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The effects of a computerized-algebra program on mathematics achievement of college and university freshmen enrolled in a developmental mathematics course

We face a world in which a college degree increasingly dictates the likelihood of life success. At the same time, there has been an ever increasing population of students who have not been prepared adequately through their high school education to meet the rigors of college/university-level content. The present study investigated the effects of a web-based technology centric course, Assessment and Learning in Knowledge Spaces (ALEKS, 2001), on the remediation of college freshmen enrolled in an intermediate algebra class. Mathematics anxiety and attitudes toward mathematics were investigated to determine if ALEKS lowered mathematics anxiety, as well as improved attitudes. The findings of this research found that ALEKS Intermediate Algebra students performed as well as the control group taught by lecture. The anxiety of the experimental group decreased more than the control group, and the experimental group's attitude toward mathematics improved at a greater rate than the control group.

With the proliferation of developmental students, colleges and universities must seek effective teaching methods and programs so that underprepared students can gain the knowledge necessary to complete a rigorous post-secondary education. The present study was designed to explore the differences in mathematical achievement of underprepared college freshmen in an intermediate algebra course using different teaching approaches based on students' demographics, algebra tests, mathematics anxiety, and mathematics attitude.

Background

A major problem facing colleges and universities is the large percentage of entering freshman who are underprepared for college mathematics courses. Of the 67% of high school students who earn a traditional diploma, only 43% graduate high school with college-entry skills (McDade, 2000). In 2000, 76% of the colleges and universities that enrolled freshmen offered at least one remedial reading, writing, or mathematics course. Remedial classes are offered at 100% of community colleges, 80% of public four-year institutions, and 59% of private four-year institutions (National Center for Education Statistics [NCES], 2003).

Nationally, one third of incoming freshmen had to take at least one remedial class in reading, writing, or mathematics (National Commission on Excellence in Education, [NCEE], 1998; NCES, 1996). Because of past failures, students are afraid of mathematics and are convinced that success in a mathematics class is unattainable (Jones, Wilson, & Bhojwani, 1997; Paravate, Anjaneyulu, & Rajan, 1998; Strawser & Miller, 2001).

Developmental Education Students

For more than 45 years, the profile of the developmental student remained relatively unchanged with the majority White and from blue-collar families (Cross, 1971; Roueche & Roueche, 1993; Saxon & Boylan, 1999). Nationally, 67% of developmental students were White while 23% were African American, 6% were Hispanic, 3% were Asian, and 1% American Indian (Boylan, Bonham, & Bliss, 1994; Saxon & Boylan, 1999; Texas Higher Education Coordinating Board, 2005). The average age of community college developmental students was 23; 59% were younger than 24; 24% were between 24 and 34; and 17% were 35 and older (Boylan et al., 1994; Saxon & Boylan, 1999; Texas Higher Education Coordinating Board, 2005). Fifty-five percent of developmental students were female, and 45% were male. Most were unmarried, 22% to 28%, (Boylan et al., 1994; Saxon & Boylan, 1999) and first generation college students who viewed college as a way to a higher paying job and a better way of life (Cross, 1971; Roueche & Roueche, 1993).

Today's developmental student can be described with some of the same phrases: (a) They have little or no support from home, (b) are first-generation college students, (c) have experiences that include minimal academic college success, (d) have weak self-concepts, and (e) work at least 30 hours per week to support themselves (Roueche & Roueche, 1993). In a 1999 report, Saxon and Boylan indicated that 50% of developmental students reported they were financially independent with 54% of those students reporting having an annual income of $20,000 (Boylan et al., 1994; Saxon & Boylan, 1999).

Effective Instructional Strategies

If we are to succeed in educating the large number of entering college and university students who need remediation, effective instructional strategies must be addressed. Keup (1998) suggests that a strategic plan must be devised and implemented. This plan would interrupt the students' cycle of poor mathematics performance, thus resulting in students who would be prepared for rigorous college courses in an appropriate amount of time. Part of the problem is that anxiety is presumed to be a factor in students' inability to learn mathematics or their inability to pass mathematics tests and their perception of mathematical inadequacies (Jones et al., 1997; Robert, 2002; Scott, 2001; Steele & Arth, 1998). Findings by Goolsby, Dwindell, Higbee, and Bretscher (1988) indicated that students' confidence in their ability to learn mathematics is the only variable included that contributed to prediction of performance in a developmental mathematics course (Goolsby et al.). Similar results were found in subsequent research (Dwindell & Higbee, 1991; Thomas & Higbee, 1999). Students in developmental classes would benefit from a plan to increase confidence and lower anxiety levels associated with mathematics (Schwartz, 2000).

Purpose

The purpose of the present study was to look at differences in student achievement in a web-based, computer-assisted curriculum in remedial mathematics classes as compared to classes that use a traditional lecture method of instruction. The study examined the effects each treatment had on students' mathematics anxiety and mathematics attitude.

Research on the effects of computer-based instruction has been conducted in the past 10 years. An analysis of 123 colleges and universities that used computer-based instruction revealed that the use of a computer as a tutor designed to supplement regular instruction had the following positive effects: (a) Students learned more in less time, (b) had slightly higher grades on posttests, and (c) had improved attitudes toward learning (Kinney, Stottlemyer, Hatfield, & Robertson, 2004; Kulik & Kulik, 1986). Students also benefited from computer-mediated learning because all students met at the same time with the same instructor, which gave them a sense of community, and the students were more likely to meet the course objectives on schedule (Kinney & Robertson, 2003). Research conducted by D. P. Kinney & Kinney (2002) suggested that students should be advised in making informed decisions between computer-mediated or lecture classes and be allowed to enroll in the class the student believed was best. Allowing students to make their own decisions resulted in increased confidence and improved attitude toward mathematics. Kinney (2002b) found from focus group discussions that students often chose computer-mediated classes because of negative experiences in their high school lecture classes.

Mediated learning gives students control over their learning by allowing them to navigate through software at a pace and along a path that best meets their needs. Mediated learning offers students an alternative to the direct-instruction approach learned in traditional lecture classes (Lundell, Higbee, Chung, Ghere, & Kinney, 2001, p. 47).

Students who self-selected into computer-based courses reported that they felt they had more control over their learning since they chose what topics to study, they set their own pace, and they received more individual instruction than they did in a lecture-driven course (Kinney, 2001, 2002a).

This study focused on the following research questions:

1. Does a mastery learning perspective of remediation, where students are expected to learn all the objectives in an intermediate algebra class, make a difference in mathematics achievement?
2. What differences exist between students using Assessments and Learning in Knowledge Spaces (ALEKS) compared to students who are taught Intermediate Algebra using a traditional lecture style?
3. Are there differential mathematics effects for either group based on demographic factors such as gender, age, ethnicity, number of mathematics courses taken in the past, and degree plans?
4. Do differences emerge between the two groups of students in their perceived level of mathematics anxiety?

5. Are the students' attitudes toward mathematics a factor in students' inability to be successful in Intermediate Algebra?

Method

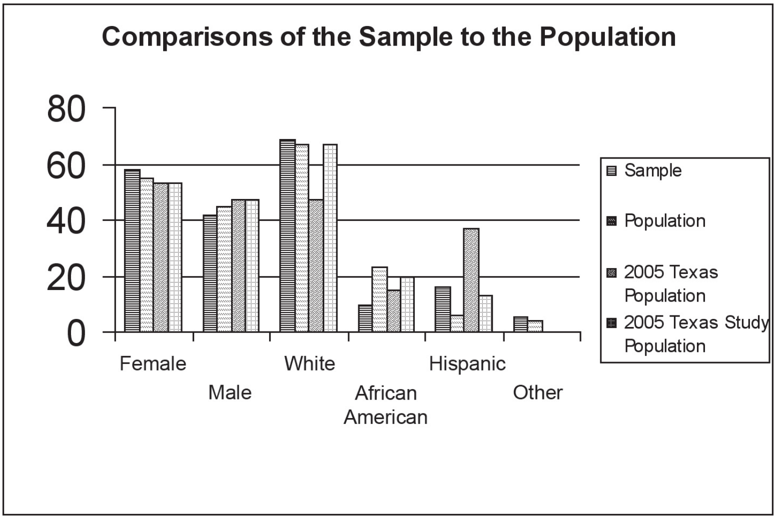
Sampling Strategy Participants

The participants in this study included 54 freshmen students (enrolled in experimental courses using ALEKS) and 39 control students (enrolled in traditional lecture courses) registered for intermediate algebra classes at three colleges and two universities. The sample was a convenience sample. According to Wilkinson and the Task Force on Statistical Inference (1999), using a convenience sample does not automatically disqualify a study from publication, but it harms your objectivity to try to conceal this by implying that you used a random sample. Sometimes the case for the representativeness of a convenience sample can be strengthened by explicit comparison of sample characteristics with those of a defined population across a wide range of variables. (pp. 3-4)

Figure 1 illustrates that the current sample is comparative to the relatively unchanged population of developmental education students. The present sample had a higher enrollment of Hispanics; however, the present study was situated in Texas and therefore the higher Hispanic population was not a surprise to the researcher (Boylan et al., 1994; Saxon & Boylan, 1999; Texas Higher Education Coordinating Board, 2005).

Multiple universities and community colleges were asked to be part of this study to ensure sufficient sample size. The 54 students in the experimental group attended two different universities labeled lu and cc. The 39 students in the control group attended three different community colleges and were labeled bre, bry, and ntcc. The small sample size resulted from the student selection process. The instructions were distributed to the chairs of the Mathematics Department in the colleges who were then to distribute them to up to 1500 students in the two colleges. Students were to voluntarily log on to a specific Web site to complete 3 surveys. There was no follow up to this first distribution. For future studies this is a concern that needs to be addressed. Possibly the researcher needs to go to the colleges and administer the surveys herself to ensure a larger sample size. Students were judged as not being prepared to begin college level mathematics classes by various measures by performance on the SAT, ACT, THEA, and other entrance exams.

Figure 1 Comparisons of Sample with Population of Development Education Students.



Note. Population statistics based on numbers from Boylan et al. (1994) and Saxon & Boylan (1999), and Texas Higher Education Coordinating Board (2005).

Instrumentation

Students in the experimental (n = 54) and control (n = 39) groups were administered the following pretests in September and posttests in December via the web: (a) National Achievement Test, First Year Algebra Test ([NATFYAT]; Webb & Hlavaty, 1962); (b) Mathematics Anxiety Rating scale ([MARS]; Suinn & Winston, 2003); and (c) Fennema and Sherman scales ([F-S scales]; Fennema and Sherman, 1976). In addition, demographic data were collected from each student participant. The NATFYAT (Webb & Hlavaty, 1962) has 48 multiple-choice questions suitable for an intermediate algebra class. The MARS (Suinn & Winston, 2003) has 30 questions on a 5-point Likert Scale. In fact, "despite the usefulness of the original scale, researchers have sought a shorter version of the scale to reduce the administration time of the 98-item inventory" (Suinn & Winston, 2003, p. 167). Suinn created a shortened version of the MARS that was "devoid of some of the prior deficiencies" (p. 268) of other versions of the MARS and that "was comparable to the original MARS 98-item scale" (Suinn & Winston, p. 167). The F-S scales (Fennema & Sherman, 1976) have 47 questions rated on a 5-point Likert Scale. The

F-S scales are a Likert Scale testing for positive and negative attitudes. The positive questions are scored 5 to 1 and the negative questions are scored 1 to 5, with a possible score of 235 (all 47 questions).

Data Screening

Prior to analysis, pretest and posttest of NATFYAT, MARS, F-S scales, and demographic surveys were examined through various Statistical Package for the Social Sciences SPSS programs for (a) incomplete data that resulted in deleting incomplete scales and surveys, (b) linearity between two variables by inspection of bivariate scatterplots, and (c) the assumptions of multivariate analysis. Multivariate effect sizes were reported as partial η^2 and were found by computing 1-Wilks' lambda. An α level of .05 was set as significant for all main effect analyses. For ANOVAs, post hoc analyses were performed using multiple univariate *F* tests, adjusting family wise α with the Bonferroni correction (0.05/4 = 0.0125). The Bartlett test is essential to verify sphericity of the data and that the data conforms to the assumptions of Multivariate analysis of variance (MANOVA).

Data Analysis

Reporting of results in the present study adhered to recommendations by Wilkinson and the American Psychological Association Task Force on Statistical Inference (1999). Therefore, *p* values, effect sizes, and score validity and reliability statistics were all reported (Capraro, Capraro, & Henson,2001; Crocker & Algina, 1986; Henson, 2001; Thompson, 2003). Some authors interpret effect sizes by using Cohen's (1988) benchmarks for "small," "medium," and "large" effects (p.104). Cohen (1988) himself put forth his benchmarks "with much diffidence, qualifications, *and invitations not to employ them if possible* [italics added]" (p. 532). For the present study variance accounting for effect sizes of 5% were deemed important.

The two groups of scores being compared are independent samples. This study is a comparison of two sample means. MANOVA was performed to determine what, if any, statistically significant differences existed between the NATFYAT pretest and posttest of each student in the control group and the computerized-algebra group. The NATFYAT was the dependent variable, as well as the MARS and F-S scales. A separate regression analysis of the two groups was used to determine the relationship between the NATFYAT and MARS, NATFYAT and F-S scales, and demographics. The findings showed that success in mathematics is increased or decreased as a result of anxiety, attitude, gender, age, ethnicity, number of mathematics courses taken in the past, or degree plans.

Results

Reporting practices followed the guidelines established by the American Educational Research Association (2006) and Wilkinson and the Task Force on Statistical Inferences (1999). Both entities recommend the reporting of means and standard deviations, inferential statistics, and effect sizes.

Validity and Reliability

An exploratory factor analysis with a principal component analysis and varimax-rotation was conducted on the 48-item NATFYAT. Scree plot results suggested that the 48 items tested for one factor: algebra concepts. An exploratory factor analysis with a principal component analysis and varimax-rotation was conducted on the 30 items of the MARS. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin value was .803, exceeding the recommended value of .6 (Pallant, 2001), and the Bartlett's Test of Sphericity reached statistical significance, supporting the factorability of the correlation matrix. Principal component analysis revealed the presence of two components. An inspection of the scree plot revealed a clear break after the second component; therefore, two components were retained and labeled Mathematics Anxiety Pretest Studying (MAPRS) and Mathematics Anxiety Pretest Calculation (MAPRC). An exploratory factor analysis with a principal component analysis and an oblique rotation was conducted on the 47-item F-S scales. An oblique rotation (oblimin) was conducted because the factors did not appear to be orthogonal. An inspection of the correlation matrix revealed the presence of many coefficients of .3 and above; the Kaiser-Meyer-Oklin value was .737, exceeding Pallant's recommended value of .6, and the Bartlett's Test of Sphericity reached statistical significance, supporting the factorability of the correlation matrix. An inspection of the scree plot revealed a clear break after the fourth component; therefore, four components were retained. The F-S scales items to the variables supported content validity: confidence, anxiety, value, enjoyment, and motivation (Tapia & Marsh, 2004). A factor analysis of the intercorrelations of responses to 51 items indicated the same general factors as in the original study.

It is critical to select scales for research studies that yield reliable scores. One main concern is the scale's internal consistency (i.e., the degree to which the items that make up the scale are related). Are items all measuring the same underlying construct? A commonly used indicator of internal consistency is Cronbach's alpha (Pallant, 2001). In previous studies, the score reliability of NATFYAT Form A was .905 and Form B was .911. In the present study, the internal consistency reliability estimates was .701 for the NATFYAT pretest and .793 for the NATFYAT posttest. In previous administrations of the MARS, the internal consistency reliability was .97 with a coefficient alpha score reliability of .914 with a test re-test of .894 (Capraro, Capraro, & Henson, 2001). In the present study, the condensed version of the original MARS was administered to the experimental group ($n = 54$) and the control group ($n = 39$). Cronbach's alpha for the present study was .930. In previous administrations of the F-S scales, internal consistency estimates of the reliability of scores on the total scale and on each scale for the short form were acceptable, with coefficient alpha ranging from .72 to .89 (Alkhateeb, 2004). In the present study, the internal consistency reliability was .926 for the F-S scales pretest and .929 for the F-S scales posttest. These are considered sufficient for further statistical analyses (Pallant, 2001).

Research Question I

Does a mastery learning perspective of remediation, where students are expected to learn all the objectives in an intermediate algebra class, make a difference in mathematics achievement?

Bivariate correlations indicated a positive relationship between algebra pretest and posttest for the experimental group $r(52) = .411$, $p = .002$. Calculating the coefficient of determination resulted in explaining 17% of the variance. As shown in Table 1, results from the paired-samples t test indicated statistically significant differences existed on algebra achievement from the pretest to the posttest. These results suggested that mathematical achievement did improve with the use of ALEKS.

Research Question I Answer

The data analysis suggested that mathematical achievement improved with the use of the computer algebra system, ALEKS. The mean scores went from 16.56 to 20.56, an increase that was statistically significant, with a Cohen's d of about 0.611. Although there was a statistically significant difference from pretest to posttest, this implies that ALEKS was instrumental in improving mathematical achievement of some students but not all of the students. Continued research on best practices for this group of students is essential to assure that the students will be ready for college level courses.

Research Question II

What differences exist between students using ALEKS compared to students who are taught Intermediate Algebra using a traditional lecture style?

Table 1 Paired t Test and Descriptive Statistics for Algebra, MARS, and F-S Scales Pretest and Posttest Scores for Experimental, Control, and Both Groups

	Algebra Pretest/Posttest			MARS Pretest/Posttest			F-S scales Pretest/Posttest		
	Exp (n = 54)	Control (n = 39)	Both (n = 93)	Exp (n = 54)	Control (n = 39)	Both (n = 93)	Exp (n = 54)	Control (n = 39)	Both (n = 93)
t	-4.49	-3.96	-5.86	5.40	2.02	5.40	-1.52	2.15	.62
df	53	38	92	53	38	92	53	38	92
Significance	<.001	.001	<.001	<.001	.051	<.001	.14 .04	.54	
Pretest									
Mean	16.56	13.89	15.44	79.54	83.59	81.24	176.02	170.59	173.74
SD	5.49	5.49	5.40	18.01	18.04	18.07	21.77	23.91	22.72
SE	.79	.75	.56	2.46	2.90	1.87	2.96	3.82	2.36
Posttest									
Mean	20.26	19.67	20.01	66.61	78.46	71.58	179.61	162.41	172.40
SD	6.67	6.67	7.08	18.95	18.67	19.63	22.61	22.09	23.85
SE	.77	1.40	.73	2.58	2.99	2.04	3.08	3.54	2.47

Differences between Groups on the Algebra Test

Bivariate correlations indicated a positive relationship between algebra pretest and posttest for the experimental group, $r(52) = .411$, $p = .002$, and a smaller correlation for the control, $r\ (37) = .203$, $p = .213$, explaining 17% and 4% of the variance respectively. As shown in Table 1, results from paired-sample t tests indicated statistically significant differences on algebra achievement for the experimental group from the pretest to the posttest, and the control group from pretest to the posttest, suggesting that differences existed between the groups. Further examination of the results indicated that the control group outperformed the experimental group. In light of these results, for some students lecture method is best; for other students the computer algebra systems seems to be the best method.

Differences on the Mathematics Anxiety Rating Scale

Results from a factor analysis indicated two components labeled Perceived Mathematics Anxiety in some students considering taking a mathematics test and Calculating Mathematical Problems. Lower scores on the posttest MARS indicated less anxiety.

Bivariate correlations indicated a positive relationship between MARS pretest and posttest for the experimental group, $r(52) = .550$, $p = .0001$, control group $r(37) = .627$, $p = .0001$, and both (experimental and control) groups between the two variables, $r\ (91) = .585$, $p = .0001$, explaining 30%, 39%, and 34% of the variance respectively. As shown in Table 1, results from paired-samples t tests indicated statistically significant differences from pretest to posttest for the experimental group, no statistically significant differences from pretest to posttest for the control group, and statistically significant differences from pretest to posttest for both (experimental and control) groups. Results suggested that the anxiety level of the experimental group and the control group both decreased, but the anxiety level of the experimental group decreased more than that of the control group.

Differences on the Mathematics Attitude

Bivariate correlations indicated a positive relationship between F-S scales pretest and posttest for the experimental group, $r(52) = .693$, $p = .001$, control group $r(37) = .466$, $p = .003$, and both (experimental and control) groups between the two variables, $r\ (91) = .592$, $p < .001$. As shown in Table 1, results from paired-sample t tests indicated no statistically significant differences for the experimental group from the pretest to the posttest, statistically significant differences for the control group from the pretest to posttest, and no statistically significant differences between both (experimental and control) groups from the pretest to posttest. The results here suggested that statistical significance did not occur for the experimental group, but their attitudes toward mathematics did improve. On the other hand, the control group showed statistical significance, but their scores showed that their attitude toward mathematics was not as good at the end of the semester.

Research Question II Answer

Results from the analysis of the data suggested that both groups improved on the algebra tests, but the control group outperformed the experimental group. Mathematics anxiety decreased at a greater rate in the experimental group than the control group; therefore, the anxiety of the experimental group was less than the anxiety in the control group. Even though the mathematics attitude in the experimental group was not statistically significant, the attitudes of the experimental group did improve. The control group was statistically significant, but their attitudes toward mathematics did not improve. Their attitudes toward mathematics were worse at the end of the semester. Therefore, one could make an argument for the computer algebra system because of the fact that the students walk away from intermediate algebra with more confidence and internalize the usefulness of mathematics in their lives with less anxiety.

Research Question III

Are there differential mathematics effects for either group based on demographic factors such as gender, age, ethnicity, number of mathematics courses taken in the past, and degree plans?

Research Question III Answer

Results showed that there were no differences in mathematical achievement by gender, ethnicity, or age. Students enrolling in college have come from secondary schools that require at least 3 years of mathematics, so there was no variance for this factor. All students reported that they planned to complete either a two- or a four-year program, so there was no variance for this factor.

Research Question IV

Do differences emerge between the two groups of students in their perceived level of mathematics anxiety?

Bivariate correlations indicated a positive relationship between MARS pretest and posttest for the experimental group, $r(52) = .550$, $p = .001$, control group, $r(37) = .627$, $p < .001$, and both (experimental and control) groups between the two variables, $r\ (91) = .585$, $p < .001$. As shown in Table 1, results from paired-samples t tests indicated statistically significant differences for the experimental group from pretest to posttest, no statistically significant differences for the control group from pretest to posttest, and statistically significant differences for both (experimental and control) groups from pretest to posttest. Cohen's d for this data was .736 (experimental group), .424 (control group), and .560 (for both groups).

The results from a MANOVA showed statistically significant differences existed between the experimental and control groups of students on MARS pretest and posttest, $F(2, 90) = 4.773$, $p = .011$, with moderate effect size ($\eta^2 = .10$).

Research Question IV Answer

Results from the analysis of the data showed that the anxiety of the experimental and control groups decreased from the beginning of the semester to the end of the semester. The experimental group's mathematics anxiety decreased at a greater rate than that of the control group. Even though the anxiety level of both groups decreased over time, the students in ALEKS seemed to be less anxious.

Research Question V

Is the student's attitude toward mathematics a factor in student's inability to be successful in Intermediate Algebra?

Bivariate correlations indicated a positive relationship between F-S scales pretest and posttest for the experimental group, $r(52) = .693$, $p = .001$, control group, $r(37) = .466$, $p = .003$, and both (experimental and control) groups between the two variables, $r\ (91) = .592$, $p < .001$. As shown in Table 1, results from a paired-samples t tests indicated no statistically significant differences for the experimental group from pretest, statistically significant differences for the control group from pretest, and statistically significant differences in both (experimental and control) groups from pretest. The results of a MANOVA showed statistically significant differences did exist between experimental and control groups of students on F-S scales pretest and posttest, $F(2,90) = 7.41$, $p = .001$, with a moderate effect size ($\eta^2 = .14$).

Results from a paired-samples t test on the four components of the F-S scales (Confidence, Teacher, Usefulness, and Male Dominance) showed there was not a statistically significant difference for the experimental group from pretest to posttest, a statistically significant difference for the control group from pretest to posttest, and there was not a statistically significant difference for both (experimental and control) groups from pretest to posttest. The experimental group results suggested that there was no statistically significant difference, but their attitudes toward mathematics did improve. The rate of change for the experimental group on Confidence increased at a greater rate than the control group, although the control group also increased very slightly. The rate of change for the experimental group on Teacher component increased, while the control group decreased. The rate of change for the experimental group on the Usefulness component slightly decreased, while the control group decreased at a greater rate. The rate of change for the experimental group on the Male Dominance component decreased, while the control group decreased at a similar rate. Results suggested that, even though a statistical significance was found for the control group, their attitudes toward mathematics were not as good as their attitudes were at the beginning of the semester.

The results of a MANOVA of the four components--Confidence, Usefulness, Teacher, and Male Dominance--showed statistically significant differences existed between experimental and control groups of students on F-S scales pretest and posttest for the four components, $F(8,84) = 2.646891$, $p = .012$, with moderate effect size ($\eta^2 = .201$).

Research Question V Answer

The results showed that the experimental group's attitudes toward mathematics improved, but did not show statistical significance, and their mathematics achievement improved. In conclusion, mathematics attitude possibly could contribute to mathematical achievement for some students. On the other hand, the control group's attitudes did show statistical significance, but that significance was negative, not positive, and their attitudes toward mathematics were not as good by the end of the semester, even though their performance on the algebra test increased at a greater rate than did the experimental group. In this case, the conclusion has to be that the control group's mathematics attitude did not positively contribute to their mathematics achievement.

Summary of Important Results

Underprepared students will enroll in colleges and universities, and these students will need assistance (Casazza, 1999). The open door policy has encouraged many more students to pursue a college education, even though those students may not be academically prepared. These students believe the only way to a better life is through a college education. The colleges and universities must rely on research for best practices for teaching this growing population of students to ensure they receive the education they seek and deserve. The present study investigated developmental students enrolled in an intermediate algebra class for mathematics achievement, anxiety associated with mathematics, and attitudes toward mathematics and found three take-home messages for developmental teachers.

Methods of Instruction for Developmental Students

Teachers of developmental students must investigate and implement the best practices for their underprepared students. Boylan (2002) has done extensive research in this area so the information is readily available. The results of this study suggested that a computer-mediated curriculum does improve mathematical achievement for some students. For other students, the lecture method seems to be best. Teachers must evaluate what is best for their students and implement these best practices and possibly give the students a choice of either lecture or computer-mediated instruction.

Mathematics Anxiety

Teachers must be aware that developmental students have had many years of frustration and anxiety associated with mathematics. Teachers must find ways to alleviate this anxiety so that the students become confident in their ability to learn mathematics. In 1989, the National Council of Teachers of Mathematics (NCTM) encouraged the use of calculators as an instructional aid and computational tool in the classroom. NCTM asserted that "[t]echnology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (2000). Acelajado (2001) found that the use of technology reduced anxiety in mathematics problem solving. Ma (1999) found from a meta-analysis of 26 studies that higher mathematics achievement resulted in lower mathematics anxiety. The present study suggested that the students' anxiety level was decreased after a semester of using the computer-mediated algebra instruction.

Mathematics Attitude

Teachers of developmental students must understand that negative attitudes toward mathematics can affect the ability of their students to learn mathematics (Thomas & Higbee, 2000). Teachers can play an important role in the lives of their students by helping students see the usefulness of mathematics. Teachers can also encourage students in such a way that they become confident in the teacher, in themselves, and in their ability to learn mathematics. The present study suggested that some of the students' attitudes toward mathematics was improved after a semester of using the computer-mediated instruction.

Future Research

With the large number of underprepared students enrolling and attending colleges and universities in the United States, research must continue to ensure that these students will receive the help that they so desperately need. Research shows that only 20% of developmental students enrolling in colleges and universities will actually earn a degree, compared to 50% of regular students (Boylan & Saxon, 2004; Cross, 1971;

1976; Maxwell, 1979; McDade, 2000; NCES, 2000). Evidently research has not found the answer to retaining and educating developmental students, or maybe research has found solutions, but researchers have not found a way to implement these findings to bring about lasting change. The findings in the present research indicated that there are anxiety issues, as well as negative attitudes, that can affect mathematical achievement, and that a computer-algebra program can be just as effective as lecture classes in teaching mathematics.

The present study suggests that underprepared students can learn from different means (i.e., computer algebra or lecture), and research needs to continue to investigate the best practices for these students. Researchers need to be diligent about finding what method will help these students. Further research should be conducted on this growing population in college and universities.

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