DOCUMENT RESUME

ED 476 644 SE 067 960

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TITLE	The Influence of Classroom Environment on High School Students' Mathematics Anxiety.
PUB DATE	2003-04-21
NOTE	11p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, April 21, 2003).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	*Classroom Environment; Evaluation; *Mathematics Anxiety; Perception; Secondary Education

ABSTRACT

This study investigates associations between the classroom environments perceived by high school students and their level of mathematics anxiety. A revised and updated version of the Plake and Parker Revised Mathematics Anxiety Ratings Scale (RMARS) was used to assess students' mathematics anxiety. A revised version of the What is Happening in This Class (WIHIC) survey was used to assess students' perceptions of the following aspects of the mathematics classroom learning environment: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity. This study provides valuable information regarding the validity and reliability of the RMARS for assessing mathematics anxiety. There was statistical significance between two of the learning environment scales and one of the mathematics anxiety factors. (KHR)

The Influence of Classroom Environment on High School Students' Mathematics Anxiety

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The two distinct research areas of mathematics anxiety and learning environments each have separately yielded a great amount of information regarding students' feelings and perceptions in the mathematics classroom. But, while each area has provided educators and researchers with rich insights, hardly any research has attempted to bring the two fields together. Our study attempted to do that.

Objectives

The purpose of this research was to investigate associations between the classroom environments perceived by high school students and their level of mathematics anxiety. Investigating the reliability and validity of the instruments used was also a major purpose of this research as well.

Theoretical Framework

The study of mathematics anxiety progressed with the creation of the Mathematics Anxiety Ratings Scale (MARS) (Richardson & Suinn, 1972; Suinn, Edie, Nicoletti, & Spinelli, 1972) in the early 1970s. This survey allows researchers to probe the level of mathematics anxiety that a person feels, both in and out of the classroom environment. This initial research tool spawned many others, including revised versions of the MARS (Alexander & Martray, 1989; Plake & Parker, 1982), the

Paper presented at the annual meeting of the American Educational Research Association, Chicago, April 2003.

Mathematics Anxiety Questionnaire (Wigfield & Meece, 1988), and the Fennema-Sherman Mathematics Attitude Scale (Fennema & Sherman, 1976).

All of these instruments attempt to identify the level of mathematics anxiety by measuring the feelings and emotions associated with mathematics situations. The causes of mathematics anxiety, however, are not that easily discernable according to Martinez and Martinez (1996):

> Mathematics anxiety is complex. It rarely follows a straightforward, single-cause/single-effect, linear progression. It has multiple causes and multiple effects... (p. 6)

Martinez and Martinez go on to state that identifying that someone is mathematics anxious only defines the symptom, not the cause of the anxiousness. Because of this, it is difficult to pinpoint the various components surrounding a student's mathematics anxiety, some of which can be internal and some which can be environmental. This research investigated the learning environment in which students find themselves as an important determinant of the level of anxiety which students feel.

One area that has been agreed upon by many researchers as a key element in mathematics anxiety is the role of the teacher in the classroom (Martinez & Martinez, 1996; Tobias, 1978; Zaslavsky, 1994). But the learning environment encompasses more than just the teacher's role in education. It focuses on many aspects and interactions found in the classroom.

Learning environments research has its roots in the work of Herbert Walberg and Rudolf Moos and their individual attempts at studying students' perceptions of various learning situations (Walberg & Anderson, 1968; Moos, 1979). From this foundation, the study of learning environments has flourished and expanded into many areas over the previous few decades (Fraser, 1994, 1998; Fraser & Walberg, 1991; Goh & Khine, 2002).

By using research tools from learning environment research, it was hoped to improve our understanding of factors that influence mathematics anxiety and, subsequently, to guide improvements for students suffering from mathematics anxiety.

Methods & Techniques for Research

One of the more powerful trends in research today is the combining of qualitative and quantitative research methods to obtain a clearer picture (Fraser & Tobin, 1991; Tobin & Fraser, 1998). This approach allows a triangulation of data, which is fundamental in obtaining validity in research (McKnight et al., 2000).

In our research, quantitative data were obtained through the use of two well-documented tools. First, a revised and updated version of the Plake and Parker Revised Mathematics Anxiety Ratings Scale (RMARS) (1982) was used to assess students' mathematics anxiety. Second, a revised version of the What is Happening in this Class (WIHIC) survey (Aldridge & Fraser, 2000; Fraser & Chionh, 2000; Fraser, McRobbie, & Fisher, 1996) was used to assess students' perceptions of the following aspects of the mathematics classroom learning environment: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity. Using simple correlation and multiple regression analyses, data obtained from administering these scales were inter-related to identify relationships between mathematics anxiety and classroom environment characteristics. Factor analysis and reliability coefficients were also used to check the validity and reliability of the instruments and to identify salient factors.

A standardized open-ended interview using extreme case sampling was implemented to amplify and clarify the findings from the quantitative data collection (Patton, 1990). This allowed possible confirmation or denial of the survey findings by questioning students, who had either extremely high or very low mathematics anxiety, regarding their perceived classroom environment and its effect on their anxiety level.

Data Sources

Data were collected from high-school students (Grades 9-12) from four schools in the Southern California area. These co-educational high schools, both public and parochial, have diverse cultural and socioeconomic settings. The sample of 745 students from over 40 classes was satisfactory for carrying out the various statistical analyses required. Selected mathematics classrooms across all grade levels from each school were used in the research. A breakdown of the grade levels is found in Figure 1. Approval from school administrations and guardians was obtained.

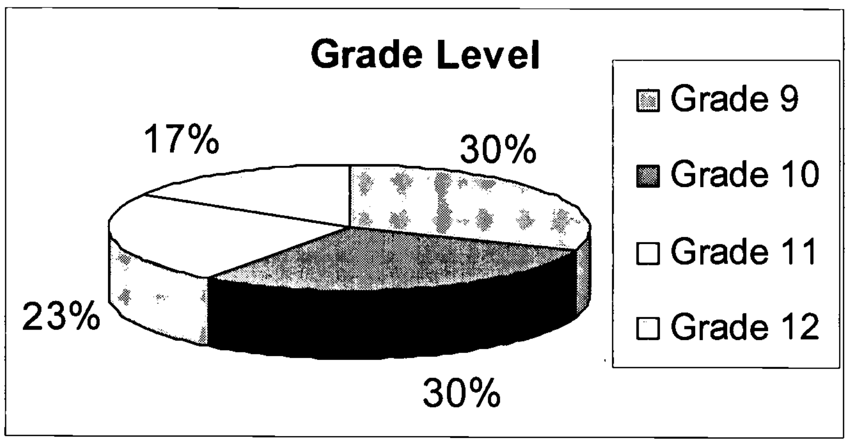

Figure 1. Percentage of the Sample from Each Grade Level

Factor Analysis and Reliability

The RMARS was investigated by use of factor analysis and Cronbach alpha reliability estimates. Similar analyses of the WIHIC instrument are forthcoming. However the strong factorial validity and reliability of the WIHIC has been consistently demonstrated in studies in Australia and Taiwan (Aldridge & Fraser, 2000), Singapore (Fraser & Chionh, 2000) and Canada (Raaflaub & Fraser, 2002).

Factor analysis was carried out by using principal component analysis involving scree plots, eigenvalues of factors greater than one, and using a varimax rotation method with Kaiser normalization.

Results

The RMARS was found to have a Cronbach alpha coefficient of 0.94 and a standardized alpha coefficient also of 0.94. This confirms, even with some minor adaptations and revisions, the high reliability of this instrument. The Learning Mathematics Anxiety Factor had an alpha of 0.92 and the Mathematics Evaluation Anxiety Factor alpha was 0.91.

Factor analysis of the RMARS yielded confirmation of the findings of Plake and Parker, even after the revisions and adaptations performed. They found two factors were salient in the original findings: Learning Mathematics Anxiety and Mathematics Evaluation Anxiety. The findings for this factor analysis are almost identical, except for a few minor substitutions within the factors. See Table 1 for salient items in each factor.

Table 1
Factor Analysis of RMARS

Learning Mathematics Anxiety (LMA) **Item**	Factor Loading
1. Watching a teacher work an algebra equation on the blackboard.	.68
2. Being given a mathematics textbook on the first day of class.	.53
3. Solving a square root problem.	.60
4. Reading and interpreting graphs and charts.	.55
5. Getting your schedule and seeing a mathematics class on it.	.74
6. Listening to another student explain a mathematics formula to you.	.69
7. Walking into a mathematics class.	.77
8. Looking through the pages of a mathematics textbook	.69
9. Starting a new chapter in a mathematics class.	.70
10. Walking onto campus and thinking about a mathematics course.	.65
11. Picking up a mathematics textbook to begin working on a homework assignment.	.66
12. Reading a word associated with mathematics, such as "geometry" or "average".	.63
13. Listening to a lecture in a mathematics class.	.65
14. Having to use a calculator or table to solve a problem.	.75
15. Being told how to solve an algebra equation or write a geometry proof.	.51

LMA Eigenvalue = 10.120
% of Variance = 42.168

Mathematics Evaluation Anxiety (MEA) Item	Factor Loading
1. Being given a homework assignment of difficult problems which is due the next class meeting.	.75
2. Thinking about an upcoming mathematics test the day before you take it.	.77
3. Taking an examination (quiz) in a mathematics course.	.81
4. Working on an abstract mathematical word problem.	.69
5. Reading a formula in a science class.	.53
6. Taking an examination (final) in a mathematics class.	.87
7. Getting ready to study for a mathematics test.	.71
8. Being given an unannounced quiz in a mathematics class.	.86
	MEA Eigenvalue = 2.915 % of Variance = 12.145

Salient factors > .50 factor loading
Response alternatives for the RMARS range from not at all anxious to very anxious using a 5 point Likert scale.

Table 2 reports the simple correlation and multiple regression analyses for associations between each factor of mathematics anxiety and classroom learning environment. The simple correlation analyses using Pearson product-moment correlation coefficients revealed that Student Cohesiveness had a statistically significant ($p < 0.01$) and negative association with the Learning Mathematics Anxiety factor, while Task Orientation and Cooperation were also statistically significantly correlated.

The multiple regression analysis, with the LMA factor as the dependent variable, yielded a significant relationship for Student Cohesiveness ($p<0.01$) and Investigation ($p<0.05$). It appears that, with the other WIHIC scales mutually controlled, mathematics anxiety is lower in classes with more Student Cohesiveness and less Investigation.

Table 2
Simple Correlation and Multiple Regression Results for Associations Between Factors of RMARS and Classroom Environment

Environment Scale	LMA Factor		MEA Factor	
	r	β	r	β
Student Cohesiveness	-0.14 ***	-0.31 ***	-0.04	-0.15
Teacher Support	-0.04	-0.01	0.03	0.04

Involvement	-0.01	0.02	-0.02	-0.02
Investigation	0.05	0.14 *	0.01	0.01
Task Orientation	-0.09 *	-0.07	-0.03	-0.04
Cooperation	-0.08 *	-0.01	0.02	0.01
Equity	-0.07	-0.04	0.01	0.01
Multiple Correlation, *R*		0.160 ***		0.074

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

Multiple regression and correlation analysis between the learning environments scales and the Mathematics Evaluation Anxiety factor did not yield any significant correlations nor a significant predictive relationship between the scales and MEA either.

Conclusion

First, the study provided valuable information regarding the validity and reliability of the Revised Mathematics Anxiety Ratings Scale (RMARS) for assessing mathematics anxiety. The high alpha coefficient and factor analysis results confirm that the RMARS is still a valid tool in its third decade of use.

Secondly, while the multiple regression analysis yielded statistically significance between two of the learning environment scales and one of the mathematics anxiety factors, the results seem to point towards high collinearity. With further factor analysis, this analysis may more clearly define relationships between these two areas.

There are many opportunities for further research in this area. Further research into factor structure and reliability, especially of the WIHIC, is needed. Through this analysis, a better view of the dimensions of learning environments and their relationship to mathematics anxiety is likely to emerge. Qualitative data still needs to be evaluated in order to confirm and clarify possible relationships. Lastly, it is hoped that this research will lead to a better understanding of, and to practical improvements for, those students suffering from mathematics anxiety through its identification of associations between their anxiety levels and what is taking place in their classroom settings.

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