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ABSTRACT

This paper reports the effects of thematically integrated mathematics instruction on achievement, attitudes, and motivation in mathematics among middle school students of Mexican descent. A school-university collaborative effort led to the development and testing of a thematic approach undertaken as a means of contextualizing instruction for students considered to be at risk for school failure. Instruction relied heavily on small collaborative learning groups and on hands-on activities designed to help students make real-world sense of mathematical concepts. As hypothesized, experimental and control students made equivalent gains in computational skills, but experimental students (who received thematic instruction) surpassed controls in achievement on mathematical concepts and applications. The two programs did not have a differential effect on students' attitudes toward mathematics or self-perceptions of motivation in mathematics, but motivational variables did predict achievement outcomes for both groups. Issues related to the opportunity to learn the full range of mathematics content of the curriculum within a thematic approach are examined. (Contains over 50 references.) (Author)

RESEARCH REPORT: 5

MATHEMATICS AND MIDDLE SCHOOL STUDENTS OF MEXICAN DESCENT: THE EFFECTS OF THEMATICALLY INTEGRATED INSTRUCTION

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THEMATICALLY INTEGRATED INSTRUCTION

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Mathematics and Middle School Students of Mexican Descent: The Effects of Thematically Integrated Instruction

Abstract

This paper reports the effects of thematically integrated mathematics instruction on achievement, attitudes, and motivation in mathematics among middle school students of Mexican descent. A school-university collaborative effort led to the development and testing of a thematic approach undertaken as a means of contextualizing instruction for students considered to be at risk for school failure. Instruction relied heavily on small collaborative learning groups and on hands-on activities designed to help students make real-world sense of mathematical concepts. As hypothesized, experimental and control students made equivalent gains in computational skills, but experimental students (who received thematic instruction) surpassed controls in achievement on mathematical concepts and applications. The two programs did not have a differential effect on students' attitudes toward mathematics or self-perceptions of motivation in mathematics, but motivational variables did predict achievement outcomes for both groups. Issues related to the opportunity to learn the full range of mathematics content of the curriculum within a thematic approach are examined.

INTRODUCTION

The fact that Hispanic students are perpetually at risk for underachievement and failure in American schools is well documented (Laosa & Henderson, 1991; Orum, 1986; Valencia, 1991). The problem is especially acute in mathematics (Haycock & Navarro, 1988; MacCorquodale, 1988; Policy Analysis for California Education, 1990). The difficulties Hispanic students face in school, and particularly in mathematics, are compounded by the demands of an increasingly technological work force. The problem of underachievement in mathematics is profound not only because it imposes limitations on the educational and career opportunities available to the individuals affected, but also because it poses a broader problem for the nation. An increasing number of new scientists and engineers must come from populations that are currently underrepresented in that sector of the workforce (Holden, 1989). This challenge must be met by schooling that is appropriately constructed to help underrepresented students develop competence and confidence in mathematics and science (Massey, 1989).

This paper reports on the first two years of an effort to address the problem of underachievement and low participation in mathematics among students of Mexican descent. The project was part of a larger effort that brought an interdisciplinary group of university-based researchers together with middle school teachers in a collaborative effort to enhance the educational experience of a population of at-risk students in a middle school. (See Garcia, 1990; Henderson & Landesman, 1990; Matute-Bianchi & Alvarez, 1990.) The present paper reports on mathematics outcomes and associated patterns of attitudes and self-perceptions of academic motivation over the first two years of the project. Our more specific purpose is to examine the effects of thematically organized instruction in mathematics, to describe student attitudes relevant to mathematics, and to test hypotheses regarding the relationship of motivational variables to mathematics outcomes. We also examine some of the special difficulties, within a thematic approach, of providing comprehensive coverage of topics designated for the middle school mathematics curriculum.

It is important at the outset to acknowledge recent improvements in the mathematics performance of Hispanic students. Data from the National Assessment of Educational Progress (NAEP) demonstrate steady gains by Hispanic students at all of the levels tested: ages 9, 13, and 17 (National Council of Teachers of Mathematics, 1988). Some reports in the mass media have attributed these results to the "back to basics" movement (Fisk, 1988). There may be some justification for this attribution, because the pattern of improvement appears to mirror the different ways in which the educational reform movement has been implemented. In minority schools, the bulk of resources and energy has been focused on basic skills, whereas, according to Simmons (1985), schools with predominantly white enrollments have devoted more of their attention to higher order abilities. Therefore, it is probably no coincidence that improvement in scores of minority students has been confined primarily to lower-level computational skills.

Several researchers and educators have argued that the problem of Hispanic underachievement in schools should be addressed through curricular restructuring to achieve cultural compatibility (Moll & Diaz, 1987; Trueba, 1988). A series of studies by Laosa (1978, 1980, 1982) offers insights into processes that may contribute to the problems Hispanic children and their teachers have in making sense of one another's behavior. Laosa (1980) identified significant differences in the maternal teaching styles of Hispanic and non-Hispanic white mothers, but these differences virtually disappeared when the amount of formal education completed by the mothers was controlled statistically. Less educated mothers used a modeling or demonstration approach, whereas more educated mothers used more questioning, with praise for correct responses (Laosa, 1978). Hispanic mothers with more education apparently imitated the instructional style of school classrooms: i.e., the recitation script that serves as the pervasive protocol of instruction in American classrooms (Tharp & Gallimore, 1988).

Mexican-American children consistently have been found to exhibit a more field dependent cognitive style than their Anglo-American peers (Garcia, 1983). The causes and implications of the field dependent/independent construct are subject to debate (Henderson, 1980), but the consequences for instruction of differences in cognitive style remain an important issue. The more field dependent style of Mexican-American children may reflect what Tharp (1989) calls holistic/visual thought. Because children from cultures that employ holistic/visual patterns of cognition tend to learn in their natural environments, Tharp (1989) suggests greater curricular contextualization as a means of making instruction more compatible with the home culture of these students.

Thematic instruction may provide an effective way to contextualize instruction. It incorporates a concrete learning-by-doing orientation and has the potential to facilitate cooperative and interactive learning opportunities in the classroom. Cooperative learning can provide opportunities for hands-on activities that result in products on which students perform mental operations, and in situations that engage students in the use of concepts and materials (Tharp, 1989). These features have been identified as characteristics of classrooms that have proved effective for Hispanic students with limited proficiency in English (Garcia, 1991).

The central features of the collaborative approach reported here include "untracking," that is, assigning students to classes on a heterogeneous basis; developing a thematic (rather than the traditional subject-based) approach to instructional organization; and emphasizing cooperative learning groups. The approach was designed to incorporate instructional strategies that emphasize higher order thinking and have been identified as attributes of schools that are effective for students with limited English proficiency (Tikunoff, 1983; Wong Fillmore, Ammon, McLaughlin, & Ammon, 1985), especially Hispanic students (Garcia, 1988, 1991). We assumed that thematic integration of the curriculum would enable students to encounter mathematical concepts within socioculturally relevant problem-solving contexts that would be more meaningful than the traditional basal-text oriented approach. Specifically, we hypothesized that students participating in the thematic curriculum would make greater achievement gains than their counterparts in traditionally organized mathematics classes. Because traditional instruction has emphasized computational skills for minority students, we anticipated that performance in computational skills would not differ for the two groups.

THEORETICAL PERSPECTIVE

Contextualized Instruction

Although the advantages of thematic instruction remain to be demonstrated, there are sound theoretical reasons to think that such an approach holds promise. The rationale for the thematic integration of instruction might be seen most clearly by means of contrast with the dominant mode of teaching mathematics in contemporary schools.

As usually practiced, mathematics instruction is dominated by bottom-up information processing assumptions. Individual concepts and skills are presented, followed by practice in their application. Instruction follows the recitation script, described by Tharp and Gallimore (1988) as the dominant form of interactive teaching in American schools for over 90 years. Teachers ask questions requiring convergent answers, and successful students respond with known (presumably correct) information. There is little demand to think about what specific problems mean or how to approach them, because all of the problems are generally of the same type.

Students are expected, on the basis of such a foundation, to be able to combine skills and concepts appropriately to solve future problems. The demanding nature of this challenge may be appreciated when one considers that the mathematics curriculum has been "chopped into small pieces, which focus on the mastery of algorithmic procedures as isolated skills" (Schoenfeld, 1988, p. 162). Unfortunately, many students are unable to put these isolated skills together (Sternberg, 1988) and to derive mathematical meaning from them on their own. They have special difficulty relating the mathematical problems they have practiced to the varieties of environmental and contextual information to which they apply. In information processing terms, many students lack environmentally relevant, conceptually driven information to give meaning to the problems posed in mathematics classes.

If instruction is to overcome barriers to learning that result from an inadequate match between the culture of the school and the community backgrounds of cultural minority students, the schools must, as Tharp (1989) suggests, help these students by demonstrating how rules, abstractions, and verbal descriptions are drawn from the everyday world and how they are applied to it. If the fragmented and decontextualized nature of contemporary mathematics instruction poses barriers to achievement and participation for important segments of the population, then the practices that promote integration and provide a meaningful context for learning offer a potential remedy worth trying.

Cooperative learning and heterogeneous grouping do not, by themselves, guarantee success. But they can be employed to involve students in finding, inventing, and solving problems in familiar contexts, and these procedures enable students and teachers to engage in authentic, subject-based exchanges. Small groups organized around specific tasks make it possible for assisted learning (Tharp & Gallimore, 1988) to take place, leading to the internalization of the metacognitive skills students need to regulate their own learning (Henderson, 1986). Such autonomous learning is considered essential to the development of higher order thinking in mathematics (Fennema & Peterson, 1985). Learning based on concrete activities rather than on textbook abstractions enables learners to make real-world sense of their school experiences. Such opportunities are likely to be especially important for students whose out-of-school experience may not be highly congruent with the often abstract learning experiences of traditional classrooms (Tharp, 1989).

Thematic Integration and Opportunity to Learn: Tensions and Prospects

We have argued that thematic instruction offers a potentially powerful way to assist Hispanic students to connect mathematical concepts and problem-solving strategies to socioculturally relevant experiences. Although there is strong theoretical justification for this view, we must acknowledge a certain tension between instruction that organizes content around themes, on the one hand, and the need for comprehensive coverage of the mathematics curriculum on the other. School administrators and parents are not without justification when they ask the practical question, "Will students who participate in thematic instruction cover the mathematics curriculum for this grade thoroughly?" Data from the Second International Mathematics Study (Travers, 1988) provide convincing evidence of a substantial relationship between what schools actually teach and what students learn. Students tend to do well on the topics that are emphasized in the actual curriculum, and conversely, they tend to achieve poorly on those topics that received little attention in their schools. Patterns of curricular emphasis vary from nation to nation, and to some extent, from school to school within nations. Thus, there are variations in students' opportunity to learn. Thematically integrated instruction may provide an effective means of helping students to learn the skills and concepts they use in this context by connecting them to socioculturally relevant experiences. But we must be concerned whether the thematic approach affords students the opportunity to learn the full scope and sequence of mathematics content that will enable them to move on to more advanced learning of mathematics. We therefore will report on initial efforts to examine the fit between thematic instruction and the prescribed mathematics curriculum. (See page 9.)

Attitudinal and Motivational Dimensions

In addition to examining the effects of thematic instruction, we were interested in determining the nature of attitudes toward mathematics among Mexican-American students and the effects of instruction on those attitudes. Attitudes toward mathematics and beliefs about the nature of mathematics appear to play an important role in students' mathematics achievement and participation (Haladyna, Shaughnessy, & Shaughnessy, 1983; McLeod, 1985; Silver, 1985). There is a widely held belief among educators that children of Hispanic descent experience early and repeated failure in school, which results in poor academic self-concept, negative attitudes toward school subjects, and alienation from school. It was important for us to know whether the students with whom we were working liked or disliked mathematics. Cocking and Chipman (1988) review reports suggesting that parental attitudes toward mathematics may direct Hispanic children away from the subject. MacCorquodale (1988) argues that Hispanic girls, in particular, may be discouraged from pursuing mathematics. Cocking and Chipman report the following for Hispanic and Native American populations:

> There is a negative image of math, whereby mathematicians are perceived as remote, sloppy, obsessive and (no pun intended) calculating. No matter what your socioeconomic status happens to be, it is not likely that you will strive hard to become an unscrupulous, calculating, cold, sloppy, and obsessive number cruncher. (1988, p. 32)

We did not know if this generalization would apply to our sample of students of Mexican descent. Therefore, for both descriptive and follow-up purposes, we wished to ascertain these students' perceptions of the usefulness of mathematics, their intention to take more mathematics, and their interest in careers that involve the use of mathematics. We expected the thematic approach to result in improvement in students' attitudes toward mathematics (relative to attitudes of comparison students) and in their view of the importance of mathematics. Considering the integrated nature of the thematic approach, in which a variety of mathematical skills and concepts are applied to broad problems, we also hypothesized that students would develop broader perceptions of mathematics as a discipline.

The final purpose of the research reported here was to examine student self-perceptions in a way that would enable us to begin to link our work with this population to models of motivation that have been developed with non-minority populations and to ascertain the applicability of those models to Hispanic students. Our aims were guided by Carol Dweck's model of academic motivation (Dweck, 1986; Dweck & Leggett, 1988), which postulates a chain of causal associations between students' interpretation of events and their adaptation to challenging academic situations. Dweck suggests that some students are motivated by learning goals, whereas others are motivated by performance goals. Those who are oriented to performance are concerned about being correct. They tend to make choices that are likely to invite favorable judgments of their performance or that will minimize the chances of negative judgments of their competence by others. Thus, they may undertake a difficult task if they believe they can accomplish it successfully. However, when their confidence in a successful outcome is low, they are likely to pursue a less challenging task. In contrast, students who are oriented toward learning goals are more likely to explore, take initiative, and pursue tasks that promote intellectual growth, even when they are not confident that their efforts will be rewarded with success.

Although goal orientation has been identified as a potentially important factor in academic achievement in general (Dweck, 1986; Dweck & Leggett, 1988; Elliot & Dweck, 1988) and in mathematics achievement in particular (Peterson, 1988), little is known about the dynamics of goal orientation in natural classroom settings or for different ethnic groups. A learning orientation is normally associated with an inclination to seek intellectual challenge and to persist in the face of difficulty. We expected the two variables, goal orientations and challenge seeking/persistence, to predict learning outcomes. Our reasoning was that working on long-range problems requiring higher order thinking processes would influence students in the theme program to be more concerned with learning than with performance outcomes and that the nature of this instruction would have a positive influence on their willingness to persist in the face of difficult challenges.

METHOD

Subjects

The subjects who participated in this research attended a middle school serving a population predominantly of Mexican descent. Academic achievement among students in this school was generally acknowledged to be the lowest of the four middle schools in the district, all of which serve a population comprised largely of Mexican immigrant farm workers and other unskilled laborers. In the school we studied, 90% of the students were Hispanic; 60% of the Hispanic students were identified as limited English speakers (Garcia, 1990). The school, located on a busy street adjacent to the railroad tracks in a neighborhood dominated by agricultural storage sheds and packing plants, serves the poorest barrio in the community (Matute-Bianchi & Alvarez, 1990). Buildings are kept in good repair, but the limited financial resources of the district are reflected in what project ethnographers characterized as the "threadbare vestige" of the school (Matute-Bianchi & Alvarez, 1990).

During year one, 102 seventh grade students were randomly assigned either to the theme treatment or to traditionally organized classes that served as a comparison condition. Comparison students followed the school's traditional pattern, participating in non-integrated content classes with different combinations of students during the six classes of the day. Theme students were grouped into two heterogeneous classes, one of which was taught in English only, while the other was taught bilingually. Theme students remained together for mathematics, reading, language arts, and social studies or science. (Social studies was taught for one semester and science the next semester.) Theme students were integrated with other students for physical education and an elective subject. A small number of scheduling changes were made for administrative reasons during the first few days of the academic year, creating minor exceptions to complete randomization.

A similar arrangement was followed during the second year. except that assignment to treatment groups was not random. The school administration assigned students to treatment conditions with a view toward equivalency in achievement level between comparison and theme classes. Approximately half of the students in each treatment condition received instruction in English, while the others were instructed bilingually. After attrition, 103 students participated in either the theme or the comparison treatment for the entire school year.

Instruments

Parallel forms of an instrument were developed for pre- and post-administration to assess computational skills (40 items) and concepts and applications (45 items). The tests were devised to parallel the standardized achievement tests used by the school district, thus providing data that would be meaningful to district policy makers but with the further advantage of yielding detailed item-level information not available from records of standardized testing. To produce Spanish versions of both tests, back-translation procedures were performed by native speakers of Spanish who were proficient in both Spanish and English. All students were given the opportunity to be tested in the language of their choice, Spanish or English. Reliabilities for pre- and posttest versions were comparable. The alpha reliability coefficient for the Computation test administrations over the two-year period ranged from .84 to .86. Alpha coefficients for the Concepts and Applications test ranged from .77 to .88.

An attitudinal measure was constructed to produce items that paralleled selected items used with the sample of 13-year-olds in the Fourth National Assessment of Educational Progress (Dossey, Mullis, Lindquist, & Chambers, 1988). These items sampled attitudes such as students' liking for mathematics, their beliefs about how good they are with numbers and with word problems, their beliefs regarding the nature of mathematics and the usefulness of the subject, and their future expectations of working in an occupation requiring mathematical knowledge. The attitude scale employed a four-point likert format, with response alternatives ranging from *strongly agree* to *strongly disagree.*

A second part of the attitude scale employed items adapted from the NAEP measure of student attitudes toward the school subjects of science, social studies, mathematics, English, and reading. Items assessing student judgments regarding the importance of these subjects employed a four-point scale, with responses ranging from *very important* to *very unimportant.* Items ranging from *like it a lot* to *dislike it a lot* were used to assess student liking for the subject. Their judgments regarding the ease or difficulty of each subject were assessed with a four-point response scale ranging from *very easy* to *very difficult.*

The assessment of motivational self-perceptions consisted of two subscales, Goal Orientation and Challenge-Seeking/Persistence. The item format was adapted from the self-perception scales used by Harter (1985). In an examination of the discriminative validity of these and other self-perception scales, Henderson and Rankin (1988) reported alpha reliability coefficients of .85 for Challenge-Seeking/Persistence and .81 for Goal Orientation. Students chose to respond to either an English or Spanish language version of the measures. Again, all items were subjected to back-translation.

Procedures

Students participated in the selection of subsequent themes. Discussions leading to the nomination and selection of themes were conducted as group meetings in which the two thematic groups and their core teachers participated. Both teachers and students contributed suggestions for themes. In each instance, the group arrived at something approaching consensus, with considerations of both student interest and instructional potential entering into the decision. Teachers were active participants but did not dominate the decision-making process. Themes used during Year 1 were fine arts (which included popular music, art, and fashion), the ocean, and crime. Second year themes were careers, the environment, world issues, sports, and the future. The rationale for each theme differed from the others, but they had in common the quality of relating to students' present experiences and to their concerns about what the future might hold for them. For example, the arts theme drew upon student interest in popular music, art, and fashion, providing opportunities for the students to gather and analyze data on preferences among their peers and to summarize and communicate these inclinations by means of various forms of mathematical representations. As a second example, crime and its impact on the community, especially through drugs and gang activity, built upon matters that are regularly present in the experience and consciousness of these young students.

RESULTS

Data for the two years were first pooled for an overall analysis. A multivariate analysis of variance (MANOVA), with treatment group as the independent variable and the two mathematics posttests as dependent variables, revealed an overall significant effect (Multivariate $F = 8.27$, df 2, 168, $p < .001$). Univariate F ratios showed this outcome to be attributable to the effect of the treatment on Concepts and Applications outcomes ($F = 11.20$, df 1, 169, $MSe = .90$, $p < .001$). The effect of treatment on Computation posttest scores was non-significant. Analyses of covariance (ANCOVAs) with pretest scores as the covariate were then conducted to examine the effects of treatment on posttest performance (Kerlinger, 1986) separately for each year. The results of both ANCOVAs were congruent with the findings from the MANOVA with pooled data. Posttest scores of the themes treatment surpassed those of the comparison groups on Concepts and Applications posttests (year one $F = 5.15$, df 1,74, $p < .03$; year two $F = 6.53$, df 1,72, $p < .01$), but the two groups did not differ on the Computation posttest. Adjusted means from the analyses of covariance are presented in Table 1.

Table 1

Posttest and Adjusted Means for Concepts and Applications Posttest

Group	Posttest Mean	Adjusted Mean
Comparison Group		
1988-1989	19.54	19.58
1989-1990	21.94	21.94
Theme Group		
1988-1989	22.67	22.30
1989-1990	25.80	25.81

Preliminary analyses on data pooled across the two years of program implementation showed no treatment group differences on the self-perception and attitudinal subscales, so data were pooled across both groups and years for subsequent analyses. Responses on subsets of items from the Mathematics Attitude scale were summed to form subtest scores. Items pertaining to positive Personal Experience with Mathematics as well as items reflecting positive views of the value of mathematics formed a personal experience with mathematics subscale. Items designed to assess sex-role stereotyping with regard to mathematics and computer use formed a Gender Attitude subscale. Items reflecting the nature of mathematics were summed to form a Mathematics as a Discipline subscale. Preliminary repeated measures analyses of variance revealed that neither treatment group made significant changes in attitudes from pre- to posttesting. Therefore, data were pooled across the treatment groups for descriptive purposes. Table 2 (page 8) presents summary data on responses to items forming the Personal Experience with Mathematics, Math in Future, Mathematics as a Discipline, and Gender Stereotyping subscales.

From the pattern of responses to items that parallel those reported as personal experience with mathematics in the Fourth National Assessment of Educational Progress (Dossey, Mullis, Lindquist, & Chambers, 1988), it was clear that, to a degree equal to or exceeding the national sample, students in our sample reported that they liked mathematics, thought they were good at it, felt good when they solved problems successfully by themselves, and thought mathematics was easy.

Data reflecting student beliefs regarding the nature of mathematics suggest that, to a greater degree than students who scored in either the upper or lower quartile of mathematics performance in the Fourth National Assessment of Educational Progress, students in the target school believed that doing mathematics involves mostly memorization, that there is always a rule to follow, that mathematics involves mainly symbols rather than ideas, that it is comprised of unrelated topics, and that new discoveries are rarely made in mathematics. However, students in the target school did endorse strongly the view that it is just as important to know why an answer is correct as it is to get a correct answer.

Assessments of students' judgments of the importance of various school subjects showed that students in both treatmer. :ps professed a strong belief in the importance of the core subjects of the curriculum: science, social studies, mathematics, English, and reading. Assessments of students' liking for various subjects and their judgments of how easy the subjects are showed that there was a tendency for comparison subjects to judge the subject as more difficult on the posttest than on the pretest, while the theme group showed a small but consistent trend in the opposite direction.

Since the preliminary analysis showed that the treatment groups did not differ on the motivational dimensions, stepwise multiple regression analyses were conducted with pooled data to determine if mathematics posttest outcomes were predicted for the combined sample by pretest scores for Goal Orientations and Challenge-Seeking/Persistence. With alpha-to-enter set at .15, only Challenge-Seeking/

Table 2

Mathematics Attitudes Subscales and Items: Percent Agree or Strongly Agree with Attitude Statement

PERSONAL EXPERIENCE WITH MATHEMATICS	1988-89		1989-90	
Item	Pre	Post	Pre	Post
1. Usually understand what's talked about in math class	90.9	83.0	89.3	90.2
2. Good at working with numbers	80.2	88.3	84.3	85.9
3. Good at word problems	60.9	65.9	53.4	67.4
4. Doing math makes me nervous*	33.6	25.5	37.6	32.6
5. Math is boring to me*	41.7	26.6	30.1	24.7
6. Willing to work hard to do well in math	92.7	92.6	97.1	93.5
7. Like math	71.6	76.6	85.4	75.6
9. Feel good when I solve math problem by myself	90.9	92.6	93.1	90.2
10. Good at math	63.0	73.4	69.7	68.1
MATH IN FUTURE				
Item				
8. Like to work at job using math	54.6	57.5	54.9	55.4
11. Like to take more math	58.9	63.8	58.8	67.0
16. Expect to work in area that requires math	60.6	61.7	70.9	66.3
MATH AS A DISCIPLINE				
Item				
17. Learning math is mostly memorizing*	80.0	76.3	84.5	80.4
18. Always a rule to follow in math*	88.9	92.5	90.2	90.2
ϑ. Mathematicians work with symbols rather than ideas	61.8	43.6	66.0	59.8
20. Math made up of unrelated topics*	38.5	41.5	47.5	51.1
21. New discoveries seldom made in math*	54.1	59.6	65.4	55.4
22. Knowing why correct as important as getting correct	90.9	88.3	91.2	87.9
GENDER STEREOTYPING				
Item				
12. Math is more for boys than for girls*	14.0	4.3	14.6	10.9
24. Computer knowledge as important for girls as boys	88.2	82.6	94.1	93.4
27. Boys naturally better at computers than girls*	21.1	13.1	15.5	18.5

Note: Tabled values rounded to tenths

*Indicates items for which lower values represent positive responses to items

1 .

Persistence made a significant contribution to the prediction of posttest scores for Computation (R = .44, df 1, 69, p, < .001). Both motivational variables ontributed to the prediction of learning outcomes for Concepts and Applications (R = .33, df 2, 67, p < .02), with Challenge-Seeking/Persistence accounting for 6% of the variance and Goal Orientation contributing the remaining 5%.

THEMATIC INSTRUCTION AND THE MATHEMATICS CURRICULUM

How thoroughly did the theme approach cover the mathematics content prescribed for seventh grade? Interviews with the mathematics teacher who participated both years provide some insights into her mode of dealing with the tension between thematically focused teaching and curricular coverage. She reported that she covered about one half of the traditional textbook topics within the context of the themes, whereas she dealt with about three quarters of the text in her traditional classes. There is a reasonably good match between the textbook and the state curriculum framework for mathematics, so we accepted textbook topics as a rough gauge of students' opportunity to learn the designated curriculum. The theme teacher's means of covering material that was not encompassed within thematic units was to teach the omitted content between themes and after the conclusion of the final theme for the academic year. This meant that those topics were covered in a traditional mode, rather than by means of thematic instruction.

A closer examination of curricular coverage can be accomplished by scrutinizing one theme as an example. The first project taken up in Year 2 in the mathematics classes as part of the careers theme involved designing and building bridges. This activity drew upon a published resource (Pollard, 1985). Within each of the theme classes, students were divided randomly into groups of five. These groups then formed construction companies, giving their enterprises names such as The Pajaro Builders, Albert Einstein Co., The Mexican Corporation, and Trust Us Co., Inc. Within each company, different career-related roles were assigned by the group to its members. The roles were those of Manager, Engineer, Transportation Officer, Architect, and Accountant. The duties of each were explained at meetings of all students assigned to a particular role. All goods needed for construction were purchased from a "warehouse." Materials included cardboard (representing land), glue, toothpicks, and so on.

Each company was allotted 1.5 million dollars for its project. Calculating amounts, writing checks, and keeping records of accounts brought arithmetic operations into play. Determining the amount of material needed to construct the bridges involved estimation. Before constructing the bridge, students had to develop their plans on graph paper, drawing figures to scale. This involved measurement. At the next stage, students dealt with lengths, perimeters, and areas to assure the bridge would fit where they wanted it. Next came geometric visualization and discussions of similarity and congruence of figures. Finally, stress tests on the bridge and a discussion of optimal design involved some basic concepts of physics. The finished products were subjected to stress testing, using weights. Some were so strong they underwent "earthquake" testing as well.

The following key mathematical topics (each with many sub-topics) were included in the scope and sequence: 1) addition, subtraction, multiplication, and division of whole numbers; 2) decimals; 3) fractions; 4) properties of the real numbers; 5) problem solving; 6) estimation; 7) geometry; 8) measurement; 9) ratio, proportion, and percent; 10) statistics and probability; 11) pre-algebra; and 12) technology. All but two or three of these topics were incorporated into the study of careers. This is not to say that everything included under these topics in the curriculum guide was covered, but this does illustrate that many topics can be incorporated into a theme in a way that makes sense to students and avoids the "chopped up" nature of contemporary mathematics instruction, as characterized by Schoenfeld (1988).

The teacher was able to present several abstract topics successfully following the careers theme, before moving on to the next theme. These topics included the solving of simple linear algebraic equations with one unknown (e.g., $50x - 600 = 0$). Topics in geometry were also taught during the interim between themes. Specific topics included material on angles, measurement in degrees, the use of a protractor, and the classification of different types of angles. Triangles were also studied, with emphasis on equilateral and isosceles triangles and their properties. Instruction also included work on the concepts of rays, parallel lines, perpendicular lines, intersecting lines, transversals, regular polygons, congruent figures, symmetry, and reflections. Based on her experience, the teacher had the impression that the study of this material was made easier because of the mathematics already treated in the careers theme. She could relate many of these topics directly to the bridge engineering activities.

Certainly, some of the mathematical topics covered after the theme could have been incorporated into the theme. As an example, upon reflection we realized that, although the solving of a simple linear algebraic equation does not occur to one immediately as relevant to the careers theme, it could have been incorporated as well. Some such equations, after all, are nothing more than division problems. They could have been presented as a final abstraction of many such numerical calculations which the students were already doing when figuring out costs of materials and wages to pay employees for time worked.

DISCUSSION AND CONCLUSIONS

University researchers' most common modes of involvement in schools are either to use school students as subjects in research dictated strictly by the researchers' theoretical or empirical interests or to devise school improvement interventions in relative isolation from classroom teachers and then attempt to implement these fully designed interventions in schools. This project, in contrast, was from the beginning a collaborative undertaking between teachers and researchers. Although some planning began during the summer, the consequence of a commitment to collaboration was that no comprehensive program was ready to be implemented at the beginning of the school year. The program was developed as we went along. Therefore, implementation of the programmatic features described earlier was spotty, especially in the early stages. Neither the teachers nor the university researchers had a formula, but they did agree on a set of basic principles. Although they agreed with these principles, the school staff lacked previous experience teaching heterogeneously grouped classes at the middle school level. The elimination of ability tracking was especially anxiety-producing for the mathematics teachers. While committed to the approach at an intellectual level, they were not entirely confident that they could be as effective with heterogeneous classes as with the more homogeneous classes to which they were accustomed.

Considering the evolutionary nature of program development and implementation, it was encouraging to find support, even during the first year, for the hypothesis that students in the theme group would surpass their peers in conventional classes in achievement on mathematical concepts and applications. Students in both the theme and comparison conditions demonstrated significant gains in computation, but, as expected, neither group exceeded the other. This finding was congruent with our reasoning that computation would receive a great deal of attention in comparison classes, and that theme students would be exercising computational skills in meaningful problem-solving contexts rather than practicing skills and algorithms as isolated ends in themselves. The fact that, overall, the heterogeneously grouped theme students did somewhat better than those in more conventional classes served to alleviate the mathematics teachers' anxiety about teaching students in heterogeneous ability groupings, and they were extremely relieved that their students did not do less well in computation than they might have done in a more conventional class. The achievement data, then, provide considerable cause for optimism. With refinement and experience, we believe that the thematic approach could become even more effective. In this regard, it is especially important to recall a major advantage of thematic and other approaches that include small group instruction: They provide the opportunity to engage students in instructional conversations (Goldenberg, 1991; Tharp & Gallimore, 1991). From a sociocultural perspective, learning takes place first on a social plane (intermental functioning), with skills, concepts, and understandings acquired in social interaction later becoming internalized, enabling individual students then to function independently on the intramental plane (Wertsch, 1991). Language is the vehicle of learning within this framework. Lacking opportunities for this kind of linguistic engagement in their home environment, students from linguistic and cultural minority backgrounds will continue to be disproportionately at risk for failure in mathematics. In fact, as conventional assessments of mathematics achievement give way to more varied approaches to assessment (Romberg, Zarinnia, & Collis, 1990), including more open-ended problems, it is reasonable to expect an increase in the achievement discrepancy between native speakers of English and minority students whose instruction fails to promote linguistic engagement in problem solving.

The attitudinal data present an interesting characterization of this mainly poor, predominantly Hispanic sample of middle school students. On the basis of historical and demographic data, it seems safe to assume that many of these students are at risk for educational failure and school drop out. If we expect, therefore, to find among these students a high proportion who are alienated and consider themselves to be failures at mathematics, the data suggest we are mistaken. The data for both the first and second years of the study present a consistent picture. These students expressed a high degree of liking for mathematics. Moreover, they generally considered themselves to be good at it. The majority indicated that they wanted to take more mathematics, and, to a greater degree than the NAEP sample, they indicated that they expected to work in an occupation that would require mathematics. It was also encouraging to note that the majority did not express anxiety about the subject. Furthermore, relatively few considered mathematics to be boring.

On the face of it then, these data seem to present an optimistic picture. The finding of positive school attitudes seems consistent with recent data from the California Identity Project showing that Hispanics in California, although disproportionately poor, do not demonstrate the characteristics usually associated with an underclass (Hayes-Bautista, Hurtado, Valdez, & Hernandez, 1990). However, it is disconcerting when we consider these data in relation to achievement outcomes. Although there was improvement over the course of both years, the absolute level of mathematics achievement of the students in our study was actually quite low. The majority of students had some difficulty with simple arithmetic skills that should have been mastered in elementary school. The juxtaposition of low achievement with the belief held by most students that they were good at mathematics suggests that they may have gained misleading expectations from their elementary school experience. If teachers set lower goals for minority students than for non-minority students, as the literature suggests (Cocking & Chipman, 1988), students may be deprived of bench marks from which to judge the level of their own performance. In this regard, it is interesting to recall Gándara's (1982) finding that many Hispanic females with exceptional educational accomplishments attributed part of their success to having attended integrated schools with high-achieving students who established a standard of comparison. In the context of the theme approach, it is especially interesting to speculate about how students can be involved in predominantly non-competitive educational experiences and still develop realistic conceptions of their achievement.

The likelihood that the students in our study had been exposed to elementary mathematics instruction that emphasized rote skills and computation seems to be supported by their conceptions of mathematics, as expressed on the attitudinal instrument. In general, these students tended to see mathematicians as people who deal primarily with symbols rather than ideas. Students in the target school also saw mathematics as an assortment of unrelated topics and characterized the learning of mathematics as mainly memorization. This image of mathematics might also reflect the level of mathematical knowledge of their elementary teachers and those teachers' own conceptions of the nature of mathematics.

Although the descriptive data are interesting, it was disappointing to find that thematic instruction had no effect on attitudes toward mathematics. It is possible that the generally high positive values on the pretest for both treatment groups left little room for positive change, but we were surprised that so many theme students, even after experiencing a program that emphasized the higher order thinking processes, continued to view mathematics as mainly involving memorization and the application of rules (algorithms). Further work is needed to examine the basis of this perception.

We expected to find positive changes in self-perceived scholastic competence and challenge-seeking/persistence for the themes group, but not for the comparison group. This expectation was not sustained. However, the stepwise multiple regression analyses of these data lent support to hypotheses derived from Dweck's (1986) model of academic achievement. Goal Orientations predicted Concepts and Applications outcomes but not Computation outcomes, indicating that students with learning (as opposed to performance) orientations experienced superior achievement. Challenge-Seeking/Persistence was a significant predictor of both Computation and Concepts and Applications.

While we are optimistic about the potential of thematic instruction as a means of involving minority students in meaningful learning experiences in mathematics, we are concerned whether students will have the opportunity in these contexts to learn the full range of mathematics content defined by the curriculum, especially considering strong evidence that coverage of mathematical content is a very important variable in student achievement (Travers, 1988). Review of the mathematics content of the themes suggested that some opportunities to incorporate aspects of the standard seventh grade mathematics curriculum were not pursued to full advantage. It takes a considerable amount of careful planning to recognize all of the opportunities a given theme may present, and time for such detailed planning may be difficult to find amid the daily pressures of teaching. Moreover, it is an unfortunate fact that many middle school mathematics teachers do not have a strong mathematics background. We think it would be especially difficult for teachers with a superficial grasp of mathematics to recognize the opportunities to incorporate important mathematical concepts and problem solving into a theme. We are addressing this issue under the auspices of the National Center for Research on Cultural Diversity and Second Language Learning by identifying resource materials and by developing and testing frameworks for a variety of thematic units. The proposed frameworks are intended to preserve the potential of thematic instruction to be responsive to diverse cultural backgrounds and community settings while ensuring that students have the opportunity to learn the full range of mathematical topics that are prerequisite to participation in more advanced mathematics.

1

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