

**A Comparative Analysis of Mathematics Self-Efficacy of Developmental and
Non-Developmental Freshman Mathematics Students**

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Students' ability to learn mathematics has been the concern of researchers for many years. Previous mathematics achievement has dominated the research landscape concerning student success in mathematics. Not until recently has there been a great deal of discussion about students and their belief system concerning mathematics.

Researchers (Campbell & Hackett, 1986; Hackett, Betz, O'Halloran, & Romac, 1990) have determined that previous mathematics performance and perceived ability are both key elements for success in mathematics.

Perception of ability to perform tasks and accomplish goals is defined by Bandura (1997) as perceived self-efficacy. Bandura asserts that this personal belief influences action, effort, perseverance, resilience to adversity, and realization of goals. Therefore, the beliefs associated with individual capability often determine outcomes before any action occurs. In addition, Bandura suggests that a triadic reciprocal relationship between the environment, interpersonal factors, and behaviors influence human functioning. With an understanding of how beliefs might affect outcomes, individuals can increase perceived self-efficacy and thus increase the likelihood of success in achieving desired goals.

There are four principal sources of self-efficacy information defined by Bandura (1997): performance accomplishments, verbal persuasion, emotional arousal, and vicarious experiences. Each of these contributes to perceived ability to accomplish a goal or task such as successfully completing a mathematics class. Bong (1999) finds when students are enrolled in advanced mathematics classes in high school, their judgments about

perceived mathematics ability based upon performance accomplishments are more accurate than those of students who have not had the exposure to higher level classes. Betz and Hackett (1983) also find certain groups of students, such as females, have lower self-efficacy ratings in mathematics mostly due to a lack of exposure to such advanced classes.

Research by Pajares and Miller (1997), Betz and Hackett (1983), and Campbell and Hackett (1986) concerning self-efficacy and gender roles in mathematics indicates that there is little information addressing why gender differences occur in mathematics self-efficacy. Therefore, the relationship between gender and mathematics self-efficacy merits further investigation.

Stemming from the United States Supreme Court case, United States v. Fordice (1992), the board of the Institutions of Higher Learning for the State of Mississippi mandates that all public institutions in the state of Mississippi have similar admission policies and offer similar developmental learning programs in the areas of English, reading, and mathematics. In the area of mathematics, each of the eight public institutions of higher learning offers Intermediate Algebra, a non-credit course designed to enhance student understanding of basic algebraic concepts. Admission to such a course is based on the student's ACT score. All entering freshmen with an ACT Mathematics subtest score of 16 or less are required to take Intermediate Algebra during the first semester of enrollment, while those scoring between 17 and 19 are strongly encouraged to take Intermediate Algebra.

Because of the mandatory enrollment associated with developmental classes, previous research (Bassarar, 1986; Higbee & Thomas, 1999) indicates that there is a

stigma associated with being labeled as a member of a remedial math class. The embarrassment of enrollment in remedial mathematics is especially damaging to females and minorities (Green, 1990) and their perception of mathematics (Glennon & Callahan, 1968). Research by Betz and Hackett (1983) suggests that educators need to gain a complete understanding of how females are affected academically because many career decisions are based on the perception of ability to excel in a given field.

The purpose of this study was to examine the relationship between mathematics self-efficacy and class level (i.e., Intermediate Algebra versus Calculus I) in freshman college students. As previously indicated, Bong (1999) suggests that high school student perceptions of mathematical ability are more accurate when the student has been exposed to higher-level math classes. This study focuses on college mathematics students and class level because there is no previously established relationship. The classes chosen for this study are Calculus I and Intermediate Algebra, each of which is offered at every college in the State of Mississippi. Additionally, as Casazza (1999) notes, since nearly 80% of all institutions of higher learning offer some type of developmental classes, this study could serve as a future guide to institutions nationwide by identifying a large group of students with a low level of self-efficacy thus suggesting the implementation of new methods of instruction to increase self-efficacious behavior in all students.

Research Design

This study used a comparative design to examine the differences in mathematics self-efficacy of freshman Developmental Mathematics students and freshman Calculus I students enrolled at the University of Mississippi in the fall of 2001, as measured by the subjects' responses to the 34-item Mathematics Self-Efficacy Scale.

Subjects

The subjects in this study included both male and female freshman students who were enrolled in one of two freshman level math classes (Developmental Mathematics ($N = 375$) and Calculus I ($N = 400$)) at the University of Mississippi for the fall 2001 semester. Placement of students into classes is based on ACT math sub scores. Math 261 is Calculus I designed for engineering, physical science, and mathematics majors and DS 99 is Intermediate Algebra. Classes chosen to participate in the study were clusters randomly selected from the total number of classes offered.

The total sample size of 185 was chosen based on the power of the analysis performed. Gall, Borg, and Gall (1996) suggest that the minimal sample size needed to detect a medium to large difference between the groups at the $\alpha = .05$ level with a statistical power of .7 is 100 participants from the group.

The measures used in the study were administered in the class at the beginning of the semester. Only data from students who completed the instrument were included in the study. Upper class students were not included in the survey because the purpose of the study was to measure self-efficacy in freshman students. Also, no class credit was given for participation in the study. Students could choose whether or not to participate with no detriment to their grade.

Instrument

Consisting of three subscales and a total of 52 items, the Mathematics Self-Efficacy Scale (MSES) was developed by Betz and Hackett in 1983. The Mathematics

Tasks subscale contained 18 items based on the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972). The purpose of the Mathematics Tasks subscale was to measure student confidence in the ability to perform everyday math tasks. A 16-item subscale titled Mathematics Courses was used to assess student confidence to persist in math-related courses with a B or better. Finally, the Mathematics Problems subscale, consisting of 18 items, based on the Mathematics Confidence Scale (Dowling, 1978), was used to assess student confidence in their ability to solve math problems. Betz and Hackett reported reliability coefficient alphas of .96 on the total scale, .92 for the Tasks subscale, .96 for the problems subscale, and .92 for the courses subscale.

Procedure

This study was conducted in accordance to the University of Mississippi Institutional Review Board's principles for research on human subjects. Therefore, harmful situations were not present for the participants.

Students in the courses selected for study were approached during the third week of class and asked to participate in the study of perceived mathematical ability and performance. A brief description of self-efficacy, the study, and a pledge to confidentiality was given to the students, and the students who were interested in participating in the study were asked to read and sign a consent form and complete the questionnaire. Students were also informed that failure to participate in the study would have no effect on their grade or standing in the class.

The questionnaire administered to the students consisted of three sections. Contained in the first section is a set of questions concerning demographics and general information about the student. The second and third sections of the questionnaire

consisted of the Math Tasks and Math Courses subscales of the MSES (Betz & Hackett, 1993).

Data Analysis

The research question is designed to identify differences in the level of mathematics self-efficacy and class level. Betz and Hackett (1993) suggest using total scores on the MSES to analyze math self-efficacy. Mathematics self-efficacy was the dependent variable while class enrollment was the independent variable.

Since it was assumed from similar research (Betz & Hackett, 1983; Lent, Brown, & Gore, 1997; Lent, Lopez, Brown, & Gore, 1996) that differences would be present between groups such as females and males, minorities and non-minorities, the research question was analyzed using one-tailed t-tests to evaluate differences in the means between class levels. The Statistical Package for Social Sciences (SPSS for Windows) will be used in the analysis of the data.

Results

The data collected from freshman students enrolled in Calculus I and Developmental Mathematics at the University of Mississippi and the results of the statistical analyses used to interpret the data are presented in this chapter. Descriptive data about the subjects are presented followed by the results of a t-test for independent means. Since the risk of harm to the participants associated with committing a Type I error are minimal, all tests conducted in this study were done at the $\alpha = .05$ level of significance.

Descriptive Analysis of Sample

A total of 185 freshman students from four Calculus I courses and four Developmental Mathematics courses were included in the final sample. Eighty were enrolled in Calculus I, while 105 were enrolled in Developmental Mathematics. Eighty-five of the students were male, while 100 of the students were female. A total of 125 of the students were white/Caucasian. A total of 50 of the students were African-American. Only 10 students reported ethnic/racial backgrounds (i.e., American Indian, Asian American, Mexican, Puerto Rican, or Other) that for the purposes of the present analysis will be grouped as "Other." The mean age of participants was 18.75 years ($SD = 3.57$ years). Eight were 17 year olds, 129 were 18 year olds, 34 were 19 year olds, 14 were 20 year olds and older. The mean ACT/SAT math subscore for Developmental Mathematics students was 16.25 ($SD = 1.69$). The mean ACT/SAT math subscore for Calculus I students was 26.31 ($SD = 4.12$). Fifty students attended private high schools, while 125 attended public high schools. Seventy-five percent of the participants listed Calculus as the highest math offered at their high school.

Within the courses, a total of 80 students were enrolled in Calculus I. The number of males and females was similar where 43 respondents were male while 37 were female. Sixteen of the students in Calculus I were African-American, 57 were white/Caucasian, and 7 were of Other ethnicity.

There were a total of 105 students enrolled in Developmental Mathematics. Contrary to the Calculus I class, more females than males were enrolled in the Developmental Mathematics courses. There were 42 males and 63 females surveyed from the Developmental Mathematics course. As for ethnicity, the Developmental Mathematics course consisted of 42 African-American respondents, 68 white/Caucasian,

and 3 of Other ethnicity. The percentage of African-American respondents in the Developmental Mathematics courses exceeded the Calculus I percentage. In addition, 31.4% of the Developmental Mathematics respondents were over 18 years of age as compared to 18.8% of the Calculus I respondents.

T-Test Results

An independent t-test was conducted to determine if there was a difference between the two courses in mean Mathematics Self-Efficacy Scale (MSES) score. The score for each participant was found by computing the mean of the 34 items on the MSES. The mean MSES score for the Developmental students was 5.33 ($SD = 1.4464$) while the mean for the Calculus students was 7.08 ($SD = 1.1411$). The results of the t-test ($t = 8.902, p < .001$) suggest that the means are not equal. Thus, there is a statistically significant difference between the level of mathematics self-efficacy between freshman students enrolled in Calculus I and Developmental Mathematics, where the Calculus I students exhibited a higher self-efficacy than the Developmental Mathematics students. In addition, the results of the Mann-Whitney U-Test ($z = 8.003, p < .001$) further substantiate the results of the t-test.

Discussion and Recommendations

By definition, self-efficacy is the perception of individual ability to perform and complete tasks. Therefore, self-efficacy information helps individuals determine how much effort they should expend in order to complete a task. Bandura (1997) suggests that individuals attribute their self-efficacy to past experiences and how those experiences relate to them personally. Self-reflection of exposure to, or lack of exposure to, mathematics classes is therefore the primary source of mathematics self-efficacy.

Bandura notes that if individuals have no basis of the knowledge required to properly assess their ability, then their assessment will in the end be flawed. In essence, it is difficult for students to objectively evaluate themselves on topics for which they have little knowledge. Therefore, exposures to mathematics with positive outcomes increases mathematics self-efficacy while exposure to mathematics with negative outcomes decreases mathematics self-efficacy, provided the positive outcomes are attributed to increases in personal capability.

Most educators would agree that a given amount of mathematical knowledge is necessary for all college graduates. Although not all students need to learn Calculus, all students do need a comfortable level of mathematical ability that does not limit their choices of college majors. Thus, the role of educators should be to do whatever is necessary to aid students in increasing their perception of actual ability. In classes such as Developmental Mathematics, raising the mathematics self-efficacy of all students to a level where students' choices of majors are not limited should therefore be a primary concern of educators.

Past experiences, often times failures, in mathematics usually dictate student opinions concerning their perception of their ability in mathematics as well as their optimism about career choices where mathematics is a basis of the curriculum. Therefore, without confidence in mathematical ability, students' choices of majors, and ultimately their futures, are limited to areas where mathematics is rarely used. Though some students would naturally choose to major in such an area, the point is to give students choices and not limitations. Hence, institutions of higher learning and educators themselves should implement modes of instruction that develop and enhance self-efficacy

in groups of students with lagging self-concepts of mathematical ability. Doing so would allow students to more adequately understand their actual ability thereby helping students to make better choices concerning college majors and their ultimate future.

Because self-efficacy has been shown to be a mediating influence on motivation and performance (Bandura, 1997; Ponton, Horine-Edmister, Ukeiley, & Seiner, 2001), enhancing mathematics self-efficacy should be the beginning of any effort to aid in the academic growth of students enrolled in lower level classes of mathematics. Enhancing self-efficacy can be accomplished by providing positive experiences for students.

Unfortunately, there are no easy solutions to the complex problems that confront students with low levels of mathematics self-efficacy. However, continual attempts should be made at enhancing the learning experience for students that have been shown to have low levels of self-efficacy thereby enabling individuals to master the important concepts of mathematics while enabling them to become lifelong, self-regulated learners.

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