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THE EFFECTS OF GRADE LEVEL, GENDER, AND ETHNICITY ON ATTITUDE AND LEARNING ENVIRONMENT IN MATHEMATICS IN HIGH SCHOOL

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ABSTRACT. The purpose of this study was to investigate different factors (grade level, gender, and ethnicity) that might affect the attitudes and learning environment perceptions of high school mathematics students in Los Angeles County, California, USA. The study involved the administration of the administration of the What Is Happening In This Class? (WIHIC) questionnaire and an attitude questionnaire based on the Test of Mathematics-Related Attitude (TOMRA) to 600 Grades 9 and 10 mathematics students in 30 classes in one high school. Quantitative research method was used in collecting information from the sample. The quantitative data were statistically analyzed using ANOVA and MANOVA. The results showed that male consistently reported slightly more positive perceptions of classroom environment and attitudes than did females. Anglo students' scores consistently are a little higher than Hispanic students' scores. There is strong evidence of associations between students' attitudes and the learning environment.

KEYWORDS. Mathematics, Gender, Ethnicity, Grade Level, Attitude, Learning Environment.

INTRODUCTION

The objective of this study was to investigate factors (grade-level, gender, and ethnicity) that might affect the attitudes and learning environment perceptions of high school mathematics students in Los Angeles County, California, USA. The study evolved the administration of the What Is Happening In this class? (WIHIC) questionnaire and an attitude questionnaire based partly on the Test of Mathematics-Related Attitudes (TOMRA) to 600 Grade 9 and 10 mathematics students in 30 classes in one high school. Quantitative research method was used in collecting information from the sample.

The quantitative data consisted of the administration of the questionnaire to the sample (N=600 students). The data gathered were statistically analyzed. Effect sizes, ANOVA, and MANOVA were used to determine grade-level, gender, and ethnic differences in students'

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attitudes toward mathematics and their perceptions of the learning environment. Finally, simple correlation and multiple regression analysis were conducted to determine the relationship between the nature of the classroom environment as assessed with the WIHIC and students' attitudes.

Objectives

The purpose of this study was to investigate different factors that affect the attitudes and learning environment perceptions of high school mathematics students. The specific research questions are listed below:

1. Are there differences in the learning environment perceptions and attitudes of high school mathematics students according to: a) grade level, b) gender, and c) ethnicity?
2. Is there a relationship between the nature of the classroom environment as assessed with the WIHIC and students' attitudes?

Background

Today, minority students form a large and growing portion of the school-aged population in the United States. However, they are underrepresented at every level from elementary to graduate school. Furthermore, they are the ones who are most left out of science and mathematics. Currently, we face the potential of a serious shortfall in the number of minorities entering the fields of science and mathematics. Ultimately, the lack of preparation in science and mathematics among underrepresented minority groups in the early elementary grades undermines success rates in secondary-level school programs and in college and career choices later in life. Adequate preparation in science and mathematics enables students to develop socially and intellectually, and to participate fully in a technological society as informed citizens (Clark, 2006). However, minority students less frequently study science and mathematics.

A basic understanding of these subjects is essential for all students, not only those pursuing careers in scientific and technical fields. Minority students are depriving themselves of many career choices, including skilled technical and computer-oriented occupations as well as access to high-salaried occupations dominated by white males.

According to the National Science Foundation (2004), in 2000, racial and ethnic minorities in the USA constituted 22% of the civilian labor force, but only 14% of the science and engineering labor force. Underrepresented minorities (Blacks, Hispanics, and American Indians) represented 19% of the total labor force and 8% of the science and engineering labor force. There are several factors that contribute to unequal participation of minorities in science and mathematics education which include the understaffed and under-equipped schools that usually are found in minority communities, tracking, judgments about ability, the number and quality of science and mathematics courses offered, access to qualified teachers, access to resources, and curricular emphasis (National Science Foundation, 2006).

As more women have decided to enter the workforce instead of playing the role of homemaker, it has been noted that approximately 85% of new entrants to the workforce in the United States have been females. However, the number of women represented in the scientific and technology professions is not proportional to the whole population of females. For instance, statistics reveal that women are underrepresented in science-related and mathematics-related careers. According to the National Science Foundation (2004), women made up a staggering 46% of the labor force in all occupations, but only 22% of the science and engineering labor force.

In considering the statistics, one wonders why these ethnic and gender differences exist in the area of mathematics and science. Could these differences be a product of schooling in America? Do educators provide all students, regardless of ethnicity and gender, with a positive learning environment that instills positive attitudes toward mathematics and science? These questions were the starting point of our study, which aimed to investigate ethnic and gender differences in learning environment and attitudes in mathematics. By investigating gender and ethnic differences, this study hopefully will clarify factors that influence students' attitudes towards mathematics and perceptions of the classroom environment.

Theoretical Framework

Learning Environments

In the past, most research in mathematics education focused on student academic achievement. Very little attention was devoted to studying the learning environment as a determinant of learning outcomes. However, over the last 30 years, remarkable progress has been made in conceptualizing, assessing, and investigating the learning environment (Taylor, Fraser, & Fisher, 2007).

The evolution of the field of learning environments in the past three decades has seen the development of a variety of instruments that can be used to assess the classroom environment. The evolution of classroom environment instruments has facilitated learning environments research at the secondary and post-secondary level, such as in the studies conducted by Kim, Fisher, and Fraser (2005). The literature suggests that learning environments research is needed at all grade levels, Therefore, this study assessed high school mathematics students' perceptions of the classroom learning environment using the WIHIC and sought to investigate if grade level, gender, and ethnic differences in learning environment perceptions existed.

Student Attitudes toward Mathematics

The low number of women in scientific professions has become a national concern. It has been proposed that the attitude of girls toward mathematics is one factor that influences their lack of participation in science-related careers. This concern has resulted in a variety of studies designed to identify gender differences that could affect the number of girls in the scientific pipeline (Oaks, 2000). Particularly in the United States, boys hold more positive attitudes toward mathematics than do girls (Kahle, 2003; Kurth, 2007). These gender differences seem to predominate as students move from the elementary to the high school level (Kanai & Norman, 2007). For instance, research studies indicate that gender differences in attitudes toward mathematics do not exist in the elementary grades. In the middle school grades, gender differences begin to appear in attitudes toward mathematics and boys are more likely than girls to find mathematics interesting (American Association of University Women, 2002; Lockheed, Thorpe, Brooks-Gumn, Casserly, & McAloon, 2005; Oakes, 2000). By high school, few young women consider mathematics and science-related careers as desirable options. Experts attribute this phenomenon to the fact that, during the middle school years, adolescents formulate their gender identities and career aspirations (American Association of University Women, 2002; Oakes, 2000; Sadker, Sadker, & Klein, 2001). Therefore, this study aimed to investigate if gender and grade-level differences in attitudes toward mathematics exist among high school students.

METHODS

Instruments

Versions of the What Is Happening In this Class? (WIHIC) questionnaire and an attitude questionnaire based on the Test of Mathematics-Related Attitudes (TOMRA) were used in this study. The WIHIC is an instrument developed for assessing perceptions of classroom learning environments in terms of seven dimensions (Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity). The WIHIC questionnaire was originally developed by Fraser, McRobbie, and Fisher (1996) by combining the scales from past learning environment instruments that have been proven to be useful and significant reactors of learning outcomes with scales that are salient in modern-day classrooms such as cooperative learning and equity. The WIHIC was highly valid and reliable when used with high school students (Aldridge & Huang, 1999; Zandvliet, 2004).

I added a third scale, Student Self-Efficacy, to the attitude questionnaire to measure students' self-concept as it relates to their mathematics ability. A sample item from the Self-Efficacy scale reads "I am good at mathematics." This Self-Efficacy scale was based on Aldridge and Huang's (2003) adaptation of a scale developed by Jinks and Morgan (2000).

Research Approach

The research approach taken in this study made use of quantitative research method. The quantitative data were collected through the administration of the two questionnaires to investigate students' perceptions of the learning environment and their attitudes toward mathematics.

Sample

The data were gathered in an urban high public school located in a middle-class to upper-middle-class neighborhood in the Los Angeles County area of South California. The total number of participants in the study consisted of 600 students in Grades 9 and 10 in 30 integrated mathematics classrooms.

Data Analysis Method

Average item mean, average standard deviation, effect sizes (magnitude of differences), and F values from MANOVA were calculated for each of the scales of the WIHIC and attitude questionnaire utilizing the day gathered from the 600 high school mathematics students. These analyses were used to investigate differences in attitudes and learning environment perceptions of high school mathematics students according to grade level, gender, and ethnicity. To investigate the relationship between students' perceptions of the mathematics learning environment and their attitudes toward mathematics, simple correlation and multiple regression analyses at two units of analysis were conducted (individual and class mean).

RESULTS

In order to investigate grade level, gender, and ethnic differences in learning environment and attitude scores, a three-way MANOVA was conducted. The set of dependent variables consisted of seven learning environment scales assessed by the WIHIC and the three attitude scales. The independent variables were the two-level grade-level variable (Grades 9 and 10), the two-level gender variables (female and male), and a two-level ethnicity variable (Hispanic and Anglo).

Of the 600 students in the sample, 510 students could be reliably classified as either Hispanic or Anglo. The other 90 students consisted of relatively small groups with a variety of other ethnic backgrounds (e.g. Asian, Native American, and Multiracial). However, the smallness of the number of students in these other ethnic groups made it impossible to conduct meaningful data analyses, so these 90 students were excluded from the MANOVA. Because of the MANOVA yielded significant results for the set of 10 dependant variables as a whole (using Wilks' lamda criterion), the univariate ANOVA results were interpreted for each dependent variable. Table 1 shows ANOVA results obtained for each main effect and each criterion effect for each of the 10 classroom environment and attitude scales. Table 1 indicates that, overall, the MANOVA and 10 individual ANOVAs yielded a total of 10 cases in which the F ratio was statistically significant (p<0.05). Except for one significant ethnicity effect for Equity and a significant grade x ethnicity interaction, all of the other statically significant effects occurred for the grade effect. The results are discussed in subsections below, which are devoted to (1) grade-level differences, (2) gender differences, and (3) ethnic differences.

Table 1: MANOVA Results for Grade Level, Gender, and Ethnic Differences in Mathematics Students' Scores on the Seven Scales of the WIHIC and Three Attitude Scales.

Scale				***F***			
	Grade	Gender	Ethnicity	Grade × Gender	Grade × Ethnicity	Gender × Ethnicity	Grade × Gender × Ethnicity
Classroom Environment							
Student Cohesiveness	10.53**	0.10	0.45	0.13	0.44	3.47	0.26
Teacher Support	19.03**	0.35	1.18	0.12	3.94*	0.12	1.11
Involvement	1.08	0.83	1.43	2.19	0.21	1.21	0.05
Task Orientation	44.80**	0.11	3.04	0.06	3.70	0.78	0.05
Cooperation	3.44	0.65	0.03	0.27	0.10	0.14	1.05
Equity	4.37*	3.26	5.73*	0.40	2.86	1.33	0.08
Investigation	1.26	2.09	0.70	1.24	0.11	2.08	0.12
Attitude							
Attitude to Inquiry	8.92**	3.28	2.35	0.23	1.73	0.35	0.12
Enjoyment of Mathematics Lessons	0.20	1.26	0.71	0.00	1.41	2.75	0.19
Student Self-Efficacy	7.05**	0.36	2.21	0.28	0.95	0.22	1.14

**p*<0.05 ***p*,0.01

N=298 Hispanics, 212 Anglos, 234 males, 276 females, 245 Grade 9 students, and 265 Grade 10 students.

Grade-Level Differences

Regarding grade-level differences, the MANOVA results in Table 1 show that statistically significant result ($p<0.05$) occurred for the four learning environment scales of Student Cohesiveness, Teacher Support, Task Orientation and Equity and for the two attitude scales of Attitude to Inquiry and Student Self-Efficacy.

Table 2: Average Item Mean, Average Item Standard Deviation, and Effect Size for Grade-Level Differences for Seven WIHIC Scales and Three Attitude Scales.

	Average Item Mean[a]		Average Item Standard Deviation		Difference Between Grades[b]
Scale	Grade 9	Grade 10	Grade 9	Grade 10	Effect Size
Classroom Environment					
Student Cohesiveness	3.15	3.42	1.20	0.77	0.27**
Teacher Support	4.30	3.90	0.84	1.00	-0.43**
Involvement	4.05	3.95	0.76	0.91	-0.12
Task Orientation	4.25	3.68	0.82	0.93	-0.65**
Cooperation	4.09	3.93	0.78	0.92	-0.19
Equity	3.88	4.02	0.86	1.01	0.15*
Investigation	4.03	3.93	0.78	0.92	-0.12
Attitudes					
Attitude to Inquiry	3.95	4.16	0.86	0.94	0.23**
Enjoyment of Math Lessons	4.16	4.17	0.91	1.00	0.01
Student Self-Efficacy	4.11	3.87	0.91	0.88	-0.27**

N=245 Grade 9 and N=265 Grade 10 mathematics students.

[a] Average item mean=Scale mean divided by the number of items in that scale.

*$p<0.05$, **$p<0.01$

[b] Significance levels are taken from the MANOVA results in Table 1.

The interpretation of the results for grade-level differences is illustrated in Table 2, which provides the average item mean and average item standard deviation for each scale in Grade 9 and Grade 10. (The average item mean is simply the scale mean divided by the number of items in that scale, and it facilitates meaningful comparisons between scales containing differing number of items.) The last column in Table 2 reports the magnitudes of grade-level differences (as distinct from their statistical significance) in terms of effect sizes. The effect size for a scale is the difference between the Grade 9 and Grade 10 mean divided by the pooled standard deviation. It expresses a difference between grades in standard deviation units.

Finally, the statistically significance results from MANOVA in Table 1 have been included in the last column of Table 2 as significance levels. Table 2 shows that the effect sizes for the six statistically significant grade-level differences range from 0.15 to 0.65 standard deviations. These magnitudes suggest that there are some educationally noteworthy grade-level differences. Whereas there was an increase in Student Cohesiveness, Attitude to Inquiry, and Equity scores between Grades 9 and 10, there was a decline between Grades 9 and 10 on each of the other three scales (Teacher Support, Task Orientation, and Student Self-Efficacy).

Gender Differences

Regarding gender differences, Table 1 shows that MANOVA revealed no statistically significant gender differences for any of the 10 learning environment and attitude scales. Table 3, which reports average item means and effect sizes, confirms this pattern in that the magnitudes of the gender differences on the 10 scales are quite small (ranging from only 0.00 to 0.16 standard deviations). Nevertheless, although the magnitude of the gender difference is quite small for each scale, the direction of the difference is in a consistent direction. Females consistently reported slightly more positive perceptions of classroom environment and attitudes than did males.

Table 3: Average Item Mean, Average Item Standard Deviation, and Effect Size for Gender Difference for Seven WIHIC Scales and Three Attitude Scales.

	Average Item Mean[a]		Average Item Standard Deviation		Difference Between Grades[b]
Scale	Male	Female	Male	Female	Effect Size
Classroom Environment					
Student Cohesiveness	3.29	3.29	0.99	1.03	0.00
Teacher Support	4.07	4.12	0.87	1.00	-0.05
Involvement	4.03	3.97	0.82	0.86	0.07
Task Orientation	3.97	3.94	0.88	0.96	0.03
Cooperation	4.04	3.98	0.91	0.97	0.15
Equity	4.03	3.89	0.91	0.97	0.15
Investigation	4.04	3.93	0.83	0.87	0.13
Attitudes					
Attitude to Inquiry	4.13	3.99	0.80	0.99	0.16
Enjoyment of Math Lessons	4.21	4.13	0.90	1.00	0.08
Student Self-Efficacy	4.02	3.96	0.88	0.91	0.07

N=245 Grade 9 and N=265 Grade 10 mathematics students in Los Angeles County, California.

[a] Average item mean=Scale mean divided by the number of items in that scale.

[b] Significance levels are taken from the MANOVA results in Table 1.

Ethnic Differences

Tables 1 and 4 show that ethnic differences on the 10 environment and attitude scales are small (with effect sizes ranging from 0.02 to 0.22 standard deviations) and are statistically significant only for the Equity scale. However, an interesting pattern is that the direction of the small ethnic difference is consistent for all 10 scales. For each environment and attitude scale, Anglo students' scores are a little higher than Hispanic students' scores.

Table 4: Average Item Mean, Average Item Standard Deviation, and Effect Size for Ethnic Difference for Seven WIHIC Scales and Three Attitude Scales.

	Average Item Mean[a]		Average Item Standard Deviation		Difference Between Grades[b]
Scale	Hispanic	Anglo	Hispanic	Anglo	Effect Size
Classroom Environment					
Student Cohesiveness	3.27	3.31	1.01	1.01	0.04
Teacher Support	4.05	4.16	1.01	0.85	0.12
Involvement	3.96	4.05	0.86	0.80	0.11
Task Orientation	3.89	4.05	0.98	0.83	0.18
Cooperation	4.00	4.02	0.86	0.85	0.02
Equity	3.87	4.07	0.98	0.88	0.22*
Investigation					
Attitudes					
Attitude to Inquiry	4.00	4.13	0.94	0.86	0.14
Enjoyment of Math Lessons	4.14	4.21	1.01	0.88	0.07
Student Self-Efficacy	3.93	4.06	0.92	0.86	0.15

N=245 Grade 9 and N=265 Grade 10 mathematics students in Los Angeles County, California.
*$p < 0.05$
[a] Average item mean=Scale mean divided by the number of items in that scale.
[b] Significance levels are taken from the MANOVA results in Table 1.

Associations between each of the three attitude scales (Attitude to Inquiry, Enjoyment of Mathematics Lessons, and Student Self-Efficacy) and the seven learning environment scales were explored using simple correlation and multiple regression analyses. The simple correlation analyses provide information about the bivariate association between each learning environment scale and each attitude scale. The multiple regression analyses reduces the Type I error rate and provided a more parsimonious picture of the joint influence of correlated learning environment scales on attitudes. All analyses were conducted twice, once with the individual student as the unit of analysis and once with the class mean as the unit of analysis. Table 5 shows that the simple correlation between an environment scale and an attitude scale is statistically significant in all 21 cases with the student as the unit of analysis, and in 17 cases with the class as the unit of analysis (with the exception being the Attitude to Inquiry with Teacher Support and Task Orientation and for Student Self-Efficacy with Student Cohesiveness and Equity). In every case, statistically significant correlations are positive, confirming a positive relationship between attitude and learning environment scales.

The bottom of table 5 shows that the multiple correlation between each attitude scale and the set of seven learning environment scales is statistically significant with either the individual or the class as the unit of analysis. In order to interpret which individual learning environment scales were responsible for explaining the significant multiple correlations, the standardized regression weights in Table 5 were examined, with the following findings:

Table 5: Simple Correlation and Multiple Regression Analyses for Relationship between Learning Environment and Attitude Scales for Two Units of Analysis

Scale	Unit of Analysis	Attitude to Inquiry		Enjoyment of Mathematics Lessons		Student Self-Efficacy	
		r	*β*	*r*	*β*	*r*	*β*
Student Cohesiveness	Individual	0.38**	0.70**	0.35**	0.05	0.32**	0.04
	Class	0.55**	0.36	0.56**	0.33*	0.34	0.11
Teacher Support	Individual	0.58**	-0.06	0.61**	0.09*	0.58**	0.06
	Class	0.34	-0.43	0.59**	-0.08	0.68**	-0.03
Involvement	Individual	0.73**	0.33**	0.70**	0.23**	0.67**	0.23
	Class	0.61**	0.30	0.73	0.06	0.76**	0.11
Task Orientation	Individual	0.58**	0.07	0.06**	0.09*	0.65**	0.25**
	Class	0.30	0.18	0.54**	-0.05	0.83**	0.49**
Cooperation	Individual	0.71**	0.25**	0.70**	0.25**	0.66**	0.16**
	Class	0.63**	0.32	0.72**	0.09	0.63**	0.11
Equity	Individual	0.61**	0.16**	0.56**	0.02	0.49**	-0.06
	Class	0.60**	0.35*	0.44*	-0.11	0.28	-0.12
Investigation	Individual	6.67**	0.10*	0.68**	0.18**	0.65**	0.19**
	Class	0.58**	-0.06	0.82**	0.74**	0.82**	0.35
Multiple Correlation (R)	Individual		0.79**		0.77**		0.75**
	Class		0.82**		0.88**		0.91**

*p<0.05 **p<0.01

N=600 students from 30 classes in one high school in Los Angeles County, California.

- For Attitude to Inquiry and with the student as the unit of analysis, Student Cohesiveness, Involvement, Cooperation, Equity and Investigation were all statistically significant independent predictors of attitudes when the other environment scales were mutually controlled.
- For Attitude to Inquiry and with the class of the unit of analysis, only Equity was a statistically significant independent predictor of attitudes.
- For Enjoyment of Mathematics Lessons and with the student as the unit of analysis, Teacher Support, Involvement, Task Orientation, Cooperation and Investigation were all statistically significant independent predictors of attitudes.
- For Enjoyment of Mathematics Lessons and with the class mean as the limit of analysis, Student Cohesiveness and Investigation were statistically significant independent predictors of attitudes.
- For Student Self-Efficacy and with the student as the unit of analysis, Involvement, Task Orientation, Cooperation and Investigation were all statistically significant independent predictors of attitudes.
- For Student Self-Efficacy and with the class as the unit of analysis, only Task Orientation was a statistically significant independent predictor of student attitudes.

It is noteworthy that every statistically significant regression weight in Table 5 is positive. Overall, the results in Table 5 provide strong evidence of associations between students' attitudes and their perceptions of classroom environment as assessed by the WIHIC.

CONCLUSION

The data gathered were analyzed to investigate grade level, gender, and ethnic differences in learning environments perceptions and attitudes. Additionally, the relationships between the nature of the classroom learning environment as assessed with the WIHIC and students' attitudes toward mathematics were explored. The key findings are (1) Some educationally noteworthy grade-level differences were found. For instance, an increase in Student Cohesiveness, Attitude to Inquiry, and Equity scores between Grades 9 and 10 were found. Also, a decline between Grades 9 and 10 on Teacher Support, Task Orientation, and Student Self-Efficacy were found; (2) Small and statistically nonsignificant gender differences for each learning environment and attitude scale were found. However, males consistently reported slightly more positive perceptions of classroom environment and attitudes that did females; (3) Small ethnic differences on the 10 environment and attitude scales were found, with a statistically significant difference only on the Equity scale. However, for each environment and attitude scale, Anglo students' scores consistently are a little higher the Hispanic students' scores; and (4) Strong evidence of associations between students' attitudes and the learning environment was found.

This study is of significance to the field of learning environments. First, the present research study provides further results about ethnic, gender, and grade-level differences in high school mathematics students' perceptions of the learning environment and their attitudes toward mathematics. This is noteworthy because very few learning environment studies have looked at these three factors when studying the learning environment and/or student outcomes. Additionally, results of this research add another study to the strong and common line of past classroom environments research, namely, the investigation of outcomes-environment associations.

Most importantly, this study is significant because it provides information about how students from different grade levels, ethnicities, and gender perceive their mathematics classroom environment and what attitudes they have toward mathematics. The results are likely to be especially helpful for educators, educational policy-makers, parents, and/or community members who will be able to read the results and determine if the findings can assist them in advocating for funding at local, state and federal venues to increase educational reform that will help narrow the gap between grade levels, gender, and ethnicities in classroom environment perceptions and attitudes toward mathematics.

With the increasing need for more workers in science-related and mathematics-related careers, ensuring that more high school students, regardless of grade level, ethnicity, and/or gender status, perceive a more positive mathematics classroom environment and have better attitudes toward mathematics is a worthwhile goal to pursue.

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