ED 406 216 SE 059 954

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TITLE Hispanic Teachers' View of Mathematics and Its Effects on Instructional Practice.
SPONS AGENCY National Science Foundation, Arlington, VA.
PUB DATE 25 Mar 97
CONTRACT NSF-9353644
NOTE 45p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-28, 1997).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Conventional Instruction; High Schools; Hispanic American Culture; *Hispanic Americans; Inquiry; *Mathematics Teachers; Student Attitudes; *Teacher Attitudes; *Teacher Background; Teaching Methods; Teaching Styles
IDENTIFIERS Texas

ABSTRACT

This preliminary case study examined the philosophical perspectives of mathematics teachers at a high school situated near the Texas/Mexico border along the lower Rio Grande river valley. Ninety-eight percent of the students and 69% of the teachers are Hispanic. The mathematics teachers were administered a questionnaire that gauged their philosophical perspectives relative to the Formalist Views and the Growth and Change Views of mathematics. The survey also required the respondents to self-report their classroom activities. Of the 16 mathematics teachers, 11 teachers were observed using a classroom observation instrument designed to rate the teachers' mathematics teaching in three categories: (1) student autonomy; (2) meaning and understanding; and (3) higher-order thinking strategies. The students of the observed teachers were administered a survey that gauged their attitudes toward mathematics and their perception of the frequency of particular classroom activities. The data analysis revealed that the teachers held a Formalist View of mathematics and their teaching practices were reflective of this belief. Consequently, their students experienced traditional mathematics teaching, such as lectures, worksheets and tests. Includes a section of recommendations for instruction and staff development. The student survey is found in the appendix. Contains 24 references. (Author/PVD)

Hispanic Teachers' View of Mathematics and Its Effects on Instructional Practice

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March 25, 1996

Paper presented at the annual meeting of the American Education Research Association, Chicago, IL.

The research reported in this paper was supported in part by the National Science Foundation Grant No. 9353644. The opinions expressed in this paper are those of the author and do not necessarily reflect the views of the National Science Foundation.

Abstract

This preliminary case study examined philosophical perspectives of high school mathematics teachers. The high school is situated near the Texas/Mexico border along the lower Rio Grande river valley. The mathematics teachers were administered a questionnaire that gauged their philosophical perspectives relative to the Formalist Views and the Growth and Change Views of mathematics. The survey also required the respondents to self-report their classroom activities. Of the 16 mathematics teachers, 11 teachers were observed using a classroom observation instrument designed to rate the teachers' mathematics teaching in three categories, student autonomy, meaning and understanding, and higher order thinking strategies. The students of the observed teachers were administered a survey that gauged their attitudes toward mathematics and their perception of the frequency of particular classroom activities. The data analysis revealed the teachers held a Formalist View of mathematics and their teaching practices were reflective of this belief. Consequently, their students experienced traditional mathematics teaching, e.g., lecture, worksheets and tests.

Introduction

Individual teachers possess particular beliefs of varying degrees of conviction that develop into a philosophical perspective. A combination of beliefs may be described as belief system(s) which is restructured as individuals reflect on their beliefs. This implies that an individual's beliefs are influx. The belief system is organized into a teacher's conception of mathematics whose components consist of conscious or subconscious beliefs, concepts, meanings, rules, mental images, and preferences concerning the discipline of mathematics (Thompson, 1992). According to Ernest (1988), teachers' conceptions of the nature and meaning of mathematics, coupled with mental models of teaching and learning mathematics are crucial to teachers' approach to mathematics teaching. Hence, teachers' beliefs are an integral feature of a mathematics classroom.

Beliefs should be encountered and challenged. It is important that individual teachers may come to understand both subconscious and conscious beliefs and how they effect their teaching practices. One may conclude that in order to promote changes related to reform efforts in mathematics education, researchers should take aim at altering teachers' belief systems. Although some researchers (e.g., Dougherty, 1990; Helms, 1989; Peterson, Fennema, & Carpenter, 1987; Thompson, 1984) have conducted studies on mathematics teachers' beliefs, conceptions and instructional practices, very few researchers have examined these issues with Latino teachers. The purpose of this exploratory study was to gain an understanding of the mathematics beliefs and teaching at a high school. This preliminary case study sought to answer the following questions:

i) What are the philosophical perspectives held by the teachers regarding mathematics?

ii) What are the characteristics of the mathematics teaching that the students are experiencing?

Theoretical Framework

Levels of Mathematics Classroom Research

Researchers have determined that there are several levels of complexity related to research on teaching (Koehler, & Grouws, 1992). One level involves multiple classroom observations to gain a detailed understanding of instruction in mathematics. This level is often referred to as process-product research. Classroom processes are usually defined as what is occurring in the classroom. Coding schemes are developed for recording classroom events during observation. Some examples of coded behavior are types of questions asked and length of responses.

At another level, both the student and teacher characteristics play important roles. The confidence that students' have in their ability to learn mathematics, a belief that mathematics is useful to them and whether or not they feel that they can discover mathematics are some examples that can influence students' actions (Koehler, & Grouws, 1992). It is assumed that teacher behavior is influenced by various factors related to pedagogical knowledge and content knowledge. An influence on what is taught depends on the teacher's attitudes. For instance, if teachers believe that students learn by explicit example, repetition, extensive practice, and who view their role as dispensers of knowledge would behave differently than those teachers who believe that students learn by discovery or investigation with a role of a co-explorer with the students (Koehler, & Grouws, 1992).

The types of questions asked may also be considered related to teacher beliefs about mathematics and teaching. There are basically two types of questions, product and higher order, that can be asked during mathematics instruction. Higher order questions require the students to analyze information or to go beyond recall, which includes elaboration and the integration of meaningful material into existing prior knowledge (Baker, 1990). The prevalence of this type of questioning encourages problem solving, where students develop conjectures, argue for a stance in relation to a problem, and creates a safe classroom environment for students to express their thinking (Lampert, 1988). Product type questions are generally considered to be questions that required a targeted student to simply recall a fact, definition, or provide a single answer without going beyond simple computation or recall. The prevalence of this type of questioning can lead to a classroom where students learn by explicit example, repetition, or by extensive practice (Koehler & Grouws, 1990).

Mathematics Teaching Traditions

According to Gregg (1995), two forms of classroom instruction have developed, "teacher-centered," and "inquiry" mathematics traditions. Cuban (1984) described features of teacher-centered instruction which included teacher talk that exceeds student talk, the teacher directs instruction to the whole class, rather than working with small groups or individuals, and where students are seated in rows of desks that face the teacher and determines the use of class time (Cuban, 1984). This picture of mathematics teaching was later described and expanded upon by Cobb, Wood, Yackel, and McNeal (1992) as the "school mathematics tradition." Typical classroom practices in this form of instruction include a familiar routine of checking answers from the previous day's assignment, working some of the homework problems on the board, presenting new material with examples and assigning seatwork. Brown, Cooney, & Jones (1990) contended that in the school mathematics tradition, there is an emphasis placed on formalized mathematics where mathematics is presented as a collection of facts and procedures. The act of doing mathematics is considered to be simply replicating procedures presented in class. The teacher and the textbook are the mathematical authorities in the classroom. Hence, students learn mathematical rules that they regard as fixed and self-evident (Cobb et al., 1992).

In comparison, the current reform movement in mathematics education, supported by the National Council of Teachers of Mathematics (1989) advocated the development of an "inquiry mathematics tradition." Students who experience this tradition are encouraged to explore, develop conjectures, prove, and problem solve (Fennema, Carpenter, & Peterson, 1989). The assumption in this tradition is that students learn by resolving problematic situations to challenge their conceptual understanding. Students are also encouraged to discuss their ideas and results, often within small, cooperative groups, as well as with the teacher. As a result, students are offered opportunities to develop intellectual autonomy-themselves becoming mathematical authorities where the teacher's. role is one of a facilitator. Students are required to demonstrate their understanding by explaining and justify their actions taken when resolving problematic situations rather than following procedural instructions to obtain correct answers (Gregg, 1995).

Associated with the school mathematics tradition and the inquiry tradition are beliefs aligned with the Formalist view and Growth and Change view of mathematics (Nickson, 1994). Formalists regard mathematics as a discipline, based on the epistemology of logical positivism, with unchanging truths; and mathematics is considered a process that uses abstract ideas and is rule driven. Mathematical knowledge is not considered to have a social origin, but it lies outside of human action, disregarding experience and the context of everyday life.

The pedagogy usually associated for those who hold a Formalist view becomes one of what is mathematics really about, not what is the best way to teach mathematics. Teachers who hold the this view tend to teach mathematics as rules to be memorized, and portray mathematics as an infallible discipline. Mathematics is also presented to students in a way that suggests that it is a linear subject, facts and skills related to number are taught, and generally features paper-and-pencil activity. There is also a strong reliance on the textbook, and a strong imbalance between conceptual teaching and skills in favor of skills teaching rather than applications (Porter, Gloden, Freeman, Schmidt, & Schwille, 1988). This type of teaching tends to produce an environment with little teacher-student interaction or among the students and produces an emphasis on right or wrong answers.

A stereotypical mathematics classroom tends to reflect a Formalist View of mathematics. Romberg (1992) described a stereotypical mathematics classroom where students sit in straight rows, the teacher lectures and presents problems, the students then work at their desks practicing similar problems presented by the teacher. A reliance on teacher centered instruction is characteristic of what Paulo Freire described as "banking education," the depositing of information into the students' minds by the teacher, and the students are expected to return it upon request (Aronowitz, 1993). This type of classroom has its own cultural norms including roles for teacher and student. Consequently, teaching from the Formalist perspective creates a barrier erected by its formal and abstract nature, which segregates students from teachers as well as teachers/students from mathematical activity.

The Growth and Change View of mathematics is based on Popper's (1972) contention that knowledge results from theories that are debated, made public, and tested until falsified by a better theory. Judgment and choice play important roles resulting in the role of different value systems. This view is very similar to the Fallibists view of mathematics where mathematics is seen as a body of knowledge that has socially agreed upon truths, mathematics is changing and new discoveries are being made. Teachers with this perspective would allow students to explore, investigate, form hypothesis and test them. Problem solving is central to this perspective where purposeful activity stems from the problem situations that require reasoning and creative thinking, gathering and applying information, discovering, inventing, communicating and testing ideas (Thompson, 1992). Teachers must be confident in their ability to make decisions regarding the implementation of a curriculum that encourages shared activity where problems and ideas flow back and forth from student to teacher and vice versa where learning and application can become meaningful. Consequently, the classroom takes on a constructivist environment. Students are encouraged to socially construct knowledge, contribute their ideas, try their solutions and challenge the teacher (Nickson, 1994).

Methodology

Background

The high school is located in a border community situated near the lower Rio Grande river valley of south Texas. Both the student and teacher populations are Hispanic with 98% and 69% respectively. A vast majority, 86%, of the students are classified as economically disadvantaged. The language classification of the students includes 22% Limited English Proficient and 18% Bilingual.

A total of 11 teachers were randomly selected; their classrooms were observed The teachers taught Algebra I, Algebra II, Informal Geometry, Geometry, pre-Calculus, and Calculus. In some categories, gifted and talented classes were observed. The teachers were also asked to complete a questionnaire concerning their beliefs about mathematics and mathematics teaching. A student survey was administered to 226 mathematics students that gauged their attitude toward mathematics and classroom experiences (see Appendix).

The observations included collecting data related to the teaching of mathematics and the types and frequency of questions asked by the teacher. The length of each observation was 90 minutes. Each class was observed three times by different pairs of observers during the months of April, and May, 1996. One observer focused on the teaching behaviors, using an observation instrument that was first employed by McMullen (1993) in the Innovative Mathematics Assessment Project, and the second researcher recorded the type of questions asked by the teacher. The observer who tallied questions selected a target student to observe every minute. After each passing minute, another student was targeted for observation. The type of question addressed to the student was tallied (i.e., higher order, and product type questions). The teacher observation instruments were analyzed using SAS.

Mathematics Philosophy Survey. Prior to the observations, a pilot mathematics philosophy survey was administered to the 16 mathematics teachers at the high school. A five-point Likert scale was used, ranging from one to five where a one indicated a strong disagreement, and a five indicated strong agreement. The survey was partitioned into three sections. The first section contained items one to nine that described ideas related to the Formalists Views of Mathematics. A second section contained items ten to 16 that represented ideas associated with the Growth and Change View of Mathematics. The third section, items 17 to 30, required teachers to self-report on various classroom activities. Of the teachers surveyed, 12 hold Bachelor's degrees, and four teachers hold a Master's degree. Fifty percent of the teachers surveyed had five years or less teaching while the remaining teachers had six or more years teaching experience. The results were analyzed using the SAS system.

Classroom Observation Instrument

The observation of mathematics teaching instrument is modeled after Peterson (1988) and adapted from McMullen (1993). There are three primary classroom processes that are considered to be essential for promoting the learning of higher-order thinking skills, (a) an emphasis on meaning and understanding (MU), (b) encouragement of student autonomy and persistence (SA), and (c) direct teaching of higher order cognitive strategies (HO). The classroom observation instrument focused on classroom interactions that reflect these three processes (see Appendix).

The first twelve items include statements that reflect particular actions that demonstrate an emphasis on meaning and understanding-illustrated by classroom structure and curriculum implementation. Teaching for meaning refers to instruction that helps students perceive the relationship of parts to wholes, providing tools to construct meaning with mathematical tasks and the world in which the students live. Meaning and understanding also involves making explicit connections between subject areas and within mathematics as well as between what is learned in school and students' home lives

(National Council of Teachers of Mathematics, 1996). The second group of seven items referred to the student attitudes and interests in mathematics as reflected through the encouragement of student autonomy and persistence. The third group of seven items provide an indication of whether or not direct teaching of higher order strategies is implemented. The observer did not expect to have the opportunity to rate all items in each observation since some lessons lend themselves to one or the other indicators. However, it was assumed that over three observations all or most of the indicators would be rated. Each of the three aspects and associated indicators were rated using a six level process based scale:

0 Not present

1 Implied but not overtly present

2 Present but not developed

3 Present and used

4 Used in an insightful manner; room to expand

5 Developed and used; understanding obvious (McMullen, 1993, p. 8)

Descriptive statistics were produced for each criterion and a total score was calculated for each of the three categories of the teacher observation form, MU, SA, and HO. Also, an overall correlation was produced for the three major categories of the teacher observation form. The observers were community college mathematics teachers who were enrolled in a doctoral program, and a university professor who was field-based at the high school.

The observers met several times, prior to conducting the observations, in order to discuss any issues related to the instrument's criteria. McMullen (1993) reported an agreement rating, for two raters, of 88 percent for Meaning and Understanding; 92% for Autonomy and Persistence; and 87 percent for Higher Order Strategies.

Student Questionnaire. The students enrolled in each of the 13 observed classes were administered a questionnaire adapted from Telese (1993). The total number of students surveyed was 226, whose student classification ranged from freshmen to seniors. The questionnaire examined two areas: i) student attitudes toward mathematics, and ii) the classroom activities experienced by the students, which were grouped into traditional and nontraditional activities. The traditional category included activities such as, teacher lead presentations, and completing worksheets. The nontraditional category included activities such as, completing math projects, making up their own problems. The traditional activities were in line with the Formalist view of mathematics while the nontradtional were more aligned with the Growth and Change View of mathematics. The students responded to items one to ten using a Likert scale from one to five where a one represented that the student disagreed and a five represented that the student agreed. For the remaining items, 11 - 25, the Likert scale represented the frequency in which the student experienced the stated activity, where a one meant "never" and a five meant "a lot." The questionnaire was administered to students in 12 classes. Due to scheduling conflicts, 11 of the 12 classes were observed by the researchers. Of the teachers observed and surveyed, one teacher did not administer the student survey to his/her students.

Results

This section will present results of the teacher survey, teacher observations followed by classroom interaction data in terms of types and frequency of questions asked by the teachers, and excerpts from student interviews. Since the number of teachers surveyed was 16, statistical analysis of the survey is highly constrained. The results of the philosophical survey focused on descriptive features.

Teachers' Philosophy of Mathematics.

Table 1 presents the items reflecting the Formalist views of mathematics, their overall means, and standard deviations.

Table 1

Item Means Reflective of the Formalists Views of Mathematics

Item	Mean n = 16
1. Mathematics is rooted in logic.	4.77 (0.44)
2. Propositions in math are verified by reference to experience.	3.56 (0.73)
3. The foundations of math lies outside of human action.	2.38 (1.20)
4. Mathematics consists of unchanging truths.	2.88 (1.54)
5. Mathematics consists of unquestionable certainty.	3.38 (1.26)
6. Problem solving is not really a part of mathematics.	1.38 (0.62)
7. Math as a subject can stand alone.	2.87 (1.68)
8. Math does not really relate to everyday life.	1.19 (0.40)
9. Math is really a formal derivation of stated axioms.	3.00 (0.82)

Note: The number in parenthesis is the standard deviation.

Item one has the greatest mean value of 4.77, and standard deviation (SD) of 0.44, indicates that the teachers hold the belief that logic is central to mathematics. This is a fundamental view of Formalism, and it is contrary to the belief that mathematics is intuitive and based on experiences. The teachers tended to agree that experiences are important in mathematics as indicated by item two with a mean of 3.56 and SD of 0.73. This agreement indicated that the teachers felt that although mathematics is rooted in logic, experience plays a role in gaining mathematical knowledge. In the Formalist tradition, experience or connections to the real world play a Platonic role. A Platonic view considers mathematics as a static and unified discipline held together by logic and meaning. The teachers tended to disagree, with item eight as indicated by a mean of 1.19 and SD of 0.40 and with item six whose mean was 1.38 and SD of 0.38

The percentage of teachers who agreed and disagreed with the items is presented in Figure 1.

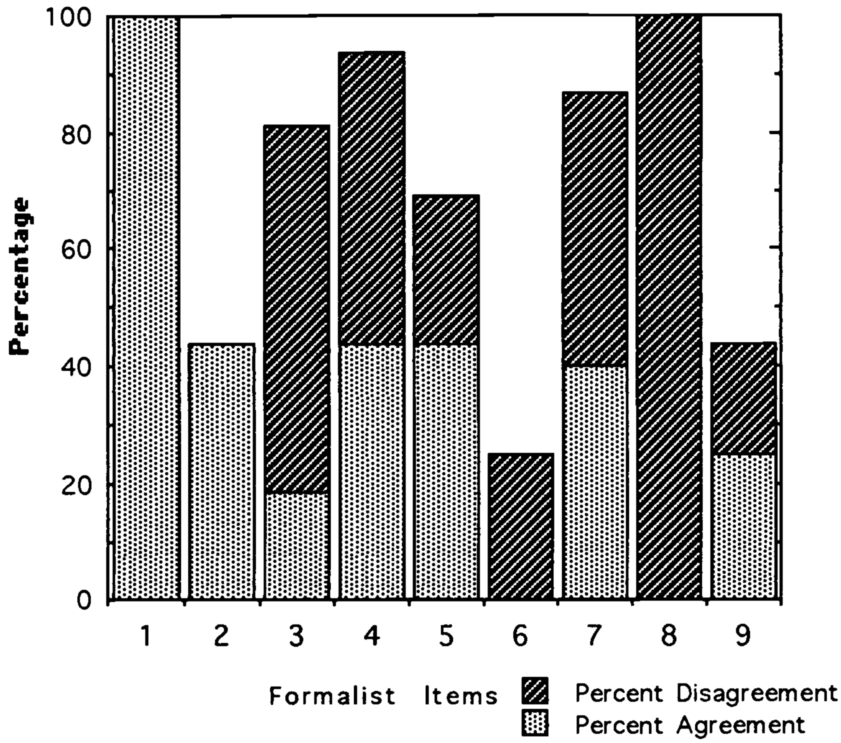

Figure 1. Formalist Views' Percent Agreement and Disagreement.

There was 100 percent agreement on item one, and 100 percent disagreement with item 8. Where the graph does not indicate either an agreement or disagreement portion, the respondents had a neutral opinion. For example, for item six, teachers responded by disagreeing with the item and the remaining teachers held a neutral opinion. Item three also had a large percentage of disagreement. The teachers were nearly split on item four with 44 percent agreeing and 50 percent disagreeing with the item. More teachers disagreed with item four than item five which had the same percent agreement as item four. There was also a close split on item seven with 40 percent agreeing and 47 percent disagreeing with the item. Item nine had 25 percent of the teachers agreeing with it while 18 percent disagreed.

Table 2 presents the items reflecting the Growth and Change view of mathematics, their means and standard deviations.

Table 2

Item Means Reflective of the Growth and Change View of Mathematics Item

Item	Mean n = 16
10. Math knowledge results from agreed upon and tested theories until falsified	3.75 (0.68)
11. Judgment and choice play an important role in creating math knowledge.	3.44 (0.73)
12. The method by which math knowledge is developed is a social and cultural phenomenon.	3.25 (1.06)
13. Learning math is based on the social construction of meaning.	3.50 (0.89)
14. A person's values influence the development of mathematical knowledge.	3.69 (0.79)
15. A problem may be approached from several perspectives.	4.75 (0.45)
16. Mathematical discovery is important to experience.	4.31 (0.70)

Note: The number in parenthesis is the standard deviation.

Overall, the items with the greatest means were items 15, and 16, with means of 4.77 and a SD of 0.44, and 4.31 and a SD of 0.75, respectively. The teachers also tended to agree with item ten, whose mean is 3.75 and SD 0.68, that mathematics involves a socialization process where theories are agreed upon by a community of mathematicians and later changed when the theories are falsified through testing and experimenting. Yet, they held a neutral position in regard to item 12 that considers mathematics to be a social and cultural endeavor. The mean and standard deviation for this item is 3.15 and 0.99, respectively.

Figure 2 illustrates the percent agreement and disagreement for the items related to the Growth and Change View. The percent agreement on item ten was 75 percent with a six percent disagreement. The teachers were nearly in total agreement with item 16 where 88 percent agreed. The remaining teachers held neutral opinions on this item.

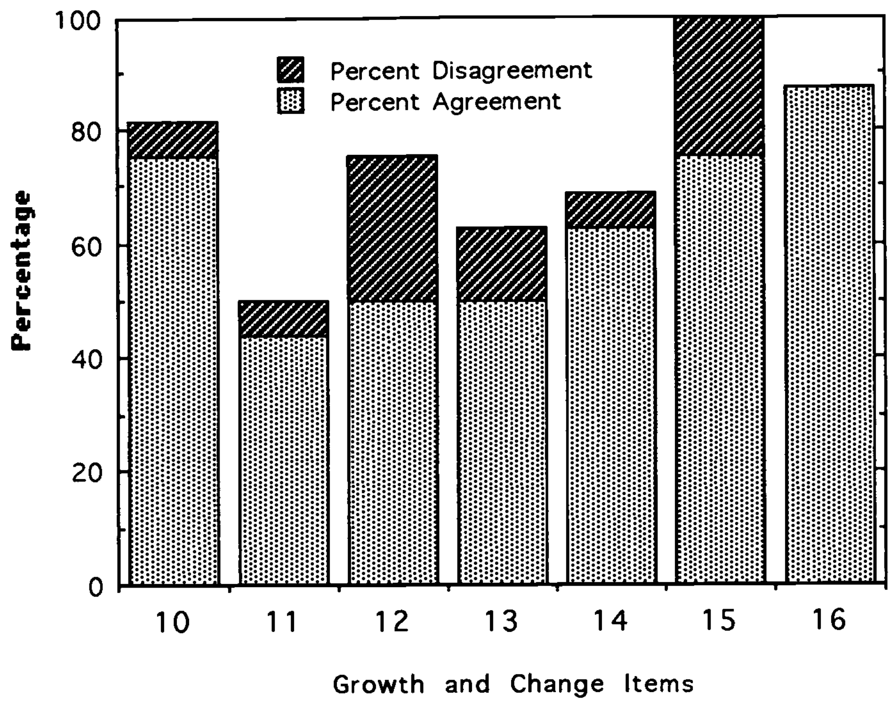

Figure 2. Growth and Change Views Percent Agreement

The trend in agreement coincides with the mean ratings illustrated in Figure 3. The greatest percentage of disagreement was 25 percent which is revealed on items 12 and 15. A majority of the teachers agreed with item 15 that problems can be approached from several perspectives. Approximately 50% of the teachers agreed with item 12 that mathematics is part of one's culture, and math is socially constructed.

Classroom Activities. Table 3 provides the mean ratings for the self-reported classroom activities. Items 18 and 19 refer to the influence of the state's mandated assessment, the Texas Assessment of Academic Skills (TAAS) test that students must pass in order to graduate from high school.

Table 3

Means and Standard Deviations of Teacher Reported Classroom Activities

Statement	Item Mean
17. I rely upon my math textbook when lesson planning	3.13 (0.96)
18. What I teach is influenced by the TAAS.	3.44 (1.21)
19. I would like to be more creative, but I can't seem to make the TAAS blend with my ideas.	3.20 (1.15)
20. I stress the manipulation of numbers and other symbols.	3.75 (0.85)
21. I try to relate mathematics to my students' everyday life.	4.13 (0.34)
22. My students communicate their mathematical knowledge through dialogue with me.	3.56 (0.81)
23. There is an emphasis placed on right and wrong answers in class.	3.19 (1.33)
24. My students are allowed to generate theories and test them.	3.31 (0.94)
25. The process of teaching mathematics in my class is a shared activity open to discussion.	3.81 (0.75)
26. The teaching of math should include mathematical investigations.	4.27 (0.59)
27. Students in my class are assigned worksheets.	3.73 (0.96)
28. What I teach is centrally controlled by TEA.	3.85 (0.86)
29. I feel I can teach in whatever manner I deem appropriate.	3.43 (0.94)
30. I allow students to share ideas and problems among themselves.	4.20 (0.77)

Note: Number in parenthesis is the standard deviation.

Overall, the teachers were neutral in their opinion that they rely on their textbook for lesson planning. The neutrality rating may have indicated that the teachers reluctant to self-report on some issues. The mean for this item was 3.38 with a standard deviation of 0.87. The means for the classroom activities that the teachers reported conducting indicated neutral opinions on items 17,18, 19, 23, 24, 29, and there was a tendency for the teachers to agree with items 20, 21, 22, 25, 26, 27, 28, and 30. The strongest agreement were on items 21, 26, and 30 each with a mean of 4.15, and standard deviations of 0.38, 0.55, and 0.80 respectively. The teachers reported that they relate mathematics to students' everyday lives; they agreed that mathematics teaching should include mathematical investigations, and that students are permitted to share ideas and problems among themselves. Yet, the teachers held a neutral position in regard to mathematics being a social and culture discipline where theories are agreed upon by a community of mathematicians until new information is collected and the theories are modified in light of the new discoveries.

Figure 3 presents the percentage of teachers who agreed or disagreed with the statements that describe various mathematics classroom activities and outside constraints.

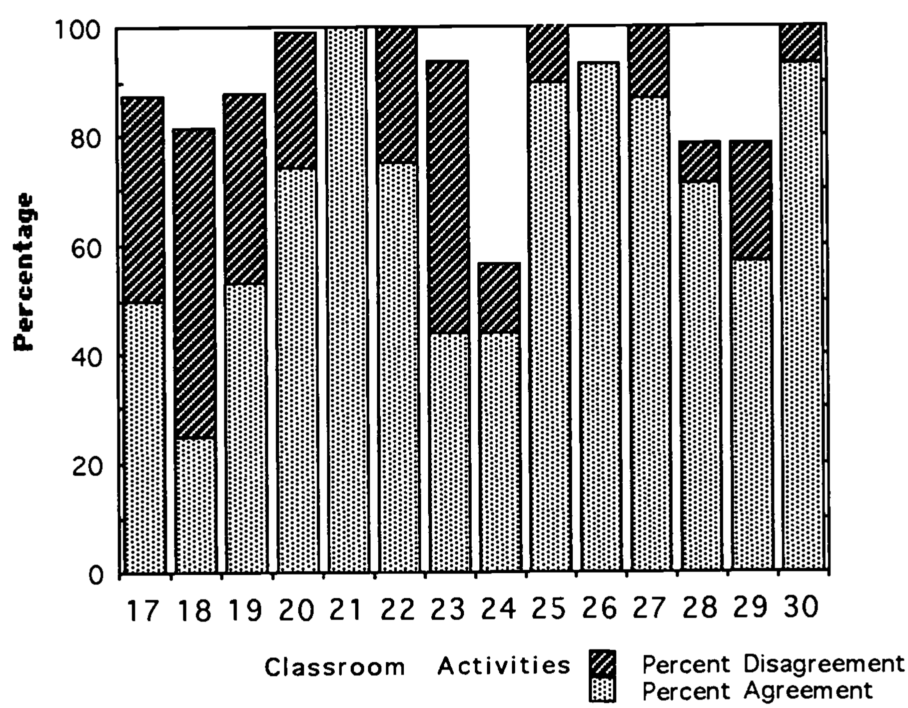

Figure 3. Classroom Activities Percent Agreement and Disagreement

The teachers tended to disagree with item 18 with 56 percent and 25 percent agreed. Item 19 showed a majority, 53 percent, of the teachers agreeing. A large percentage, 74%, of the teachers agreed with item 20. The teachers were in 100 percent agreement with item 21, relating math to students' everyday lives. Nearly half of the teachers reported that they do not stress right and wrong answers while the other half reported that they do place an emphasis on right or wrong answers. The percent agreements on items 25 through 28 range from nearly 70 percent to over 90 percent.

Teacher Observations

This section includes the overall description of the observed mathematics teaching followed by selected rater comments concerning the classes will also be presented. The overall correlation of the three categories, MU, SA, and HO indicated that there was consistency by the raters on observing the criteria associated with each category. Table 4 presents the Pearson Correlation Coefficients for each of the major categories.

Table 4.

Pearson Correlation Coefficients for the Major Categories of the Teaching Observation Instrument

	MU	SA	HO
Emphasis on Meaning & Understanding (MU)	1.00	0.763*	0.888*
Encouragement of Students' Autonomy (SA)	0.763	1.00	0.755*
Direct Teaching of Higher Order Strat. (HO)	0.888	0.755	1.00

* $p < 0.0001$, $n = 40$

Although the Pearson Correlation Coefficients are lower than the percent agreement found by McMullen (1993), the raters were fairly consistent in their ratings. Another view of this result is that the constructs were interrelated; in other words, the constructs were not free standing. The three major areas correlated among themselves which resulted in a holistic view of higher order mathematics teaching.

Table 5 presents the overall means for each of the criteria and for the three major categories, MU, SA, and HO. The highest values for MU, SA, and HO are 60, 35, and 35, respectively. The highest rating given to a criterion is five with zero being the lowest value assigned.

Table 5

Overall Means for MU, SA, HO, and their Criteria

Criteria	n	Mean
Emphasis on Meaning and Understanding (MU)	40	24.78 (12.52)
1. Math problems cannot be solved quickly.	38	1.47 (1.64)
2. Math problems have more than one answer.	39	1.59 (1.73)
3. Focuses on what students know rather than what they don't know.	40	2.63 (1.44)
4. Uses informal assessment to provide feedback to students.	40	2.80 (1.59)
5. Mathematics is useful and makes sense.	38	1.29 (1.43)
6. Mathematical processes are used in context rather than in isolation.	39	1.62 (1.68)
7. Emphasizes understanding of mathematical concepts	40	2.60 (1.46)
8. Provides opportunities to restate and formulate problems	39	2.08 (1.64)
9. Provides opportunities to ask questions . . .	39	3.18 (1.60)
10. Math is expressed through pictures, diagrams, graphs, . . .	39	2.87 (1.61)
11. Uses a variety of math tools, models, manipulative, calculators . . .	39	2.28 (1.79)
12. Provides opportunities for students to plan, invent, projects . . .	39	0.87 (1.56)

Table 5 (cont.)

Encouragement of Students Autonomy and Persistence (SA)	40	17.15 (8.14)
13. Students learn at their own pace.	40	2.20 (1.57)
14. Students who perform with difficulty are not labeled as failures.	40	2.95 (1.78)
15. All students are expected to be able to learn mathematics.	40	3.22 (1.41)
16. Students work on extended assignments or investigations.	39	1.64 (1.77)
17. Speed is not an important factor in determining achievement.	40	2.20 (1.71)
18. Students are encouraged to think, be persistent, and self-directed.	40	2.63 (1.67)
19. Students work together to develop mathematical skills.	40	2.41 (1.62)
Direct Teaching of Higher Order Cognitive Strategies (HO)	40	10.45 (9.38)
20. Teacher helps students to formulate and refine hypotheses.	40	1.93 (1.83)
21. Opportunities are given for collecting and organizing inform.	39	0.79 (1.38)
22. T. helps students to learn & practice a variety of strategies . . .	40	2.35 (1.79)
23. T. encourages students to reflect on...problem solving strategies.	40	1.78 (1.66)
24. Students are asked to explain concepts orally or in writing.	39	1.72 (1.83)
25. Opportunities ...to work with open-ended or...real-life problems.	39	0.58 (1.25)
26. Students are provided situations in which they enjoy doing math.	39	1.41 (1.78)

Note: N = the number of times the criterion was rated.

The maximum score for the section of the observation instrument, emphasis on meaning and understanding (MU) is 60. The score may reflect an unrealistic goal for teachers. However, overall, the mean total rating score was nearly 25 with and SD of 12.52. This indicated that the observers saw a variety of teaching practices with respect to the instrument. Hence an overall and specific picture of the mathematics teaching practices can be obtained by examining the ratings on each of the criterion.

The teaching practices that were rated the highest, in the emphasis and understanding (MU) section, were criterion nine, 10, four, three, and seven. The mean ratings were close to a three, present and used, with the exception of criterion nine whose mean rating was 3.18 and SD of 1.60. Apparently, the teachers offered opportunities for students to ask questions. Math pictures, diagrams and graphs were present and used as indicated by the mean of 2.87 and SD of 1.61. The teachers made strong attempts at focusing their instruction on understanding of mathematical concepts and on what the students know rather than what they do not know. Tools, such as calculators, are used to aide in the students' development of mathematical understanding.

It appeared that the teachers implied that mathematics problems can not be solved quickly. This was indicated by the mean rating of 1.47 with a standard deviation (SD) of 1.64. Occasionally, teachers communicated to the students that math problems have more than one answer, but tended to focus on one right answer to a problem. This was also reflected by the low rating on criterion 12; the observers found that mathematical projects or investigations were not employed. The teachers rarely communicate that mathematics is useful and makes sense as indicated by a mean of 1.59 and SD of 1.73, which suggested that the teachers make implications that math is useful but do not develop the notion. It also appeared that teachers generally presented mathematics in isolation rather than in contexts, which could include real-life or an application of concepts to other areas. This was indicated by the mean rating of 1.62 and SD of 1.68.

Turning to the second category, Encouragement of Students' Autonomy and Persistence, the overall total rating was 17.15 and SD of 8.14. If each criteria was rated a five, then the total would be 35 for this section. The observers found that the teachers do not label their students as failures and expect them all to be able to learn mathematics. This was indicated by the means of 2.95 with a SD of 1.78, and 3.22 with a SD of 1.41, respectively. These actions were generally present and used. Other teacher actions that were present and used was their encouragement of students to think and be self-directed and for the students to work together in small groups. Students did not generally have a chance to work at their own pace, or to work on extended assignments or investigations.

The total rating of the direct teaching of higher order cognitive strategies was generally lower than the previous two categories. The mean rating was 10.45 with a SD of 9.38 out of a possible 35, if five's were assigned to each criteria, in other words the criterion were developed and used with obvious understanding by the students.
The teachers presented opportunities for students to formulate hypotheses, but they were undeveloped, indicated by a mean of 1.93 and SD of 1.83. Similarly, students were offered occasions to explain concepts as indicated by the mean rating of 1.72 and SD of 1.83. The teachers offered a variety of strategies but did not develop them as indicated by the mean of 2.35 and SD of 1.79. Students were not afforded opportunities to work with open-ended or real-life problems. This was indicated by the mean rating of 0.58 and SD of 1.25. Students were not also provided opportunities in which they enjoyed doing mathematics as indicated by the mean of 1.41 and SD of 1.78.

The results for each of the course areas will include the total for the three major categories as well as a graphical representation of the mean ratings for each criteria. The horizontal line marks the maximum rating level for Student Autonomy and Direct Teaching of Higher Order Cognitive Strategies. Also, selected observer's comments, as representative excerpts from a selected observation, will follow the statistical results.

Figure 4 illustrates the mean observer ratings for each of the four course categories.

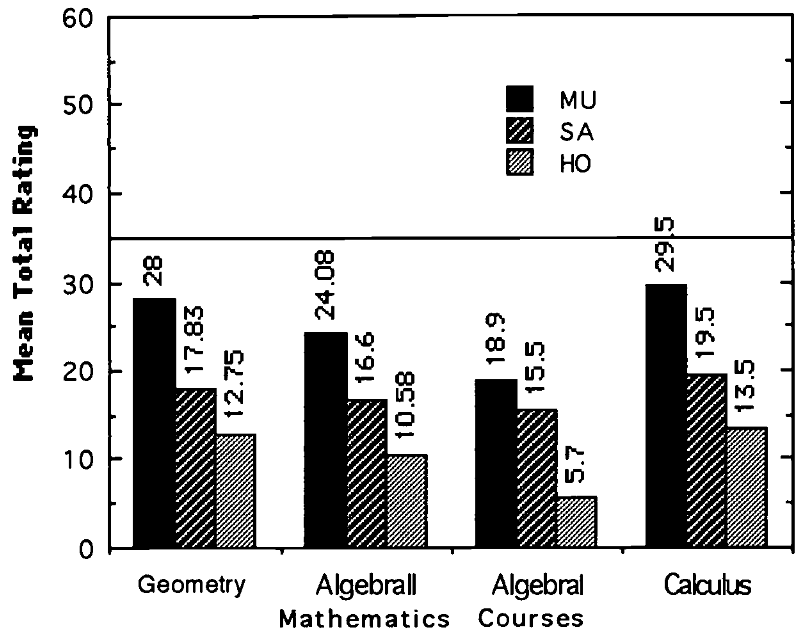

Figure 4. Overall Teacher Observation Mean Ratings for Courses.

In each of the courses, the criteria associated for the direct teaching of higher order strategies is lower than the mean ratings for the other criteria. The degree of emphasis placed on meaning and understanding was similar in each course category. For example, in comparison to Informal Geometry, the MU category is nearly equal to the Calculus mean with 28.0 with an SD of 13.84, and 29.50 with an SD of 10.56, respectively. The direct teaching of higher order cognitive strategies was observed to a greater degree in the Informal Geometry classes than in other courses. The level of student autonomy varied from course to course, in particular, the level of student autonomy was greatest in the Calculus category when compared to the other course categories.

In contrast, Algebra I has the lowest means for each of the three major categories of the teacher observation instrument, MU, SA, and HO. There is less emphasis placed on meaning and understanding, student autonomy, and there is less direct teaching of higher order cognitive skills in Algebra I when compared to the other three course categories.

The teachers appeared hesitant to communicate that mathematics problems can not always be solved quickly or that mathematics problems may have more than one answer. The raters observed that there was very little mentioned concerning the usefulness of mathematics and that it makes sense.

The direct teaching of higher order cognitive strategies was highly limited. Students were not encouraged to use a variety of strategies to solve problems. The students had little opportunity to collect or organize information, and explain their understanding in writing or orally. It appeared that students were placed in situations in which they did not enjoy doing mathematics as perceived by the observers.

Classroom Questions

Overall, there was a total of 58 higher order questions (32%), and 126 product questions (68%) that were addressed to students. The percentage of correct responses to the product questions (86%) was greater than the percentage of correct responses to higher order questions (55%). In the no response category, the percentage for the higher order questions was greater than product questions with 24% and 16% respectively. Likewise, the higher order questions had a greater percentage of partially correct responses and no response.

This trend is evident in Table 6, where the number of higher order and product questions are presented for each combined mathematics subject. The Informal Geometry class had nearly an equal occurrence of higher order questions in comparison to the GT or regular Geometry class. There was a total of 15 higher order questions in the informal class in comparison to the combined total for the GT and regular classes with 17 questions. The regular Algebra classes had more questions presented than in the lower level, Algebra I-4 class. The incidence of no response was also greater in this class. Similarly, the Algebra II class had a greater incidence of no responses in comparison to the Algebra II-GT class. The percentage of higher order questions was nearly equal in both subjects. The number of higher order questions observed was greater in the pre-Calculus class than the

Calculus class with four and zero respectively. In both of these classes, the lack of partial or no responses indicated that the students were able to respond either correctly or incorrectly.

Table 6

Response Percentages to Questions Addressed to Students

Classes	Question Type	Total	Correct	Incorrect	PartiallyCorrect	No Resp.
All Classes	Higher Order	58	55%	10%	9%	24%
	Product	126	86%	9.5%	2.4%	16%
Informal Geometry	Higher Order	17	65%	0	24%	12%
	Product	22	100%	0	14%	5%
Geometry	Higher Order	2	100%	0	0	0
	Product	10	100%	0	0	0
Geometry GT	Higher Order	13	31%	23%	0	46%
	Product	11	100%	0	0	0
Algebra1	Higher Order	11	52%	18%	15%	15%
	Product	36	80%	10%	0	10%
Algebra2	Higher Order	9	44%	11%	11%	33%
	Product	14	64%	29%	0	7%
Algebra 2-GT	Higher Order	2	50%	50%	0	0
	Product	16	88%	0	0	12%
Pre-Calc.	Higher Order	4	100%	0	0	0
	Product	15	87%	13	0	0
Calculus	Higher Order	0	0	0	0	0
	Product	2	100	0	0	0

Note: The percentages may not add to 100 due to rounding.

Observer's Comments. The major highlights in this algebra I course included the use of informal assessment to provide feedback to students, mathematics was expressed through the use of pictures, diagrams and graphs, all students were expected to learn mathematics, and students were given a chance to work together. The use of tools such as, calculators or manipulatives, was permitted, but on a limited basis.

The lecture, in an Algebra II GT class, communicated to students that there is more than one way to arrive at a solution to a problem. The teacher emphasized the need to understand mathematical concepts. The students were provided with ample opportunities to ask questions, and they worked in small groups on review problems.

The teacher lectured, worked some examples on how to simplify radical expressions. The students worked on twenty problems in small groups. The students, working in small groups, were allowed nearly all of the class period to complete the assignment. Many students were off-task, discussed other activities and not working on the assignment.

Students in this class needed various opportunities to restate problems, design mathematical ideas, and use various instructional tools. There were few opportunities for students to work with open-ended questions and mathematics was not related to real-life situations, nor did they seem that they enjoyed doing mathematics. Gifted and talented students ought to be provided opportunities to discover, explore, and formulate their own ideas.

Students in an Algebra II Gifted and Talented class checked their homework problems using answers that were written on the side board. The teacher presented answers to questions with minimal student interaction. A new lesson was introduced by reading from the textbook. A student commented that many students do not listen to the teacher reading the text. Definitions were written on the board, and the students were required to copy the notes.

In a regular Algebra II class, there was very little emphasis placed on mathematical meaning and understanding. There were no manipulatives or technological tools used. The topic for the day was dividing polynomials. The teacher began by doing examples on the board, then the students were asked to go to the board to work problems from the textbook. There was very little enthusiasm displayed toward mathematics. Although the teacher encouraged questions from students, they did not ask questions. The teacher helped the students to formulate and refine hypotheses so much that the students allowed the teacher to do all their thinking. This particular group of students did not appear to enjoy mathematics at all. The students did work together on a drill sheet, but it appeared that some students were copying other students instead of trying to learn from one another.

Overall, students in Algebra II encountered few real-life or contextualized problems. Also, very little opportunity existed for the students to collect and organize information in a meaningful way. Mathematics was expressed through the use of diagrams, pictures, or graphs in a limited manner. There was also a limited use of tools like the calculator or manipulatives. Students in Algebra II met with limited use of extended assignments or investigations.

The Informal Geometry teacher attempted to involve students in the daily lesson. The teacher was constantly asking questions, and the students had to respond, all students were active participants. The students were constantly receiving positive feedback from the teacher. Various instructional tools were used to construct the bisector of an angle and probed students' previous knowledge to develop an idea. The teacher guided the students through critical thinking skills, asked leading questions to encourage students to find or discover solutions. The teacher did not criticize an incorrect response but provided leading questions; students realized an answer to their own questions. Consequently, the teacher allowed students to formulate their own mathematical ideas such as the concept of angle bisector and related equations.

In a pre-Calculus class, the lesson topic was trigonometric functions and their principal values. The teacher presented several examples on the board. Students were assigned several problems to finish from the text, in particular, five through 43 on page 337. The graphing calculator was used to illustrate solutions to some problems. While working some examples, the teacher asked mostly recall of facts questions. The questions were generally directed to the whole class. Six students out of 16 dominated the responses. All students interacted with each other when the opportunity came for students to work together on the assignment. There was little encouragement for the students to be persistent. There was no connection established between inverse trigonometric functions and real-life situations or how math can be useful in our daily lives. The main feature of this class was drill and practice.

A calculus AP teacher focused on students' prior knowledge before introducing a new topic. The class began with students working homework problems on the board. The teacher explain each problem and made certain that the students understood the procedures used to solve the problems. The graphing calculator was used when the new topic was introduced. The calculator was used to check their solutions only after they worked the problems. Students worked together on assigned problems. They had the opportunity to ask questions at any time during the lecture and illustrations. Students were encouraged to learn and practice a variety of strategies for doing mathematics, and they appeared to enjoy what they were doing in class because all remained on task. Throughout the teaching of the new topic, the teacher encouraged the students to use higher order thinking. The classroom was full of interactions between the teacher and the students, and between students.

Another observer summarized the experience in an AP calculus class. It was, once again, a classroom where the facts were presented and were used to find the answer to "problems" in the text. There was no teaching of the concepts behind the facts. Based on the questions and answers presented by the students, it was concluded that there was no indication that conceptual teaching occurred in the past. For example, the teacher seemed to know the facts well, but the concept of what a derivative was and why it was necessary to find it was not addressed.

Student Survey. This section presents a summary of the results for the student survey which probed students' attitudes towards mathematics and the type of activities students experienced in their classroom (see Appendix). For detailed descriptions of the data see Telese (1997) and Telese and Olivarez (1997). Cronbach Coefficients were calculated for each category, positive attitude, negative attitude, nontraditional activities and traditional activities, 0.81, 0.53, 0.55, and 0.68 respectively. The reliability coefficients were fairly high. The negative attitude and nontraditional activity had the lowest reliability that may be due to some items that could be considered either a positive attitude or a negative attitude such as, guessing is OK to use in math or knowing why an answer is correct is important. A nontraditional activity, using a calculator, may have been perceived by the students to be more of traditional activity. The Cronbach Coefficients indicated that the survey was reliable.

Students were unsure of their attitudes regarding several of the ten attitudinal items, for example, student were neutral when asked to respond to the statements that mathematics is a body of knowledge to be memorized, and that mathematics is interesting. Both female and male students tended to believe that there is always a rule to follow when doing mathematics with means of 4.49 with an SD of 0.90 and 4.22 with an SD of 1.20. This indicated that students hold a Formalist perspective, valuing logic, rules and procedures rather than problem solving or creativity. However, the students believed that mathematics is useful in daily life, male students' mean was 4.17 with an SD of 1.19 and female students' mean was 4.35 with an SD of 1.07.

Student reported activities also reflected the teachers' results. The overall mean student reported frequency of mathematics classroom activities indicated that the students seldom engage in mathematical projects or investigations. This is indicated by a mean of 1.66 and SD of 1.09. The students almost always watch the teacher work problems on the board as indicated by a mean of 4.47 and SD of 0.98. Students were frequently assigned worksheets, worked problems from the text, and were assessed through tests and quizzes. The means for these two activities are 3.73 with a SD of 1.14, 3.57 with and SD of 1.24, and 4.46 with an SD of 0.90, respectively. Occasionally, students used calculators and almost never used a computer. They were also offered opportunities to explain solutions. Students reported that they worked alone at their desks more often than with other students as indicated by the means of 3.59 with an SD of 1.17 and 3.20 with an SD of 1.24, respectively.

Student Interviews. Ten students were interviewed using a semi-structured format. There were core questions, but the interviewer had the flexibility to lead the interview into a direction that he/she felt would be productive. During the transcription process, it was revealed that there were some difficulties in the interviews' audio taping process such as background noise due to limited facilities for conducting the interviews in a quiet place. In order to protect anonymity, the students' first name and initials are used for identification. Hence, some of interviews were difficult to transcribe. This section will present summaries of the student interviews.

Generally, the students could not define mathematics. It seemed that this may have been the first time students were asked to actually think about what is mathematics. Typical responses to this question included, "I don't know," or "numbers." Pedro was an exception. He viewed mathematics "as a science," rather hesitantly, he continued by saying, "it helps in science, like in Biology, for like for example, uhm, in converting like in converting like uhm from well when we use uh, the different uh, what are they called, the measuring system." Pedro appeared to be aware that mathematics is useful in science but had difficulty conceptualizing its usefulness in some detail. To him, mathematics use was a way to convert units with little understanding in how the units were related.

An Algebra II GT student, JDL, suggested that "mathematics is the study of numbers and how you use them and the way that they are helpful." This student's definition implies that he/she understands that mathematics has a practical side, but it is not fully realized. The student could not give an example, and does not like problem solving, in fact he/she said, "I don't like problem solving."

The dislike toward problem solving was typical among the students. When asked do you like problem solving, JJ responded, "No, not at all!" After further probing, JJ revealed, however, that he does get the word problems right on tests. The student revealed his/her technique, "I read the problem five times, determine an equation, then I try to figure out what type of problem it is, substitution problem, slope, and figure it out." Another student, DG said, "Problem solving? its [. . .] just trying to get the answer step by step." DG's response indicated that she viewed problem solving as a procedural process. Conceptual understanding within problem solving seems lacking in the students. These responses suggested that the student has encounter problem solving in lock step following particular sections from the textbook rather than gaining a holistic view of problem solving. Similarly, in regard to reading the problem several times, JG said, "What you read, like, you have to understand it, so you can work the problem." the student's response indicated that reading comprehension is important to his/her success at problem solving. It appears that problem solving is not greatly emphasized in the students' classes regardless of the course.

Similarly, students typically could not provide an example of how mathematics relates it to real life. The students' responses indicated that the teacher uses the idea that math is useful but fail to have the students internalize the notion through actual examples. AL, an Algebra II student, mentioned, "When you're going to the store, if your taking the SATs." It appeared that applications of mathematics is used very little to explain concepts.

In relation to classroom activities, the students typically mentioned that the teacher lectures, "some are boring, and some are not," and they work on a lot of worksheets and textbook problems. Al was asked about this and responded, "she assigns them (worksheets) like, every night." The interviewer asked, "Does she use the textbook sometimes?" Al said, "yeah." The interviewer asked, "For homework? About how many problems do you do?" Al responded, "Like 30 or 40 problems a night." Edith when asked the same question said worksheets are assigned "everyday."

Calculators were mentioned by the students as a tool used in making fast calculations. This was indicated by GL who said, "Uh, huh, its mainly, we understand what's going on, the calculator's just an instrument to help us go faster, and speed the practice up instead of, having to multiply everything in you head, just type it in." In another interview, the interviewer said, "So, you use the calculator but not in problem solving." The student, AL, said, "Sometimes, the calculator doesn't give you the answer you want and you have to figure out the long way, you have to figure it out on paper." It appeared that calculators are conceived as a device to aide in getting answers, rather than as a tool to develop conceptual/procedural understanding. It is used strictly for calculations, to get things done quicker.

Discussion and Conclusion.

As an exploratory case study, the data provides a baseline in which to gauge future efforts. The results of the teacher philosophy survey should be viewed with the perspective that the survey was a pilot and that the number of teachers who completed the survey was small. However, the data does provide some insight into their philosophical perspectives toward mathematical knowledge.

The teacher philosophy survey data analysis suggests that the teachers have laid a mathematics foundation in the Formalist tradition, but they are building a perspective toward the Growth and Change philosophy of mathematics. This was indicated by the means of several items, both in the Formalist and Growth and Change views, that were in the neutral range with an occasional consensus on particular items. Generally, when the means from both traditions were compared, the Formalist item means were lower than the means for items related to the Growth and Change View. The statements related to the major tenets of Formalism were in the high agreement range. The teachers tended to believe that mathematics is rooted in logic, and that there is unquestionable certainty in mathematics. This could be considered a Platonic view-mathematics seen as a monolithic structure, unchanging and discovered, not created (Ernest, 1988). Yet, at the same time, the teachers held a sociological perspective in that mathematical theories develop within the community of mathematicians, that problems can be approached from several ways, and mathematical discovery is important to experience. This view according to Ernest (1988) may be described as a problem-solving view. In other words, mathematics is created rather than discovered. There may have been some confusion by the teachers related to the word "discovery;" the intended meaning was in the sense of creating.

Within the Growth and Change view, the teachers basically agreed that mathematics is a social construction where theories are tested, verified and agreed upon by a community of mathematicians, whose values influence the development of mathematical knowledge. They saw problem solving in mathematics as approachable from several avenues. Consequently, the teachers have built upon the logical nature and certainty of mathematics to establish a Growth and Change view, favorable for establishing a learning environment conducive for the teaching of problem solving and are open to the ideas that are related to the reform effort in mathematics education.

In regard to classroom activities, the teachers agreed that they relied on the textbook when lesson planning. The teachers reported that the TAAS test does not influence what they teach, but they would like to be more creative in blending their ideas with the TAAS objectives. This indicated that the teachers are concerned about the TAAS test, but agreed that it is not influential in what they teach. Teachers agreed that what they teach is centrally controlled. Yet, they felt a sense of autonomy; they can teach in whatever manner they feel is appropriate. However, the teachers view teaching to TAAS objectives as important because over half of the teachers have some difficulty in creatively adapting TAAS objectives to their instructional practices.

The teachers reported that they make attempts at relating mathematics to the students' daily lives. Although the teachers reported that they value problem solving and applications of mathematics to real life, these activities were rarely observed or reported by the students. The teachers agreed that there should be mathematical investigations, yet worksheets are often assigned. The students are provided opportunities, as reported by the teachers, to share ideas and have discussions of their answers.

The reported teacher activities tended to reflect the teacher's transitional phase from the Formalist philosophy to the Growth and change philosophy. The teachers relied on textbooks and worksheets, but believed that mathematical investigations should be included in their curriculum, and that the shared activity occurs. Perhaps more investigations or problem solving would take place if the teachers could see how these activities meet the TAAS objectives.

The teacher observations and observers' comments indicated that the teachers allowed their students a great deal of autonomy. This is a first step toward the development of higher order thinking. Most of the teaching practices that occurred dealt with lower order strategies and basic skills. The teaching practices generally reflected a Formalist view or a particular view of mathematics where one must learn methods first and understand uses, applications or relevance afterwards. Moreover, this is supported by the interview transcripts of students. The students have implied that the teachers have presented the procedures or systems of mathematics and then later learn to apply them in the future, during employment, or some other process, perhaps as a motivating feature.

The students reported, and the observers noted, that there was a great deal of emphasis placed on drill and practice through worksheets and textbook problems. Teacher lectures were the primary methods of dispensing instruction. The direct teaching of higher order cognitive strategies was very minimal. This was indicated by the low observer ratings and the number of higher order questions directed to the students. However, there were some instances were the teachers encouraged the students to use higher order cognitive strategies such as in the Informal Geometry and Calculus classes.

The Algebra I students had the least amount of autonomy and experienced less direct teaching of higher order thinking strategies than students in the other course categories. Students in Geometry had little opportunities to discuss arguments related to theorems or postulates. Mathematics teaching in each course category emphasized getting the right answer. Problem solving activities were avoided. Applications of mathematics to real-life or to other content areas were nearly non existent in the curriculum. Meaningful class discussions were rarely observed; yet, the students reported a high frequency of class discussions. This may be due to the students' interpretation of the word, "discussion" as being provided an opportunity to give an answer to a problem.

The teaching practices and the beliefs held by the teachers were reflected in the student survey. The students consider mathematics as mostly memorizing, following rules, and considered mathematics to be useful in everyday life, but could not provide specific examples when probed during an interview. The students have generally a poor attitude toward mathematics with the students enrolled in Algebra I having the most negative attitude in comparison to students in other classes. Although nearly equal in degree, the female students overall had a more negative attitude toward mathematics than the male students. The female students reported a greater frequency of traditional teaching activities than the male students.

In summary, the findings of this study correlates with previous research describing how teachers' beliefs about mathematics influence what is taught. The teaching methods and strategies of the participating teachers are housed within the school mathematics tradition with a developing perspective toward the reform efforts in mathematics education. However, the students listened to lectures, watched the teacher do examples, worked alone and/or with their peers to do worksheets or textbook problems. The students had opportunities to work with one another on problems and appeared to have a code of reciprocity, "if you help me, then I'll help you." Hence, the teachers are aware of the reform efforts, but are not implementing the ideas in the classroom.

Limitations

There were some limitations of the methodology which should be mentioned. One limitations was the small number of teachers surveyed with the mathematical philosophy survey. Another limitation dealt with the interview process. The transcriptions of the interviews where limited because of the locations where the interviews were conducted, background noise interfered with the transcription. Also, some interviewers did not adhere to proper interviewing techniques. For example, some responses were not extended by asking for examples from interviewees to illustrate their otherwise highly abstract and therefore often ambiguous answers.

Response to Research Question One.

What are the philosophical perspectives held by the teachers regarding mathematics?

The philosophical perspective regarding the teachers' views of mathematics includes a Formalism foundation. The teachers value the rules and procedures related to the logical nature of mathematics. While simultaneously, the teachers believe in the social aspect of mathematics. They are leaning toward the Growth and Change View with an emphasis in problem solving and constructivism. The teachers appear to be aware of the reform efforts but are not implementing them in a direct manner.

The tradition of the mathematics classroom is strongly based on the school mathematics tradition. Students are expected to return to the teacher what the teacher has deposited. The teacher is the director in the classroom rather than being a facilitator of learning activities. The procedures are of central importance rather than establishing connections between the concepts and procedures. The teachers' expectations are for the students to produce correct answers. The view of mathematics is one that is rigidly developed by the teachers rather than a context being one of activity, negotiation and discussion. The use of the students' strategies and potential for problem solving is limited.

The observed cultural features of the mathematics classroom can be classified as instrumentalist in nature. The content is organized into a hierarchy of skills and concepts; they are presented in sequence to the whole class, or to small groups. The teacher's role is to demonstrate, explain, and define the material in an expository fashion. The students' role is to listen, and participate in didactic interactions by responding to teacher questions, and do exercises modeled by the teacher. Instrumentalism does not actively involve the students in the processes of exploring and investigating ideas (Thompson, 1992).

Response to Research Question Two

What are the characteristics of the teaching that the students are experiencing?

The teaching practices that were observed and recorded focused on lecture, and drill and practice routines. The development of the lessons devoted a great deal of time to seatwork and teacher lecture. The facilitative process of the teacher to initiate meaningful acquisition of an idea by the student was hindered. Problem solving was not generally a focus of the teachers. Students were often seated in straight rows that faced the teacher, but were provided opportunities to work with peers in small groups, and discuss solutions to problems. There was a strong emphasis placed on the development of meaning and understanding through the use of lectures and worksheets. The students were provided with a fair amount of autonomy, and there was a positive classroom climate where students were not labeled as failures and all students were expected to be able to learn mathematics. Students were not encouraged to think and be self directed, features of a problem solver. The direct teaching of higher order cognitive strategies was limited. The applications of mathematics to real life were not made clear to the students. There was very little use of technology except for the use of calculators which were used as a tool to make fast calculations rather than as a tool to assist in conceptual development.

The teaching practices that were observed were aligned with the teachers' beliefs of mathematics. The strongest beliefs were related to the Formalist view of mathematics. This was evident in the teacher survey as well as the student reported activities. The teachers taught in a stereotypical fashion while the students were required to complete worksheets based on teacher lectures; a community of mathematicians was nearly non existent.

Recommendations

This section presents recommendations for instruction and staff development. The instructional recommendations are based on the reform view of mathematics teaching as espoused by the National Council of Teachers of Mathematics. Overall, the recommendations suggest that greater efforts should be directed toward the design of instructional practices that enhance understanding, blend basic skills with higher-order thinking and reasoning, incorporate technology, and foster open communication about mathematical ideas among students and their teachers .

Instructional:

- Encourage a problem-solving approach to teaching that reflects a conceptual growth view of mathematics requiring reasoning, gathering and applying information, discovering and communicating ideas.
- Portray mathematics as a non static, evolving, growing, and changing discipline.
- Encourage students to propose ideas and suggest problems and methods.
- Engage students in genuine experiments that allow students to develop hypotheses, test them and to generalize their methods.
- Encourage greater student involvement in the learning process by clearly showing students the relevancy of mathematics to real life situations.
- Permit students to be active constructors of their own knowledge, not passive absorbers of information.
- Classroom discussion needs to encourage critique and challenges to ideas.
- Allow the development of a problem-solving environment where approach(s) to mathematical issues are valued more highly than memorizing algorithms and using them to get right answers.

- Develop assessment practices such as portfolios, projects, journals, or interviews, that inform instructional decisions and that facilitate problem solving abilities in students .
- Allow for teacher control in developing reform-based curriculum activities.

Staff Development

- Make available a wide array of curriculum materials to help teachers think of the big ideas.
- Schedule common planning periods.
- Provide as part of staff development avenues for teachers to gain understanding of their students through the design of interest surveys, and reflection on students' needs for the creation of relevant and meaningful units.
- Improve the contexts in which teachers work, inform parents of reform efforts, administrators should become more supportive and tolerant of innovative classrooms.
- Have professional development meetings to discuss current research on learning and instructional strategies, debate the nature of mathematics and redefine basic skills.
- Provide opportunities for teachers to examine their beliefs and practices.
- View teachers as intellectuals who belong to learning communities that place inquiry at their center.

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Appendix

Descriptive Statistics for Student Survey

Attitude Toward Mathematics	N	Mean	Standard Deviation
1. Learning math is mostly memorizing.	223	3.03	1.29
2. Math is interesting.	225	3.38	1.35
3. Guessing is OK to use in solving math problems.	226	2.41	1.30
4. There is always a rule to follow when solving math problems.	226	4.36	1.06
5. New discoveries are seldom made in math.	225	3.10	1.22
6. Math is mostly about symbols rather than ideas.	226	3.06	1.28
7. In math knowing why an answer is correct is important.	225	4.35	1.15
8. Math is useful in everyday life.	226	4.27	1.13
9. I would like to have a job that uses math.	222	3.04	1.44
10. Math is fun.	225	3.08	1.38

Classroom Activity	N	Mean	Standard Deviation
11. Do math problems from the textbook.	224	3.57	1.24
12. Work alone at my desk on math.	224	3.59	1.17
13. Use a computer to work on math problems	224	1.51	0.93
14. Work on math problems with a group of classmates.	220	3.20	1.24
15. Show all of my work on a test or quiz.	222	3.80	1.25
16. Do Math practice worksheets.	222	3.73	1.14
17. Play math games.	223	1.73	1.12
18. Have class discussions about math problems.	224	3.77	1.27
19. Watch the teacher work problems on the board.	223	4.47	0.98
20. Do math projects.	223	1.66	1.09
21. Take math tests and quizzes.	220	4.46	0.90
22. Talk to the teacher about how I am doing in math.	224	3.13	1.27
23. Make up my own math problems to solve.	224	1.91	1.23
24. Use calculators to solve math problems.	225	3.42	1.38
25. Students explain how they solve math problems.	225	3.28	1.15

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