2006-1659: SELF-REGULATED LEARNING AND CLASSROOM ENGAGEMENT IN CALCULUS ACHIEVEMENT AMONG FRESHMEN ENGINEERING STUDENTS

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SELF-REGULATED LEARNING AND CLASSROOM ENGAGEMENT IN CALCULUS ACHIEVEMENT AMONG FRESHMEN ENGINEERING STUDENTS

Abstract
The current study examined the impact of self-regulated learning and classroom engagement activities among freshmen engineering students in a large Midwestern university enrolled in the first calculus course. Two variables self-regulated learning and class engagement were examined in relationship to calculus success.

Introduction

Engineering programs in American colleges have several core courses that engineering students take as prerequisites to subsequent engineering courses majors. Calculus is one of theses courses. Calculus provides the foundation for understanding higher-level science, mathematics, and engineering courses. Further, calculus is identified as a starting point in mathematics instruction for many engineering programs. The importance of succeeding in the first year of calculus among freshmen engineering students has been emphasized in a number of studies. Due to poor performance in calculus among freshmen students in the last ten years, the undergraduate calculus course has attracted an unprecedented level of national interest.

The 2003 National Science Foundation report emphasized that Science and technology will continue to be the engines of the US economic growth and national security [1]. The report further indicates serious problems lying ahead that may threaten U.S. long-term prosperity and national security. Among various trends is a reduced domestic student interest in critical areas, such as engineering and the physical and mathematical sciences[1]. Future projections indicate that employment in engineering and science will increase by 51 percent or approximately 1.9 million jobs by the year 2008. [2]

Numerous studies have examined plausible explanations and factors contributing to dropout rates among engineering students in many of the engineering programs in the country. [3,4,5] Most of these studies have looked at the problem 'globally'. Studies have focused on developing models of prediction persistence and retention based on a myriad of factors. At the same time, theories advanced in the field have continued to advocate for both institutions' learning environments in addition to students' attributes as plausible explanations for students persistence as well as success in their college academic life. [3]

Studies examining college environments as well as students' attributes have identified specific factors contributing to students' progression through their engineering programs. For example, Levin and Wyckoff[6] identified both non-cognitive and cognitive variables were predictive of freshman year persistence. Another factor that has been found to play a role in the dropout rates among freshmen engineering students has been the introductory courses. [7, 8] These introductory classes are in science and mathematics.

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. 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. [5, 6, 7, 8, 9]

Background

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. 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 became necessary.

While many studies have suggested that pre-college mathematics background as one of the predictors of calculus success among freshman students[7, 8] there are still questions to why even students with good mathematics background from high school as well as high scores in ACT or SAT still perform poorly in their first calculus course.
The current study examined two of the students' attributes that may be linked to calculus performance. These were self-regulated learning and classroom engagement activities. The study was guided by two research questions:

1. Does self-regulated learning predict calculus achievement among freshmen engineering students?
2. Does classroom engagement predict calculus achievement among freshmen engineering students?

Method

This was a *post-facto* (after the fact) study. A telephone survey was used to collect the information from participating students who had taken the calculus course during fall 2002 and spring 2003.

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. Out of the 295 students, 20.3% were female (n = 60) and 79.7% were male (n = 235). Euro-American students comprised 80% of the sample (n=237), 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 %.

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.

One of the independent variable examined in this study was academic engagement. Academic engagement is a term often used to describe active involvement, commitment, and attention as opposed to apathy and lack of interest. [10] Researchers of academic engagement identify certain indicators of engagement. For example, Singh, Granville and Dika[11] consider doing homework, coming prepared for classes, regular attendance, not skipping classes as a reflection of student engagement. In addition, Klem and Connell[12] 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.

Self-regulated learning literature identifies key indicators of self-regulated learning strategies. These are organization, concentrating, participating, 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 such as sports, parties, and social life in general. These extracurricular (social) 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. [13]

Four items in the instrument assessed classroom engagement. These items dealt with doing homework, assignment completion prior to class, studying, and taking notes in class. Self-regulated learning was assessed with self-regulated learning subscale from Bandura's Multidimensional Scales of Perceived Self-Efficacy developed in 1989. [13] This scale was designed to measure student's perceived capability to use various self-regulated strategies. The subscale has 11 items. Each item is rated along a 7-point Likert type scale. For example, "How well can you complete your homework assignments by posted deadlines?" Choices are "1" = "not well at all" to "7" = "very well" (see Appendix A).

Studies that have used this scale have reported on the internal consistency reliability of the subscale. For example, Miller [14] reported alpha coefficient estimates of .90 with a sample of junior high students. In addition, Williams and Hellman [15] reported an alpha coefficient of .79 while assessing the self-regulated learning strategies of a sample of college students in an online class. In the current study, coefficient alpha for self-regulated learning scale was .74, suggesting a reasonable level of reliability.

Classroom engagement was assessed using 11 likert type scale items. These items were developed from literature on classroom engagement (see the items on Appendix A). A sum total of each of the subscale provided a measure of self-regulated learning and classroom engagement respectively. Higher score in each of the subscale indicated a higher level of self-regulated learning and classroom engagement. The dependent variable was end of semester calculus grade

Results

SPSS version12 for windows was used to analyze the data in this study. Descriptive statistics indicate that the mean calculus grade at the end of the course was a high C, whereas the mean scores on the class engagement and self-regulated was at the above average (see Table 1).

Table 1: Descriptive statistics for variables: Total number, mean, standard deviation, minimum Maximum values, and range of possible scores

Variable	N	Mean	SD	Min-Max	Range
Calculus	243	3.5	1.4	1 - 5	1-5
Class engagement	275	40.9	9.3	17 - 64	11 - 77
Self-regulated learning	293	56	8.2	29 - 72	11 - 77

Regression analysis was conducted to assess the two variables; self-regulated learning and class engagement. The two variables accounted for a small percentage of calculus variance (1.1%), ($F(2, 223) = 1.217$; $p = .2$).

The regression analysis results prompted further investigations on the data. A comparison between passing and failing students was done by examining distribution of self-regulated learning variable with calculus grades (see Figure 1).

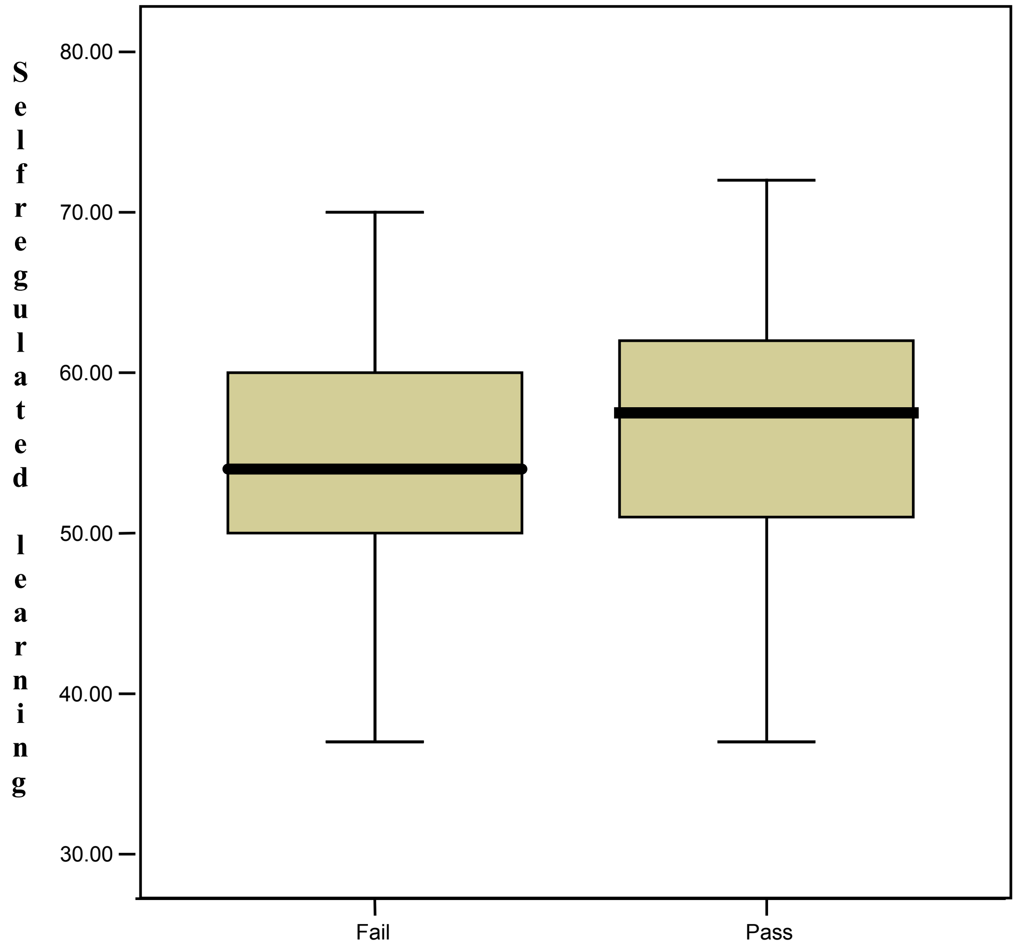

Figure 1. Distribution of Self-regulated by calculus

The box plots in figure 1 show that students who passed calculus course (i.e. "C", "B", "A" grades) had a higher median score on self-regulated learning compared to the ones who failed the course (i.e., "D", "F" grades). In addition, 50% of passing students' self-regulated learning scores span from 52 to 62 while the failing students' span from 50 – 60. (see Figure 1).

Similarly, classroom engagement distribution across grades was examined (see Figure 2). The distribution indicates that median of passing students was less than the failing students. However, the lower inter-quartile range for passing students is higher than the failing students. The 50% of passing students distribution is smaller compared to the failing students' distribution.

Independent t – test was performed on the data to find out if there were any differences between the two groups of students in their class engagement activities as well as their self-regulated learning. The results are shown in table 2.

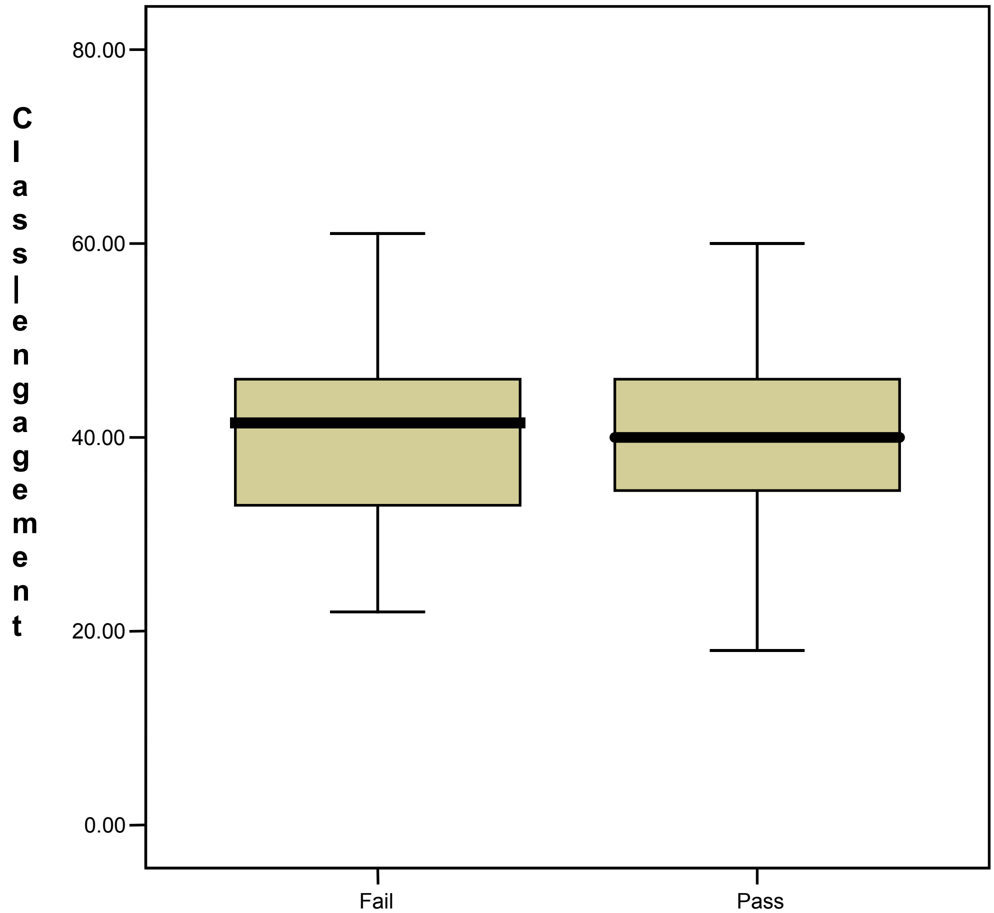

Figure 2. Distribution of classroom engagement by calculus

Table 2: Means and Standard deviations of class engagement and self-regulated learning of passing and failing students

Variable		N	Mean	Standard Deviation
Class engagement	Fail	172	43	8.6
	Pass	103	40	9.5
Self-regulated learning	Pass	182	56	8.0
	Fail	111	55	8.5

Statistical significance differences was found between the passing and failing students on class engagement (t= 2.7, d.f. = 273, p-value = .00). Failing students had a mean of 43 on class engagement score whereas passing students had a mean of 40. However, on self-regulated learning there were no statistical differences between passing and failing students.

Discussion and Implications for students advising

This study provides a foundation to evaluating further non academic factors influencing engineering students succeeding in the entry level calculus course. The self-regulated learning scale used in this scale assessed student's ability to set goals, stay on task in the midst of distractions, planning and organization, as well as executing the plan. Despite the non significant difference in self-regulated learning between passing and failing students on the entry level calculus course among freshmen engineering students in this study, the distribution (see figure 1) highlight interesting pattern on self-regulation behaviors between the two groups. Passing students' distribution is positively skewed with a higher median suggesting that students with high self-regulated learning scores are likely to pass.

This study suggests that students need to develop goals that are realistic as well as relevant to their academic work. Both faculty and student advisors can help students develop goals. Specific tasks related to success may be discussed in the class or in advising sessions. These may include setting goals on how to successfully do assignments, study a section, and even studying for a test.

Class room engagement on the other hand had interesting results. The distribution (see Figure 2) of classroom engagement behavior indicated that students who had failed the course had relatively higher scores on this variable than the passing students. In addition, the distribution was positively skewed indicating that majority of failing students portrayed a higher classroom engagement behaviors than passing students. This finding is contrary to extant research in this area.[17,18,19]

There are several possible explanations to these findings. One possibility could be failing students engage may have conceptual difficulties that impede their understanding of the subject matter. As such, they work hard at doing all that they can to understand the material by doing their assignments, studying, attending class, etc. These classroom engagement behaviors incidentally do not influence their performance.

Another possible explanation could be that failing students have high classroom engagement scores, do not necessarily retain what they study. Hence when tested, they are unable to recall what they learned. A third possibility could be failing students may perceive themselves as highly engaged contrary to reality. They may have assessed themselves relatively higher while in reality they may be practicing lower classroom engagement behavior.

In conclusion, this study suggests a need for more research on non-cognitive variables on how they influence performance among engineering students. Specifically, investigations should focus on variables associated with success in the entry level courses. By exploring these factors, administrators, faculty, students' advisors and students may be informed to take necessary actions before it is too late. Consequently, retention rates may be improved. This study shows some distributional differences between failing and passing students in a calculus course on self-regulated learning and classroom engagement behaviors. A qualitative study of the two groups would be an appropriate approach to investigate further what the students actually practice as they take the course.

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Appendix A

Multidimensional Scales of Perceived Self-Efficacy

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

Classroom engagement Items

The next set of questions focus on your MATH 2144 “CALCULUS I” experience at the University. Chose the response that BEST describes your situation.

1. 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)

2. 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)

3. 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%)

4. 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)

5. 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)

6. 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)

7. 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)

8. 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.)

9. 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)

10. 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)

11. 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)

12. 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)