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Attitudes toward Mathematics and Mathematics Self-Efficacy on a Learning Community Model: A Case Study[1]

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This study investigates the change in two theoretical constructs, attitudes toward mathematics and mathematics self-efficacy, among college students involved in a learning community model. The case of this study was a developmental mathematics class offered at a historically black college located in the southeastern United States. Subjects included 31 students enrolled in an introductory mathematics course, some of whom participated in a learning community (treatment group). The participants completed mathematics attitudes and mathematics efficacy instruments twice: at the beginning of the semester and again at the end. Data was analyzed using descriptive statistics and a non-parametric statistic. The results showed that students' attitudes toward mathematics and mathematics self-efficacy are strongly correlated; the mathematical problem-solving efficacy changed significantly over time and it is significantly higher in the treatment group than in the control group; and the treatment group produced better outcomes. These findings indicate that a learning community model can increase students' mathematics self-efficacy beliefs. It is recommended that mathematics self-efficacy and attitudes toward mathematics be measured over an extended period of time when a learning community is implemented.

Keywords: attitudes toward mathematics, mathematics self-efficacy, learning community
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INTRODUCTION

In recent decades, the number of students entering colleges with limited academic skills has gradually increased. Some of them have no more than 6th grade level skills in reading, writing, and mathematics (Tinto, 1998). These so called developmental students have difficulty passing basic courses needed to go forward in their study areas, and consequently, they are not successful in college, often don't return in the second year, and must give up the dream of a college education. Historically black colleges and universities (HBCU), especially those that are small and located in rural areas, have seen a significant increase in freshmen who are considered developmental students. Such colleges and universities have stake in helping developmental students be successful in their first year so they are more likely to obtain an undergraduate degree and the institutions maintain a reasonable retention rate. One such effort, a learning community model, can be implemented in developmental courses, with the assumption that a learning community model would have a positive influence on students' attitudes and self-efficacy, as well as outcomes, and this study addresses this assumption in a developmental mathematics class.

Attitudes toward mathematics and mathematics self-efficacy have been studied as variables to students' success in learning mathematics. For example, attitudes toward mathematics have an influence on a student's mathematics performance (Ma & Xu, 2004), and students' self-efficacy beliefs influence academic motivation and are powerful predictors of academic outcomes (Pajares & Miller, 1997). The main purpose of this study is to investigate a change in the attitudes and self-efficacy of African-American students in learning developmental mathematics, and to establish a positive relationship between the two constructs.

REVIEW OF LITERATURE

Learning Communities

Since Tinto (1987) introduced a learning community where co-registration or block scheduling of students that enables them to take courses together and form study teams, it has been considered an innovative model to improve the academic performance of developmental students. He asserted that students' behavior could not be understood outside the social and cultural context in which they experience postsecondary education. So, how do colleges and universities increase students' sense of social and intellectual integration with the institution? Price (2005) reported that the learning community model of academic and social interaction represents an ideal structure to increase students' connection with the college in general and with the learning process specifically. In this sense, Gabelnick, MacGregor, Matthews & Smith (1990), expanding Tinto's discussion, newly defined a learning community as "one of a variety of curricular structures that link together several existing courses so that students have opportunities for deeper understanding and integration of the material they are learning, and more interaction with one another and their teachers as fellow participants in the learning enterprise (p. 19)."

Contemporarily, the learning community model is exemplified by a theoretical framework for the developmental program on student retention. For example, Lenning & Ebbers (1999) call for the higher education community to intentionally develop learning communities that promote and maximize student learning; and Price (2005) suggests that a learning community increases student retention and success and provides students with the support, skills, and knowledge needed to be successful at the post-secondary level. It has been reported that the causality is found between learning communities and a range of student educational outcomes, such as credit accumulation, GPA, course passing rate, and term-to-term retention (Lenning & Ebbers, 1999; Price, 2005).

Mathematics Self-Efficacy

Self-efficacy, defined as the belief in one's capability to organize and execute the sources of action required managing prospective situations, is a powerful psychological construct by which that how an individual behaves can be better predicted by self-efficacy beliefs rather than by what they are actually capable of accomplishing (Bandura, 1977, 1986, 1997). Human behavior is motivated by anticipatory thought processes in which the capability of forethought is used to cognize desirable future states and select courses of action that are regarded as paths to these states, which is a process that is mediated by capability perceptions perhaps without the presence of actual capability (Bandura, 1997; Zimmerman, 1990). That is, regardless of one's actual skills to perform a task, motivation with self-efficacy can serve as a mechanism through which students overcome finite ability and successfully achieve the desired goals (Bandura, 1997; Zimmerman, Bandura, Martinez-Pons, 1992; Zimmerman, 1990). Thus, self-efficacy influences academic motivation and is a powerful predictor of academic behavior and performance.

However, the specificity has been a major issue in the study of self-efficacy. Researchers have been found that self-efficacy is task-specific, and situation-specific (Bandura, 1977, 1986); and domain-specific rather than a general expectancy (Pajares, 1996; Schunk & Pajares, 2001). It is in this sense that a particularized self-efficacy has been studied in the academic context of, for example, mathematics, which is defined as "a situational assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular mathematical task or problem" (Hackett & Betz, 1989; Kranzler & Pajares, 1997). Studies have revealed that a student's mathematic self-efficacy is a great factor to predicting his or her mathematical performances and outcomes. For example, mathematics self-efficacy of college students is more predictive of their mathematics interests and choice of mathematics-related courses and majors than either their prior mathematics achievement or mathematics outcomes (Pajares & Miller, 1994); self-efficacy is strongly related to mathematics problem solving (Pajares & Kranzler, 1995); self-efficacy held greater predictive power of problem solving success than did mathematics self-concept, background in mathematics, perceived usefulness of mathematics, and gender (Pajares, 1996); and conclusively, students' self-efficacy beliefs influence academic motivation and are powerful predictors of academic outcomes in mathematics (Pajares & Miller, 1997).

Attitudes toward Mathematics

Attitudes toward mathematics are defined as a general emotional disposition toward the subject of mathematics (Haladyna, Shaughnessy & Shaughnessy, 1983). Research has shown that attitudes have an influence on a student's mathematics performance. For example, Ma & Xu (2004) found a moderate causal relationship between attitude toward mathematics and achievement among high school students, and argued that students must have a positive attitude toward mathematics in order to succeed in a mathematics course. This understanding can be extrapolated to college freshmen, including developmental students, in mathematics courses, since freshmen are generally only one year out of a high school. In addition, developmental mathematics is a recap of high school mathematics courses. In addition, Tapia & Marsh (2004) mentioned that regardless of the teaching method used, students are likely to exert effort according to the effects they anticipate, which is regulated by personal beliefs about their abilities, the importance they attach to mathematics, enjoyment of the subject matter, and the motivation to succeed. That is, students' attitudes toward mathematics can influence their learning outcome regardless of a teacher's instruction.

Mathematics anxiety relates inversely to positive attitudes toward mathematics and contributes to a direct avoidance of the subject. Studies have examined the negative effect of mathematics anxiety on mathematics achievement outcomes and cognitive factors like self-efficacy. For example, mathematics anxiety has been linked to poor performance on mathematics achievement tests (Hembree, 1990); mathematics self-efficacy has shown a direct effect on mathematics anxiety (Hackett, 1985); mathematics self-efficacy has demonstrated a significant negative relationship with mathematics anxiety (Cooper &

Robinson, 1991); and students' self-efficacy beliefs about their mathematics capabilities have had strong direct effects ($\beta = 0.394$) on mathematics anxiety even when general mental ability is controlled (Pajares & Kranzler, 1995). From this view of literature, it is hypothesized that mathematics self-efficacy is positively related to attitudes toward mathematics. This hypothesis will be tested later in this paper.

METHODS

Instruments

Two instruments were used in this study: the Attitudes toward Mathematics Inventory (ATMI), and the Mathematics Self-Efficacy Scale (MSES). The ATMI was used to measure students' attitudes toward mathematics. It was developed for high school students (Tapia & Marsh, 2004), and later verified for college students (Tapia & Marsh, 2005). The ATMI includes 40 items, which use a 5-point Likert scale format with the anchors of

(1) strongly disagree,
(2) disagree, (3) neutral,
(4) agree, and
(5) strongly agree.

Eleven items are reversely worded. Scores range from 40 to 200, with the higher score correlating with a higher level of positive attitudes toward mathematics. The AMTI had a Cronbach alpha reliability coefficient of 0.97 (Tapia & Marsh, 2004) and a test-retest reliability coefficient of 0.89 over a 4-month period (Tapia & Marsh, 2005). Construct validity was established based on the factor analysis which resulted in the best fit simple structure of four factors: confidence, value, motivation, and enjoyment (Tapia & Marsh, 2004). These factors are exemplified as follows:

- Confidence: Mathematics makes me feel uncomfortable.
- Value: Mathematics is a very worthwhile and necessary subject.
- Motivation: I am willing to take more than the required amount of mathematics.
- Enjoyment: I get a great deal of satisfaction out of solving a mathematics problem.

The Mathematics Self-Efficacy Scale has been widely used to measure students' mathematics self-efficacy. The MSES was developed from the reinforcement of mathematics self-efficacy (Belz & Hackett, 1983), and it has been revised twice (Pajares & Miller, 1995;, 1997). The latest revision of the MSES consists of three subscales of the problem-solving (or problem), the task, and the course, but this study only analyzes only the problem-solving and the task subscales. The 18 problem-solving items address how confident students are when they solve mathematics problems, and the 18 task items test how confident they are in their ability to perform the particular mathematical tasks. An example item of each subscale follows:

- Problem item: The second is twice the first and the first is one-third of the other number. Their sum is 48. Find the largest number.
- Task item: Determine the amount of sales tax on a clothing purchase.

The MSES uses a five-point Likert rating scale with responses from not confident at all to completely confident. Possible scores on the problem-solving and task subscales range from 18 to 90. An exploratory factor analysis indicated that the three subscales are independent, supporting the construct validity of MSES, and the internal consistency reliability Cronbach alpha coefficients for the problem and task subscales (n = 522) were 0.95 and 0.94, respectively (Pajares & Miller, 1997). In this study, the Cronbach alpha of the problem subscale was 0.95 in Week 3 and 0.93 in Week 16, and the Cronbach alpha of the task subscale was 0.93 in Week 3 and 0.94 in Week 16.

Settings and Participants

Data was collected from a small, rural historically black college in the southeastern United States. The student population of the college was approximately 400 for the 2007 academic year. The major portion of freshmen consisted of developmental students. The mathematics placement test at the beginning of the 2007 fall semester indicated that 70% of incoming freshmen needed to take a developmental mathematics course. The college is a member of a learning community project in science, technology, engineering, and mathematics with several other HBCUs. A learning community model was implemented for students majoring biology who co-registered in three developmental courses in biology, English, and mathematics. This study looked at a single class of 38 students in the developmental mathematics course, Introduction to Mathematics. Only 31 students voluntarily participated in the study. In the class, there were two groups: the treatment group consisted of 19 biology majors participating in a learning community (LC) and the control group of 12 traditionally scheduled students. Ages varied from 18 to 52, with an average of 20.26; most of the students were first year freshmen.

Procedure

Data was collected from the class twice a semester: once at the beginning, in Week 3, and again at the end, in Week 16 of the 2007 spring semester. The survey given to participants consisted of the student demographic questionnaire, the ATMI, and the

MSES. The student demographic questionnaire contains questions pertaining to gender, age, classification, education, and the participation in a learning community. Participants had to complete the survey in 45 minutes. The order of the instruments in the survey was arbitrary. Some students completed the MSES first, and others completed the ATMI first. To keep students' identities confidential, their names or identification codes were not asked.

RESULTS

The descriptive statistics (Table 1) showed that the mean scores for attitudes over a single semester were not different, while the mean score of self-efficacy for the treatment group changed from 127.58 to 138.79. The difference between the treatment group and the control group in Week 3 was not significant in each scale or subscale, whereas that in Week 16, differences were significant. It was deemed necessary to test if these differences are meaningful.

Table 1. Descriptive Statistics

When	LC		N	Minimum	Maximum	Mean	Std. Dev.
Week 3	Treatment	Attitudes	19	79	180	135.26	26.185
		Efficacy	19	72	159	127.58	25.231
		Problem	19	36	78	62.53	12.043
		Task	19	36	84	65.05	13.542
	Control	Attitudes	12	95	182	132.42	25.685
		Efficacy	12	62	157	122.83	31.325
		Problem	12	26	82	59.67	17.768
		Task	12	36	80	63.17	13.947
Week 16	Treatment	Attitudes	19	82	193	142.00	33.558
		Efficacy	19	101	170	138.79	20.970
		Problem	19	50	86	69.84	10.710
		Task	19	51	85	68.95	10.559
	Control	Attitudes	12	72	179	129.17	30.355
		Efficacy	12	76	161	124.00	23.958
		Problem	12	39	80	62.17	11.606
		Task	12	37	81	61.83	12.605

Since the small sample size ($N = 31$) in this study does not guarantee the existence of a parameter, non-parametric statistics was used to analyze the data. The result of Mann-

Whitney U test (Table 2) shows that the p-value is less than the significance level alpha = 0.1 only for the problem subscale.

Table 2. Non-Parametric Statistics

a. Between the groups

When		Attitudes	Efficacy	Problem	Task
Week 3	Mann-Whitney U	105.500	105.000	106.000	103.000
	Wilcoxon W	183.500	183.000	184.000	181.000
	Z	-0.345	-0.365	-0.325	-0.447
	Asymp. Sig. (2-tailed)	0.730	0.715	0.745	0.655
	Exact Sig. [2*(1-tailed Sig.)]	0.734	0.734	0.765	0.675
Week 16	Mann-Whitney U	90.000	75.500	71.500	77.500
	Wilcoxon W	168.000	153.500	149.500	155.500
	Z	-0.974	-1.562	-1.725	-1.482
	Asymp. Sig. (2-tailed)	0.330	0.118	0.084	0.138
	Exact Sig. [2*(1-tailed Sig.)]	0.346	0.120	0.085	0.141

b. Between the time

LC		Attitudes	Efficacy	Problem	Task
Treatment	Mann-Whitney U	161.000	137.000	124.000	154.000
	Wilcoxon W	351.000	327.000	314.000	344.000
	Z	-0.569	-1.270	-1.652	-0.774
	Asymp. Sig. (2-tailed)	0.569	0.204	0.098	0.439
	Exact Sig. [2*(1-tailed Sig.)]	0.583	0.212	0.103	0.452
Control	Mann-Whitney U	71.500	71.000	68.500	65.500
	Wilcoxon W	149.500	149.000	146.500	143.500
	Z	-.029	-0.058	-0.202	-0.376
	Asymp. Sig. (2-tailed)	0.977	0.954	0.840	0.707
	Exact Sig. [2*(1-tailed Sig.)]	0.977	0.977	0.843	0.713

Additionally, correlation analysis was conducted among the scales over a single cell of N = 31. See Table 3. The Pearson coefficients between the ATMI and the MSES are 0.75 at Week 3, and 0.85 at Week 16. The coefficients of the ATMI for the problem and task subscales are, respectively, 0.77 and 0.72 at Week 3, and 0.85 and 0.83 at Week 16. The coefficients among the MTES and its two subscales are over 0.98 at both Week 3 and Week 16. These coefficients in the table are significant at the alpha level 0.01.

Table 3. Correlation Analysis

When		Attitudes	Efficacy	Problem	Task
Week 3	Attitudes	1	0.754	0.765	0.716
	Efficacy		1	0.984	0.982
	Problem			1	0.932
	Task				1
Week 16	Attitudes	1	0.847	0.847	0.827
	Efficacy		1	0.988	0.989
	Problem			1	0.954
	Task				1

Finally, the participants' course grades were examined. In Table 4, the numbers of students obtaining grades of A, B, C, or D in the class were 3, 5, 3, and 7, respectively, out of 31. The number of students obtaining each grade in the treatment group was 2, 4, 2, and 4, respectively, out of 19. The numbers in the control group was respectively, 1, 1, 1, and 3 out of 12.

Table 4. Students' Outcome

LC	Grade					Total
	A	B	C	D	F	
Treatment	2	4	2	4	7	19
Control	1	1	1	3	6	12
Total	3	5	3	7	13	31

DISCUSSION

Significance Level Alpha = 0.1

Efficacy beliefs are more malleable than other constructs such as self-confidences, self-esteem, and attitudes (Bandura, 1986; Tschannen-Moran & Hoy, 1998). Even though this study was conducted to determine the change of students' attitudes and self-efficacy in learning mathematics, it focuses on the change of the self-efficacy construct over a relatively short period of a single semester. The results indicate that the increase of developmental students' mathematics self-efficacy over a single semester is not significant at the alpha level 0.05. However, changes in the scores of the problem subscale for the LC-treatment group was significant ($p < 0.098$) at the alpha level 0.1. Empirically, the period of one semester is not long enough to implement a learning community model so it is perhaps not reasonable to expect a significant change in students' outcomes. Use of at least 2 years was suggested in implementing a learning community model. In fact, Price (2005) stated that it is reasonable to use quantifiable outcomes for any learning community demonstration project and that these outcomes can be reliably measured over a 24-month period. Thus, in this study, the author decided that the use of the significance level at alpha = 0.1 is reasonable rather than at alpha = 0.05.

Non-Parametric Analysis

A parametric statistic was not secure enough to report the significance of the LC-treatment effect due to the small sample size ($N = 31$), in which a bell-shaped distribution of the data set is limited and thus the existence of parameter is doubted. In this case, we use a non-parametric statistic, Mann-Whitney U test, to analyze the data (see Table 2).

In the first table, the null hypothesis of the test is that the medians of the treatment group and the control group are the same. Using the significance level of alpha = 0.1, the null hypothesis is rejected if the p-value is less than 0.1. The fact that $p = 0.084 < 0.1$ for the problem-solving subscale gives enough evidence to say that there is a difference in the median grades of the LC-treatment group and the control group. In other words, students' participating in a learning community over even a single semester may experience an increase in self-efficacy in mathematical problem solving. The second Mann-Whitney U test was to check the significance of the changes in scales or subscales under the LC-treatment. In the table, only the problem subscale was significant ($p < 0.098$) with alpha = 0.1. These results support the theoretical arguments that self-efficacy is more malleable than attitudes. In fact, we observed that students' mathematical problem-solving efficacy was significantly changed in one semester of participating in a learning community.

Correlations among Scales

We hypothesized that self-efficacy and attitudes have a positive correlation, as both constructions are factors influencing students' mathematics learning. The current study verified this hypothesis. Pearson correlation analysis showed that the students' attitudes toward mathematics, mathematical problem-solving efficacy, and mathematical task efficacy are strongly positively correlated over the whole semester (Table 3). Especially, the attitude scale correlates to the self-efficacy scale and its two subscales with Pearson coefficients of 0.7s at Week 3, and 0.8s at Week 16. This result indicated that use of a learning community model may help attitudes and self-efficacy become more closely correlated.

Student Outcome

In order to investigate the effect of LC-treatment on students' mathematics learning outcome, each student's performance was graded, and the passing rate of each group was analyzed. Passing grades are A, B, C, and D. In Table 4, the passing rate of the treatment group at 12/19 = 63.2% was higher than that of the control group, which was 6/12 = 50%. In many institutions of higher learning, a grade of D in an introductory mathematics course is not considered a passing grade with students instead receiving a grade of No Credit (NC), to prevent lowering a student's GPA. If we adjust the passing grade to A, B, and C only, the adjusted passing rate of the treatment group is 8/19 = 42.1%, and that of the control group is 3/12 = 25%. Even though the grade of C is regarded as a passing grade, it is not considered a proficient level. Given that only a grade of A or B demonstrates proficiency, instead of using the passing rate, the proficiency rate of the treatment group is 6/19 = 31.6%, and that of the control group is 2/12 = 16.7%. The proficiency rate of the treatment group is nearly twice that of the control group.

Since the course of the developmental mathematics in this study is one of the most basic courses for the further study in each student's major area, it is desirable that the students would achieve a proficient grade. This result implies that students' participating in a learning community will help more students pass the courses as well as help students become more proficient in mathematics learning. Even though we did not make a direct connection between a theoretical constructs such as efficacy and students outcome, we see in this study that the students participating in a learning community gain more positive attitudes and efficacy beliefs. This learning community model, despite the short study time did make a meaningful change in the mathematical problem-solving efficacy, and led to an enhancement in mathematical outcomes.

CONCLUSION

In this study, we investigated the effectiveness of a learning community model on mathematics self-efficacy and attitudes toward mathematics in a college developmental mathematics course. Despite the limitations of the sample size and the period of time, the results of the study provided enough evidence that a learning community model can have a positive influence on students' mathematics self-efficacy and course outcomes. Since this study was conducted on one college developmental mathematics course at a historically black college, the result cannot be generalized to a larger population without more investigation. Nonetheless, it demonstrates the potential that a learning community model, if used in a proper form and for a longer period, can be a solution to the problem faced by many institutions of higher learning wherein a majority of students needs developmental education. A longitudinal study is expected to reveal causal relations between learning communities and student achievement, passing rate, and retention at the college level. It also is of interest to determine if different types of learning communities have different effects in students' academic performances, passing rates, and retention.

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