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ABSTRACT

This handbook provides information on the purpose, organization, and use of Teacher Education and Mathematics (TEAM) modules within the context of a teacher education course for elementary education students or as supplementary materials to such a course. The four mathematics and four attitudinal modules are designed to produce four outcomes for learners: (1) increased mathematics knowledge and skills; (2) more confidence (and less math anxiety) in dealing with mathematics; (3) skill in identifying sex-role stereotyping in curriculum materials and teaching behaviors; and (4) perception of mathematics as useful and appropriate for females. Topics addressed in the mathematics modules include patterns, approximation and estimation, choice and chance, and metric measurement. Topics addressed in the four attitudinal modules include sex-role stereotypes, women and mathematics careers, women as mathematicians, and demystifying mathematics. A general overview of these modules, recommended instructional strategies, ways to create a positive learning environment, and attitudinal interventions are provided in the handbook. A list of references, research evidence in support of TEAM strategies, and sample class logs are also provided in appendices. (JN)

Instructor's Handbook

A Course to Reduce Math Anxiety and Sex-Role Stereotyping in Elementary Education

TEAM

TEACHER EDUCATION AND MATHEMATICS

Queens College of the City University of New York
Women's Educational Equity Act Program/U.S. Department of Education

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A Course to Reduce Math Anxiety and Sex-Role Stereotyping in Elementary Education

Instructor's Handbook

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INTRODUCTION

There is a body of literature that details the nat : and consequences of math anxiety. Tobias (1976) described math anxie nonrational distaste for and avoidance of math and math-related cts. Kogelman (1978) has defined math anxiety as a manifestation people's fear and dislike of mathematics, while Aiken (1976) in his extensive review of the literature on attitudes toward math discusses "anxiety in the presence of mathematics." Richardson and Suinn (1972) state that "mathematics anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematics problems in a wide variety of ordinary life and academic situations." Lazarus (1979), using Zacharias' "mathophobia, an irrational impeditive dread of mathematics," has suggested that a majority of children and adults experience this negative affect.

For women, besides these negative feelings which they probably share with men, there is the additional factor of sex-role socialization processes that foster the belief that mathematics is not an appropriate female domain. Fox (1976) has clearly stated this view:

> Although anxiety about mathematics may not in every case be a direct result of sex-role socialization conflicts, it is likely that the sex-typing of mathematics as a male domain by parents, teachers, and peers results in the acceptance of math-anxiety in females as inevitable or irrelevant to their development. (p. 49)

The National Assessment of Educational Progress found that although male and female achievements in mathematics are fairly equal at age 9, females begin to decline in relative achievement by age 13 (National Assessment, 1975). Fennema (1974) analyzed studies concerned with sex differences and mathematics achievement and concluded that there are no significant differences that consistently appear between the learning of boys and girls in the fourth to ninth grade. Sex differences in math avoidance and achievement become apparent with the onset of puberty, and these differences support the view that most girls by the ages of 12 or 13 have learned that mathematics is not feminine (Fox, 1976). That mathematics is perceived as more a subject for males than a subject for females reflects sex-role stereotypes.

An important consequence of these attitudes is the tendency for young women in high school to discontinue the study of mathematics when it becomes an optional part of the curriculum (Sells, 1973; Fox, 1976; Fennema and Sherman, 1977; Casserly, 1978; Ernest, 1976). It is clear that sex differences in mathematical experience contribute to sex differences that have been documented in mathematics achievement (Fennema and Sherman, 1977).

By far the majority of undergraduate elementary teacher education students are female. These women are typical of college women generally, since many of them have failed to study mathematics. Since many teacher education programs do not include mathematics requirements, these women may be especially math avoidant and anxious. Their concern about their ability to guide children in the learning of mathematics is not without foundation. It is also likely that they hold traditional sex-role stereotypes that promote mathematics for boys and that female pupils can learn unfavorable attitudes toward mathematics from them. Teachers' attitudes, classroom activities, and sex-role stereotyping in elementary school mathematics textbooks all serve to reinforce the perception of mathematics as a male domain. There is some evidence that attempts are being made to eliminate sexism in the more recently published elementary mathematics series (Kepner and Koehn, 1977; Kuhnke, 1977; Reyes, 1979).

The elementary school teacher has a large part to play in developing children's attitudes toward mathematics and the relation between sex role and achievement in mathematics: "If the teacher is tense and ill at ease with mathematics, such feelings infect the class with the idea that mathematics is hard or unpleasant" (Lazarus, 1975). A female teacher can also be expected to be a role model for the girls in her class. Girls will be particularly sensitive to any negative attitudes toward math and the mathematics accomplishments of women that the woman teacher reflects. Teachers who consciously or unconsciously hold the widely extant view that mathematics is a male subject will transmit this to their pupils in both subtle and direct ways. Furthermore, teachers who are anxious about their own ability in mathematics or who lack the confidence to guide children in learning mathematics can be expected to convey these attitudes to their pupils, both girls and boys. Ernest (1976) reported finding that 40 percent of a mathematics class for future teachers had expressed either negative or indifferent attitudes toward mathematics. He emphasized the need for teachers who are "competent in mathematics, who love the subject, who enjoy teaching it and who will not project sexist expectations on the students" (p. 8). Donady and Tobias (1977) point out the need for teachers to become free of math anxiety so that they can help their students avoid or overcome discomfort with mathematics.

Sex-equity issues, which closely bear on mathematics attitudes, are not treated adequately in current teacher education curriculum materials. Sadker and Sadker (1979), analyzing the content of the most popular teacher education textbooks, pointed out the widespread sex bias that exists in mathematics and science methods texts. They found that none of the mathematics education texts they analyzed referred to girls' and boys' achievement differences in mathematics, to attitudinal problems related to learning math or science, or to the stereotyping of math as "male" territory. Among the texts analyzed, those in math and science showed the least awareness of girls' particular needs. As a whole, these teacher education materials give little reason for being optimistic about future teachers' sensitivity and skills in identifying and responding to girls' learning needs.

The need is clear for programmatic approaches in teacher preparation that foster teachers' skills and positive attitudes toward math, awareness of sex stereotyping in math curriculum materials and classroom practices, and perception of math as an appropriate domain for females. TEAM modules are a response to that need.

HOW TO USE TEACHER EDUCATION AND MATHEMATICS (TEAM)

Have you observed students who seem tense when they have a mathematics problem to solve? Have you noticed that some students seem to go to great lengths to avoid having to work out a numerical computation? Have you been surprised when a student who is obviously intelligent and articulate can't seem to get started when confronted with a mathematical problem? How many incidents like these have involved women students? These observations suggest that you have witnessed math anxiety in operation. The modules in this course, developed by the Teacher Education and Mathematics (TEAM) project, were prepared to help teacher education students to develop positive attitudes toward and to deal effectively with mathematics. Specifically, the TEAM modules are designed to produce the following outcomes for learners:

- Increased math knowledge and skills
- More confidence (and less math anxiety) in dealing with mathematics
- Skill in identifying sex-role stereotyping in curriculum materials and teaching behaviors
- Perception of mathematics as useful and appropriate for females

ORGANIZATION OF MATHEMATICS MODULES

The four mathematics modules cover the following topics:

Patterns: Natural Numbers, Sums of Natural Numbers, Geometric Strategy, Triangular Numbers, Even Numbers, Sums of Even Numbers, Odd Numbers, Sums of Odd Numbers, Square Numbers, Inductive Reasoning, Binary Sequence, Fibonacci Sequence

Approximation and Estimation: Approximate Numbers, Order of Operations: The Calculator, Reference Numbers, Rounding Numbers, Chopping Numbers, Rounding Up, Comparing Large Numbers, Numbers in Words, Scientific Notation, Reasonable Results

Choice and Chance: Equally Likely Events, Multiplication Principle, Tree Diagram, Outcomes and Events, Permutations, Subsets, Probability, Events and Ordered Pairs, Mutually Exclusive Events, Complementary Events, Experimental Probability

Metric Measurement: Decimal Structure and Prefixes, Precision in Measurement, Reference Measures, U.S. Customary and Metric Systems, Volume, Area, Conversion

Each of these mathematics modules consists of an Instructor's Text, Instructor's Guide and Solutions to Student Exercises, Student Materials and Exercises, and Student Summary and Review. A module kit includes one copy of each.

The Instructor's Text provides (1) directions for the instructor on specific steps to take in guiding lessons and (2) commentary directed toward both math content learning and math attitudes. The directions suggest to the instructor what to do and how to do it. The commentary provides explanations, additional instructional options, attitudinal interventions, and organizational alternatives. Content objectives are specified for each module. A set of questions from which the instructor can select items for quizzes is provided as student evaluation materials; this pool of items includes several questions for each content objective.

Student Materials and Exercises provides such things as diagrams and charts which can be used during instruction. Instructors may plan to make transparencies of these diagrams for use on overhead projectors while they are working with students. Exercise materials include problems that apply the concepts and problem-solving strategies developed in the modules. These problems can be used as part of instructional activities, as content for small-group activities, as assignments, or as review materials.

Instructor's Guide and Solutions to Student Exercises describes approaches to and solutions for problems.

Student Summary and Review summarizes the module's content (i.e., formulas, terminology, key concepts, problem-solving strategies and illustrative examples of techniques used). These notes are to be provided to students after they have participated in the learning activities of a module.

ORGANIZATION OF ATTITUDINAL MODULES

There are four attitudinal modules: Demystifying Math; Sex-Role Stereotyping in Mathematics Education; Women, Mathematics, and Careers; and Women as Mathematicians. Each of these modules consists of an Instructor's Text and Student Materials.

The Instructor's Text provides directions and commentary analogous to those described above. Two audiotapes and their scripts are provided: (1) Getting from Here to There is for use with Women, Mathematics, and Careers, and (2) Interviews with the Past is for use with Women as Mathematicians. These audiotapes can be used during whole-class instructional times, or as small-group or individual learning activities. Strategies that can be used to assess changes in students' attitudes or skills are noted.

Student Materials includes things to be used in class sessions (e.g., checklists, guidelines, readings) or in assignments (e.g., rating forms, interview guides). An instructor may choose to make transparencies or to provide multiple copies of some forms by using a duplicating master or photocopier.

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COURSE USE

The TEAM program operates within the context of a teacher education course for elementary education students or as supplementary materials to such a course.

As a Teacher Education Course

The entire set of modules constitutes a program designed to increase math skills and improve the attitudes of elementary education students prior to the taking of a mathematics methods course. Small classes that allow for discussion provide the best setting for such a course. The TEAM materials are designed to be used by teacher educators or mathematics department instructors working alone or in consultation with a counselor or psychologist.

A sample course description might be: A course for prospective elementary school teachers to increase math understanding, skills, and confidence. Content includes: Patterns; Approximation and Estimation; Choice and Chance; Metric Measurement; Demystifying Math; Sex-Role Stereotyping in Mathematics Education; Women, Math, and Careers; and Women in Mathematics. (3 class hours per week)

As Supplementary Materials

Each module was constructed as a complete unit and can be used without reference to the others. A selection of modules can be made, therefore, to supplement existing materials. For example, any or all of the math modules can be used as part of a mathematics course for students studying elementary education. The attitudinal modules can be used singly or as a set in foundations of education, educational psychology, or mathematics methods courses.

TIME FRAME

Approximately eight hours of instructional material are provided in each of the mathematics modules. Approximately twelve hours of material are provided in the four attitudinal modules, which vary individually from two to six instructional hours. The entire product can serve as the content of a typical semester-long course.

PURPOSES AND STRATEGIES

TEAM modules have been designed to reduce students' math anxiety, to increase students' sense of mathematics as an appropriate domain for females, and to increase students' awareness of and competence to counter sex-role biases in curriculum materials and classroom practices. The focus of each module has been identified and ways for evaluating students' progress have been provided.

INSTRUCTIONAL STRATEGIES AND CONTENT

Instructional strategies for this program are designed both to foster positive attitudes and to develop skills. But to what specific student needs should such a program be addressed? Is it appropriate for the instructor to assume that teacher education students lack sufficient background and have negative attitudes toward mathematics? Clearly, even when a class is largely female, such an assumption is questionable. Based on the TEAM experience, it is appropriate to expect that there will be a wide range in students' preparation and attitudes. Thus, these materials were based on the assumption that individuals vary in their needs for attitude and skill development. The strategies that have been selected and designed, therefore, deal with the range of students' needs for mathematics knowledge and skills while concurrently addressing students' attitudes.

Since an increase in personal mat kills is usually accompanied by an increase in confidence in dealing with situations or problems calling for mathematics, much emphasis in the program is placed on techniques to develop mastery of math content. Attention to attitudinal considerations is integrated with math content through the commentary provided in the mathematics modules. No artificial separation of cognitive and affective learning opportunities occurs; rather, integration of these is emphasized.

It is recommended that instruction be carried out by a mathematics educator. However, a math department instructor may also find these modules useful in classes designed for students who are taking nonmajor mathematics courses. Commentary on attitudinal aspects has been provided regularly so that an instructor, without counseling training, working alone, can attend to and intervene on attitudinal issues. Having a college counselor or psychologist available for consultation is, however, recommended.

Modules that specifically focus on personal experience, mathematics anxiety reduction, attitudes toward math, sex-role stereotyping, and math as a domain for females are part of the program. These modules may be used in the sequence in which they are organized, or each may be used as a separate segment selected to meet the particular needs of students. The assistance of a counselor may be particularly useful with these modules.

Priority is given in the mathematics modules to developing students' mathematical concepts and knowledge rather than their computational skills. Calculators, considered standard daily equipment in contemporary society, should be available for students' use during class sessions.

MATH CONTENT

Mathematics modules deal with Patterns, Approximation and Estimation, Choice and Chance, and Metric Measurement. These content areas were selected, in consultation with mathematics educators, to meet the needs of current college students who may have underdeveloped mathematical knowledge and skills. In making this selection, a number of factors were considered.

1. High interest appeal

   Students who have been unsuccessful with mathematics often find it difficult to pay attention to material they found dull and uninteresting in the past. Using topics that would spark student interest and enthusiasm was an important criterion.

2. Present and future needs of college students who will become classroom teachers

   Experienced mathematics educators who have worked with teachers and prospective teachers recognize that many of them have mathematical limitations that need to be overcome.

3. State curriculum guides and other materials concerned with the mathematics education of children

   Clearly, prospective teachers should have the skill and confidence to deal with the mathematics they will be asked to teach children.

4. National Assessment of Educational Progress (NAEP) mathematics objectives

   Because the NAEP evaluates what the students of the United States are learning, it was important to consider the mathematics objectives this group is using as the basis of its testing.

5. National trends and technology

   Such matters as the adoption of the metric system of measurement and the proliferation and use of calculators and computers were considered.

6. The National Council of Supervisors of Mathematics (NCSM) position paper on basic skill

   Mathematics educators agree that the ability to compute is only one of a number of basic skills that will be needed in the future. Therefore, the NCSM Ten Basic Skills listed below were considered important.

a. Problem Solving
b. Applying Mathematics to Everyday Situations
c. Alertness to the Reasonableness of Results
d. Estimation and Approximation
e. Appropriate Computational Skills
f. Geometry
g. Measurement
h. Reading, Interpreting, and Constructing Tables, Charts, and Graphs
i. Using Mathematics to Predict
j. Computer Literacy

Mathematics content perceived by students as interesting, purposeful and relevant to life experiences was considered basic in developing the modules. New and different materials have been included where possible so that learners would not feel that they were reworking old, perhaps distasteful, content. Problems that offer the learner the challenge and opportunity to choose strategies, to pose questions, to use logic, and to interpret and question conclusions have been selected and designed.

The problems presented and the directed math learning activities in the modules are designed specifically to develop the student's ability to identify and use problem-solving processes. Among the key processes included are (1) looking for a pattern (numeric, geometric or algebraic); (2) using an orderly, systematic approach to the information given; (3) recording information systematically, so that a pattern can be perceived; (4) referring to one's existing skills in problem solving based on prior experience; (5) working on a smaller or easier problem that is a prototype or part of a larger problem; and (6) transferring a successful method from the context of a simple problem to that of a more complex one. These key processes are introduced early in the math instructional materials and repeated regularly within new contexts. Opportunities for students to practice these processes are provided in the student materials.

Mathematical vocabulary is defined by exemplification. The development of meaning within a mathematical context leads to greater precision and is more economical of the learner's time. An individual learner's difficulties with mathematical vocabulary are diagnostically significant and need prompt attention. Such difficulties are frequently related to limited earlier experience and to extended time breaks in studying mathematics.

The modules are designed to involve the learners in the inductive learning process. Each topic is presented in a series of experiences, such as problems to be solved or observations to be made, through which students can arrive at a generalization to account for or explain those specific learning experiences. The generalizations frequently appear as formulas. As the learning proceeds toward generalizations, processes that have utility in problem solving are introduced early in the modules and are systematically revised. As the learners proceed from specific facts, quantities, terms, and so on toward generalizations, they are encouraged to anticipate next steps and to question proposed steps.

This process, which proposes moving from specifics toward generalizations, and in some cases from concrete experiences toward abstractions, is heavily represented in current published curriculum materials for children. The mathematics laboratory approach, widely used in regular school classes as well as in remedial programs, exemplifies this process. The college students who will be using these modules may profit in a number of ways from a personal opportunity to learn mathematics inductively. They may be able to appreciate both the value of the contribution of this process to a learner's understanding of mathematical concepts and the feelings that a learner experiences while engaging in the process.

Since it is vital that students move through experiences that lead to generalizations, they should not be given a text in advance. This would defeat the purpose of the inductive approach, an approach that provides an opportunity for the learner to experience the satisfaction of discovering a principle or relationship from the activities in which he or she has engaged. The Student Summary and Review for each module provides a thorough summary and explanation of generalizations. It is to be given to students after they have worked on the module topics. It is helpful for students to have those notes to use in reviewing materials in preparation for a quiz. The loose-leaf format of these modules makes it possible for the instructor to distribute sections at appropriate times.

The impact of stereotyping on female students' perception of themselves as math learners has been attacked both directly, through instructional materials and activities, and indirectly, through role modeling. Opportunities to learn what sex bias entails and to examine mathematics curriculum materials for evidence of bias are provided. Student materials have been designed to include information on the contributions of women to mathematics. It would be ideal to have available as role models a staff of attractive women who vary in age and life stage, and who display comfort with and interest in both math-related activities and traditional female concerns.

These instructional strategies have been developed based on information in the research literature on mathematics attitudes, math anxiety, sex-role socialization, sex-role stereotyping, mathematics instruction and educational psychology. See Appendix A for a discussion of this literature. The section begins on page 21.

LEARNING ENVIRONMENT: SUPPORTS AND CHALLENGES

A nonthreatening learning environment is essential for using these instructional materials. Both support and challenge are needed to create a climate in which learning is sustained. Students need to be encouraged to "think aloud" and to feel that their ideas are worth consideration. A student need not be constrained by having to state only a fully developed or "correct" idea. This means that instructors emphasize the processes with which the students are working, rather than focusing only on getting answers. It means further that in problem solving alternative routes should be sought rather than a single approach to obtaining a right answer. By providing practice and support for seeking out alternatives, the instructor implicitly recognizes that students differ in learning styles, approach to subject, and background experiences.

Students should be made aware of the steps that usually take place during problem solving. Tension is often experienced while one is searching for a strategy that will work. Students should become aware that some tension is to be expected.

In addition to being supportive, the learning environment should stimulate and challenge. Students efforts are enhanced when students feel that the problems they are working on and the questions they are answering are worthy of their efforts. Since interest is a catalyst in the learning process, students' curiosity about problem solutions and processes in solutions should be encouraged.

TEACHER COMMUNICATION

In order to provide a supportive and challenging learning environment, an instructor needs to refrain from responding quickly to a student's idea with a statement of its "rightness" or "wrongness." This concern for maintaining openness while ideas are being considered needs to be balanced with the concern for students' having clear knowledge of the correctness, efficiency and merit of the various ideas which may be considered. This balance is difficult to achieve and maintain. One strategy is to empathi with students' needs and struggles to master the math materials. This empathy can exemplify an attitude toward students that facilitates supportive, nonthreatening, yet task-oriented instructor behavior.

Teacher attitudes are communicated in both obvious and subtle ways. When a teacher is working with a group of students who have developed anxieties about their ability to deal with or to learn mathematics, the teacher's attitudes play an especially significant role. Instructors may feel they are being helpful when they say, "It's easy." Students, on hearing this and accepting the instructor's judgment, tend to blame themselves when they don't understand an idea. Their old sense of failure can be reactivated. It is helpful when the instructor recognizes explicitly that a concept is difficult. The most supportive message is given when difficulties are acknowledged and faith in the learner's ability to master the materials is communicated.

Waiting appropriately for students' responses to questions contributes significantly to students' learning and attitude formation. The "Wait-Time" studies by Mary Budd Rowe (1974), which describe the degree to which teachers do not wait appropriately for students' answers before they speak again, provide the basis for this strategy. Instructors' increasing their waiting time to five seconds after they raise a question was found to increase student participation and learning at elementary school levels. Extrapolation to mathematics questions directed to math-sensitive young adults has been useful in the TEAM project.

STUDENT-TO-STUDENT COMMUNICATION

Positive student-to-student attitudes and behavior can enhance the learning environment immeasurably. A key step that instructors can take to promote positive student attitudes is to design opportunities for students to cooperate on tasks. Cooperation, not competition, fosters a student's sense of being part of a mutual support system that can encourage curiosity, experimentation and intuitive thinking. Pairing students during class sessions so that one can serve as a resource for the other can contribute to enriching a student's experience in the class group. Competition may still arise within groups working on a problem. The instructor needs to recognize signs of tension associated with heightened competition. Maintaining a constructive level of competition and preventing individuals from "dropping out" are the goals. If tension gets too high, the instructor should change the specific activity or class organization.

Students' comments to each other, rather than detracting from the learning process, frequently enhance it. Learners can be particularly sensitive to someone else's struggles, especially when they have experienced similar struggles themselves. Since teaching is their career goal, the students may find it especially meaningful to assist each other.

PEER TUTORING

Establishing tutoring sessions both during and between classes may provide an important resource for learners with marginal preparation in math or with "rusty" skills. Tutors may be selected prior to the beginning of the course from among skilled, interested students, or selected early in the semester based upon achievement. Once the course has been offered, a pool of prospective tutors becomes available from among those students who were successful and enthusiastic. The research literature emphasizes the beneficial effects of tutoring for tutors themselves, as well as for those tutored, and well justifies the effort required for the instructor to establish and work with a coterie of peer tutors.

CLASS ORGANIZATION

Variety in class organization, in accord with the nature of specific objectives and activities, helps to hold students' attention and increases instructional efficiency. At times, large-group instruction, to present specific content to the class, makes best use of the instructor's time. Small groups working on problems can strengthen and expand students' mastery of specific concepts by applying what has been learned, and can give students opportunities to clarify their understanding of concepts. Small groups also provide an excellent vehicle for discussion of students' feelings, reactions, responses, and questions. Individual activities give students an opportunity to evaluate their own learning status and to confirm their understanding or their skills. The modules use all three of these class organization schemes, and the modules suggest which organization scheme may be most useful for particular objectives, content areas, and activities.

LEARNING MATERIALS

When students find meaning in learning materials, their motivation for on-task behavior is enhanced. The content of the math and attitudinal modules has been selected and developed to provide materials that are interesting, challenging, and relevant to college students' needs.

Materials such as audiotapes, readings, charts and other graphics, and problems have been included in the modules. The variety of materials from which the instructor can choose increases the flexibility of the modules. Students may also be given opportunities to make selections from alternative learning activities. When students have opportunities to choose from several approaches and to use different modalities, their motivation may be enhanced.

TIMING AND PACING

Instructors develop sensitivity to each class as a group. This sensitivity guides the process of selecting alternatives or deciding upon beginning and ending points in a learning sequence. Since each class has, and during the term further develops, its own character, the instructor can time activities according to attitudinal and cognitive factors, such as the group's response to new content, to challenges, to speed, or to repetition. The group's profile of skills and math experience is also a basis for deciding how to pace activities.

Some schools schedule classes in one-hour units, while others schedule units of two or three hours. A break is clearly necessary during these longer sessions. Having coffee or tea available during breaks, or available for individuals to have when they wish, m be helpful. Having a break determined by the instructor rather than by a school bell can add to the atmosphere in the class. The instructor might decide to break when the class has reached a logical stopping point in content, when it has worked through a problem, or when it has reached some resolution of feelings about an issue. Sometimes it's useful to break before a problem is solved. Fresh ideas may be forthcoming after a break.

A key point in pacing is to recognize that no single pace can meet the needs of all students. Working in subgroups during a class session makes it possible to accommodate students who are at different points in concept mastery and who have different learning rates and styles. Specific suggestions for subgroups are given in the math modules.

STUDENT EVALUATION: PRETESTS AND QUIZZES

At the beginning of any academic content sequence, instructors face such questions as "Have the students learned this before?" "Do they have the skills necessary to begin this work?" "Do they have incorrect ideas about these concepts?" While these questions might be answered by using a pretest, the degree of anxiety that could be generated by a test might seem a high price to pay for diagnosis. Students who have successfully avoided math are likely to experience feelings such as "I'll never learn that," or "I knew I couldn't do math," or "I'm stupid." They might direct their energy to battling with these feelings rather than to working on math tasks. If pretests are used, students should be given opportunities to clarify their feelings. The instructor should help students become desensitized to such tests by discussing both the students' feelings and the purposes of the tests.

An alternative to using pretests for diagnosis is to observe students closely. Their attentiveness during sessions that call for applications of concepts, and the progress they make in assignments and quizzes, can give a clear picture of students' mastery of skills and concepts.

Quizzes should be clearly related to the content objectives of each module. It is useful for students to have a list of objectives before each quiz so that they can identify key ideas. The instructor should describe the role of evaluation--and especially that of quizzes--in the design of the course, and students should have an opportunity to discuss it.

Quizzes should be announced. When an instructor wants to foster positive attitudes toward learning and using mathematics, a quiz shouldn't be a surprise. Fear of failure and anger at being "caught" with less than optimal preparation tend to be aroused by surprise quizzes. Instructors should expect that students' test anxiety will be aroused, and feelings about previous math testing experiences will be evoked, whenever a quiz is announced. These feelings should be acknowledged by asking students how they felt when they heard the word quiz. This acknowledgment, which may be brief, can help to reduce the intensity of associated feelings. Knowing that other people have experienced tension about tests will help students to develop the attitude that they can and will cope. A moderate amount of tension tends to improve an individual's performance. Relief from all tension is not, therefore, an appropriate or desirable goal, nor is it likely to be attainable.

With a quiz date set, the instructor has an excellent opportunity to discuss quiz (or test) preparation with students. In discussion it should be pointed out that reviewing notes or trying to learn material again in the same way it was learned originally does not prepare one fully for a test. Adequate preparation is related to the performance being tested. In this mathematics class, a student should be solving problems, answering questions, using a calculator to perform computations, or whatever is essential to the required performance. Anticipating the specific questions that are likely to be asked and answering them can help students focus when they prepare for quizzes. TEAM students were assigned the task of predicting at least five out of ten questions that would be asked on each quiz.

A quiz can play a significant role in learning. By identifying what a student does and does not know, quiz data provide the basis for future learning experiences designed to increase students' mastery of the material. A policy of permitting students to retake quizzes is recommended. This policy proved useful in both increasing achievement and developing positive attitudes during the TEAM project. MacDonald (1980) also found positive results when quiz retaking was permitted in an experimental college-level introductory mathematics course. She noted that the psychological security provided by this policy may be its primary benefit.

The feedback they receive when quizzes are returned has also always created tension for students. In addition to the feelings evoked by the current experience (expressed in such ways as "I should have studied more," or "Why did I study those things?" or "Where did they get those questions?"), residual feelings associated with former testing experiences may be evoked (for example, "What will the other people say?" "What will the teacher think of me now?" "What if I fail?"). When giving back quiz results and reviewing answers, the instructor should be aware that if students have an opportunity to express these feelings, they can develop more positive attitudes and greater confidence. They can also be shown how to use multiple strategies in problem solving. Instructors should try to give students their quiz results at the first opportunity possible, typically in the next class session (or later during the same class if someone else can score the papers). Review of a quiz is more fruitful when students can see their papers and can raise questions.

STUDENT SELF-EVALUATION

Self-evaluation is an important facet of a student's sense of self as a math learner. While people usually engage in some amount of self-evaluation in a general way, TEAM found it useful to ask students to evaluate their status periodically in a specific way. Prior to each quiz, students were asked to rate their preparation and readiness for the quiz and to predict their score on the quiz. More anxious students tended to be less realistic in their ratings than less anxious students. Opportunities for reappraisal were available for students who underestimated or overestimated their performance. Undertaking this kind of reappraisal in a situation that is emotionally supportive can facilitate positive change. The instructor or a counselor may be available to discuss the questions raised by self-rating with individuals for whom the group discussion opportunities are not sufficient.

Students' explanations of their success or failure on quizzes (or on assigned tasks) should be noted. TEAM students tended to attribute their success on quizzes to external variables (for example, "It was an easy test" or "I got lucky"). They rarely gave themselves credit by attributing success to their ability, although they did attribute success to their efforts or hard work. Students found it interesting to learn that their attribution patterns were characteristic of those noted for females (Ernest 1976). They were able to recognize that they had learned these "female" patterns. (For a discussion of sex differences in causal attribution in mathematics performance, see Wolleat et al., 1980).

In summary, the learning environment should provide appropriate challenges within an emotionally supportive climate. Students should experience success as learners of mathematics. As they recognize the changes in their behavior, they can experience a concomitant positive change in their attitudes.

ATTITUDINAL INTERVENTIONS

Anxiety is not necessarily a negative factor in learning. Low and moderate levels of anxiety can facilitate problem solving and enhance test performance. Individuals differ widely in their basic anxiety levels. Anxiety usually ebbs and flows in class groups. The goal is to provide tension levels that are useful, not debilitating. To maintain such levels, the instructor needs to recognize anxiety when it appears, to permit students to express their feelings, to listen carefully, and to monitor tension levels during class activities.

Math anxiety can sound like a disease to some students. Some may even consider it a kind of terminal condition: when there's math anxiety, there can be little hope for college success. It may, therefore, be a good deal more useful to talk instead about math confidence and confidence building in general with students.

DEMYSTIFYING MATH

Students need help in knowing and understanding themselves as math learners. An important step in developing this self-knowledge is to consider previous learning experiences--one's "math autobiography." Since personal math history is specifically elicited in Demystifying Math, the instructor should consider using that module first. Students typically see what has caused some of their negative feelings and how they have maintained behavior that is self-defeating. Once students can see that their behavior is no longer useful, they can begin to replace it with more appropriate, self-enhancing learning strategies. As behavior begins to change, positive attitudes usually develop. Students become increasingly aware of how they approach and handle math by keeping in touch with their reactions to math learning experiences. A weekly log in which students discuss their feelings, ideas, reactions, questions, and so on has proved to be a highly useful assignment. It serves first as an opportunity for the students to clarify priorities, feelings, and concerns. Some TEAM students were able to write their weekly logs with a "Dear Diary" attitude and found this approach especially illuminating; substantial self-knowledge and confidence accrued.

The weekly log also provides the instructor with effective feedback both on students' attitudes and on their mastery of content. Attention to the needs of individuals is facilitated by this flow of information. Log data can serve as the basis for class discussions with a counselor or for individual referrals for consultation with a counselor. In addition, the logs and the discussion of their contents might yield ideas for class interventions. (See Appendix B, page 25, for examples of log entries.)

The class sessions may be organized to provide opportunities for small-group discussions of reactions or feelings. For example, two small groups may be working on problems that enable them to practice using concepts learned earlier in class. At the same time, another group may be talking with the instructor about such topics as the feelings evoked when someone makes an error, the kinds of incidents that bring back old feelings, and so on. The groups may rotate so that the instructor has an opportunity to participate in discussions with all the students.

Small groups can also provide to students who find it difficult to speak in class an environment that makes it easier for them to participate. The instructor has an important opportunity to get to know students in such small groups.

The instructor may find it useful to discuss with students the purposes of the math work they're doing. While many of the problems and tasks are inherently interesting and should arouse students' curiosity, there may be times when motivation is low. As students see the usefulness of particular concepts and activities, their involvement in the learning process can be enhanced.

ATTITUDINAL COMMENTARY

The attitudinal commentary in the modules is designed to alert the instructor to times when interventions are likely to be needed. For example, the first time that a mathematical symbol or formula is written on the chalkboard, or a mathematical term is used, students may experience difficulties. A key point to make is that students can learn these terms and use these symbols now, as adults, more readily and meaningfully than they could as children. Their experiential background and greater verbal facility give them an advantage they didn't have as children.

POSITIVE RELAXATION AND MOTIVATION

The instructor needs also to help students relax and recognize their potential for learning even when they face a problem for which no immediate solution is apparent. Students should be encouraged to go ahead and begin work. By facing anxiety and dealing actively with such challenges, students begin to feel more competent. The instructor can suggest ideas that will help students get started despite their negative feelings or fear. If students focus chiefly on their inability to cope, they may make little progress. Encouraging students to recognize tension or other disruptive feelings can help dissipate the tension and move students toward productive problem-solving activity. As they progress in their work, students will also experience the excitement that accompanies solving a problem.

In summary, the instructor provides the structure and encouragement that enables students to shed tensions and replace them with growing confidence. Key strategies are to cultivate sensitivity to students' feelings and responses and to provide help with the technical problems students encounter.

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APPENDIX A

RESEARCH EVIDENCE IN SUPPORT OF TEAM STRATEGIES

The TEAM approach is based on information in the research literature on mathematics attitudes, math anxiety, sex-role socialization, sex-role stereotyping, mathematics instruction, and educational psychology.

Classroom approaches for college students who are anxious about mathematics have been described by Donady, Kogelman, and Tobias (1976) and by Schafer (1977) based on their work with women preparing for college math courses. Typically, these classes have been described as precalculus courses. The importance of providing opportunities for students to reflect on personal mathematics learning experiences and to discuss their feelings about mathematics has been stressed by these authors. Group discussion, group problem solving, and the availability of counseling for individuals have been features of these programs at Wellesley College and Wesleyan University. Blum (1976) and Fennema (1977), in contrast, have emphasized the importance of the development of mathematical knowledge and skills as a way of helping individuals to face their fears or lack of confidence about mathematics. Both of these emphases--on attitudes and on skills--have been described as fruitful ones for students. Hendel's work (1978) has suggested that the appropriateness of particular instructional techniques may depend on the level of math anxiety; for example, low to moderately anxious individuals may profit most from emphasis on direct mathematics instruction.

The TEAM strategies incorporate emphasis on the development both of positive attitudes and of mathematics knowledge and skills. The joint focus seems appropriate, since the needs of the target students may differ from those of a precalculus group whose members have gone to a math clinic and have acknowledged that they are experiencing considerable anxiety. Models in which this joint thrust is carried out by a team of instructors have been found viable (Donady and Tobias 1977, Hendel 1978, Donady, Kogelman, and Tobias 1976).

The development of an environment that is nonthreatening and that stimulates curiosity has been described by Kreinberg (1976). Schafer (1977) also describes the importance of students' being free from tension during learning sessions. She has suggested specific techniques--such as testing "by committee" and having students, rather than the instructor, write on the chalkboard--to increase students' confidence and sense of mastery. Flexibility in approaches to the reduction of math anxiety within a supportive environment has been emphasized by Tobias (1978) and Donady and Tobias (1977).

The emphasis on developing mathematical knowledge and skills is supported by research evidence on the inverse relationship of such knowledge and skills to anxiety (Richardson and Suinn 1972, Suinn and Richardson 1973). Since these affective and cognitive variables are closely related, a simultaneous attack on both seems most appropriate.

TEAM's emphasis on students' mathematical understandings--on the development of a "feel for math," rather than on computational skills--is based on evidence presented by major professional organizations. The National Advisory Committee on Mathematical Education (NACOME 1975) and the National Council of Supervisors of Mathematics (NCSM 1977) counsel that computational skills must not be overemphasized to the exclusion of the other skill areas that are "needed by students who hope to participate in adult society" (NCSM 1977). A narrow definition of basic skills as computational skills does not suffice. It is recognized in these modules that, in today's world, complicated calculations will usually be done with a calculator. Thus, it becomes more important for a person to be able to carry out rough approximations and to inspect all results for errors than to compute with large numbers. According to NACOME (1975), "Impending universal availability of calculating equipment suggests emphasis on approximation, orders of magnitude, and interpretation of numerical data--not drill for speedy, accurate application of operational algorithms." Furthermore, reports NACOME, overemphasis on computation has a "stultifying effect on student interest in mathematics, in school, and in learning itself."

The point that mathematical applications must be meaningful and should "include all of the practical uses of mathematics needed by everyone for daily life today and in the future" is emphasized in the NACOME report. Mitzman (1977), writing about a project that was designed to help elementary school teachers experience mathematics as useful and even aesthetically pleasing, emphasizes the need for seeing mathematics as part of everyday life. Problems have been used in the TEAM modules, therefore, that relate to many facets of daily life. Facts and figures that a person may see any day in a newspaper, for example, have been incorporated in problems.

According to NCSM (1977), "Learning to solve problems is the principal reason for studying mathematics." The TEAM math modules focus on problem-solving processes that can be generalized or transferred. Based on evidence from a study by Bloom and Broder (1950) and on case studies that identified effective problem-solving approaches, key processes were selected. The findings of these studies support the contention that if students are given appropriate experiences, they can learn how to become effective and efficient problem solvers.

The research literature on the impact of sex-role stereotyping in young women's perceptions of themselves as mathematics learners and of mathematics as an appropriate domain for females burgeoned in the 1970s. Fox (1976) has pointed out the changes in girls' behavior from elementary school, when interest in mathematics may be substantial, to high school, when math is labeled a masculine domain. She urges that teachers of mathematics and science at all school levels examine curricular materials and their own instructional practices so that they can direct efforts toward fostering girls' interest in mathematics. Fennema and Sherman (1977) suggest that because females, from adolescence on, believe that math is a male domain, they do not achieve as well as they might in math, nor do they study mathematics to the extent that they would if they perceived it as sex neutral. Fennema and Sherman further point out that young women, seeing mathematics as a male pursuit, lack motivation to achieve in math and fail to recognize the usefulness of mathematics in their lives.

It is important for prospective teachers to be familiar with this literature and to develop skills that will enable them to identify and counteract sex bias. Otherwise, they are likely to perpetuate the problems associated with math anxiety by repeating stereotypic teacher behaviors and providing biased learning experiences for children.

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APPENDIX B

CLASS LOGS

There were several themes that could be identified in the class logs. One of these themes concerned the students' feelings of not being "alone" or "left behind," and of a "growing comradeship" which evolved out of students' anxieties about mathematics.

> It seems as though there is a growing comradeship for most people in the class. I know everyone's problems in math and they know mine.
>
> When I realized I was not the only one confused, it made me feel better.
>
> Now I know I will not be left behind while the rest of the parade marches on to the mystical land of learning without me.

Another theme focused on the emotional climate in the classroom and its importance for the students.

> [Before] I was afraid of asking dumb questions or being laughed at.
>
> There's hope. . . . I really like the time and patience the professors of TEAM math offer and give to their students, from math skills to mental stabilization about anxiety attacks.
>
> I keep waiting for her [the math instructor] to give up on me.
>
> I'm glad to see that when I ask her [the math instructor], she is patient and goes back over the material slowly. She doesn't put anyone down, or make you feel stupid. She is willing to stop and go back over things. That makes you feel more relaxed.
>
> Her patience seems to be the key: "If you don't understand it, we will do it again."

The students expressed very positive reactions to the test preparations that were designed as one part of the effort to reduce anxiety.

> I feel secure in knowing that the material on the test was covered completely in class.
>
> Talking about the material before the test was handed out helped [relieve anxiety or pressure] and so did the promise of a retest if I didn't do well enough.

I want you to know that this was the first time I took a math exam and wasn't scared to death when looking at the questions.

The meaning that the logs came to have for some of the students is reflected in the following entry.

I can't believe this is the last log; I think I'm actually going to miss writing them! They've really been a help to me all along, and I think it would be good to go back and reread my earlier logs. I realize that I have learned a lot (the METRIC SYSTEM!) as far as both competence and confidence are concerned. However, it would still be very interesting to actually see any weekly changes in my attitude.

The changes in attitudes that some students experienced are evident from the log entries of Diane and Kathy (fictitious names). Diane's pretest to posttest scores on the Math Anxiety Rating Scale showed a significant reduction (approximately 150 points), while her Confidence subtest score on the Fennema-Sherman Mathematics Attitude Scales showed a substantial gain. Her Math Concepts score increased substantially (15 points).

It took me quite a while to decide if I should take this course. It sounded like a good idea because I need something to help me get over my math anxiety but I thought nothing could really help and that it was just another math course to dread going to all the time. I finally decided to sign up because it made me realize that if there is a course like this one, I can't be the only one with this attitude. I don't expect to be a scholar in math but I do hope to acquire a positive attitude toward math.

I really do not know why I have such a dislike toward math. Some of the worst experiences I can remember are during grammar school, when I had to go to the board, especially if I had the wrong answer.

When [the teacher] called on someone for an answer I began to get nervous and forgot everything. When I realized that I was not the only one confused, it made me feel better.

I felt today's lesson went well for me. . . . I realized there is more than one way to solve a problem. When there is no one pressuring me to solve a problem a certain way, I don't feel nervous and I can choose a procedure that I feel comfortable with.

When I was called on to give an answer, I became a little anxious, but I knew that I had the right answer. I don't know why I got that feeling, but as soon as I gave my answer the anxious feeling went away.

I found that math a little difficult; however, when [the teacher] helped me out it became clear to me.

It was such a good feeling to understand the concept of rounding numbers. I want to do more of them because I can't believe I finally got it.

One of the questions I thought I didn't know the answer to, I did. I wrote it down, but then I crossed it out. I don't know why. I think that perhaps it seemed too easy.

It [metrics] really doesn't seem all that bad. I'm sure it will take time to learn it completely but I'm not at all dreading it as I had been quite a while ago.

I really enjoyed today's class. I've always wanted to know about the metric system but I've never really looked into it. I used to think I'd never be able to learn a whole new system, but I do not feel that way anymore.

When I started the test I did not feel at all nervous, which is a good feeling. I really makes it much easier to concentrate.

I find I am really interested in learning something new. It's a much better feeling not having to worry about it. I never thought I would enjoy coming to a math class.

[After the final] I feel pretty good. I feel I learned quite a bit from this course.

Kathy's pretest to posttest scores on the Math Anxiety Rating Scale showed a significant reduction (approximately 100 points), while her Confidence subtest score on the Fennema-Sherman Mathematics Attitude Scales showed a substantial gain. Her Math Concepts score increased substantially (15 points).

There are numerous reasons why I have a bad way of looking at math. Since grade school I haven't liked math and was usually scared to go to class. I would be very nervous before, during, and after class. I remember having the problem of not catching on the first time something was explained. I usually needed things to go a little more slowly to understand. There probably were others in the class who did, too, but when someone would ask the teacher to go over it once more, the teacher would get exasperated or sarcastic or even shout. This happened to me a lot. It was very embarrassing and frightening, so soon I just didn't even bother to ask. I sat there and tried to fake it. If I was called on, I usually guessed an answer.

Another thing about math is that I'm afraid of it. I feel that maybe I have a mental block against it. Before I even look at a problem I tell myself I can't do it. By the time I see it, I've already convinced myself that I'll never be able to figure it out.

. . . so the reason I took this class is to try to overcome this block or fear I have of math. Also, I want to prove to myself that if I'm not afraid to do it, to learn it, that I most likely <u>will</u> learn it. The other reason for taking the class is that I want to teach elementary school, and I want to feel comfortable, or at least more confident, with math.

When I understood the lesson I felt pretty good, until I started to worry about whether I would understand the other lessons to come.

Another thing is that not only has my conditioning been to have negative experiences with math--but my mother even picked it up. When I came home, she didn't have anything for me to eat because I usually can't eat after a math class. She merely assumed that because I had a math class I would not be hungry. But I was hungry. I guess that's a good sign.

After class I felt pretty proud of myself. I felt really proud of myself. I felt good because I understood everything and was able to figure out the problems without too much of a struggle. It even felt like fun when I got the problems.

But I still feel a little suspicious about the work yet to come. Will I be able to grasp it or at least understand it? I feel a little bit more optimistic in comparison to how I felt after last week's class, though.

Today I felt frustrated a few times during class because I was getting a little confused at times. Also, when checking the homework I found that I worked out the problems correctly, but made mistakes in the multiplication. This disappointed me because in the past, if by some rare chance I would understand the math, I would make silly multiplication or addition or subtraction errors - but the problems would be marked wrong anyway. So, when this happened again, I got the same old frustrating, discouraging feelings back again.

I got help after class, and that helped a little, but I still felt disappointment in myself for those homework problems. I didn't feel as good and as confident as I did after the last class, but I did understand the material once [the teacher] helped me.

I felt very proud of myself. I was getting every problem correct and even beginning to enjoy it! I was beginning to feel more confident in myself.

I'm getting a better feeling about math already. I'm actually beginning to enjoy it. It's getting to be fun.

Today we had our test. I really wasn't too nervous; or so I thought, but I must have been inside because I knew the material and understood everything we had learned, but I couldn't remember the formulas on the test. I was about to freak out but I just told myself not to quit. Some of the problems I had to do the long way and some of the formulas I derived. I find, in math, when I'm studying I know it, but on the test, even though I know the material something inside tells me, "No, that's wrong." I'm not confident in what I write down. I begin to doubt myself. I don't trust my answers, but I wasn't really upset. I knew I could take the test over, I was basically disappointed in myself for forgetting some of the formulas. I was tense while waiting for the results of the test, which I was glad were returned right away.

When I got back, I was relieved. Also--I did well! Much better than I had expected.

I guess I can't expect everything to happen overnight. At least I wasn't a nervous wreck as I usually am, and I didn't get a stiff pain in the back of my neck as I usually do. So I did forget some things because of nerves. It's still an improvement. Maybe the next time I won't forget anything and I'll be even less nervous.

I was disappointed though, as I said in class, that you said, "Only two more minutes." Because doing math fast is one of the fears I have, I need to do it at my own rate. Since in this class we are trying to overcome our fears of math, extra time helps for some, especially during a test.

After class last session I felt very "smart." I'm really getting the hang of things. I'm beginning to believe that if I had had understanding teachers, as I do now, honestly, then I would have no trouble with math as I do now. I am beginning to believe that I have the ability to learn and understand math, if it is taught to me with understanding and with skill. I'm not saying that I can learn very advanced math overnight, but I think that I wouldn't be as frightened to try.

After class I felt okay because I understood everything. At one point I didn't, but she [the instructor] went over it and then I got it.

. . . I felt so proud of myself, it's good to know something but better if you can apply it.

I wasn't even nervous before the test--just a little bit but not as bad as the last one--but I really wanted to get 100%. I really studied, and I just wanted to prove to myself that I could get them all right. I didn't and so I was a little disappointed, but I'm going to take a retest and try to get them all right.

After class I felt pretty good. I understood what we learned and there weren't any problems. I think that the interview will be an interesting assignment, at least.

I found that I was very tired for class because the night before I was up until three a.m. This affected my concentration. It was hard for me to really concentrate as much as I would have liked to, but I managed and I covered all of the material.

After class I felt a bit confused. Not confused in a bad sense, but in a good sense. I felt I learned so much that I was a little confused. I felt I wanted to sort it all out. When we went over fractions, and I understood, I felt great. I felt I had learned something I should know and was embarrassed that I hadn't. Then I realized I said I did understand at the time when I didn't. Maybe I can learn it because I want to.

. . . after the final exam: Relieved! I feel I could have done better on the final, but I learned so much in this class on the whole that I'm very satisfied. Very glad I took this excellent class.

For a more complete discussion of the information in students' logs and of the evaluation procedures used in the TEAM project, consult the project's Final Report (available from ERIC and on file with the U.S. Department of Education, January 1981).