = 6) and IF (QA3 = 6) and IF (QA4 = 6) SKP

Variable Name:  QB2
Variable Label:  Overall, how would you rate your HIGH SCHOOL CALCULUS
         learning
         experience in preparation for College Calculus I (MATH 2144)? Would you
         rate your learning experience as...
Values:  1 = Poor
         2 = Fair
         3 = Good
         4 = Excellent
         8 = DON'T KNOW
         9 = REFUSED
IF (QA7 = 6) and IF (QA8 = 6) and IF (QA9 = 6) SKP

Variable Name:  QB3
Variable Label:  Was your High school schedule...
Values:  1 = Block Schedule
         2 = Regular Schedule
         8 = DON'T KNOW
         9 = REFUSED

Variable Name:  QB4
Variable Label:  In high school how much time OUTSIDE CLASS per week did you
         devote to
         doing MATH homework? Would you say you devoted...
Values:  1 = None
         2 = 1 hour or less (1 to 60 min)
         3 = 1 to two hours (61 to 120 min)
         4 = 2 to three hours (121 to 180 min)
         5 = 3 to four hours (181 to 240 min)
         6 = More than 4 hours
         8 = DON'T KNOW
         9 = REFUSED

Variable Name:  QB5
Variable Label:  In your ALGEBRA II class, did you cover...
Values:  1 = Less than ½ of the MATH textbook.
       2 = ½ of the MATH textbook but less than ¾.
       3 = ¾ of the MATH textbook, but less than the entire book.
       4 = The entire MATH textbook.
       8 = DON'T KNOW
       9 = REFUSED
IF (QA3 = 6) SKP

Variable Name:  QB6
Variable Label:  When you took College Calculus I (MATH 2144), how many times would you
       say you missed class?
Values:  1 = 0 times
       2 = 1-2
       3 = 3-4
       4 = 5-6
       5 = 7-8
       6 = 9-10
       7 = More than 10
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QB7
Variable Label:  How often did you READ the textbook sections BEFORE class that
       corresponded to that day's lecture?  Would you say...
Values:  1 = Never
       2 = Rarely
       3 = Sometimes
       4 = Often
       5 = Always
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QB8
Variable Label:  What percentage of the assigned problems did YOU do?
Values:  1 = 0% - Never did them
       2 = 1 - 50%
       3 = 51 - 69%
       4 = 70 - 79%
       5 = 80 - 89%
       6 = 90 - 100%
       8 = DON'T KNOW
       9 = REFUSED

Variable Name: QB9
Variable Label: What percentage of the time did you ATTEMPT your homework
      problems
      WITHIN THE WEEK they were assigned?
Values: 1 = 0% - Never
      2 = 1 - 50% of the time
      3 = 51 - 69% of the time
      4 = 70 - 79% of the time
      5 = 80 - 89% of the time
      6 = 90 - 100% of the time
      8 = DON'T KNOW
      9 = REFUSED


Variable Name: QB10
Variable Label: What percentage of the homework problems did you COMPLETE
      BEFORE the
      next CLASS SESSION?
Values: 1 = 0% - Never
      2 = 1 - 50% of the time
      3 = 51 - 69% of the time
      4 = 70 - 79% of the time
      5 = 80 - 89% of the time
      6 = 90 - 100% of the time
      8 = DON'T KNOW
      9 = REFUSED


Variable Name: QB11
Variable Label: What percentage of the homework problems did you COMPLETE
      BEFORE the
      next TEST or EXAM?
Values: 1 = 0% - Never
      2 = 1 - 50% of the time
      3 = 51 - 69% of the time
      4 = 70 - 79% of the time
      5 = 80 - 89% of the time
      6 = 90 - 100% of the time
      8 = DON'T KNOW
      9 = REFUSED

Variable Name:  QB12
Variable Label:  How many times did you contact your INSTRUCTOR for help during
          OFFICE
          HOURS?
Values:  1 = 0
          2 = 1-2
          3 = 3-4
          4 = 5-6
          5 = 7-8
          6 = 9-10
          7 = More than 10
          8 = DON'T KNOW
          9 = REFUSED

Variable Name:  QB13
Variable Label:  How many times did you contact your INSTRUCTOR for help by E-
          MAIL or
          ON-LINE open group discussion?
Values:  1 = 0
          2 = 1-2
          3 = 3-4
          4 = 5-6
          5 = 7-8
          6 = 9-10
          7 = More than 10
          8 = DON'T KNOW
          9 = REFUSED

Variable Name:  QB14
Variable Label:  How many times did you ASK QUESTIONS IN class during the
semester?
Values:  1 = 0
          2 = 1-2
          3 = 3-4
          4 = 5-6
          5 = 7-8
          6 = 9-10
          7 = More than 10
          8 = DON'T KNOW
          9 = REFUSED

Variable Name:  QB15
Variable Label:  How many times did you RECEIVE help or ATTEND REVIEW
        SESSIONS during the semester?
Values:  1 = 0
       2 = 1-2
       3 = 3-4
       4 = 5-6
       5 = 7-8
       6 = 9-10
       7 = More than 10
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QB16
Variable Label:  How many times did you go to the MATH LEARNING RESOURCE
        CENTER (MLRC) for additional instruction?
Values:  1 = 0
       2 = 1-2
       3 = 3-4
       4 = 5-6
       5 = 7-8
       6 = 9-10
       7 = More than 10
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QB17
Variable Label:  How much time did you spend STUDYING the assigned sections
        BEFORE YOU started the homework problems?
Values:  1 = Never studied
       2 = Half-hour or less (1 - 30 minutes)
       3 = Half-hour to 1 hour (31 minutes - 60 min)
       4 = One hour to 1 ½ hours (61 minutes - 90 min)
       5 = More than 1 ½ hours (91 minutes or more)
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QB18
Variable Label:  How many notes did you take?  Would you say you took...
Values:  1 = None
       2 = Occasionally recorded important concepts.
       3 = Recorded a summary of each lecture.
       4 = Recorded everything the instructor wrote/showed on board or screen.
       8 = DON'T KNOW
       9 = REFUSED

Variable Name:  QB19
Variable Label:  How much time did you spend REVIEWING YOUR NOTES when
           working on that day's assigned homework problems?  Was it...
Values:  1 = Never reviewed
         2 = Half-hour or less (1 - 30 minutes)
         3 = Half-hour to 1 hour (31 minutes - 60 min)
         4 = One hour to 1 ½ hours (61 minutes - 90 min)
         5 = More than 1 ½ hours (91 minutes or more)
         8 = DON'T KNOW
         9 = REFUSED
IF (QB18=1) SKP
IF (QB18=8) SKP
IF (QB18=9) SKP


Variable Name:  QB20
Variable Label:  How many HOURS did you spend studying for your FIRST major
exam?
Values:  1 = 0 - Not at all
         2 = Some but less than one hour
         3 = 1-2
         4 = 3-4
         5 = 5-6
         6 = 7-8
         7 = 9-10
         8 = More than 10
         9 = Not applicable
         88 = DON'T KNOW
         99 = REFUSED


Variable Name:  QB21
Variable Label:  How many HOURS did you spend studying for your SECOND major
exam?
Values:  1 = 0 - Not at all
         2 = Some but less than one hour
         3 = 1-2
         4 = 3-4
         5 = 5-6
         6 = 7-8
         7 = 9-10
         8 = More than 10
         9 = Not applicable
         88 = DON'T KNOW
         99 = REFUSED

VITA

Mwarumba Mwavita

Candidate for the Degree of

Doctor of Philosophy

Thesis:      FACTORS INFLUENCING CALCULUS COURSE SUCCESS AMONG
             FRESHMEN ENGINEERING STUDENTS.

     Major Field:   Educational Psychology

Biographical:
     Education:
              Bachelor of Education in Science from Kenyatta University,
              Nairobi, Kenya in May, 1989

              Master of Education in School Administration from University of Central
              Oklahoma, Edmond, Oklahoma in July, 1994.

              Completed the requirements for the Doctor of Philosophy Degree with a major in
              Educational Psychology at Oklahoma State University, May, 2005.

     Professional Experience:
     High school Principal 1991-1997
              Oklahoma State University College of Education Research Associate 1998-2000
              Oklahoma State University-Chemistry Department,
               Internal Evaluator and Professional Development Instructor 2001-2003
              Center of Science Literacy, Evaluator and Instructor, 2004 to present.

     Professional Memberships:
              American Educational Research Association (AERA).
              American Evaluation Association (AEA).

Name:  Mwarumba Mwavita                    Date of Degree:  May, 2005

Institution:  Oklahoma State University          Location:  Stillwater, Oklahoma

Title of Study:   FACTORS INFLUENCING CALCULUS COURSE SUCCESS
                  AMONG FRESHMEN ENGINEERING STUDENTS.

Pages in Study:  161              Candidate for the Degree of Doctor of Philosophy

Major Field:  Educational Psychology

Scope and Method of Study: Calculus has been viewed as a critical filter among freshmen engineering students. Since passing the entry level calculus course is crucial, research studies have focused on identifying factors that predict calculus course success. This study uses expectancy-value theory to identify factors associated with calculus course success. Eight theoretical expectancy-value variables were tested. These included four expectancy-related variables and four value-related variables. The expectancy-related variables identified in this study were total number of mathematics courses taken at junior and high school level, ACT composite, ACT math, and high school GPA. The value-related variables used in this study were utility value, class engagement, help-seeking behavior, and self-regulated learning. Two hundred and ninety five freshmen engineering students enrolled in an entry level calculus course participated in this study.

Findings and Conclusions: Bivariate correlation and path analysis via multiple regression were used. The results showed that the two sets of expectancy-value variables measured their respective constructs. The analysis identified high school GPA, ACT math, Utility value, and Help-seeking behavior as strong predictors of calculus course success, accounting for 39.8 % of variance in calculus course success.

ADVISOR'S APPROVAL:      Dr. Janice Miller _____