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Standards-based Mathematics Curriculum and Hispanic Middle School Students' Attitudes and Classroom Experiences

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Abstract

Sixth-grade, Mexican American, middle school students completed a survey which gauged attitudes toward mathematics and the frequency of traditional and nontraditional classroom activities, following the implementation of a standards-based curriculum. Analysis of variance procedures were conducted using Gender, Ethnicity, and School as main factors. The results indicated that on average students held favorable attitudes toward mathematics, and they experienced primarily nontraditional classroom activities. There was a significant gain in achievement scores as measured by the Texas Assessment of Knowledge and Skills test. The implications are that a standards-based curriculum promotes favorable attitudes in middle school mathematics students and encourages teachers to use nontraditional methods of instruction while improving student achievement.

Accountability in the State of Texas has been "a fact of life" for school districts in the State since the mid eighties. At that time, students were tested for basic skills. Students are assessed at a higher cognitive level on the Texas Assessment of Academic Skills (TAAS) test. The test calls for students to respond to items that measure deeper understanding of mathematics concepts. The implication is that teachers in Texas have to teach for deeper conceptual understanding of mathematics. There is general agreement that the quality of school mathematics programs must be improved to afford all students an opportunity to succeed in mathematics (Reys, Reys, Lapan, Holliday, & Wasman, 2003) and pass the test. One avenue to achieve success for all in mathematics is through providing a Standards-based curriculum, which has the potential to offer a great opportunity to teach mathematics for deeper understanding (Senk & Thompson, 2003).

A standards-based program develops student knowledge and understanding of mathematics by focusing on connections among the core ideas of mathematics, and applications outside of school (Ridgway, Zawojewski, Hoover, & Lambdin, 2003). Moreover, a standards-based curriculum (e.g., Connected Mathematics) is organized around interesting problem solving activities that are designed to involve groups of students and encourages discourse and reflective writing, incorporating practice with computation and symbolic manipulation to build conceptual foundations for the skills (Ridgway, et al, 2003).

Questions remain whether a standards-based curriculum is beneficial for all students, teachers, and situations (Chappell, 2003; Ridgway, et al, 2003). Although some researchers (e.g., Garofalo, 1989; Schoenfeld, 1985; Underhill, 1988) have conducted studies on the affective domain, very few studies have been conducted with Latino(a) student populations (e.g., Telese, 1999). Research conducted with minority student populations has generally focused on cultural influences on the learning of mathematics (e.g. Khisty, 1995; McLeod, 1992; Orr, 1987). When examining how students interact with different curricula, it is important to examine affective factors (Chappell, 2003). The purpose of the present study was to determine Mexican-American students' attitudes towards mathematics after they have experienced a standards-based mathematics curriculum.

The study sought answers to the following research questions:

1. What is the attitude toward mathematics of middle school, Mexican American students upon experiencing a standards-based curriculum?
2. What types of classroom activities occur in middle school mathematics classrooms when a standards-based curriculum is being implemented throughout a school district?
3. What are the differences in attitudes toward mathematics of Mexican American middle school students and their perceptions of classroom activities?

The Importance of Examining Beliefs and Attitudes

Research on the affective domain has maintained an active role in mathematics classroom research. Students have particular needs that must be addressed during mathematics instruction. Meeting the needs of students requires the identification of the beliefs and meanings that both the teacher and the students bring with them into the learning process (Nickson, 1992). The affective domain was considered by Koehler and Grouws (1992) when they described various levels of mathematics classroom research. Of the four described levels, one level assumed that pupil characteristics include attitudes as well as achievement. Another level included cultural factors such as students' gender, race, ethnicity, socioeconomic status, and confidence level that can affect teacher practice and student behavior. The mathematics classroom is an arena where students build and establish particular beliefs regarding mathematics teaching and learning, and a place where these beliefs develop gradually over time (McLeod, 1992).

Just as teachers should be aware of their students' beliefs and attitudes toward mathematics, other important individuals such as parents and counselors should also have a similar awareness of what attitudes students have towards mathematics since parents and guardians can help support positive attitudes at home. Both teachers and counselors may use the information to adjust instructional practices that may promote positive attitudes toward mathematics and to promote success in other mathematics courses.

A study conducted by the National Action Council for Minorities in Engineering [NACME] (1995) revealed that 60 percent of Latino students intended to drop mathematics at the first opportunity. Poor student attitudes toward mathematics can influence teachers' recommendations for students to enroll in advanced courses. The NACME (1995) study showed that only 53 percent of the students surveyed indicated that they were encouraged by their teachers to take more advanced mathematics and science. Ultimately, attitudes and beliefs toward mathematics play a critical role in future career choices (Thorndike-Christ, 1991). Other researchers (e.g., Eccles & Jacobs, 1986; Watt & Bornholt, 1994) have found that attitudes toward mathematics affect their school mathematics course selection, as well as career choices (Watt, 1995). Thus, a lack of guidance and direction coupled with negative attitudes may further reduce high school students' enrollment in other high school mathematics classes and impact on the influence of future career pathways in mathematics or science.

Success generally breeds success. Students who do well in a mathematics class tend to develop a positive self-image. The role of attitudes and its relationship to achievement was examined by Singh, Granville, & Dika (2002). They accumulated research that suggested attitudes, among other constructs, are critical to learning. A path analysis revealed that attitudes and interest influence achievement. The affective factors can be modified through the use of innovative curricula and instructional approaches. Hence, when students experience a challenging curriculum, centered on problems and interesting topics, their attitudes and achievement tend to be positively impacted.

Moreover, attitudinal differences have been found between genders. Watt (2000) conducted a study of junior high students in Australia. It was found that boys had higher perceptions of mathematics talent than girls, with high achievers having a greater perception of their ability than lower achievers. Boys are expected to be more successful in mathematics than girls. Watt did not indicate which gender perceived mathematics to be most difficult. However, by the end of the year, the students perceived mathematics becoming more difficult by achievement levels with higher achievers rating the difficulty less than the low achievers. In this study, the implication is that both genders perceived the difficulty at the same level as students did in the utility of mathematics. However, regarding gender, the researcher found that girls indicated more effort, as a reflection of attitude, toward the end of the year than boys, while boys indicated greater effort early in the year. The researchers concluded that boys had more positive mathematics-related perceptions than girls. Watt's study supported that idea of a socialization process that reinforces boys' abilities and challenges girls' abilities in domains thought to be male oriented.

Understanding in Mathematics

The previous discussion indicated the importance of attitudes related to student achievement in mathematics. As mentioned, when students are successful at learning then their attitudes tend to be favorable toward the content. Understanding leads to learning and standards-based curriculum is thought to provide a foundation for developing deeper understanding of mathematical concepts.

Teaching for understanding is a complex, developmental process and counters the presumption that a student simply does not or cannot understand. Complex ideas or processes can be understood at various levels (Carpenter & Lehrer, 1999). Teaching for meaning assists in the development of understanding. It involves showing students the relationship between discrete skills and their real world application through communicating ideas, reasoning, using tools, and making connections among concepts (Knapp, Shields, & Turnbull, 1995).

The mathematics task plays a role in teaching for understanding (Romberg & Kaput, 1999). The task should encourage discourse, even though it is difficult to elicit. In a study by Spillane and Zeuli (1999), mathematics teachers were identified by their teaching strategies that were consistent with reform efforts. Yet, based on observations, Spillane and Zeuli found only a small percentage of teachers using tasks that were likely to engage students in mathematics. Few created an environment suitable for making and revising conjectures, reasoning mathematically, and justifying positions. All of which may lead to the development of critical thinking skills. Teaching for understanding contributes to the generation of new mathematics knowledge, recalling information, and application of knowledge to novel situations (Hiebert & Carpenter, 1992). Evidence from the 1996 NAEP data analysis suggests that when higher-order thinking skills and hands-on activities are used, students had higher overall achievement on the NAEP assessment than students whose teachers did not emphasize those skills (Grouws & Smith, 2000; Wenglisly, 2000). Teaching for understanding also has a positive impact on low-achieving students in high-poverty schools (Knapp, Adleman, et al, 1995).

The task is the vehicle to engage learners in mathematical activity. Tasks should be designed in such way that focus students' attention on investigations of problem situations (Fennema & Romberg, 1999). Mathematics tasks should begin by building on learners' informal knowledge of the ideas in a domain to more formal notions with no one correct sequence of concepts and activities within any domain. The tasks are the roads to which learners come to investigate increasingly complex situations within and across mathematical topics (Fennema & Romberg, 1999).

The task characteristics should include an opportunity for learners to engage in meaningful inquiry by building models, evaluating models, and if necessary, revising the models. This sequence is common practice in the mathematical community (Fennema & Romberg, 1999). The process of modeling ranges from constructing physical models to the development of abstract models as a result of encountering a situation worthy of investigation. The finding of a solution requires both recognizing the essential features of a situation and a constant monitoring of the model building process, which may lead to exploration and further identification of big ideas in a domain (Fennema & Romberg, 1999). Another characteristic of the task is the capability to stimulate assertions and their justification that stem from the investigations. The solution process includes posing and evaluating questions based on experience with current and previous task, and previous tasks, proposing and developing alternative explanations, gathering evidence, representing and presenting that information to the larger group. The tasks should be relevant to the real world and accomplishable with the use of tools and technology.

However, there may be an inherent danger when connecting mathematics to real world settings or into a specific context. Zevenbergen (2000) found that students from different socioeconomic backgrounds performed equally well on decontextualized tasks but differed on contextualized tasks. Hence, the selection of contexts may assist in fostering inequity when the tasks are related to the students' background experiences.

The above discussion implies that problem solving is at the center of teaching mathematics for understanding. Higgins (1999) conducted a year-long study on the use of problem solving in middle school, including the impact on attitudes. Students were found to have developed greater confidence in facing mathematical problems and were more likely to find mathematics to be useful or relevant to their daily lives. Similarly, Gay (1999) found that a majority of the students had confidence in themselves to solve problems as a result of engaging in a problem solving environment.

Teaching mathematics for understanding should be made approachable for all students. The idea of mathematical understanding for all brings into play the notion of equity. Does teaching for understanding, or standards-based curriculum, benefit particular students? There is a danger that if equity concerns are not addressed, then group differences may be exacerbated (Secada & Williams-Berman, 1999). Thus, a standards-based program provides a contextually based curriculum that offers an opportunity for students to learn concepts and develop favorable attitudes.

Methodology

Participants

Participants consisted of sixth grade students in a large school district in deep South Texas located along the Rio Grande River, which had six middle schools. There was a total of 1,193 out of 1250 sixth-grade students who completed the surveys. There were 599 female students and 569 male students, 25 students failed to report their gender. The ethnic break down consisted of 957 Mexican Americans, 50 European Americans, 25 Asian Americans, and 128 students who indicated "other" as a choice for ethnicity. School A had 284 students, Schools B 231, School C 222, School D 98, School E 148 students and School F 207 students while three students failed to report what school they attended.

Background of the Schools

The District's mathematics curriculum coordinator provided background information related to the schools. The data were collected through teacher interviews, site visits, and classroom observations. In School D, one teacher used the curriculum 100 percent of the time while other teachers used the curriculum in an "on-off" fashion. The coordinator reported that this school struggled with its achievement test scores.

School E was the school with the greatest percentage of students from low SES families. Many students came from poverty-stricken homes in the "colonias." Colonias are unincorporated, underdeveloped settlements along the Texas-Mexican border. Colonias typically lack water, sewer systems, electrical services, and safe, sanitary housing; however, this does not stop the thousands of residents who dream of owning a home and purchasing land in these underdeveloped settlements. At this school, again one teacher used the curriculum exclusively while three used it most of the time to develop questioning skills. The other teachers used the curriculum three days and on the other two, days used a different program or they presented it on a two-day Connected Mathematics Program (CMP) and for three days used another curriculum.

School F was a school where all the teachers taught using CMP. One teacher struggled with the curriculum. Teachers felt that there was not enough "content" in CMP. The teachers at this school did not attend the 90 hours of training provided by the district.

At School C, 50 percent of the students were from upper SES families. There was also a high rate of parental involvement. It was reported from the PTA President to the District's mathematics coordinator, that the parents did not hold a favorable view of the curriculum. One teacher used the curriculum 75 percent of the time. Two teachers in the school needed a lot of support to implement the curriculum due to the teachers' poor mathematics background. Two other teachers had a science background. Two teachers were trained in the beginning but there was a lack of coherence in the way the CMP was implemented, and these two teachers had negative comments concerning the program. Eighteen months later, these same two teachers expressed their pleasure with the program and acknowledged that they had struggled with the shift from the traditional pedagogy they had experienced as students and in which they had been trained previously.

School B had a low rate of implementation of the curriculum. The teachers maintained a classroom environment where the desks were in straight rows. The teachers were authoritarian in the presentation of mathematics concepts, and they were not comfortable with the mathematics in CMP. There was a preponderance of direct instruction in this school and a high rate of teacher absences. Also, there was a noticeable lack of administrative support.

School A had a strong administration and supported the use of CMP. The school also provided support for teacher training. At this school, questioning skills rapidly developed. Teachers developed lesson plans together and met to reflect on the lesson presentations. A few teachers struggled with the program. The mathematics teachers were involved in professional development in mathematics content.

Instrument

The questionnaire consisted of 25 items adapted from the Fourth National Assessment of Educational Progress (Dossey, Mullis, Linquist, & Chambers, 1988) that focused on two areas: i) student attitudes and beliefs toward mathematics were addressed in items one through 10, and ii) the classroom activities experienced by the students were probed in items 11 through 25. The attitude and belief items included statements representing favorable attitudes toward mathematics,

such as “Math is interesting,” and “Math is fun.” Two items related to negative attitudes toward mathematics included statements such as “Math is mostly memorizing,” and “There is always a rule to follow when doing math.” The students responded to the first ten attitude/belief items using a Likert-scale from one to five where a one represented that the student strongly disagreed and a five represented that the student strongly agreed with the statement.

The next 15 items were statements that described classroom activities associated with traditional and non-traditional activities. For this section, the Likert-scale represented the frequency with which the student experienced the activity, where a one meant “never” and a five meant “a lot.” The traditional activities such as teacher led presentations and completing worksheets were included to represent the “school mathematics tradition” and the non-traditional activities, such as completing mathematics projects and making up their own problems were included to represent the “Growth and Change View” of mathematics. Four items from the classroom activity section of the questionnaire were considered transitional items. They were categorized by two statements, “Take math tests and quizzes,” and “Students explain how they solve math problems.” The questionnaire was administered to students in each of the six middle schools.

An exploratory factor analysis using a principal component analysis was conducted on three hypothesized factors: i) Attitude Toward Mathematics, ii) Traditional Mathematics Classroom Activities, and iii) Non-traditional Mathematics Classroom Activities. This was followed by a Promax rotation on all the items to determine latent structure. Cronbach Alpha coefficients were produced for the entire survey, the subscales-traditional, and non-traditional activities.

Data Analysis

The data were analyzed using the statistical package SAS (1990) program, including exploratory factor analysis. Descriptive and inferential tests such as two-and three-way ANOVAs were conducted for the main factors Gender, Ethnicity, and School.

Results

The Cronbach Alpha Coefficients for the entire student questionnaire was 0.70. The coefficients indicated that the factorial reliability was adequate for the hypothesized categories of Positive Attitude Toward mathematics, 0.73; Traditional, 0.60, and Non-traditional Classroom Activities, 0.63. The smallest reliability coefficient, 0.34 was associated with Negative Attitude. The variables were maintained throughout the analysis with modifications where appropriate. For example, the exploratory factor analysis indicated that item 5, “New discoveries are seldom made in math,” failed to load in any of the categories; it was omitted from the analysis as well as “guessing is ok....”

A factor analysis was also conducted using items 11-25, which related to the frequency of both traditional and nontraditional classroom activities. There were four items that were hypothesized to be related to both categories. However, the analysis revealed that only one item may be related to both categories, “Show all my work on a test or quiz.” Item 13, “Use a computer to work on mathematics problems,” failed to load in either category. Consequently, items 11, 12, 15, 16, 19, and 21 were used to represent traditional classroom activities, while the remaining items were used to represent nontraditional activities.

The students definitely agreed that mathematics is useful, with a mean of 4.42, and SD of 0.09, and knowing why an answer is correct is important in mathematics, with a mean of 4.23 and SD of 1.01. Also, students clearly held a rule-oriented view of mathematics, with a mean of

3.74 and SD of 1.14. A contradiction was evident by the means associated with "I would like to have a job that uses mathematics," with a mean of 3.14 and SD of 1.29, and mathematics is fun, with a mean of 3.25 and SD of 1.37. Although students' attitudes about mathematics consisted of recognizing the importance of mathematics and its usefulness in daily life, they were uncertain whether they would like to have a job that uses mathematics. The students' neutrality on several of the attitude items indicated their indifference toward the subject. However, a positive result may be seen for some of the students who felt that memorizing is not important, with a mean of 3.33 and a SD of 1.10. This implies that they should understand concepts and procedures rather than memorizing them. It appeared that the students had a tendency to lean toward the idea that the process of guessing, with a mean of 2.81 and SD of 1.26, may be helpful when solving problems.

Statistical significance was tested using a three-way ANOVA, Gender x Ethnicity x School, with the dependent variables, Positive Attitude, Negative Attitude, Traditional and Non-Traditional Activities. There were no statistical differences for the main effects, Positive or Negative attitudes, Traditional Activities and Ethnicity for Gender, indicating that both genders held a similar degree of positive attitude toward mathematics $F(1, 1,089) = 0.59$, with a partial eta-square of 0.001. The result was similar for Negative attitudes, $F(1, 1,089) = 0.62$ with an eta-square of 0.001. The students reported the degree of frequency of traditional mathematics activities. However, there was a statistically significant difference in the frequency of non-traditional mathematics activities. Female students reported a greater frequency than male students, $F(1, 1099) = 16.16$ with an eta-square of 0.01, which indicated that the significance may be due to the large sample size.

Results for the main effect, Ethnicity, showed no differences related to the independent variables. Each ethnicity category held similar attitudes and perceptions of the frequency of classroom activity.

For the main effect, School, the results indicated no differences in attitudes either positive or negative toward mathematics. However, for Traditional Classroom Activities, there was a statistically significant difference between Schools $F(5, 1,111) = 19.14$ with an eta-square of 0.08, indicating that the difference is significant. Students from School A reported the greatest frequency of Traditional Classroom Activities with a mean of 23.73 and a Standard Error of 0.61, School E's students reported the lowest frequency of traditional activities with a mean of 12.85 and Standard Error of 0.79. Scheffe post hoc tests indicated that students from School E, with a mean of 18.22 and a SD of 5.2, and School F, with a mean of 20.07 and a SD of 4.44, experienced the least amount of Traditional Activities when compared to the other four schools whose means were: 23.73, 21.88, 23.1, and 22.95 from School A to D respectively. Even though the result, $F(5, 1140) = 5.62$, is statistically significant when comparing Nontraditional Activities to Traditional Activities, the eta square, 0.03, indicated that it may be due to the large sample size. The range of means for Nontraditional Activities was from a low of 28.42 and a SD of 4.5 from School F to a high mean frequency of 32.25 and SD of 7.06 for School E, whose SD indicated a range of perceptions of the occurrence of nontraditional activities

The results of the ANOVA also indicated that there is a statistically significant difference in the perception of the frequency of Nontraditional Activities for Gender, $F(1, 1099) = 16.16$, although the eta-square value is 0.014, female students reported a greater frequency than male students, $F(1, 1099) = 16.16$ with an eta-square of 0.01, which indicated that the significance may be due to the large sample size, and by School, $F(5, 1139) = 5.62$ with a 0.025 eta-square value.

The results for Classroom Activities revealed that students in School E, with a mean of 2.24 and SD of 1.39, and School F, with a mean of 2.58 and SD of 1.46, had the lowest frequency of using textbooks in class, which was seldom to occasionally. Overall, the students reported that they occasionally to frequently work alone on mathematics problems, with School A reporting the greatest mean of 3.75 and SD of 2.00. In contrast, the students generally worked in groups only on occasions while students from School E reported that they work in groups frequently with a mean of 4.00 and SD 1.01. Students in Schools A, B, and C frequently completed worksheets with means of 3.61, 3.86, and 4.04, respectively. In comparison, students in Schools D, E, and F seldom or occasionally completed worksheets with means of 2.86, 2.97, and 2.18 respectively. In contrast, the school means indicated that students occasionally completed projects. For example, the range of means was from 2.18 from School F to a mean frequency of 3.13 from School C. The overall pattern regarding class discussions about mathematics problems was that they occur frequently with means ranging from 3.85 from School B to a mean frequency of 4.45 from School A. Calculators are occasionally used by students with School C reporting the lowest frequency with a mean of 2.2 and School D the highest frequency of 3.36. Finally, the students very often, with the exceptions of students from Schools E and F, watch the teacher do problems at the board.

Discussion and Conclusion

The study's results indicated that middle school students' attitudes toward mathematics were similar in each school, and that both female and male middle school students held the same view whether positive or negative toward mathematics. It appears that the use of the Connected Mathematics Program had minimal impact on attitudes. The degree to which the program was implemented varied from school to school. Consequently, the attitude of students toward mathematics was generally favorable regardless of the program they experienced. This is a positive finding in that the students see mathematics in a favorable light even though they do not want to pursue a job that uses mathematics.

The frequency of classroom activities was viewed differently by the students based on the degree of implementation of the program. In schools where the program was reported to have been more fully implemented, there was a tendency to have more nontraditional mathematics activities occur. However, a surprising result was that students from School A, where there was full implementation and administrative support, had the greatest frequency of traditional activities. In contrast, School E with a high percentage of low SES students and full implementation had the lowest frequency of traditional activities. There were common activities that occurred fairly often such as the use of class discussion about mathematics problems. In addition, students frequently explained their thinking regardless of the extent the program's implementation. This indicates that the middle school teachers had a tendency to encourage discourse in their classrooms. Classroom observations would have been valuable in ascertaining the quality and type of discourse. In each school, students experienced mathematics related to real-life situations. This indicates that regardless of the extent to which the CMP was implemented, the district was successful at using real-life situations, which may have contributed to the positive nature of the students toward mathematics. However, the schools that implemented the program more fully had a greater frequency of using real-life situations, as the program requires. Similarly, three schools, C, D, and E, were reported to have used projects more often than the other three schools, A, B, and F. Hence, in schools that tended to use CMP more extensively, students reported a greater frequency of using projects and real-life situations to solve mathematics problems.

The survey inquired about the use of two tools in mathematics, calculators and computers. Students reported that projects were assigned on occasions; so, perhaps during the completion phase of the projects, other tools may have been used. Student achievement prior to the study was relatively good. However, following the implementation of CMP in each school, regardless of the extent to which it was reported to have been implemented, achievement gains were made in each school. School E had greatest number of low SES students and CMP made a significant improvement in achievement scores. This finding indicates that the CMP program may be beneficial in improving the mathematical understanding of low income and minority students.

Although the study did not include classroom observations, and the findings are based on student self-reports, the results are favorable toward the use of CMP in middle school classrooms. A teacher, who did not care for the program in the beginning, eventually saw how powerful the program is in developing mathematical understanding. The survey was sufficient to gauge both attitudes and the frequency of classroom activities. Some doubt remains concerning how the students may have interpreted the use of textbooks because even in CMP, a text is used to present the tasks. So, the frequent use of textbooks may be considered a favorable finding rather than a negative activity as it was intended to represent a traditional classroom activity. The results of this study lend support for the use of CMP in schools to help foster favorable attitudes toward mathematics and improving mathematical understanding. An avenue for further research is to examine the differences in the perception classroom activities by gender, where the female students reported experiencing more nontraditional activities than males. Why did the female Mexican American students report more nontraditional activities?

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