The effects of gender, class level and ethnicity on attitude and learning environment in college algebra course

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Abstract

The goal of this study was to investigate factors (gender, class and ethnicity) that might affect the attitudes and learning environment perceptions of college students in a college algebra course. A sample was been chosen from a regional university and quantitative research method has been used in collecting information from the sample. Non-parametric test has been used to analyze 17 Likert scale questions in four categories, value of the subject (6 statements), interest in the subject (4 statements), classroom environment (2 statements), and difficulty of the subject (5 statements). Results show that male students, White students, and freshman students consistently reported more positive perceptions in these four categories than did their counterparts. The quantitative data were statistically analyzed using factorial ANOVA. Results show that White students' final grades were consistently a little higher than Non-White students and female students' scores were higher than those of male students. The same statement is also true for freshman students.

Introduction

Typically, students view the content of a traditional college algebra course as irrelevant, as a tedious and incomprehensible barrier to obtaining a college degree. A survey was designed and conducted to focus on students' reasons for enrolling in the algebra class, learning preferences and practices, mathematics anxiety/reflexes and attitudes, self-description of academic ability, world view, and background information. This study examined the nature of the relationship between student self-perception/attitude variables and final course grades in the on campus sections of college algebra offered at a regional university. Understanding these factors may lead to amelioration of this crucial problem.

Over the past two decades, the need for pedagogical and content reform in undergraduate mathematics education has been documented [12, 14, 15, and 16]. College algebra has been plagued by high failure rates, especially among minorities. Some research conducted on college algebra students surveyed their mathematical beliefs [6], documented their often fragmented conceptual understandings [1], and examined the effectiveness of instructional strategies [16]. In 1933, Dewey [4] wrote that it is difficult for a person to change his or her attitudes. He wrote of teachers and indicated that "what can be done is to cultivate those attitudes that are favorable to the use of the best methods of inquiry and testing." However, not all students are able to cultivate favorable attitudes. Indeed, attitudes are tenacious and seem to be based on personal experience or particularly vivid personal episodes [7, 9, and 12]. Jackson and Leffingwell [8] found three clusters of grade levels during which instructional behaviors, either overt or covert, can cause anxiety for students in mathematics. Anxiety can lead to negative attitudes toward the subject area. The first of these clusters is elementary level, with grades 3 and 4 specifically mentioned, the second is the high school level, and the third is college, with the freshman year specifically mentioned. Without regard for when the anxiety began, the "negative memories were so profound that mathematics anxiety could persist for twenty or more years."

Currently the college algebra barrier is truncating the college ambitions of approximately half a million students per semester [3]. The investigators, a statistician and a mathematics educator, structured and conducted a study in all on campus college algebra sections. The goal of this study was to investigate three factors that might affect the attitudes and learning environment perceptions of college students: gender, class level and ethnicity.

Background

College algebra, according to the 2007 Conference Board of the Mathematical Sciences (CBMS) survey [2], has the largest enrollment of any credit bearing mathematics course, being approximately equal to the combined enrollments in all calculus courses. In 1980 college algebra enrollment was only 73% of the combined calculus enrollments [9]. Lamar University offers several flavors (traditional on campus courses, online courses, off-campus courses, and high-school courses delivered via TV) of college algebra courses. This introductory mathematics course is taken by approximately 800 students per semester. It is in the Core Curriculum for many majors and serves as a prerequisite for more advanced mathematics courses. Records indicate that in Fall 2008, 855 students enrolled for this course and approximately 23% of them failed to earn a final grade of C or better (Research and Reporting, Lamar University). For African American students and Hispanic students this rate was about 30% and 27% respectively. Similar, if not worse, failure rates exist on campuses throughout the entire country. For many students, college algebra is their last formal contact with mathematic; even students who earn passing grades (D or better) may leave the university with mathematics skills that are inadequate to function effectively in the complex world in which they will live [9]. Lamar University records also show that First Time In College (FTIC) and freshman students have more success than their other classmates. Fall 2008 data reveals that 81% of FTIC and freshman students earned C or better in college algebra, while the passing rates for sophomore, junior and senior students were 77%, 66% and 65% respectively. It could be hypothesized that the students should be strongly encouraged to complete college algebra within the first two semesters of college work.

Sample and Learning Environment

The sample (Table 1) selected for this study included all of the students enrolled in all on-campus sections of college algebra. These sections are taught in a large, auditorium type classroom, in which students are seated at tables, that are ramped for visibility. The lighting and sound in the classroom are good. The classroom has multiple chalkboards and an oversized screen on which images from the computer, a laptop, a video recorder, or a document camera may be projected. Instructors use most of this equipment during class periods, with a variety of presentation styles, varying from traditional chalkboard explanations and exercises to algebra software and web sites provided by the publisher of the text. All college algebra instructors use the same syllabus and text. The text is a custom edition, which includes only the sections pertaining to the topics taught. Some of the instructors have terminal degrees, but most have masters degrees in mathematics, with 18 or more graduate hours in mathematics. The 11 to 14 sections range in size from about 30 to about 90 and there are classes in the mornings, afternoons, and evenings. The sample consisted of 276 (36%) male students and 471 (64%) female students, 440 (59%) White students and 306 (41%) Non-White students, 444 (61%) freshmen, 106 (15%) sophomores, 89 (12%) juniors, and 88 (12%) seniors, and the students were distributed among the Colleges -- 149 in General Studies, 272 in Arts and Sciences, 102 in Education and Human Development, 118 in Business, 58 in Fine Arts and Communications, and 44 in Engineering. Because the survey was voluntary, some students elected to not answer every question.

Attitudes toward College Algebra: The survey

An *attitude* may be defined as "a personal inclination - idiosyncratic, present in all individuals, directed to objects, events or people - that takes on a different direction and intensity according to the experiences each individual has had...it presents components from the affective, cognitive and motor domains" [17]. Such a "personal inclination" may or may not be overtly acknowledged, but is generally well established and closely held. Students, who are unable to cultivate positive attitudes, may not be able to persist to valid solutions for problems and, therefore, may not experience success in mathematics [4, 11, 18]. The attitudes survey for this study consists of 17 statements, for each of which the student was asked to indicate how strongly he or she agrees or disagrees. For the purpose of this discussion, the statements have been grouped in four categories (Table 2).

VALUE: Six statements address how highly students value the college algebra they are studying. While 46% of responding students indicate appreciation of mathematics, 68% consider a good grade to be the most important component of the course -- more important than understanding the mathematics. About 60% feel that mathematics classes are definitely boring and almost half consider mathematics to be mere memorization of facts. Fewer than 14% expect college algebra to help them in everyday life and more than 60% feel that college algebra is only preparation for the next mathematics course.

INTEREST: Four statements specifically address the individual student's interest in mathematics. Only 27% of responding students report that they enjoy solving mathematics problems and about 65% indicate that "enjoyment" of mathematics is irrelevant as a factor of success, while 87% believe that getting a B in mathematics would mean that he or she is "not good" at it. Clearly, responding students do not credit hard work for their success, since only 2.8% agree with this statement.

CLASSROOM ENVIRONMENT: Two statements deal with poor/good teaching skills. With only 4% agreeing with the statement about poor teachers, it is clear that the students who responded to this survey do not blame instructors for ruining their appreciation for mathematics. Nor do students credit good instructors with improving appreciation for mathematics, only 1% of students agree with this statement.

DIFFICULTY: The last group of five statements addresses the students' perceptions of how their abilities and habits affect their attitudes toward mathematics. About the same percentage of students feel that mathematics comes easy (40%) as feel that it does not come easy (36%); it is interesting that 21% of students are undecided about this statement. Only 14% of students believe that it is possible to like mathematics without being good at it. As a matter of fact, 72% feel that success in mathematics is a result of a genetic "gift" and nothing can change inborn ability or inability to succeed at mathematics and 43% consider early achievement an indicator of future achievement. In other words, "try, try again" is not of value; 88% do not feel that repeated practice is of any benefit.

The attitudes expressed by the responding students have been built up over their lifetimes of experiences in elementary, secondary, and post secondary classrooms. Such attitudes are resilient, difficult to change, and influence achievement.

Data Analysis Method

Mann-Whitney Test:

The Mann-Whitney U test is a non-parametric test which examines whether two samples of data could have come from the same population. It does not require two sets of paired data, nor need they be normally distributed, nor are there necessarily equal numbers in each set. This test is an alternative to the independent group t-test. This, like many non-parametric tests, uses the ranks of the data rather than their raw values to calculate the statistic. The Mann-Whitney U test determines the number of times a score from one of the samples is ranked higher than a score from the other sample. To conduct the Mann-Whitney U test, each case must have scores on two variables, the grouping variable (independent or categorical variable) and the test variable (dependent or quantitative variable). The grouping variable divides cases into groups or categories, and the test variable assesses individuals on a variable with at least on ordinal scale. In this study, the Mann-Whitney test has been performed for three different grouping variables (gender, class and ethnicity) to test the null hypothesis that there is no difference in gender response (for example) to the statements or test variables (all Likert scale questions).

Factorial ANOVA:

Sometimes researchers want to compare the means for a variable across two or more variables, rather than one. This is known as a factorial design. For example, since we wanted to know how gender and ethnicity affect test score, we could run two separate one-way ANOVAs, or we could run a factorial ANOVA. Factorial ANOVA has two independent variables which are crossed with each other. That means each value of one variable is paired with every value of the other variable. The advantage of the factorial ANOVA is that it also allows us to examine interaction effects between our independent variables. For instance, perhaps male students who are White may have a higher score than male students who are Non-White. The best way to observe such a pattern is with a factorial ANOVA. In this study, after checking the assumptions, a 2×2 factorial ANOVA was performed using SPSS General Linear Model (GLM) to assess whether test score (dependent variable) could be predicted from gender (male and female), ethnicity (White and Non-White), and the interaction between gander and ethnicity.

Results

Mann-Whitney U Test:

A Mann-Whitney *U* test was conducted to test the null hypothesis that there is no difference in gender response to each 17 Likert scale question. The results of the tests are insignificant for all but 7 questions. That is, the tests for 7 questions find significant difference in response between male (M) and female (F) students. The test shows significant difference in response in the statements mentioned in Table 3.

Since the rank of 1 is assigned to strongly disagree, it can be seen from Table 3 that male students have positive responses toward all positive statements of the study. They value mathematics as a discipline and they think that it will help them in everyday life. Likewise, male students have positive perceptions toward the value and interest statements of the survey. It can be concluded that male students have more positive attitudes toward mathematics than their counterparts.

A Mann-Whitney *U* test was also conducted to test the null hypothesis that there is no difference in ethnic (the ethnicity has been grouped as White (W) and Non-White (NW)) response to all 17 Likert scale questions. The results of the tests are insignificant for all but 8 questions. That is, the tests for 8 questions find significant difference in response between White and Non-White students. In Table 4 the statements with significant difference in response have been shown. More Non-White students believe that doing well in mathematics is a result of hard work, that repeated practice is necessary in order to learn mathematics, and that it is possible to like mathematics without being good at it. Coupled with data indicating that significantly more White students believe that good grades are more important than understanding mathematics and that earning a "B" means that one is not good at mathematics, it is possible that Non-White students do not feel the same level of "entitlement" to good grades with "minimal" effort. A need for additional research to focus on this area of attitudes toward learning mathematics is indicated by these data.

Finally, to test the difference in class response Mann-Whitney test was conducted. The 'class' variable was grouped as freshman (F) and non-freshman (NF). The test shows significant difference in response in 8 different statements (Table 5). More freshman students indicated that mathematics is easy for them and that the mathematics in college algebra will help them in everyday life, while more non-freshman students believe that mathematics is mostly memorizing facts and that a good grade is more important than understanding mathematics. A need for additional research to determine the foundations of these attitudes toward learning mathematics is indicated by these data.

Factorial ANOVA:

The output box (Table 6), which runs three separate ANOVAs: the main effects for each of our two variables (namely gender and White and Non-White), and the interaction effect between the variables. Each of these is shown on a different row, with the variable name(s) in capitals; it gives us the degrees of freedom, F-value and p-value. Tests scores were subjected to a two-way analysis of variance having two levels of gender (male and female) and two levels of ethnicity (White and Non-White). It can be observed from Table 7 that the analysis is significant for both the main effect namely ethnicity and gender. But it's insignificant for the interaction. The main effect of gender discrepancy yielded an F ratio of 6.178, $p<0.05$ indicating that the mean test score was significantly greater for female students (Mean=63.9, SD=19.7) than for male students (Mean=59.1,SD=18). The mean effect of ethnicity yielded an F ratio of 4.024, $p<0.05$, indicating that the mean test score was significantly higher for White students (Mean=64.5, SD=18.44) than for Non-White students (Mean=60, SD=20.1). The interaction effect was non-significant, where the F ratio is 0.316, $p>0.05$.

Conclusions

Primarily, this study provides information about how students of different genders, ethnicities and class levels perceive what attitude they have toward mathematical values, classroom environment and difficulties. Additionally, the relationships between the nature of the attitude as assessed with the Likert scale questions and students' final exam grades were explored. The key findings of this study are:

(1) Only about 14% students believe that college algebra course will be used in everyday life. Similar alarming trends can be seen in almost all statements in Table 2.

(2) Statistically significant gender differences for 7 attitude questions were found and male students have overall positive attitudes toward mathematics. However, female students rely on repeated practice to do well in mathematics classes.
(3) Strong statistically significant ethnic differences on 8 attitude questions were found. In almost all questions White students consistently reported more positive perceptions of classroom environment and attitudes than did Non-White students. However, White students certainly think that mathematics classes are boring.
(4) Some pedagogically noteworthy class level differences were found. In 8 out of 17 questions these differences are statistically significant. For most of the questions, freshman students reported more positive attitudes than did their counterparts. For example, mathematics comes easy to them and they think that mathematics will be useful in everyday life.
(5) Factorial ANOVA results also support the conclusion obtained in the Mann-Whitney test. There are significant differences between male and female students, White and Non-White students and freshman and non-freshman students.
(6) The positive attitudes of White students toward mathematics reflect their performance in this course as well. The average test score for this group is much higher than their counterparts. The similar remark is applicable for freshman students.
(7) Analyzing the attitudes of the students, it has been observed that a group (White) holds more positive attitudes toward mathematics, this group also consistently perform well in mathematics. However, this group very clearly consider mathematics classes as boring. These disturbing findings need to be addressed and studied further.
Our results indicate significant differences in attitudes among different groups of mathematics students. Also the study shows that attitude is directly linked with students' performance in mathematics. These findings beg for further study about how to narrow the gap between gender, ethnicities and class levels in attitudes towards mathematics.

Table 1: Basic Demographic Data of Sample

<table>
<tr><td>Gender</td><td colspan="3">Male</td><td colspan="2">Female</td><td>Total</td></tr>
<tr><td></td><td colspan="3">276</td><td colspan="2">471</td><td>747</td></tr>
<tr><td>Ethnicity</td><td>White</td><td>Black</td><td>Hispanic</td><td>Asian/PI</td><td>AI</td><td>Total</td></tr>
<tr><td></td><td>440</td><td>227</td><td>48</td><td>28</td><td>6</td><td>746</td></tr>
<tr><td>Class</td><td>Freshman</td><td>Sophomore</td><td>Junior</td><td>Senior</td><td>Other</td><td>Total</td></tr>
<tr><td></td><td>444</td><td>196</td><td>49</td><td>38</td><td>17</td><td>744</td></tr>
</table>

College	GU	A&S	Ed	Bus	FAC	Egr	Total
	149	272	102	118	58	44	743

Table 2: Percentage of responses in each category for the 17 questions (Survey for College Algebra Students)

	SA (5)	A (4)	U (3)	D (2)	SD (1)
Value:					
It is more important to get a good grade in math class than to appreciate math.	2.9%	25.1%	23.9%	34.0%	11.7%
Math classes are boring.	11.7%	46.6%	23.9%	13.3%	3.1%
Math is mostly memorizing facts and formulas.	3.4%	26.9%	20.6%	39.9%	7.4
It's more important to get a good grade in math class than to understand math.	15.6%	52.5%	17.4%	8.4%	3.3%
Math in this course will help me in everyday life.	4.2%	9.7%	30.9%	41.0%	12.5%
Learning math prepares you for your next math class.	9.0%	52.3%	18.7%	14.9%	3.7%
Interest:					
Getting a "B" in math means you are not good at it.	31.7%	55.0%	6.8%	3.4%	0.8%
I enjoy solving math problems.	6.8%	20.2%	17.6%	39.7%	13.0%
Enjoyment of math is an important factor in being good at it.	2.4%	14.5%	16.3%	43.8%	21.9%
Doing well in math is a result of working hard.	0.4%	2.4%	5.3%	43.1%	46.9%
Classroom Environment:					
A poor math teacher can ruin a student's appreciation for math.	1.3%	3.1%	6.1%	29.7%	57.7%
A good math teacher can improve a student's appreciation for math.	0.4%	0.4%	2.4%	32.4%	63.0%
Difficulty:					
Math comes easy to me.	16.7%	23.3%	21.0%	28.5%	7.6%
It is necessary to repeatedly practice solving problems in order to learn math.	0.4%	5.2%	4.9%	42.2%	45.8%
It's possible to like math even if you are not good at it.	2.0%	11.9%	20.6%	52.8%	11.0%
You are born with the ability or inability to succeed at math and nothing can change that.	26.8%	44.6%	18.0%	6.1%	2.7%
Students who do well in math during elementary school are likely to do well in math at the high school level.	10.8%	32.3%	29.2%	22.8%	4.3%

Table 3: Significant difference in Mann-Whitney test among female (F) and male (M) students.

Statement	Mean Rank	p-value
Value		
It's more important to get a good grade in math class than to understand math.	M:393 F:352	0.005
Learning math prepares you for your next math class	M:397 F::357	0.009
Math in this course will help me in everyday life.	M:392 F:358	0.027
Difficulty		
Math comes easy to me.	M:405 F:343	0.000
Student who do well in math during elementary School are likely to do well in math at the high school	M:420 F:342	0.000
It is necessary to repeatedly practice solving problems in order to learn math	M: 341 F: 390	0.001
Interest		
Getting a "B" in math means you are not good at it.	M: 393 F:354	0.008

Table 4: Significant difference in Mann-Whitney test among White (W) and Non-White (NW) students

Statement	Mean Rank	p-value
Value		
Math classes are boring.	W: 398 NW: 331	0.000
Math is mostly memorizing facts and formulas.	W:357 NW:389	0.036
It's more important to get a good grade in math class Than to understand math.	W:383 NW:343	0.006
Math in this course will help me in everyday life.	W:395 NW:351	0.006
Difficulty		
It is necessary to repeatedly practice solving problems in order to learn math	W:333 NW:426	0.000
It's possible to like math even if you are not good at it	W:352 NW:397	0.002
Interest		
Getting a "B" in math means you are not good at it.	W:394 NW:331	0.000
Doing well in math is a result of working hard	W:343 NW:409	0.000

Table 5: Significant difference in Mann-Whitney test among freshman (F) and non-freshman (NF) students.

Statement	Mean Rank	p-value
Value		
Math classes are boring.	F: 347 NF: 404	0.000
Math is mostly memorizing facts and formulas.	F: 357 NF: 389	0.035
It's more important to get a good grade in math class Than to understand math.	F: 352 NF: 386	0.018
Math in this course will help me in everyday life.	F: 388 NF: 342	0.002
Learning math prepares you for your next math class.	F: 348 NF: 403	0.000
Difficulty		
Math comes easy to me.	F: 416 NF: 290	0.000
Interest		
Getting a "B" in math means you are not good at it.	F: 380 NF: 349	0.029
Classroom Environment		
A poor math teacher can ruin a student's appreciation for math	F:400 NF:312	0.000

Table 6: Factorial ANOVA Results for Gender and Ethnic Difference in College Algebra Final Exam Scores.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3324.972[a]	3	1108.324	3.042	.028
Intercept	1673953.108	1	1673953.108	4594.879	.000
GENDER	2250.819	1	2250.819	6.178	.013
W_and_NW	1465.885	1	1465.885	4.024	.045
GENDER * W_and_NW	115.005	1	115.005	.316	.574
Error	269588.254	740	364.308		
Total	2243716.000	744			
Corrected Total	272913.226	743			

a. R Squared = .012 (Adjusted R Squared = .008)

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