DOCUMENT RESUME

ED 359 020 SE 052 580

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TITLE MAP: Mathematics Assessment Process for the Middle Grades. User's Manual. Volume I.
INSTITUTION Georgia Univ., Athens. Dept. of Mathematics Education.; North Carolina State Univ., Raleigh. Center for Research in Mathematics and Science Education.
SPONS AGENCY BellSouth Foundation, Inc. Atlanta, GA.
PUB DATE Oct 91
NOTE 154p.; For volumes II and III, see SE 052 581-582; for the implementation guide, see SE 052 579.
AVAILABLE FROM Center for Research in Mathematics and Science Education, North Carolina State University, 315 Poe Hall, Suite 310, Raleigh, NC 27695-7801.
PUB TYPE Guides - Non-Classroom Use (055) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC07 Plus Postage.
DESCRIPTORS Adolescent Development; Classroom Environment; Curriculum Development; Educational Assessment; *Educational Planning; Elementary School Mathematics; Elementary Secondary Education; *Evaluation Methods; Faculty Development; Guidelines; Instructional Development; Long Range Planning; Mathematics Curriculum; Mathematics Education; *Mathematics Instruction; Middle Schools; Program Development; *Program Effectiveness; Program Evaluation; *Program Improvement; Secondary School Mathematics; Self Evaluation (Groups); *Teacher Effectiveness
IDENTIFIERS *Mathematics Assessment Process Middle Grades

ABSTRACT

The Mathematics Assessment Process (MAP) for the Middle Grades gives teachers and school reform leaders new tools to examine and systematically realign mathematics programs. MAP engages an interdisciplinary coalition within a school in an exploration of mathematics instructional excellence. Through an extensive self-study, a school answers the question, "How well is our mathematics program meeting the needs of the students in our school?" MAP integrates three central ideas: consensus on the need for major revisions in middle-grades mathematics, need to implement effective mathematics instructional practices targeted for adolescents, and existence of practical, tested strategies for planning change that can guide the restructuring of middle-grades mathematics programs. At the core of MAP is a set of "Criteria for Excellence" developed by a national advisory panel of middle-grades practitioners summarizing the principles underlying outstanding middle-grades mathematics education. This document, the "User's Manual," the first of a three volume set, contains six sections and appendices. Section 1 describes the trends in middle-grades mathematics and introduces the MAP "Criteria for Excellence". Section 2 explores the philosophic core of MAP, arguing that mathematics is a communication and problem-solving process. Sections 3 and 4 take team members through the approach to conducting MAP: collecting, analyzing and summarizing the data, and writing an action plan for implementing changes. Section 5 provides a staff development exercise to develop understanding of adolescents' mathematics needs. Section 6 provides annotated resource lists with over 250 references. The appendices include decision-making guidelines. (MDH)

Acknowledgments

This program planning and change model has benefited from the creative contributions of a distinguished partnership of professionals. Their work reflects the changing nature of mathematics learning and the needs of young adolescents in the last decade of the twentieth century. Teachers, principals, and central office administrators from the school districts that field tested earlier versions of the model actively participated in its development and refinement, establishing practical and workable process.

The field-test version of MAP was designed at the Center for Early Adolescence at the University of North Carolina at Chapel Hill. It built upon the Center's extensive experience with programs dedicated to enriching educational opportunities and community support for young adolescents. Two Center publications were particularly influential, Joan Lipsitz's *Successful Schools for Young Adolescents* and Gayle Dorman's *Middle-Grades Assessment Process (MGAP)*.

Many individuals were especially resourceful contributors to the early phases of this work. Rebecca B. Corwin of Lesley College and the Technical Educational Research Center (TERC), the co-author of Section II, drafted the first set of assessment questions, and helped modify early versions of the Criteria and Ideals. Her insights into and appreciation of teachers' power as leaders, assessors, and curriculum strategists molded the first edition of this assessment. As we modified the MAP framework to make it practical for middle schools, Daria Courtney, Evette Horton, and Carol Capper thoughtfully edited and re-edited versions of the text and the instruments, striving to make them personal, professionally provocative, and in the end, educationally beneficial for students. They also recommended the resources provided in this pilot edition of MAP, seeking those that would be most useful to practitioners.

Two committed advisory panels—whose members are listed in the Appendices—established a high standard for what MAP could accomplish. Their advice and ideas throughout each development phase strengthened the product. At North Carolina State University, the staff of the Center for Research in Mathematics and Science Education lent able assistance as we piloted MAP and completed this revised edition. We thank especially Sally Berenson, Delores Evangelista, and Lyn Billington for their expertise, patience, and "can do" attitude. Colleagues Jim Wilson and Tom Cooney at the University of Georgia served as a sounding board for this project, posing probing questions and offering thoughtful advice as we developed and tried out the assessment materials.

And finally, but significantly, we were extremely fortunate to have the support of Barbara Scott Nelson and Barbara Hatton at The Ford Foundation, and Pat Willis at the BellSouth Foundation. These program officers unfailingly encouraged us to be inventive and original. Their sustained interest and enthusiasm for our ideas fueled our optimism about the potential of teacher-led educational improvement, thus enabling us to build a model that is fully teacher-led and student-centered.

Preface

The Mathematics Assessment Process for the Middle Grades (MAP) is a program evaluation guide designed to assess needs and to direct improvements in middle-grades mathematics programs. It is structured on the basis of the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* and recent national reports that call for middle-grades mathematics to be more problem-centered, experience-based, and connected to modern technological society. MAP engages an interdisciplinary team of educational stakeholders—teachers, administrators, parents, and students—in a participatory process that defines the future direction of schools' mathematics programs.

MAP has a dual emphasis. First, it recognizes that effective mathematics teaching occurs within a partnership. It is most successful when mathematics teachers have the sustained collaboration of school- and district-level administrators, colleagues across disciplines, and community members and parents. Second, MAP is a framework for improvement. Recognizing the critical importance of the middle-school years, MAP establishes that effective teaching is developmentally appropriate and proposes how to design an educational program that responds to the normal changes and uncertainties of 10- to 15-year-old learners.

MAP includes three volumes of materials that, together, provide a school or school district with a self-contained set of tools for conducting its own mathematics program assessment. The contents of each volume are described below.

Volume 1: User's Manual

The *User's Manual* includes guidelines and resources for completing an assessment and directions on how to develop a long-range plan for modernizing and improving a mathematics program. It is designed with a schoolwide focus, so it can be used by an interdisciplinary team or a mathematics despartment within a school. It also can be easily adapted for use by a group of schools within a district, state, or region.

Section 1

Section 1 discusses the need for MAP by describing the trends in middle-grades mathematics; and introduces the MAP "Criteria for Excellence"—the content that frames the program.

Section 2

Section 2 explores the philosophic core of MAP through a discussion of the Criteria for Excellence. Arguing that mathematics is fundamentally a communication and problem-solving process, this section suggests examples of how the Criteria apply in middle-grades classrooms and in the community.

Sections 3 and 4

Sections 3 and 4 take team members—step-by-step—through the approach to conducting MAP: collecting, analyzing and summarizing the data; and

4

writing recommendations and an action plan for implementing changes. By following the process described in these sections, schools will complete MAP and use their findings to redesign their mathematics program so that it is consistent with the MAP Criteria for Excellence and with the recommendations of the NCTM *Curriculum and Evaluation Standards for School Mathematics*.

Section 5

Section 5 provides a staff development exercise that is designed to help schools establish a shared understanding of how mathematics programs can be more responsive to the unique needs of 10- to 15-year-olds. "Puzzling and Problem Solving: Creating Responsive Mathematics Programs for Young Adolescents" is to be completed by the faculty, mathematics department staff, parents, and administrators within a school as they begin the assessment process.

Section 6

A series of annotated resource lists completes the MAP *User's Manual* and serves as a reference for teachers, school personnel, and parents. Selected for their practicality and accessibility, these suggested references provide the research basis of the concepts within MAP. Teams may turn to the resources in these lists as they conduct their assessments and when they search for ideas about drafting a plan of action for improving their mathematics programs.

Appendices

The Appendices include guidelines for making logistical decisions throughout the assessment process and a glossary of mathematics terms used in assessment.

Volume II: MAP Instruments

Ten assessment instruments—interviews, observations, and surveys—are the core of the data-gathering process. The instruments are included in Volume II, along with descriptive material that will help teams organize and use them.

Volume III: Staff Development Guidelines

A series of seven staff development workshops enables a school's team leaders to direct its own site-based preparation for using MAP. In addition to detailed instructions on how to conduct each workshop, a comprehensive appendix offers practical suggestions to team leaders about leading workshops for professional colleagues and other adult learners. It also outlines hints for coordinating the logistics of the assessment process.

5

Mathematics Assessment Process for the Middle Grades (MAP): Project History

Initially conceived in 1987, by the Center for Early Adolescence at the University of North Carolina at Chapel Hill, MAP emerges from a concept that was designed and first field-tested in 14 middle-grades schools. The earlier version was planned as a supplement to the Center's *Middle Grades Assessment Program* (MGAP) (Dorman, 1984).

Beginning in September 1989, MAP was reconceptualized and modified to meet the developing standards of the national reform movement. Mathematics educators from North Carolina State University and the University of Georgia were selected to lead the piloting and revision of MAP. Following a year-long trial, researchers modified the program to bring it in line with new expectations for mathematics improvement and tested it in nine schools within seven school districts nationally.

Throughout the development process, mathematics teachers, supervisors, and school administrators played strong roles in molding the program. The pilots occurred in very different school contexts and communities, assuring the relevance and practicality of MAP to life in schools. In its four years of development, several hundred school- and district-level educators, parents, students, and university researchers contributed to the design and to the trials of the assessment instruments and the implementation process. Too numerous to name each one, these committed school-site practitioners willingly and continually advised and critiqued this process, helping the authors keep it "grounded" and practical for today's schools. The names of advisory board members and lead personnel associated with the project during its development are included in Appendix 4.

MAP evolves from a strong collaboration of middle-grades practitioners and researchers. As a result, its design reflects the commitment to mathematics education renewal that exists within middle-grades schools. Given time for reflection and analysis, along with committed internal and external administrative support for examining programs and planning improvements, teachers are innovative and energetic leaders of change. In the hands of site-based educators, MAP is a powerful tool for strengthening educators' capacity to change and to advance mathematics programs and teaching practices.

An Introduction and Summary of

MAP

Mathematics Assessment Process for the Middle Grades

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The Mathematics Assessment Process for the Middle Grades has been developed with funding from the Ford Foundation by staff at the Center for Research in Mathematics and Science Education, North Carolina State University, Raleigh, in collaboration with the College of Education, University of Georgia, Athens, GA. MAP was extensively pilot-tested in schools in Wisconsin, Georgia, New Jersey, and North Carolina.

A earlier field-test version of MAP was funded by the Ford and BellSouth Four 'ations at the Center for Early Adolescence, University of North Carolina, Chapel Hill. Field tests were conducted in collaboration with the New Orleans Public Schools, New Orleans, Louisiana; the Jefferson County Public Schools, Louisville, Kentucky; and the Cleveland Public Schools, Cleveland, Ohio.

MAP: A Mathematics Assessment Process for the Middle Grades

The Mathematics Assessment Process for the Middle Grades gives teachers and school reform leaders new tools to examine and systematically realign mathematics programs. MAP engages an interdisciplinary coalition within a school in an exploration of mathematics instructional excellence. Through an extensive self-study, a school answers the question, "How well is our mathematics program meeting the needs of the students in our school?"

MAP integrates three central ideas:

- Widespread consensus exists on the need for major revisions in middle-grades mathematics. A national coalition is articulating this challenge through the National Research Council (see *Everybody Counts* and *Reshaping School Mathematics*), and the *Curriculum and Evaluation Standards for School Mathematics* set by the National Council of Teachers of Mathematics.
- Young adolescents can become effective mathematics learners and thinkers only in a context that is responsive to their developmental needs. Highly effective mathematics instructional practices specially targeted to young adolescents are well-developed but not widely used in the middle grades.
- Organizational development theory and practice offer practical, tested strategies for planning change that can guide the restructuring of middle-grades mathematics programs.

At the core of the Mathematics Assessment Process is a set of "Criteria for Excellence" that summarize the principles underlying outstanding middle-grades mathematics education. Linked to the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics*, each of these Criteria expresses an essential feature of an excellent mathematics education program for students of this age level. Further, the Criteria are defined by a series of "Ideals" that represent basic elements of a comprehensive mathematics program for 10- to 15-year-olds. The Ideals concern practical application of the spirit of excellence expressed in the Criteria. Together, the Criteria and Ideals embody much of what we know about middle-grades mathematics curriculum and instructional processes, early adolescent learning and development, and the characteristics of successful mathematics programs.

A national advisory panel of middle-grades practitioners, experts in adolescent development, and mathematics education researchers helped develop the Criteria for Excellence. They were shaped following an extensive examination of innovative programs and research to identify how to serve best the 10- to 15-year-old age group. The utility of the Criteria for school practitioners was verified in a year-long field test involving teachers and students in 12 middle-grades schools. The Criteria and Ideals are fully consistent with NCMT's *Curriculum and Evaluation Standards for School Mathematics*.

MAP's Features

MAP has a number of distinctive features. First, its structure acknowledges the academic and developmental needs of young adolescent learners. It does this by integrating the social, emotional, and cognitive changes they experience into the analysis of the mathematics program. Thus, MAP examines a school's mathematics program from the perspective of the students it is designed to serve.

Second, MAP weaves mathematics research and practice into a systematic approach to data collection, undertaken by a faculty-led assessment team. Team members include teachers, administrators, staff, and parents of a MAP school. They work together to collect and analyze data. This leads to a deeper understanding of program needs and establishes priorities for meeting them. This process enables school insiders to examine the instructional services they offer in mathematics and to make adjustments according to their team's observations and recommendations.

MAP Criteria for Excellence

A. CONTENT

Uses a problem-centered curriculum to develop students' conceptual understanding of mathematics, appreciation for its applications, and proficiency in computational skills.

B. INSTRUCTION

Engages students in a variety of learning experiences designed to promote mathematical exploration and reasoning.

C. THINKING PROCESSES

Develops students as problem solvers, critical thinkers, and effective communicators in mathematics.

D. DEVELOPMENTAL DIVERSITY

Provides instruction and resources to meet young adolescents' diverse learning needs.

E. ATTITUDES

Fosters positive attitudes about mathematics and encourages and recognizes students' accomplishments.

F. RELEVANCE

Relates mathematical knowledge to students' interests, experiences, and future goals.

G. COLLEGIALITY

Inspires collegiality among faculty who work together to implement responsive programs for young adolescents.

H. COMMUNITY

Involves parents and the community in a collaborative effort to promote student competence in developing and using mathematical knowledge.

I. CONTINUING ASSESSMENT

Continually monitors student achievement, evaluates program effectiveness, and uses the results to determine the need for improvement.

Third, MAP offers a realistic approach to school change. It does not impose an idealized model or set of standards upon the school. Instead, it involves the school community in an evaluation that inspires improvement from within. In the process, there emerge as a guide, the following bedrock principles for all successful middle-grades programs:

- A school community—faculty, students, administrators, and parents—that agrees upon a vision of the school as a caring environment;
- Open, supportive, and cooperative relationships among members of the school community; and
- A commitment to creating an instructional program that is developmentally responsive and academically successful.

From these three general characteristics of good schoo: flow the nine mathematics Criteria for Excellence and the Ideals linked to them *(see Appendix 1)*. Interview, observations, and survey instruments are keyed to the Ideals and measure a school's achievement of the Criteria. A faculty-directed team plans the assessment and organizes the year-long evaluation. As team members interview, survey, and observe their colleagues, they record evidence of positive practices that nurture mathematics achievement, documenting behaviors that are consistent with the MAP Criteria. And there is broader reach. The team also interviews students, parents, other teachers, and staff in the school, as well as parents and other members of the community it serves. In the process, it acknowledges the place of mathematics throughout the middle-schools curriculum and the importance of achievement in mathematics for the community at large.

MAP's Criteria and Ideals express the belief that mathematical literacy is a basic goal of a middle-grades mathematics program, best achieved through interdisciplinary planning and programming. That is why MAP relies on a multi-disciplinary team and collects data about mathematics-related thinking from throughout the school community.

MAP is a multi-step change process *(see Appendix 2)*. When it begins with a spring planning period—for implementation in the fall and winter school terms—it can be completed during the school year. It also can be modified and shortened so an analysis of program needs can occur in a single semester. The following suggests time frames for each of the process steps, using the school-year model. Some schools will

9

need more and some less time to complete MAP to their satisfaction.

Step 1: Commit to Mathematics Program Change

(Approximately 3-4 days)

MAP is most effective when faculty and staff together make the important decision to begin the process and commit to following it through to conclusion. It is easier to share the concept with a solid representation of the school staff when planning begins in the spring or summer before the assessment year. The decision to go forward with the assessment must especially involve the mathematics teachers in all grades. While an interdisciplinary faculty team leads the process, the mathematics teachers are the critical actors in implementing recommendations for change. The principal and the central office mathematics department have key roles, too, especially in encouraging the participation of the entire staff, in providing technical assistance and logistical support, and in demonstrating a clear commitment to the year-long planning and analysis activities of the MAP team.

Identify Co-leaders

As MAP begins, a school identifies co-leaders of the proposed assessment team. This selection process is most effective when a representative group of faculty, in consultation with the school's principal and the mathematics supervisor or coordinator, leads the decision making. One of the team co-leaders should be a mathematics teacher; the partner leader should be a non-administrative faculty member representing one of the school's other teaching departments.

Select Team Members

The MAP team includes a wide representation of the school community *(see Appendix 3)*. Team members should be well-respected by colleagues and reflect the full spectrum of philosophies, styles, and groups in the school. A team of 6-10 members can serve a school of 600 to 1,200 students well. Its membership must represent: (1) the mathematics staff, (2) the school site administrative team, (3) all other teaching faculty, (4) professional support personnel such as guidance counselors, social workers, librarians, and media specialists, and (5) community representatives. Finally, a representative from the central office's mathematics department is an integral member of the team.

Administrative team members should not have staff evaluation responsibilities. This assures that the assessment process remains entirely separate from the professional evaluation structure of the school. The principal is an ex-officio team member and attends meetings at the team's invitation. The co-leaders keep the principal well-informed of the team's activities and progress through regular progress reports.

Divide Team Into Working Clusters

The process of collecting and analyzing data proceeds best when team members work in three "clusters." Cluster members become specialists in using the various assessment instruments and, in this way, they come to better understand the specific aspects of the school's mathematics program. Recommended clusters are:

- The **Mathematics Teaching Cluster (MT)** includes at least two mathematics department representatives on the assessment team. They conduct the Mathematics Teacher Interviews and Mathematics Classroom Observations, and the Mathematics Teacher Survey. With others, they also complete the Mathematics Facilities Survey.
- The **Interdepartmental Faculty Cluster (IF)**, consists of two or more teachers on the team who teach subjects other than mathematics. With the assistance of other colleagues outside of the mathematics department, this group conducts the Administrator and Faculty Interviews and the Schoolwide Observations.
- The **Administrative Support and Community Cluster (ASC)**, involves the remaining assessment team members who represent other sectors of the school community and the community served by the school. This group is responsible for Parent and Student Interviews and, with the cooperation of the Mathematics Teacher Cluster, completes the Materials and Facilities Survey.

If the school determines to modify MAP into a more streamlined process, any one of the clusters can become the assessment team. Cluster members can select and use only those instruments that will most benefit their school's self-study and analysis.

The Role of the Principal and the District Office

The principal plays a significant liaison role for MAP. The principal's commitment ensures the availability of necessary assistance to the process. School site and central office administrative personnel, especially the principal and the mathematics supervisor or coordinator, are important consultants to and advocates for MAP. Without such administrative leadership, MAP teams may find it difficult to conduct the assessment productively or, in the end, to carry forward the MAP recommendations.

Step 2: Plan the Assessment Process; Conduct Site-Based Implementation Workshop

(Approximately 2-4 days, throughout the assessment process)

Planning and conducting the assessment occurs in phases. Before beginning MAP, team members participate in a planning workshop directed by the co-leaders that prepares team members with background information in two areas:

- **Research-based framework:** An overview of the research underlying the MAP Criteria and Ideals, early adolescent development, and recommended program changes for middle-grades mathematics.
- **Techniques of data collection and reduction:** Guidance on how to conduct objectively structured interviews and observations, and procedures for preparing data for later analysis.

At this point, the team also determines how comprehensive its assessment will be, selects instruments it will use, and determines cluster responsibilities and the project's timeline.

The Role of the Central Office Mathematics Department

The MAP team includes a knowledgeable mathematics education consultant—often the district's mathematics supervisor or coordinator—who is well-respected by the school's mathematics and non-mathematics staff alike. This person provides access to four kinds of information: expertise in mathematics curriculum and teaching; knowledge of resources on early adolescent development and on middle-grades mathematics teaching and learning; direction about how to access new resources; and guidance in logistics and program coordination.

Step 3: Collect and Organize Data

(Approximately 3-6 days)

Assembling MAP data is a two-phase activity that takes from three to five months. First, working in pairs, team members collect schoolwide interview, survey, and observation data about mathematics instruction *(see Appendix 4)*. In the year-long study, those interviewed or surveyed are all faculty and staff, all members of the administrative team, and representative samples (about 5 to 10 percent) of parents, community members, and students. In shorter studies, the team determines the best sources of data they most need.

Classroom observations are a central feature of MAP. Teachers observe one another to maximize an exchange of ideas and to determine how supportive a mathematics learning environment there is in the school. The question answered by the observation process is, "Does our school develop the habits of mind and promote mathematical thinking among *all* of our students?"

Observations take place in mathematics classes, all other instructional classes, student and faculty work areas throughout the school, and instructional facilities (such as computer laboratories, the media center, and other special learning stations). Teachers observe one another in 15- to 20-minute segments, several times in each class over the course of the assessment period. These multiple brief observations throughout the school provide a composite picture of the school's mathematics learning environment.

Immediately following data collection, team members individually assemble their information to make it available for the next step, an examination by the entire team and by other faculty colleagues through a study-group structure.

Step 4: Analyze Data and Report Findings

(Approximately 2-3 days)

Analyzing Data

After the team members have tallied and organized their data, team leaders—consulting with other team members, the mathematics department, and the principal—expand the clusters into study groups to assist with the analysis. The study groups review the extensive information that emerges from the process—each group examining the data to assess how well the mathematics program matches the Criteria for Excellence.

The study groups include the entire mathematics department, colleagues from across the disciplines, and community representatives. Thus, insights from others join with those of the original assessment team. The result is a deeper understanding of and greater school-wide commitment to thinking about and integrating mathematics across the curriculum and in the community.

Guiding Analysis

The MAP team members lead the study groups' data analyses. The groups reduce the data from their cluster's interviews, observations, and surveys, identifying themes that emerge. At this point, additional staff development workshops on techniques of data reduction and analysis may be needed. The team's consultant and co-leaders lead these workshops, providing in-house guidance to complete the analysis and action planning.

Study Group Responsibilities

As the analytical process continues, it includes these steps:

- Each study group carefully reviews the results of the data collection to assess the mathematics program strengths and needs against the applicable Criteria and Ideals.
- After the analysis, each study group prepares a report of "findings" and submits it to the MAP team members to help them determine which Ideals within each Criterion should receive priority emphasis in the action planning stage.

Developing Study Group Findings

All members of the mathematics teaching staff, regardless of whether they serve on the MAP team, play strong leadership roles in the study groups. If possible, each mathematics faculty member participates in a study group, sharing the commitment to program analysis and planning early in the data-review stage. This active participation by mathematics teachers in the critical analytical stage increases the likelihood that they will help implement recommendations for program change that emerge from the process.

Reporting Findings

The data analysis includes three major activities: examining the data summaries to learn the community's perspectives on the school's mathematics program; comparing the views that emerge with the Ideals within the Criteria for Excellence; and describing the mathematics program's strengths and generating a list of the areas that need attention.

Step 5: Design an Action Plan

(Approximately 2-4 days)

Examining Study Group Reports

The MAP team, working again as a whole, reviews the study group reports to determine how the existing program is consistent or inconsistent with the MAP Criteria for Excellence. In doing so, the team identifies the Ideals that will become the focus of the school's agenda for mathematics change. Working now with assessment findings that unify the cluster reports, the group establishes consensus on improvement priorities. This phase of the team's work begins with a brainstorming session within a context provided by the Ideals, and highlights changes needed to bring the mathematics program into closer alignment with the MAP Criteria for Excellence.

Identifying Alternative Strategies

The next step is critical to producing a viable action plan: identifying strategies and alternatives to the current instructional program. It is completed through study and review of options in mathematics curriculum, teaching, and organization. Coordinated by the team co-leaders with the assistance of the mathematics supervisor or coordinator, this begins immediately following data analysis and is woven together with the action planning that concludes the assessment process. The exchange among colleagues usually reveals within the staff a wealth of fresh ideas, untapped talent, and unexplored resources.

Establishing Priorities for Mathematics Improvement

By the time action planning begins, team members know of new directions their program can take and are well-positioned to revise and update the teaching they are doing. It is necessary to first reach consensus among team members about the priorities for improvement. Establishing clear priorities for action—including some that can be achieved easily and others that require more time and support for change—is the outcome of this phase of work.

Prepare the School Mathematics Improvement Plan

Having worked together extensively, the MAP team has gained the expertise to recommend a practical and responsive plan that embeds within it the contributions of the entire staff.

The team writes an action plan to achieve rank-ordered program improvement plans. The plan must be clear, practical, and presented effectively to the entire faculty and school community. It focuses on a few key Ideals within each Criterion that represent the departure point for the school to begin its mathematics program improvement. These points are addressed by carefully considered suggestions for implementing targeted, short- and long-term goals.

Step 6: Approve School Mathematics Improvement Plan

(Approximately 2 to 3 days)

The final action plan incorporates the perspectives of colleagues who participated in the previous stages of the assessment and data review. In an open-ended exchange of views about the proposed plan, colleagues offer their final suggestions for modifying the proposals. The plan that emerges from this process becomes the outline for the next two to three years of mathematics program development.

The action plan is likely to include short-term no-cost and low-cost changes, as well as long-term strategies that require new funds or school or district policy adjustments or approvals. The important achievement at this juncture is that the school's teaching faculty has taken an active role in developing the plan's major components, so there will be broad ownership of the implementation process. This is a significant achievement—not only has an action plan for mathematics improvement been designed, but the school, community, and district have help create it. Shared ownership of the plan and for the proposed action agenda requires continuing collaboration among the mathematics department and other departments and the community. The principal, the faculty team, and the school district top administrators must now use the school's plan to make a case for the fiscal and other support they need to carry out the plan.

For additional information about MAP, please contact:

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13

Appendix 1: Criteria for Excellence and Accompanying Ideals

A. CONTENT

Uses a problem-centered curriculum to develop students' conceptual understanding of mathematics, appreciation for its applications, and proficiency in computational skills.

① The curriculum provides a problem-based context for learning.
② Mathematics problems occur in varied formats.
③ The curriculum content is balanced and comprehensive.
④ The curriculum develops number and operation sense.
⑤ The curriculum develops spatial and measurement sense.
⑥ The curriculum includes probability and statistics.
⑦ The curriculum introduces algebraic notions of variables, equations, and functions.
⑧ The curriculum emphasizes understanding of concepts and procedures.
⑨ The curriculum is research-based and responds to a changing society.

B. INSTRUCTION

Engages students in a variety of learning experiences designed to promote mathematical exploration and reasoning.

① Students actively engage in mathematics.
② Students discover meaning through manipulations with concrete materials.
③ Students learn individually and in groups.
④ Students construct meaning using a variety of resources and instructional materials.
⑤ Instruction makes appropriate and regular use of technology.
⑥ Instruction balances new learning and review; classwork and homework.
⑦ Supplementary programs and enrichment activities extend mathematics instruction beyond the classroom.
⑧ Homework extends mathematics learning and applies new study skills.

C. THINKING PROCESSES

Develops students as problem solvers, critical thinkers, and effective communicators in mathematics.

① Thinking processes reflect multiple strategies for problem solving.
② Teachers model problem solving.
③ Students pose problems and discover solutions.
④ The curriculum develops analytical reasoning abilities.
⑤ Students and teachers discuss mathematical ideas.
⑥ Students write and talk with one another about mathematics.
⑦ Teachers clarify underlying concepts and listen to students' ideas.

D. DEVELOPMENTAL DIVERSITY

Provides instruction and resources to meet young adolescents' diverse learning needs.

① Students have equal access to information, assistance, and classroom interaction.
② Teachers use fair and flexible grouping practices.
③ Teachers accommodate special needs, abilities, and disabilities.
④ Teaching strategies motivate underachievers.
⑤ The classroom environment invites participation by all students.
⑥ Staff development and planning focus on young adolescents' needs.

E. ATTITUDES

Fosters positive attitudes about mathematics and encourages and recognizes students' accomplishments.

① Teachers believe all students are competent in mathematics.
② Students believe they can be successful in mathematics.
③ Students help develop high expectations and standards for themselves and others.
④ The school recognizes and rewards the mathematics achievements of all students.
⑤ Originality and accuracy in mathematics are both rewarded.
⑥ Students are free to make mistakes and are encouraged to take risks.
⑦ The school encourages families to expect and support mathematics achievement.
⑧ School support personnel (counseling staff, media specialists, etc.) assist in promoting the mathematics program.
⑨ The community values mathematics achievement.

F. RELEVANCE

Relates mathematical knowledge to students' interests, experiences, and future goals.

① Teachers relate mathematics to individual interests.
② Imaginative uses of mathematics are stimulated.
③ Mathematics is applied to the arts and sciences.
④ The usefulness of mathematics is taught across subjects.
⑤ The program stresses the importance of mathematics in everyday life and in future career choices.

G. COLLEGIALITY

Inspires collegiality among faculty who work together to implement responsive programs for young adolescents.

① The mathematics program has strong leadership and an effective, knowledgeable, and caring staff.
② The school and district support teachers' continuing education in mathematics.
③ The mathematics department conducts regular program reviews and plans in-service activities.
④ Interdisciplinary collaboration strengthens mathematics teaching.
⑤ Administrators encourage professional involvement.
⑥ Schedules enable collaborative planning.

H. COMMUNITY

Involves parents and the community in a collaborative effort to promote student competence in developing and using mathematical knowledge.

① Parents and community are involved in improving the mathematics program.
② Parents are informed about the development and purposes of the mathematics program.
③ Parents are informed of specialized support and instructional assistance in mathematics.
④ Parents are informed of mathematics curriculum options and their consequences.
⑤ Parents and community participate in mathematics activities in and outside of school.

I. CONTINUING ASSESSMENT

Continually monitors student achievement, evaluates program effectiveness, and uses the results to determine the need for improvement.

① Individual student achievement is evaluated using multiple sources of data.
② Students and parents receive constructive feedback.
③ Assessment sources address school, district, state and national goals.
④ Grading policies are clearly defined and administered consistently.
⑤ The mathematics program is evaluated using multiple sources of data.
⑥ Teachers in all subject areas participate fully in program planning and evaluation.
⑦ The middle-grades mathematics program coordinates with the mathematics programs in local elementary and high schools.
⑧ The mathematics department monitors curriculum materials for bias.

Appendix 2: What's Involved in MAP?

1

Commit to Mathematics Program Change

(Approximately 3-4 days)

Faculty and Staff Decide to Conduct Assessment ◆ Faculty Co-leaders and Administrators Review Assessment Process ◆ Identify MAP Team and Consultants

2

Conduct Site-Based Training; Plan Assessment

(Approximately 2-4 days, throughout the assessment process)

Site Teams Participate in MAP Workshops ◆ Review Current Research ◆ Determine Data Collection Plan

3

Collect and Organize Data

(Approximately 3-6 days)

Work in Pairs to Collect Data ◆ Interview, Survey, and Observe ◆ Organize Information for Review by Study Groups and Team

4

Analyze Data and Report Findings

(Approximately 2-3 days)

Study Groups Examine and Analyze Data ◆ Identify Assets and Needs of Current Mathematics Program ◆Generate and Report Findings

5

Design Action Plan

(Approximately 2-4 days)

Review Study Group Findings ◆ Establish Improvement Priorities ◆Identify New or Alternative Mathematics Program Strategies ◆ Write Action Plan

6

Approve School Mathematics Improvement Plan

(Approximately 2-3 days)

Mathematics Department Faculty Reviews Action Plan ◆ Prioritizes Implementation Goals Into a Several-Year Plan ◆Submits Plan to Faculty for Approval

Appendix 3: Who's Involved in MAP?

Leaders

The responsibilities of the MAP team's co-leaders—a math teacher and a teacher in another discipline—include:

- Coordinating the MAP procedures, preparing recommendations for action, and directing the development of the action plan.
- Promoting schoolwide ownership of and interdisciplinary involvement in the process.
- Scheduling and convening all meetings.
- Coordinating MAP logistics.
- Coordinating and assisting the data collection, data analysis, and study group planning.
- Convening and leading designated study group meetings in the analysis and reporting of findings.
- Maintaining team records and communications.
- Keeping the school principal informed about the progress of MAP.
- Facilitating smooth relationships among team members and the school's faculty and staff.

Members

The MAP team is made up of 6-12 members, usually working in three "clusters" or interest areas. Throughout MAP, members of the team share these principal responsibilities:

- Participating in training sessions and attending all team and study group meetings.
- Collecting data through interviews, observations, and surveys of students, faculty, administrators, and parents.
- Convening and leading study group meetings to analyze and report data-based findings.
- Identifying and recommending to the MAP team priorities and strategies for addressing the elements of the school's mathematics program that are inconsistent with the Criteria and for Excellence.
- Contributing to the development of recommendations for action from the findings.
- Contributing to preparing the plan of action and to facilitating its implementation.
- Representing MAP to school colleagues and the community.

Study Groups

Study Groups compare the data gathered by the MAP team to the program's Criteria for Excellence and report "findings" about how the local mathematics program compares to each ideal. Major responsibilities include:

- Reviewing and discussing the themes identified by the Assessment team members from the data collection process.
- Assessing the match between the findings of the data and the Criteria for Excellence.
- Determining the "consistency" and "inconsistency" of the ongoing mathematics program in the school with MAP Criteria.
- Preparing a report of "findings," by criterion, to share the results of the data collection and analysis.
- Assisting in the long-term implementation and monitoring of the action plans.

Appendix 4: The MAP Instruments

The assessment instruments are a central ingredient in the MAP program, the tools that enable the assessment work to be done. By using these instruments, data are gathered through interviews, observations, and surveys of faculty, staff, administrators, parents, and students. Training for those using the instruments is offered early in the program, ensuring reasonable consistency and increasing validity of assessment results. All data and other information obtained in the assessment process is held in confidence, and is maintained with complete anonymity for those responding to or observed in the program. The MAP instruments include:

- **Mathematics Teacher Interview.** Interviews, conducted by members of the Mathematics Teacher Cluster, are far-ranging—seeking expressions of teaching philosophy pertinent to middle-grades students as well as specific information on course content.
- **Administrator Interview.** A member of the Interdepartmental Faculty Cluster solicits information about awareness of and support for mathematics instructional practices.
- **Faculty Interview.** Members of the instructional staff and other school-site faculty who do not teach mathematics focus on interdisciplinary awareness of and support for infusion of mathematics principles throughout the middle-grades curriculum.
- **Parent Interview.** A sampling of approximately 10 percent of parents is questioned about involvement in and support for the school's mathematics program and expectations for their children's competence and understanding in mathematics.
- **Student Interview.** A sampling of approximately 10 percent of students has an opportunity to express their opinions about the relevance of their mathematics instructional programs to their present lives and to their academic and career objectives.
- **Mathematics Classroom Observation.** A member of the Mathematics Teacher Cluster looks at teaching processes, environments, and procedures. Observation of teaching among colleagues is a rewarding method of exchanging ideas and broadening teaching perspectives. To promote such an exchange, MAP observers and their observed colleagues are encouraged to discuss the observation process with one another at a convenient time soon after it takes place.
- **Schoolwide Observation.** The Interdepartmental Faculty Cluster is responsible for conducting schoolwide observations of all classes and student and faculty work areas to determine the extent to which mathematics teaching and learning are promoted schoolwide.

  Each cluster member observes a designated portion of instructional classes and, in addition, observes informally in other student and staff work areas. Other faculty members may join the observation process after receiving training in the procedures from a team member.
- **Mathematics Teacher Survey.** All mathematics teachers are asked to complete the Mathematics Teacher Survey, an extensive instrument that seeks detailed information about their training, instructional approaches, course content, available materials and resources, course enrollment patterns, and evaluation procedures.
- **Materials and Facilities Survey.** Mathematics teachers also complete an extensive review of the materials and facilities available for teaching mathematics in their school, ranging from teachers' resources (such as a photocopy machine or computers), to student resources (such as calculators and computers), to resources in the media center/library (such as filmstrips and VCRs). Also sought is a detailed list of mathematics reference materials, displays, and manipulatives that are available to teachers, and information about how frequently they are used.
- **Demographic Survey.** The final instrument used in the MAP program, the Demographic Survey, summarizes schoolwide achievement data and demographic background information about the school population. It is used by the MAP team as part of the overall data-gathering process to obtain a statistical portrait of students in the school.

Volume I:
USER'S MANUAL

CONTENTS

Section 1

MAP:
An Agent of Change

MAP: An Agent of Change

Introduction

The Mathematics Assessment Process for the Middle Grades (MAP) enables middle-grades schools to analyze the strengths and limitations of their mathematics programs. It serves both as a needs assessment tool and a process for guiding mathematics program improvement. MAP engages multidisciplinary groups within a school and its community in a systematic process that answers the basic question, "How well is our mathematics program meeting the needs of our early adolescent students?" Using data collected from colleagues, parents, and students, school site teams lay the groundwork for redefining and modernizing mathematics programs in the middle grades. By reviewing current programs, reflecting on the information they gather, and revising and reconstituting their systems for guiding the development of their students' fluency in mathematics, middle-grades schools can build a local consensus for improvement that incorporates the emerging national agenda for mathematics education in the 21st Century.

Mathematicians, scientists, and educators have long recognized weaknesses in mathematics education. Nonetheless, a systematic and concerted effort to change program offerings has been slow in coming. In the last decade of the 20th Century, many influential professional organizations are pressing for immediate action by proposing specific alternatives to current instructional practices.

The most recent findings of repeated national and international studies show how the typical American middle-grades curriculum, driven by arithmetic rather than algebra, has helped create a nation of underachievers. The *Underachieving Curriculum* (McKnight, et al., 1987) sounded the warning call in the late 1980s that American mathematics instruction relies on rote learning rather than concrete experien-

A Call to Action

The past five years have seen a rising sense of urgency about the need for improving mathematics and science education in our society. The most influential of these inform the conceptual framework of MAP. They include the following:

- *Curriculum and Evaluation Standards for School Mathematics* and *Professional Standards for Teaching Mathematics*. National Council of Teachers of Mathematics, 1989, 1991.
- Dossey, J., et al. *The Mathematics Report Card: Are We Measuring Up?* Educational Testing Services, 1988.
- Lapointe, A., Mead, N., and Phillips, G. *A World of Differences: An International Assessment of Mathematics and Science.* Educational Testing Service, 1989.
- Mathematical Sciences Education Board, National Research Council. *Reshaping School Mathematics: A Philosophy and Framework for Curriculum*. National Academy Press, 1990.
- McKnight, C., et al. *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective.* Stipes, 1987.
- Mullis, I., and Jenkins, L. *The Science Report Card: Elements of Risk and Recovery.* Educational Testing Service, 1988.
- National Research Council. *Everybody Counts: A Report to the Nation on the Future of Mathematics* and *Reshaping School Mathematics*. National Academy Press, 1989, 1990.
- *Science for All Americans*. American Association for the Advancement of Science, 1989.

ces—leaving students without understanding of how mathematics works in applied contexts.

Two reports that followed from the Educational Testing Service (Dossey, Mullis, Lindquist, and Carpenter, 1988; LaPoint, Meade, and Phillips, 1989) examined the comparative achievement of American 13-year-olds with four other countries and four Canadian provinces. They demonstrated that U.S. eighth-graders rank at the bottom of these nations in overall mathematics proficiency. Performance was especially low in the application of intermediate mathematics skills to complex problems and in the use of measurement and geometric concepts.

Other findings reveal that eighth-graders fail to learn essential problem-solving and analytical techniques required to sustain the technology and economy that are this nation's underpinnings. Ironically, the ETS studies disclosed that an overwhelming majority of American students perceive themselves as doing well in mathematics. John Dossey, former president of the National Council of Teachers of Mathematics (NCTM), argues that "We have drifted into a curriculum by default . . . a curriculum of minimum expectations that resists the changes needed to keep pace with the demands of preparing students for contemporary life (National Research Council, 1989)."

Everybody Counts

The National Research Council (NRC) of the National Academy of Sciences has been intensely interested in the issue of mathematics proficiency. Its evaluation of the issue is called *Everybody Counts* (1989). This preface to the Council's multi-year examination of the topic outlines key problems and charts a general strategy for addressing them. The authors assert, "We must judge schools not by remembrances of things past, but by necessary expectations for the future. Students must learn . . . all of the ways in which mathematics occurs in everyday life. In the process, they must gain confidence in their ability to communicate and reason about mathematics; they should become mathematical problem solvers." Our national goal must be to make American mathematics education the best in the world, urges the Council.

Project 2061

In 1989, the American Association for the Advancement of Science (AAAS) began a decade-long program to demonstrate the possibilities for integrating mathematics and science education. *Science for All Americans* (AAAS, 1989) establishes a conceptual foundation for reform by defining the knowledge, skills, and attitudes in mathematics and science that students need to acquire from their school experience. The AAAS goal is to modernize the instructional content and the teaching processes through Project 2061, a series of models demonstrating how Americans can instill in young people a fundamental scientific literacy—an education in science, mathematics, and technology. Project 2061 schools are establishing examples of integrated mathematics and science curricula that develop the necessary understanding and "habits of mind" to assure America's vitality and contribution to global survival.

NCTM Standards

Significantly, the nation's teachers and mathematics researchers, organized under the umbrella of the National Council of Teachers of Mathematics (NCTM), also have asserted themselves as leaders of change. In 1989, the organization issued its long-awaited agenda for reform, *Curriculum and Evaluation Standards for*

School Mathematics (1989). In 1991, the *Professional Standards for Teaching Mathematics* became available. Together, the coordinated *Standards* constitute the most comprehensive and best-articulated design for curriculum and teaching in a major content area, demonstrating practically and clearly the possibility of departing significantly from the repetitive, traditional curriculum that has failed students in the past.

The NCTM *Curriculum and Evaluation Standards* integrate the kindergarten-through-twelfth-grade mathematics program—centering it on five core goals of mathematical literacy (NCTM, 1989, p. 5). These goals have special significance during the adolescent years, because it is during these years that students become increasingly capable of making connections between mathematics and real-life contexts. The goals are to:

- Learn to value mathematics.
- Become confident in one's own ability.
- Become a mathematical problem solver.
- Learn to communicate mathematically.
- Learn to reason mathematically.

The revised curriculum agenda calls for teaching that responds to student diversity and nurtures spontaneous knowledge and learning abilities within the context of a mathematically sound curriculum. The program argues that, in the middle grades, learning continues to evolve from students' concrete, active pursuit of mathematical principles, inventions, and ideas. It accents ways that schools can involve young adolescents physically, socially, and intellectually in practical and applied mathematics learning.

The *Mathematics Assessment Process for the Middle Grades* is a promising vehicle for addressing this agenda.

The Challenge: Creating Effective Middle-Grades Mathematics Programs

A Focus on Young Adolescent Learners

Early adolescence is a time of rapid and profound growth. The uniqueness of students during these years provides rich opportunities for planning innovative and responsive mathematics programs in the middle grades. Differing rates and times of physical, social, and intellectual development create a tremendous diversity of interests and talents among students in classes and schools that serve the age group. Emerging cognitive processes include the ability to abstract, to hypothesize, to form and understand previously inaccessible concepts, and to analyze one's own thoughts as well as those of others.

Armed with an understanding of how learning changes during early adolescence, mathematics curriculum developers and teachers can redesign their programs to acknowledge these transitions and significantly improve the content and pedagogy they use with their students.

Collaborating to Guide Improvement

The *Mathematics Assessment Process for the Middle Grades*, as its acronym—MAP—suggests, is a guide for improvement. Its strength lies in the integration of three fundamentally important components: effective mathematics curriculum and instruction, teaching approaches based on the unique developmental needs of young adolescents, and lessons from research and practice in school organizational renewal and planned change.

Informed by new understanding of cognitive psychology, mathematics teaching, and the characteristics of young adolescent learners, MAP is an exercise in the power of school site collaboration. It involves all elements of the school community: mathematics teachers, faculty in other disciplines, school and district level administrators, students, and parents. With MAP, school-based planning teams unite to evaluate their mathematics program's strengths and shortcomings, moving systematically to design and implement action plans that improve and modernize their approach to mathematics.

MAP is a change mechanism that offers an alternative way of thinking about redesigning instructional programs. By giving a voice to everyone who has a stake in the instructional outcomes, it empowers the entire school community. Although MAP focuses on improvement in mathematics programs in schools and school districts, both the process it employs and its philosophical underpinnings have far-reaching implications for affecting the school site capacity to direct change.

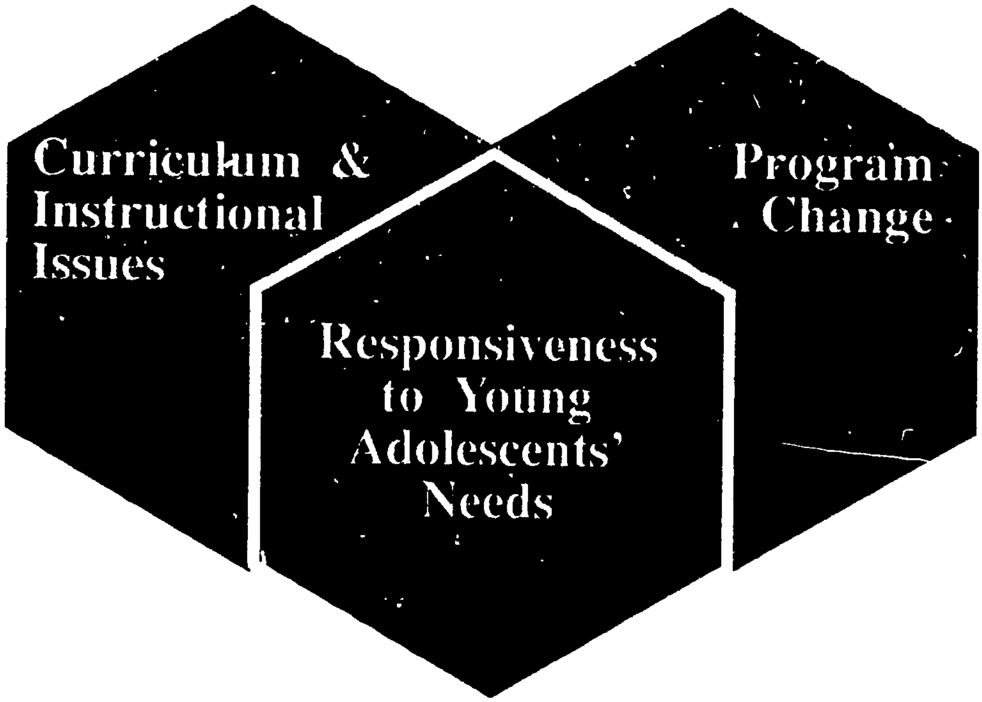
MAP Is Informed by Exemplary Mathematics Teaching Practice

At the heart of MAP are nine "Criteria for Excellence" and their enabling "Ideals." They relate not only to mathematics instruction, but also to the needs of adolescents and to planned change. The Criteria provide a frame of reference as school teams seek to evaluate their mathematics programs. The Ideals suggest how the Criteria can be met. Interviews, observations, and surveys, keyed to the Ideals, provide teams with the data they need to determine their school's progress towards establishing an exemplary mathematics program.

The Criteria and Ideals were formulated by a national advisory panel that assisted in the MAP design. They synthesize contemporary mathematics education research and the practical experience of educators. They also are consistent with the standards of excellence established by major groups of mathematical scientists and educators.

The nine MAP Criteria are clustered into three sets, each with a particular focus. The first three Criteria speak to a school's mathematics curriculum, its mathematics instruction, and to student learning. The second set of three Criteria guides educators in understanding who adolescents are and how they learn. The final set of Criteria creates a framework for continuing to evaluate the program and sustain the organizational change (see Figure 1 on the following page).

Figure 1



An Effective Middle-Grades Mathematics Program Accepts the Challenge of

Improvement in Three Key Areas

Accepting the Challenge: Curriculum and Instructional Issues

Literacy and numeracy are more than education buzzwords. They are shorthand for the heart of our nation's goals for its youth. Apart from reading and writing, mathematics is the most widely studied subject in our public schools and colleges. On all levels, we spend about $25 billion dollars annually to teach mathematics. Despite this investment, the evidence is compelling that students are failing to learn many of the most fundamental mathematics concepts that they will need in their everyday lives.

The National Academy of Science's report, *Everybody Counts*, describes today's mathematics instruction in our schools as "an enterprise rooted in antiquity, with some of today's curricula matching very closely educational patterns of 500 years ago."

Reminding us that the world of work is rapidly becoming less manual and more electronic, less physical and more verbal and varied, the authors reaffirm that in today's world economy, working smarter is more important than working harder. Workers who contribute to the world economy are mentally fit—they are prepared to absorb new ideas, to adapt to change, to cope with ambiguity, and to solve unconventional problems. It is *these* skills, not just the ability to calculate and solve repetitive problems, that are prerequisites to so many of today's jobs. "More than ever before, Americans need to think for a living; more than ever before, they need to think mathematically," say the authors of *Everybody Counts*.

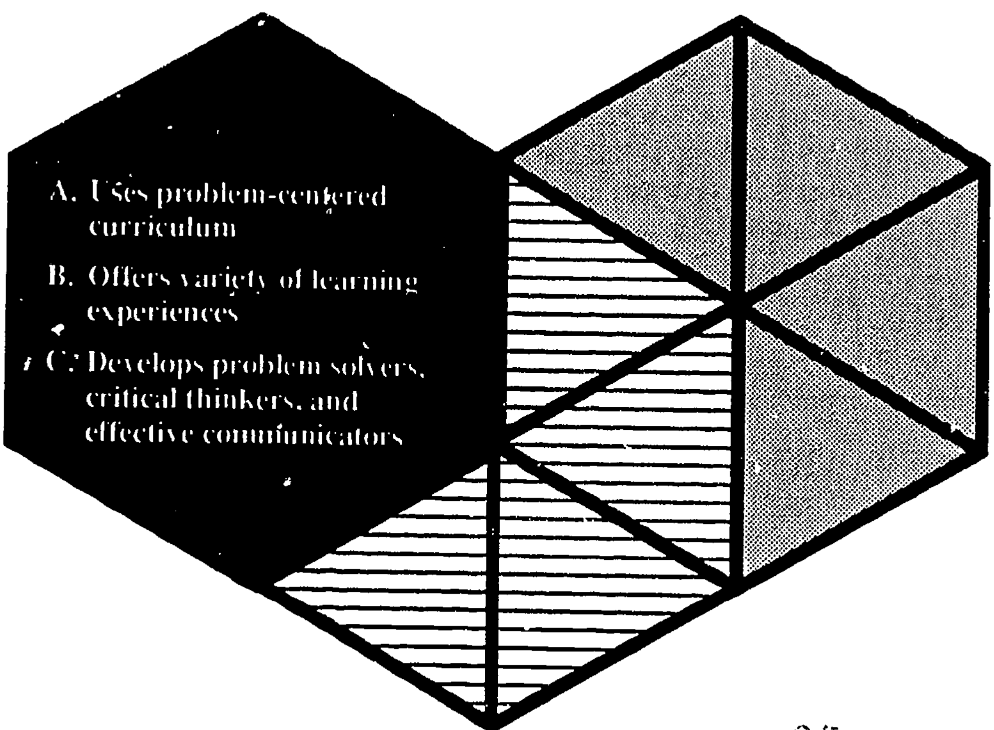
Yet this and other reports also note that:

- Far too many students, including a disproportionate number from traditionally underserved groups, leave school without the mathematical skills necessary for productive lives.
- On average, U.S. students do not master mathematical fundamentals at a level that permits us to sustain our technology-based society.
- When compared with students of other nations, those in the U.S. lag far behind in levels of mathematical accomplishment. This educational deficit impedes our ability to compete internationally.
- Public attitudes, reflected and magnified by the media, encourage low expectations in mathematics from both students and their parents. Only in mathematics is poor school performance socially acceptable.

In response to this opportunity for making changes, MAP presents three criteria for a comprehensive, effective middle-grades mathematics curriculum of quality and substance. The Instructional Issues Criteria reflect the knowledge that a good mathematics program in the middle grades:

- *Uses a problem-centered curriculum to develop students' conceptual understanding of mathematics, appreciation for its applications, and proficiency in computational skills.*
- *Engages students in a variety of learning experiences designed to promote mathematical exploration and reasoning.*
- *Develops students as problem solvers, critical thinkers, and effective communicators in mathematics.*

Figure 2



An Effective Middle-Grades Mathematics Program Accepts the Challenge:

Curriculum and Instructional Issues

25

These Criteria, and the Ideals linked to them, capture the essence of proposals put forward by scientists and mathematics educators to strengthen programs across all grade levels.

A solid foundation of research establishes that these issues have special relevance to students in the middle grades, individuals who are experiencing rapid intellectual, social, emotional, and physical development. Students' accelerated growth during early adolescence enhances their capacity for learning and determines the ways in which they learn best.

Accepting the Challenge: Responding to Young Adolescents

The years from 10 to 15 are a critical time for learning mathematics. The typical elementary curriculum develops proficiency in the four basic mathematical operations of addition, subtraction, multiplication, and division, but fails to establish the conceptual foundation necessary for mathematical thinking and understanding. After years of practicing the traditional "basics," too many students have lost both their confidence and their intuitive sense about mathematical relationships. Lacking deep understanding, they try to memorize, but memory does not take them very far; the quantity and complexity of new information quickly becomes overwhelming. Relying on rote processes alone, students can not manipulate mathematical ideas fluently or creatively, their tactics break down, and their mathematics learning, in effect, stops.

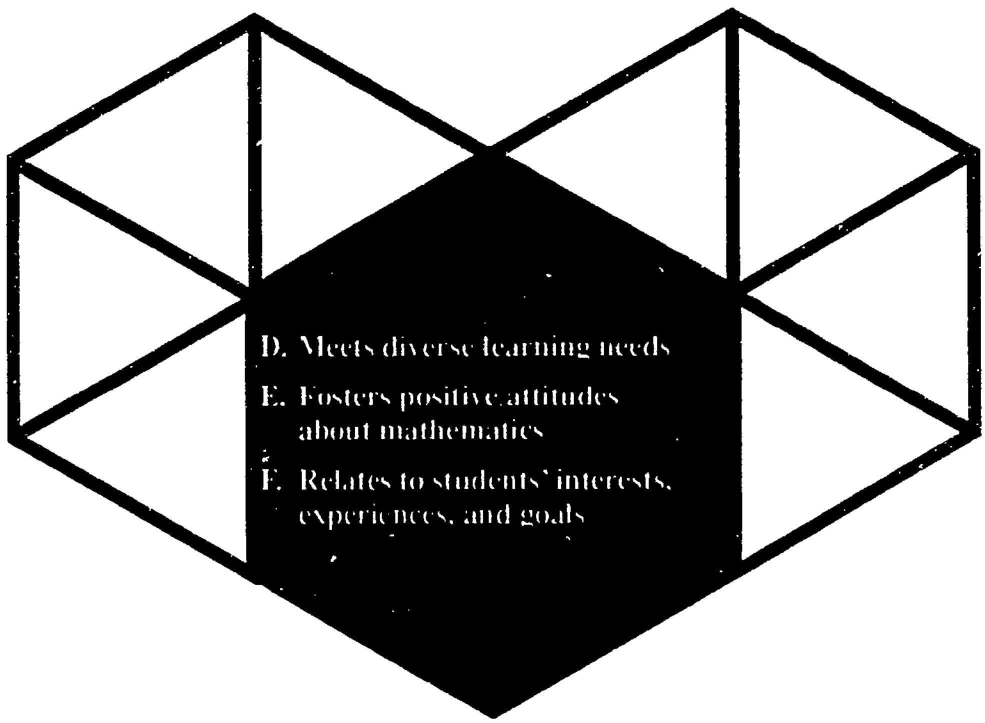
Without sufficient intellectual preparation, mathematics has no clear relevance to students' lives and, by ninth grade, many young people lose their option to take useful math courses. In practice, the consequence for many is that their mathematics education ends during the critical middle years when they failed to learn essential concepts and applications.

This problem of middle-grades mathematics instruction is addressed by MAP with its emphasis on making mathematics programs *responsive to young adolescents' needs*—the second set of Criteria and Ideals. Few middle-school organizations and teaching methods are designed to acknowledge the changing interests, intellectual capacity, and social needs of youngsters. By failing to update and offer a more substantive curriculum, they reduce the school's overall effectiveness for students. MAP fills this gap with Criteria that establish the idea that young adolescents can *only* become talented mathematical thinkers and problem solvers if their instructional programs:

- *Provide instruction and resources to meet young adolescents' diverse learning needs.*
- *Foster positive attitudes about mathematics and encourage and recognize students' accomplishments.*
- *Relate mathematical knowledge to students' interests, experiences, and future goals.*

These Criteria are core elements of the *Mathematics Assessment Process*. They set forth the principle that young adolescents' developing characteristics provide a relevant structure around which the curriculum should be organized. Furthermore, the data gathered through MAP enable students themselves, as well as parents and other personnel close to them, to reorient what should be happening in mathematics during the middle grades. This shared insight allows teachers to be more responsive to their students' markedly diverse interests and needs. Through interviews and class-

Figure 3



An Effective Middle-Grades Mathematics Program Accepts the Challenge:

Responding to Young Adolescents

room observations, the faculty brings the issue of relevance into sharp focus and is positioned to restructure the program options it offers.

Accepting the Challenge: Program Change

When national consensus develops in public education around a specific issue, lasting change can occur. An increasingly strong consensus is emerging now about the quality and content of mathematics instruction—especially in the middle school years. Educators and mathematicians are rallying around NCTM's *Curriculum and Evaluation Standards for School Mathematics*. In cluded in its curriculum and instructional goals, NCTM offers four evaluation standards in mathematics instruction that are entirely consistent with MAP.

NCTM Evaluation Standards

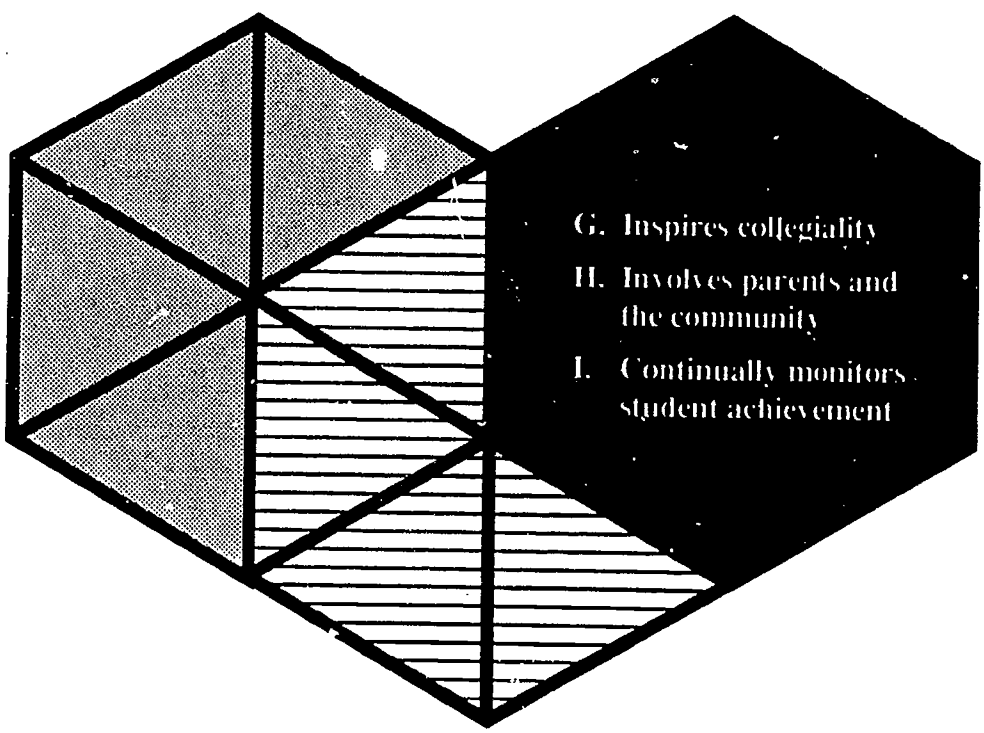
Among the standards defined by NCTM, the following four *Standards* on Program Evaluation are woven into the MAP framework:

- **Indicators for Program Evaluation** document the program's alignment with the *Standards* and its long term effects on students' developing capacity for knowing and doing mathematics; the program's attentiveness to a multiplicity of student outcomes; the parental, administrative, and collegial support system; the equal access for *all* students to every dimension of the mathematics curriculum; and the presence of a self-monitoring process for assuring the mathematics program keeps current with the dynamic nature of mathematics and what we know about teaching and learning mathematics.

- **Curriculum and Instructional Resources** establish a mathematics program's consistency with the *Standards* through an examination of goals, objectives, and mathematical content; the relative emphases of various topics and processes and their relationships; instructional approaches and activities; articulation across grades; assessment methods and instruments; and availability of technological tools and support materials.
- **Instruction and the Environment** in which mathematics learning takes place are examined, with special attention to mathematical content and its treatment; the relative emphases assigned to various topics and processes and the relationships among them; opportunities to learn; instructional resources and classroom climate; assessment methods and instruments; and the articulation of instruction across grades.
- **Evaluation Team** with expertise and training in mathematics education plans and routinely conducts assessment of the mathematics program. This team includes the stakeholders who have the greatest interest in the results of the evaluation, including teachers, mathematics supervisors, school and district administrators, and members of the community. There also is a place for parent and student perspectives (NCTM, 1989, pp. 189-248).

The NCTM clarifies the evaluation standards that monitor excellence in mathematics instructional content and practices, on all grade levels. They also specify the standards against which schools should be examining their own programs. These standards encourage action for change at the school and district level and define elements of the process that are consistent with MAP.

Figure 4



An Effective Middle-Grades Mathematics Program Accepts the Challenge:

Program Change

The Challenge of Change

The challenge now is for school-based educators, together with their parent and business communities and their district offices, to carry out the wise counsel offered by national leaders in mathematics and mathematics education. Education leaders understand the systemic inertia that impedes lasting change in school programs. For many, the memory of efforts to reform mathematics programs in the 1960s is bitter. The authors of *Everybody Counts* articulate the nature of this problem:

"Because of vast differences in both tradition and constitution," they write, "a 'top-down' approach will not work in the United States," if the goal is lasting change. "Experience has much to teach us on that score.

"Few traces remain of the expensive, major curriculum development projects so prominent in the 1960s and 1970s. These projects tried to develop, on a national scale, complete curricula (including instructional materials) that could be adopted whole by school districts. But the theorists and planners who developed these curricula were naive about the process of change; big curriculum projects failed to take root in American schools because they were transplanted fully grown into an environment better suited to locally grown methods."

Change that lasts, that moves a school or district along the path of excellence, requires enthusiasm and energy from those who are part of the process. Change in schools works best when the key players include teachers, students, administrators, parents, and community members. Ownership and commitment to new ideas and programs, locally tried and modified as needed, translates into change that is more than transitory. It offers the prospect of moving along a continuum of excellence in an orderly fashion. The lessons of the past two decades of school improvement research inform the design and implementation of any program intended to improve mathematics instruction in the nation's schools.

Reflecting much of what we have learned about how organizations change their beliefs and behavior, MAP's last three Criteria on Program Change suggest that an effective middle-grades mathematics program:

- *Inspires collegiality among faculty who work together to implement responsive programs for young adolescents.*
- *Involves parents and the community in a collaborative effort to promote student competence in developing and using mathematical knowledge.*
- *Continually monitors student achievement, evaluates program effectiveness, and uses the results to determine the need for improvements.*

NCTM's *Standards*, the work of the National Academy of Sciences National Research Council, and the contributions of other authoritative and respected voices call attention to the level of mathematical illiteracy that exists in the United States. They propose clear guidelines for promoting improvement. MAP—the *Mathematics Assessment Process*—is a method for supporting long overdue innovation in a healthy way. It offers a process for moving students, step by step, from potentially devastating levels of mathematics incompetence to productive levels of performance.

Section 2

Criteria for Excellence

Criteria for Excellence:
Characteristics of Successful Middle-Grades Mathematics Programs

Mathematics always seems special. For some teachers, mathematics is a pleasure to teach because it is precise. The answers are either right or wrong; the tasks appear straightforward. Students always know where they stand, and the subject proceeds in a rational, logical way. Comfort lies in the progression from one mathematical idea to the next. Students learn to build ideas logically and to move step-by-step from concept to concept.

For other teachers, the enjoyment in mathematics teaching is in the excitement of discovery. They encourage students to find patterns, to apply what they do to their own lives, to explore the subject in many different ways. They consider mathematics to be patterned and logical, but not necessarily linear. If students discover an intriguing pattern, with their classmates they explore it to decipher its structure and understand its usefulness. Students learn to look for meaning and to connect mathematics with their own lives, generating theories and testing them in real ways.

Young adolescents who have mathematics teachers such as these are lucky indeed. These teachers are drawn to their work, committed to teaching a subject that stimulates their curiosity and interest—one they find personally involving and challenging. It is important that our schools support and help teachers with this kind of spirit about teaching mathematics, those who want to reach out to their students and to inspire them. Teachers like these could have made a difference for a mathphobic adult recalling her early mathematics experiences, who writes:

> *I happily spent hours on my homework. [Math] was a game...the processes were the unravelling of the [mystery], the motives, and the "whodunnit." Unfortunately, when I took my work to the classroom I quickly discovered that my solutions to the mysteries were incorrect, done with the wrong processes.*

Imagine how much more successful this student would have been if a teacher had been able to harness her imagination to find ways of seeing whether her "mysteries" followed mathematical rules! Often the right/wrong aspect of mathematics is daunting to students who are bright, interested, and somewhat impulsive. This is because we fail to help students learn that mathematics can make sense to them.

The goal of all mathematics education is mathematical literacy—fluent, appropriate understanding of mathematical information in new and previously unfamiliar contexts. This is essential to young people's healthy intellectual and personal development, as is the fluent use of other expressive communication forms. Just as we expect literacy in reading and writing, we want young adolescents to be mathematically literate as well.

What goes wrong for so many children by the middle grades in mathematics? The answers lie partially in what we typically call "school mathematics," a specialized program of studies that has become largely separated from the mathematics from which it emerged. In school mathematics students rarely encounter the experience of using mathematics as a practical tool. Rather, they learn that mathematics is a set of procedures, disconnected from everyday life, to be followed simply to "get answers" to abstract numerical problems and equations. They rarely discover why those procedures might be important, nor do they understand what the procedures mean.

Mathematics is a language—a language used to communicate about a specific domain of human experience. Numbers and other symbols are the written language of mathematics. The earliest experiences that young people have manipulating such mathematical ideas as shape, form, size, quantity, volume, weight, time, and distance are represented in words, not symbolically. Small children compare sizes and shapes and talk about real things that are heavy, light, close, and far. When school mathematics begins, however, symbols are typically used very early, often too soon. Terms are defined and abstract examples are presented in the form of exercises that follow age-old rules. Ideas are explained, and students quickly move to the manipulation of symbols that stand for complex ideas, skipping the critical experience of discovering and debugging their own theories for why the symbols and rules work.

One of the problems facing mathematics teachers is imbuing symbols with meaning for children. Like premature teaching of sound-symbol relationships in reading, the too-early teaching of mathematical symbols, separated from their concrete, real-world meaning, profoundly affects a child's later learning of mathematics by depriving the child of confidence in being able to understand mathematical symbols. Effective mathematics relies on steadily, gradually accumulating understanding of meaning—in a context that makes sense to the developing child—whether that child is seven years old, trying to master telling time, or twelve years old, confronted for the first time with algebraic equations based on poorly-understood arithmetical operations.

Errors are treated very differently in the language arts and in mathematics. When young children learn to talk, they make errors as their language develops, and these are warmly accepted as signs of intelligence and progress in language learning. They invent spellings as they learn to write. Parents and teachers are comfortable with these language developments, and do not generally pounce on children to overcorrect them. This is not so for mathematics.

Children's mathematical "miscues" are errors seen as serious, and are often overcorrected. We forget that, as with language learning, children's mathematical errors are based upon their own original theories. In time, mathematical theories, like those in language, will prove to be mistaken, forcing children to adjust them as they strive to match more accurate and workable cognitive models. If we would credit the mathematics structures that children develop as educated predictions and afford them the opportunity for self-correction (as we do in language and reading miscues), we would go a long way towards reaffirming children's natural mathematical competence and inventiveness.

Mathematics is a language with both symbols and meaning that was developed to communicate complex ideas. Although students are taught the grammar of mathematics, they do not often use it in schools to communicate ideas. This is especially true during the middle years. As mathematics becomes increasingly symbolic, it is important that teachers treat mathematical ideas as discussion points and use them with students as the source of important mathematical observations and theories.

Middle graders who share and collaborate with each other, who debate and discuss their mathematical discoveries, learn to write and speak mathematics as a natural refinement of their first language literacy. The ability to communicate about and with mathematics is especially important during the middle years when developing young adolescents value and need intensive personal interactions with peers, adults, and with events and objects in their world.

Criteria for Excellence: Characteristics of Successful Middle-Grades Mathematics Programs

Criteria for excellent mathematics programs are well documented, but these standards are complex, and school organizational structures and curricula have been slow to adjust to the changes. The technological innovations of the past several decades have brought about an upheaval in the way we learn, live, and work. Ironically, in the field most responsible for this dramatic change in our lives—mathematical science—schools have been slowest to modernize.

The *Mathematics Assessment Process for the Middle Grades* is built on a solid foundation of research and practice that is summarized in the "Criteria for Excellence." Each Criterion is explicated by a set of six to eight Ideals that exemplify successful mathematics practices in middle-grades schools. The nine Criteria are described below, with a brief portrait of the classroom and supporting instructional program that is characteristic of each. This description suggests qualities of programs that have been documented in successful middle-grade schools. There are, however, rich portraits that meet the same standards but look quite different. The Criteria themselves can be evidenced in a variety of effective approaches to middle-grade mathematics. The cornerstone of this mathematics assessment is you—the effective practitioner who ultimately will define his or her own implementation of the following nine program Criteria.

A complete list of the Criteria and their accompanying Ideals concludes this section of the MAP *User's Manual.*

A. Curriculum

An effective middle-grades mathematics program uses a problem-centered curriculum to develop students' conceptual understanding of mathematics, appreciation for its applications, and proficiency in computational skills.

Mathematics education often seems to be a battle between warriors for conceptual understanding and those favoring arithmetical computation. It is not necessary to choose between them, however. The best mathematics programs incorporate both elements in their curriculum, assuring that students can compute well and that they understand what they are doing and why. If students do not understand, they cannot apply what they learn to new or unfamiliar situations. If they cannot compute, they cannot quickly assess the appropriateness of a calculator's answer to a string of operations. Mathematics programs can quite successfully incorporate both elements, developing both abilities, and having each reinforce the other.

The middle-school years are critical years for learning mathematics, setting the foundation for the more abstract high school program to come, as well as the mathematics students will have to know and use as adults. Students at this age welcome new material and, with the proper support, they are very receptive to new learning challenges. Their rapidly developing cognitive abilities allow them to work with increasingly symbolic materials, but they are still most successful if they can attach symbols to meaningful real-life experience.

Repetitive review connects young adolescents to earlier school years and is considered boring, no matter how necessary it seems to adults. Often the review and consolidation of previously learned skills can be done in practical contexts, applying previously solidified skills to new knowledge and interests. New mathematics content represents an important chance for students to prove to themselves and to show their peers that they can master interesting and challenging new work.

An integrated middle-grades curriculum that relates various disciplines has a good chance of reinforcing the critical thinking skills that are blossoming in early adolescence. A study unit focusing on data analysis could combine science content with mathematical data analysis skills, and present new materials with familiar content or familiar skills in new content areas. Instead of having two separate subjects, students can collect and analyze data that compare students' general health and their eating habits, looking for patterns in the data—differences among families with certain demographic characteristics—and trying to analyze trends in eating and its effects on health, as scientists do.

In such an integrated curriculum, the emphasis would be on mathematical processes as well as science content. It is a challenge for middle-grades teachers to develop such a balanced curriculum; one that contains the independent mathematical skills (e.g., addition, multiplication, finding common denominators), as well as broader mathematical processes (e.g., estimation, problem-solving, evaluating information). A curriculum that focuses firmly on establishing a context for its mathematical work and is committed to applying developing skills will go far in preparing students for a successful mathematical future.

Imagine, for instance, a middle-grades curriculum emphasizing flight. Students begin their study by building paper airplanes, drawing the structures they have created, measuring the parts, and analyzing the aerodynamics of the way their planes fly. They review area by finding the area of the wing of the plane, comparing the ratio of distance of flight to wing area as planes change in size and form. Graphs of data make such comparisons easier. Computer spreadsheets and calculators make the computations faster. Other variables are considered as students look for relationships, and the unit culminates with a visit to a nearby airport to talk with technicians and pilots about the variations in the capacity and behavior of airplanes with different features. In such a study, students can integrate knowledge of science, social studies, engineering and design—and are conducting genuine exploration of a topic that is not intended to become "mastered," but, rather, to provide ways of developing knowledge and exploring relationships among many pieces of information.

B. Learning Experiences

An effective middle grades mathematics program engages students in a variety of learning experiences designed to promote mathematical exploration and reasoning.

Young adolescents rapidly develop the capacity to study their own thinking. Such self-understanding goes a long way towards helping them learn most effectively. The growth that occurs during these years in "metacognition"— the ability to think about one's own thinking processes—is fundamental to students' capacity to analyze their mathematical understanding, developing and expanding their mathematical knowledge. As students move toward increasingly symbolic work, they become able to examine their own imagery and the assumptions they have made about numerical and geometric domains in mathematics. As a result, students are eager to talk with each other about their methods, comparing their understandings with those of their peers.

A variety of learning experiences supports students with a wide spectrum of learning needs and learning styles. During a teaching day, different mathematics classes might work with algebra tiles, multibase blocks, computers, protractors and rulers, tape measures, videotapes, paper and pencil, or small group project work and discussion. Teachers might use more than one material or approach during a class period. For too many young adolescents, concrete materials are not being used in mathematics classes. Yet the fullest progression of their thinking requires that they construct their own concepts, test their observations against the behavior of real objects and debate with peers about their alternative explanations and observations. Unfortunately, until recently, middle-grades students have been pressured to abandon their needs for concrete experiences prematurely. This balance between the concrete and the abstract is a key element in young adolescents' growth. Concrete models serve as essential contributors to building bridges between symbolic and concrete understanding.

Calculators and computers provide students freedom from diverting computational drudgery. These machines allow students to separate their understanding of processes from their computational ability or inability. The number-crunching power of these machines can help students as they become skillful in working with numbers in an assortment of other ways. The computer can provide a great deal of practice in writing formulas (using spreadsheets), in logic (constructing data bases), and in data analysis (graphing).

All of these are interesting and appropriate uses of sophisticated technology with young adolescents. Mathematical understanding can be the center of a seventh-grade measurement unit. Students can construct a model of a regulation-size soccer field, basketball court, or baseball diamond (depending on the groups' favorite sport or the season). They can then decide the equipment they would need to build the appropriate field, where they would turn to purchase it, and project the costs. In order to solve these problems the students work in groups, doing research, designing, drafting, and building the model and detailing estimates and cost projections.

It can take months of steady progress to accomplish such a project, and in the process students use the computer, calculators, tape measures, as well as blocks and other materials to construct scale models. If they are working on a sports field that the school does not now have available, they could present their models and cost projections to the principal and, ultimately, to the school board, as an argument for a modification in the school plan. The discussions and debates carried on in the small groups, in the larger class sessions, and finally, with school officials are instrumental in increasing students' capacity to put ideas into words, to make sound and practical arguments and judgments, and to collect and analyze information. Numerous mathematical skills are enhanced. More important, however, students become sensitive to the challenges of creating something important to them, the creativity, planning, and costs involved, and the skills needed.

Through this real and relevant problem, students develop their increasingly complex and sophisticated mathematical processes and they explore their own approach to learning. The most effective middle grade mathematics programs help students develop understanding in both these areas.

C. Problem Solving and Critical Thinking

An effective middle-grades mathematics program develops students as problem solvers, critical thinkers, and effective communicators in mathematics.

The long-term goal of any school mathematics program is to prepare students to think flexibly about mathematical problems and to intelligently deploy a complex array of skills in their solution. Reflective and critical thinking is essential as students solve mathematical problems in school. Without significant classroom discussion of problems and their various solutions, sessions on problem solving become exercises in "numerical target practice," as each student vies to be the first done with the "correct answer."

Mathematics teachers who effectively develop students' problem-solving skills spend a great deal of time in discussions, speculating about solution strategies, and evaluating and implementing alternative approaches. The teacher's critical role is to facilitate the discussion, encouraging alternative statements and comparative methods, coaching those who have not yet captured the concepts. Because being confused is a useful part of problem-solving, adequate time is provided for the resolution of such confusion. This is especially important for young adolescents who face uncertainty in so many dimensions during these years. They need the kind of encouragement that validates their confusion, helping them see that it is a normal, indeed, a valuable stop on the road to real understanding.

Experience is vital to becoming effective mathematical problem solvers. Students need to spend school time solving real-world problems and examining their interrelated applications. Most middle-grades textbooks have problem-solving assignments that are oversimplified or hypothetical pieces of a complex reality. We do our students a disservice by cutting their world into unnatural but apparently bite-sized pieces. Problem situations need to involve richness and complexity so that students easily transfer their problem-solving skills.

As part of this effort, teachers encourage students to devise solution strategies by rewarding students' creative and promising approaches, even when those do not yield a correct answer. When alternative solutions are accepted and seriously investigated, regardless of their text-centered "correctness," students learn to take their own thinking seriously and to evaluate the results they obtain by using critical thinking. What does the answer to the problem mean? How was it arrived at? Could there be alternative strategies for arriving at the same solution? Are there alternative solutions? Can this be extended to other problems? In what ways? Questions such as these allow students to find meaning beyond the specific example, and to evaluate the results of their work.

Students enjoy being actively involved in problem solving, inventing problems themselves, discussing their solution strategies, debating possible approaches, evaluating the results of their work, and generating their own heuristics. Effective teachers of problem solving model the process; they engage in it along with the students and enjoy its twists and turns.

D. Diverse Needs

An effective middle-grades mathematics program provides instruction and resources to meet young adolescents' diverse learning needs.

Young adolescents have a multiplicity of learning needs. Because of the range of cognitive and emotional levels that are present in any middle-grade classroom, it is important that schools support such diversity with a rich array of teaching approaches, content selection, materials, and learning environments. The developmental range of middle-grade students' experience and achievements challenges teachers' patience, equanimity, and creativity during these years.

A complex interaction between social uncertainty and personal values may lead students with unexplored talent and potential for success in mathematics to avoid courses in the field, therefore closing out many later career options. In particular, the failure rate in mathematics for girls and minority students has been historically so high that their absence from the pool of potential users of complex mathematics threatens the economic well-being of our country. Typically, female or minority students who enter middle grades as relatively high achievers in mathematics find themselves slipping to ever lower levels during these years. Peer pressure, unappealing content, lack of role models and parental encouragement conspire to discourage the interest of many otherwise able students.

Effective middle-grades mathematics programs are structured to prevent such patterns from developing. Students are supported and coached to tackle hard problems, and they do well. School tasks are not oversimplified, so students' genuine interest and capacity are engaged. They gain a repertoire of effective coping mechanisms, and develop a solid foundation for knowledge and strategies that stand them in good stead for later mathematics. We know that effective middle-grades schools challenge all their students and have high expectations that each will demonstrate competence and achievement. These high expectations disregard irrelevant demographic variations, and use students' uniqueness as an instrument for success.

Like all young people, middle-grades students rely for their security on the clarity of a dependable structure and knowledge about where the limits are. Their mathematics learning environment must include clearly stated policies about classroom expectations, procedures, homework policies, and how students' learning will be assessed. When students know their work has some real value, they respond well to the structure and to demands placed on their behavior.

Homework holds special potential for rich learning during the middle years. Now older and able to move more independently around the community, students' out-of-school assignments can enable them to participate in their neighborhood and town. Students can become part of a community project, collecting and interpreting data about using a park across from the school. This participation begins in the classroom, where the mathematics curriculum strengthens young adolescents' sense of efficacy.

Opportunities for exploring and defining who they are as individuals—learning how a solid grounding in mathematics is part of that growth—are essential components of a program that promotes young adolescents' healthy development. As students project themselves into a future that they can begin to imagine with increasing clarity, they need to bump up against their own skills and limitations. Effective mathematics instruction can help students observe themselves as they try new experiences. By monitoring their developing skills, applying them against new challenges, they can make a realistic appraisal of their own learning needs, styles, and preferences. Mathematics, because of its ability to model problem solutions and strategies, allows students to see possibilities without having to decide on those that are superior. Recognizing that mathematics is a "critical filter" to many careers is a vital piece of this knowledge. In learning to develop positive social interactions with both peers and adults, many effective middle-grade schools are basing large pieces of the mathematics curriculum on collaborative learning. In early adolescence, students become self-conscious. The threat, however unlikely, of making a mistake, however trivial, is daunting. Many students will not willingly answer questions or volunteer information, much less ask questions of the teacher. The fear of appearing not to know is too risky.

For these reasons, collaborative learning is a way both to diminish the fear of individual attention and to validate student discussions of important ideas with peers. Enabling students to translate mathematical symbols and logic into language, and in turn, to translate verbal logic into mathematics uses students' emerging capacity to use language abstractly.

Physical activity is also a need of young adolescents. Their bodies are changing more dramatically than at any other period in their lifetime. They will grow during these years to 98 percent of their adult size, thus generating a tremendous amount of energy. Teachers who take advantage of this energy routinely find ways to encourage their students to move about the classroom and to engage in activities that take them throughout the school. Active data collection, project planning, and the creation of physical models help focus some of this energy and build upon the intrinsic nature of the learner. Providing both support and stretching for the young adolescent is the very nature of an effective middle grades mathematics program. The range of student needs makes this both challenging and rewarding.

Finally, the emerging cognitive capacity and greater involvement with an expanding social world makes young adolescents increasingly aware of the judgments and opinions of others. Thus, if the mathematics program is to find ways for students to understand their mathematical learning potential, it must avoid labeling and sorting students into permanent groups. When growth and potential are so dynamic, labels—many of which have negative implications—are inappropriate and pernicious. Often they establish in students inappropriate self-images from which they never fully recover. Tracking, assumed by parents and teachers alike to be necessary for students, is counterproductive for the students it is most intended to serve. In fact, most students can learn best if at least part of their mathematics program is conducted in mixed ability classes. The evidence is indisputable that being labelled in early adolescence can have lifelong negative consequencees.

Every year, students are lost to higher mathematics classes and to careers in many fields because they internalize negative images of themselves as mathematics students. An effective middle grades mathematics program capitalizes on the diversity of the student body. Acceptance of diversity, encouragement of alternative approaches to problem solving, and recognition of inventiveness and thoughtful intuition rather than simply "answer getting," are mechanisms that allow students at all achievement levels to learn that they can be achievers too.

E. Attitudes **An effective middle-grades mathematics program fosters positive attitudes about mathematics and encourages and recognizes students' accomplishments.**

Early adolescence is a major gateway in the human life cycle. At this juncture, positive interventions, rewards, and recognition can powerfully affect young people's healthy development. Mathematics becomes attractive to students during these years when students see that mathematicians are respected and significant contributors to their world. By learning about appealing role models in mathematics-related fields who share their ethnic or racial uniqueness, students find reasons to pursue mathematics.

Moreover, through their own accomplishments in mathematics, students test the limits of their potential. The satisfaction they gain smooths their adaptation to adolescence, helping to offset temporary setbacks and disturbances of self-esteem that may occur. In classrooms that provide the time to finish extended mathematics-related projects, students can learn to create attractively presented computerized drawings, spreadsheets, or constructed models, experiences that enable them to experience a sense of pride about their mathematical accomplishments.

Competition is especially exciting for some, but not all, students during this period. By having choices about whether they work individually or in groups, all students have an opportunity to be part of a mathematical success story that is acknowledged publicly. That is, all may compete successfully. Displays of student work in the classroom and school hallways or in businesses or public buildings within the community can be sources of great pride for students and families alike. Confidence increases when students serve as leaders in mathematics competitions and science projects, or tutor young students who are just learning the mathematics that is routine for middle-grades students.

Many ways can be found to recognize students' achievements in a wide variety of mathematical activities. Students may design an effective plan for building a track, a game room, or a greenhouse for the school; they may develop a statistical study of the demographics of the student body and the community; they may write essays describing experiences in a mathematics class; they may help out with a fix-it project at home involving elaborate measurements. In pursuing mathematics in diverse contexts, students see that their contributions are real, they recognize that their contributions are appreciated, and significantly, they learn how mathematics is relevant to themselves and to their community.

F. Relevance **An effective middle-grades mathematics program relates mathematical knowledge to students' interests, experiences, and future goals.**

Middle-grades students seek a strong sense of efficacy and purpose. Collaboration in activities that use mathematical knowledge fosters important linkages and friendships among students and with adults, and enables young adolescents to discover for themselves how mathematics is integrated into the routines of many adults, both on and off the job. Possibilities for action projects in mathematics are numerous: building a neighborhood center; planning a camping trip or journey out of state; participating in a home building or home repair project; computing the average cost of the wasted food in the school cafeteria and figuring how many homeless people this amount of food could support. Projects like this last one have the additional benefit of bridging the gap between school and community. Real problems are the best contexts within which to conduct mathematics investigations and explorations.

Through community service students also discover role models that go beyond those in the immediate family, expanding their horizons, teaching them new skills, and allowing them to test alternative visions of themselves and their futures. Although many middle-grades students have no firm idea about future careers, they can become fascinated with the prospect of learning about occupations. The idea of adulthood is simultaneously distant and close. Too seldom do middle-grades students—especially young women and minority students—see adults like themselves who work in the sciences or use mathematics. Opportunities to think about the ways in which mathematics might relate to careers in which they are interested are vital. Experiences that bring adults into the schools and, in turn, allow students to enter the world of work are deeply important, especially when minorities and women are the workers who are using mathematics in their careers.

G. Faculty

An effective middle-grades mathematics program inspires collegiality among faculty who work together to implement responsive programs for young adolescents.

The interactions of the faculty in a school have a powerful effect on students and on their mathematics program. Faculties that help one another also help their students. Furthermore, knowing that their work matters and that they are supported by peers are positive forces in the intellectual lives of teachers.

Such adults, in turn, positively influence students and the school community in general. The faculty's knowledge about young adolescent development and their prior experience with the age group creates a context for making collegial decisions about program planning. When there is an open exchange of ideas and competition is minimized, a faculty is most successful in working together. Meetings, classroom visitations, and participation as workshop leaders and in professional meetings are the intellectual glue for the department. Excitement about the students' achievement in the school's mathematics program forms a strong bond that sustains growth and change.

Students need to feel that the adults who work with them are a team who respect each other, plan student work with a deep commitment to and concern for students' interests and welfare, and communicate with each other often and with pleasure. Such a healthy partnership models a process that students need to learn to promote their own success. Through participation and collaboration young adolescents can find school a safe place to be.

H. Parent and Community Involvement

An effective middle-grades mathematics program involves parents and the community in a collaborative effort to promote student competence in developing and using mathematical knowledge.

Mathematics is a field that is deeply affected by parental attitudes. If parents have never felt successful in mathematics, they may not be able to help their children in doing homework and making course choices intelligently. Parents who concentrate on their own mathematical weaknesses affect their children's attitudes about themselves and their potential. In this area, outreach and public relations that stress the benefits and accessibility of mathematics are vitally important. In school, projects and home assignments that involve the family in real mathematical experiences or relate the events of the mathematics class to the ongoing life of the community are very important to convincing parents that their young people have positive potential as mathematics learners.

Schools that interpret their goals to parents and provide information regularly about their mathematical programs involve parents as full partners in the mathematical lives of their children. Frequent classroom visits, before-school breakfasts, evenings of "family math," and shared home-school projects allow students and parents to understand themselves and each other as learners and as people. Community-focused activities can, similarly, inform and involve the broader community about the goals and the activities associated with middle-grades mathematics education.

When parents receive information they become interested and, in time, the walls of the school become permeable. This works to everyone's benefit, spreading the story of the effectiveness of the middle school mathematics program and bringing interested participants into the school to share their talents, their vocations, and their appreciation for mathematics in their worlds.

I. Assessing Progress

An effective middle-grades mathematics program continually assesses student achievement, evaluates program effectiveness, and uses the results to determine the need for improvement.

Assessing student achievement and its relation to program evaluation is a key element in an ongoing program evaluation process. Student test scores are but one *limited* index of understanding and involvement in mathematics. Program monitoring must encompass many elements.

In one middle school, teachers became concerned with their program when they noticed that the school's high test scores on the California Achievement Test were not sustained by the Scholastic Aptitude Test results later published in the local newspaper. They also noted that the scores were much lower in mathematics for girls and minority students. Finally, and most seriously, teachers did not see evidence in students' daily work that their mathematical thinking was reliable or applicable to nonroutine problems and practical contexts.

Investigating these phenomena, they found that girls and boys alike have limited experience applying their mathematical ideas to real-world tasks or in new mathematical contexts. While standardized tests indicated that student mathematics achievement in the elementary grades was satisfactory, by the time these students reached middle and high school, they seemed to have little idea of how to use their mathematical knowledge. A closer look also revealed that, while minority students were integrated into the regular program until the fifth grade, the school's standardized test-based procedure for grouping students in the middle grades reduced the number of minority and limited-English students in higher-level mathematics classes.

Appropriate assessment of the mathematics program requires using evaluation and assessment tools that go well beyond standardized tests. It includes recognizing trends in standardized test scores both in the school and in the nation. But, more important, comprehensive strategies for assessing students' mathematical progress require that they demonstrate their mathematical knowledge in a myriad of contexts such as: creating models and demonstrations of mathematical ideas, writing mathematical conjectures, theories, and solutions, and varying how they apply their mathematical thinking to practical contexts. Portfolios of students' routine work become the most practical record of individual growth and achievement.

Further monitoring practices may take the form of formal or informal needs assessments conducted on a regular basis. Standardized test data are de-emphasized in favor of closely examining student portfolios of mathematics work, group projects, and the regular writing students do to explain their mathematical thinking. In addition, interviews with randomly selected students, parents, and teachers, add to the data base used to routinely upgrade and revise the overall curriculum offerings. Cyclical analyses of the effectiveness of the curriculum engage the faculty in the evaluation of their program as a routine matter. In one large school district, the assessment routine includes specialized needs assessments, planned curriculum revisions, and two-year experiments with innovations, followed by clear, positive evaluations of students' work, portfolios, journals, and projects as evidence of success before program changes are adapted across the district.

Moving Toward Excellence

The *Mathematics Assessment Process for the Middle Grades* provides schools with the opportunity to reflect on these qualities of excellent middle-grades mathematics programs and to examine their own mathematics program against these criteria. Seeking out program strengths and weaknesses, through a fluid, comfortable exchange among colleagues, peers, and allies in the teaching venture, schools can determine ways their programs can better match their students' needs. In doing so, they will respond constructively to society's demand for talented young people who can sustain and advance the rapid scientific and technological developments achieved by their parents and grandparents.

MAP is designed to look closely at a school's program. It provides a way for the entire school community to check how well it is serving its student population. After collecting data and reflecting on the program, there will likely be many things schools will want to keep as they are, but there will also be some things they will feel certain need changing.

MAP is a mechanism for conducting a self-study of the mathematics program, one that is organized around the characteristics of exemplary mathematics programs nationwide, the unique needs of young adolescent students, and innovative practices and instructional advances in middle-grades mathematics teaching and learning. Thus, MAP is firmly based both in theory and in practice.

In the flurry of reports, mandates, and "standards," it is often difficult for site-based school teams to determine what they value about the mathematics program they have evolved, and what they genuinely want to change. Furthermore, finding the time and energy to plan thoughtfully and sustain curriculum change is difficult in schools. The CATALYST Project and MAP bridge the gap between reformers and teachers, putting in the hands of teachers a structure for openly examining their existing program and for leading decision-making about potential curriculum changes. With teachers working in collegial teams, probing the issues and, together with administrators, parents, and students, seeking new answers, mathematics instruction can broaden and improve.

All teachers can teach in effective middle-school mathematics programs. All middle-school students can become mathematically literate; both teachers and students have the right to school programs that help that happen.

How Will MAP Affect Our School?

The *Mathematics Assessment Process* provides the school community the opportunity to exchange ideas about how well the current mathematics program is meeting the Criteria for Excellence in mathematics teaching. Using the assessment's interviews, structured observations, and surveys, the process matches students' needs and the program's support of those needs. This becomes faculty-controlled data for possible program renewal. Because the assessment is a collaborative model of program analysis, and because the assessment instruments have been developed by considering effective mathematics programs for young adolescents, planning focuses continually and directly on appropriate programs for these students.

An important caveat: MAP is not values-neutral. It is firmly grounded in a vision of an active, problem-centered view of mathematics teaching that centers on young adolescents' learning needs. The assessment begins with students, moves to the elements that define the best teaching processes for young adolescents, and builds on a conception of school change designed by the faculty and informed by students, parents, and the community. With a vision that is both theoretical and practical, the assessment guides self-study and reflection about the quality of the mathematics program. Although an Ideal is embedded in many of the assessment Criteria, the school team evaluates which of the standards are relevant to their context. The knowledge base obtained from the data collection process informs planning sessions in which the school community reviews the information gathered, interprets its findings, and determines any follow-up actions that make sense for its teachers and students. In short, the *Mathematics Assessment Process for the Middle Grades* forms the core of a school community look at how to foster its students' mathematical growth and development. All program changes that are proposed are designed and planned collaboratively at the school site. This site-based approach ensures that there will be no hidden agendas in the program review and study; action taken after the study is completely up to the school itself.

The project directors wish to thank Rebecca Brown Corwin, Lesley College, who collaborated in writing this section.

Criteria for Excellence and Accompanying Ideals

A. Content

Uses a problem-centered curriculum to develop students' conceptual understanding of mathematics, appreciation for its applications, and proficiency in computational skills.

1. The curriculum provides a problem-based context for learning.
2. Mathematics problems occur in varied formats.
3. The curriculum content is balanced and comprehensive.
4. The curriculum develops number and operation sense.
5. The curriculum develops spatial and measurement sense.
6. The curriculum includes probability and statistics.
7. The curriculum introduces algebraic notions of variables, equations, and functions.
8. The curriculum emphasizes understanding of concepts and procedures.
9. The curriculum is research-based and responds to a changing society.

B. Instruction

Engages students in a variety of learning experiences designed to promote mathematical exploration and reasoning.

1. Students actively engage in mathematics.
2. Students discover meaning through manipulations with concrete materials.
3. Students learn individually and in groups.
4. Students construct meaning using a variety of resources and instructional materials.
5. Instruction makes appropriate and regular use of technology.
6. Instruction balances new learning and review; classwork and homework.
7. Supplementary programs and enrichment activities extend mathematics instruction beyond the classroom.
8. Homework extends mathematics learning and applies new study skills.

C. Thinking Processes

Develops students as problem solvers, critical thinkers, and effective communicators in mathematics.

1. Thinking processes reflect multiple strategies for problem solving.
2. Teachers model problem solving.
3. Students pose problems and discover solutions.
4. The curriculum develops analytical reasoning abilities.
5. Students and teachers discuss mathematical ideas.
6. Students write and talk with one another about mathematics.
7. Teachers clarify underlying concepts and listen to students' ideas.

D. Developmental Diversity

Provides instruction and resources to meet young adolescents' diverse learning needs.

1. All students, especially minorities, girls, and developing English speakers, have equal access to information, assistance, and classroom interaction.
2. Teachers use fair and flexible grouping practices.
3. Teachers accommodate special needs, abilities, and disabilities.
4. Teaching strategies motivate underachievers.
5. The classroom environment invites participation by all students.
6. Staff development and planning focus on the unique developmental needs of young adolescents.

E. Attitudes

Fosters positive attitudes about mathematics and encourages and recognizes students' accomplishments.

1. Teachers believe all students are capable of mathematics achievement.
2. Students believe they can be successful in mathematics.
3. Students help develop high expectations and standards for themselves and others.
4. The school recognizes and rewards the mathematics achievements of all students.

5. Originality and accuracy in mathematics are both rewarded.
6. Students are free to make mistakes and are encouraged to take risks.
7. The school encourages families to expect and support mathematics achievement.
8. School support personnel (counseling staff, media specialists, etc.) assist in promoting the mathematics program.
9. The community values mathematics achievement.

F. Relevance

Relates mathematical knowledge to students' interests, experiences, and future goals.

1. Teachers relate mathematics to individual interests.
2. Imaginative uses of mathematics are stimulated.
3. Mathematics is applied to the arts and sciences.
4. The usefulness of mathematics is taught across subjects.
5. The program stresses the importance of mathematics in everyday life and in future career choices.

G. Collegiality

Inspires collegiality among faculty who work together to implement responsive programs for young adolescents.

1. The mathematics program has strong leadership and an effective, knowledgeable, and caring staff.
2. The school and district support teachers' continuing education in mathematics.
3. The mathematics department conducts regular program reviews and plans in-service activities.
4. Interdisciplinary collaboration strengthens mathematics teaching.
5. Administrators encourage professional involvement.
6. Schedules enable collaborative planning.

H. Community

Involves parents and the community in a collaborative effort to promote student competency in developing and using mathematical knowledge.

1. Parents and community are involved in improving the mathematics program.
2. Parents are informed about the development and purposes of the mathematics program.
3. Parents are informed of specialized support and instructional assistance in mathematics.
4. Parents are informed of mathematics curriculum options and their consequences.
5. Parents and community participate in mathematics activities in and outside of school.

I. Continuing Assessment

Continually assesses student achievement, evaluates program effectiveness, and uses the results to determine the need for improvement.

1. Individual student achievement is evaluated using multiple sources of data.
2. Students and parents receive constructive feedback.
3. Assessment sources address school, district, state and national goals.
4. Grading policies are clearly defined and administered consistently.
5. The mathematics program is evaluated using multiple sources of data.
6. Teachers in all subject areas participate fully in program planning and evaluation.
7. The middle-grades mathematics program coordinates with the mathematics programs in local elementary and high schools.
8. The mathematics department monitors curriculum materials for bias.

Section 3

Using MAP: An Overview

Using MAP: An Overview

The Assessment Framework

The *Mathematics Assessment Process for the Middle Grades* provides teacher-directed teams in a school with tools for examining and realigning their mathematics program. The goal is to enable schools to better meet the learning needs of their young adolescent students. A consensus of need and a plan of action must be established at the classroom and school level if program improvement is to take root and flourish. That is why MAP has been designed around three central ideas:

- Widespread consensus exists among mathematical scientists and educational leaders about the characteristics of a strong mathematics program for middle-grades students. However, neither the recommended curricula nor the appropriate instructional practices are extensively used in middle-grades schools;
- Young adolescents can become accomplished mathematics learners and thinkers only in a context that understands and responds to their developmental needs;
- A sound body of organizational theory and research offers strategies for planned change that can effectively guide the restructuring of school mathematics programs.

Initiating MAP

The MAP Criteria and Ideals, described in Section 2, assume that mathematics literacy can be realized most effectively through school-based interdisciplinary planning and teaching. Therefore, MAP encourages faculty members across disciplines to join the analysis of mathematics-related teaching that occurs in the school. The instructions that follow are designed to be implemented by an interdisciplinary faculty team, led by one co-leader representing the mathematics department and another co-leader selected from another subject area.

So that teams have sufficient time to conduct an in-depth study, this manual describes a year-long, interdisiciplinary process. School teams are, however, free to modify the team structure or the length of the study to accommodate their site's needs. For example, an alternative approach to implementing MAP that has been used successfully is for the mathematics department within a school to work independently for one semester as an action research team. Another model is for a group of teachers in several schools to unite within a district and conduct a cross-school assessment. Other variations can be equally successful if the team maintains a commitment to openness and collegiality.

The step-by-step planning process explained in this manual encourages flexibility and local innovation, but key elements of the process that should not change are as follows:

- Use a collaborative, school-based team that includes teachers, administrators, and parents to plan and conduct the assessment and to write action plans.
- Assure that at least two co-leaders—both of whom are teachers—share the responsibility for coordinating the assessment team.

- Select various data gathering instruments—interviews, surveys, as well as observations—from the MAP *Assessment Instrument* volume, or modify those provided to suit the school's needs.
- Enable the team's teachers to have the primary data gathering responsibilities—interviewing one another, parents, and students, and observing across classrooms.
- Encourage administrators, parents, and students to assist with the data-gathering and planning processes, as appropriate.
- Maintain close coordination between the MAP team and school- and district-level administrators.

MAP requires from six months to a school year to complete. This timing enables the school to generate a broad base of evidence about the quality of its mathematics program, engage in a period of analysis and reflection, and emerge with a collaborative plan for change.

The assessment process begins by introducing MAP materials to team members in a several-day planning retreat, best conducted off the school campus. Here the team works under the direction of their co-leaders, discussing the research basis of the mathematics agenda embodied in the Criteria for Excellence, clarifying the purpose of conducting the assessment, and learning to interview and observe in colleagues' classrooms. The six basic steps in this process are described below and summarized in the chart on the following page. Supplementing this manual are *Staff Development Workshop Guidelines for Implementation* that provude team leaders with extensive information about how to prepare teams to conduct MAP.

Step 1: Commit to Mathematics Program Change

Three to four days of planning over a two- to four-month period prior to initiating the assessment

Initiate the Assessment Process

The *Mathematics Assessment Process* engages team members throughout a school year and beyond. Ideally, the initiative for the assessment comes from the mathematics faculty, working with site-based administrators and district-level personnel. To be most effective, MAP needs a coordinated interdisciplinary commitment to developing and sustaining a mathematically knowledgeable school and community. Thus, the entire faculty and staff should be participants in the decision to begin the assessment process and commit to following it through to its conclusion.

Identify Co-leaders

MAP begins when a school identifies co-leaders of the proposed assessment team. While one of the co-leaders must be a mathematics teacher, the partner leader should be a non-administrative staff member representing one of the other teaching departments. A faculty member held in high esteem by their colleagues in any specialization or support role is suitable for this key role.

What's Involved in MAP

1 Commit to Mathematics Program Change
(Approximately 3-4 days)

Faculty and Staff Decide to Conduct Assessment ◆ Faculty Co-leaders and Administrators Review Assessment Process ◆ Identify MAP Team and Consultants

2 Conduct Site-Based Training; Plan Assessment
(Approximately 2-4 days, throughout the assessment process)

Site Teams Participate in MAP Workshops ◆ Review Current Research ◆ Determine Data Collection Plan

3 Collect and Organize Data
(Approximately 3-6 days)

Work in Pairs to Collect Data ◆ Interview, Survey, and Observe ◆ Organize Information for Review by Study Groups and Team

4 Analyze Data and Report Findings
(Approximately 2-3 days)

Study Groups Examine and Analyze Data ◆ Identify Assets and Needs of Current Mathematics Program ◆Generate and Report Findings

5 Design Action Plan
(Approximately 2-4 days)

Review Study Group Findings ◆ Establish Improvement Priorities ◆Identify New or Alternative Mathematics Program Strategies ◆ Write Action Plan

6 Approve School Mathematics Improvement Plan
(Approximately 2-3 days)

Mathematics Department Faculty Reviews Action Plan ◆ Prioritizes Implementation Goals Into a Several-Year Plan ◆Submits Plan to Faculty for Approval

A co-leadership process helps assure broad faculty involvement. Additionally, MAP implementation benefits from the organizational skill and sharing of responsibility of several of the school's leaders.

The MAP Assessment Team

Composed of 6-10 members including:

- Mathematics Teachers*
- Other Faculty Members*
- Professional Support Personnel
- Administrators
- Parents or Business Partners
- District-office Supervisors

*NOTE: One of the mathematics teachers and one other faculty member serve as team co-leaders.

Select Team Members

A team of 6 to 12 members is suitable for schools with from 600 to 1200 students. Adjustments to the team structure can be made for smaller schools. The team includes mathematics educators, administrative team members, and support personnel such as guidance counselors, social workers, and librarians. Other members might represent other teaching faculty, including members of the arts, humanities, sciences, health and physical education, and special programs. Parents, community representatives, and business partners, plus a consulting mathematics director or supervisor from the central office also need to be included as members of the team. Team members should represent various philosophic perspectives and ranges of experiences in the school, the profession, and the community.

The school's administration also participates actively in the team process. It is important that administrators on the team serve as equal partners in the assessment process, so they must not have staff evaluation responsibilities. This assures that MAP remains entirely separate from the regular professional evaluation structure of the school.

Divide Team Into Working Clusters

The process of collecting and analyzing data proceeds by having team members work in at least three "clusters" or working groups. This arrangement enables assessment team members to become specialists in using the various instruments, and to better understand the status and needs of the school's mathematics program. Recommended clusters are:

- **The Mathematics Teaching Cluster (MT).** Including all members of the team who teach mathematics, this cluster conducts the Mathematics Teacher Interviews and Mathematics Classroom Observations and summarizes the several surveys—Mathematics Teacher and Facilities and Materials Surveys—completed by their colleagues.
- **The Interdepartmental Faculty Cluster (IF).** Including all team members who teach subjects other than mathematics, this cluster conducts the Administrator and Faculty Interviews and the Schoolwide Observations.
- **The Administrative/Support/Community Cluster (ASC).** Including the remaining team members who represent other sectors of the school community, this group conducts the Parent and Student Interviews, the Mathematics Facilities Survey, and lends additional support as needed to conducting the School Statistical Profile.

Role of School Principal and Administrative Team

It is important to establish and preserve faculty ownership of the assessment process. Therefore, the program works best when principals and central office supervisors serve as ex-officio members of the team. However, the team co-leaders are responsible for maintaining *close and continuous communication with the school- and district-level administration throughout the assessment period.* As the assessment ends, this collaborative relationship with administrative leaders is especially essential to the smooth implementation of the team's recommendations.

Who's Involved in MAP

Leaders

The responsibilities of the MAP team's co-leaders—a math teacher and a teacher in another discipline—include:

- Coordinating the MAP procedures, preparing recommendations for action, and directing the development of the action plan.
- Promoting schoolwide ownership and interdisciplinary involvement.
- Scheduling and convening all meetings.
- Coordinating MAP logistics.
- Coordinating and assisting the data collection, data analysis, and study group planning.
- Convening and leading designated study group meetings in the analysis and reporting of findings.
- Maintaining team records and communications.
- Keeping the school principal informed about the progress of MAP
- Facilitating smooth relationships among team members and the school's faculty and staff.

Members

The MAP team is made up of 6-12 members, usually working in three "clusters" or interest areas. Throughout MAP, members of the team share these principal responsibilities:

- Participating in training sessions and attending all team and study group meetings.
- Collecting data through interviews, observations, and surveys of students, faculty, administrators, and parents.
- Convening and leading study group meetings to analyze and report data-based findings.
- Identifying and recommending to the MAP team priorities and strategies for addressing the elements of the school's mathematics program that are inconsistent with the Criteria for Excellence.
- Contributing to the development of recommendations for action from the findings.
- Contributing to preparing the plan of action and to facilitating its implementation.
- Representing MAP to school colleagues and the community.

Study Groups

Study Groups compare the data gathered by the MAP team to the program's Criteria for Excellence and report "findings" about how the local mathematics program compares to and ideals each. Major responsibilities include:

- Reviewing and discussing the themes identified by the assessment team members from the data collection process.
- Assessing the match between the findings of the data and the Criteria for Excellence.
- Determining the "consistency" and "inconsistency" of the ongoing mathematics program in the school with MAP Criteria.
- Preparing a report of "findings," by criterion, to share the results of the data collection and analysis.
- Assisting in the long-term implementation and monitoring of the action plans.

Together, the principal and the matheamtics supervisor serves as liaisons with the central office, paving the way to obtaining central office confirmation of the action proposals. A school plan relies on tacit if not direct approval from the district office. At the conclusion of the process, the team will no doubt turn to the principal and the mathematics supervisor to obtain support for additional staff development, some modernized curriculum materials, and possibly, release time to continue the collaborative inter-class visits and observation that MAP initiates.

Role of the District Office

For MAP to accomplish the long-range goal of substantively improving a school's mathematics program, district office leaders ***must be both advocates for and consultants to the process.*** *Without active participation by key central office leaders, schools involved in MAP may have difficulty finding sufficient time to conduct the assessment thoroughly and may be challenged as they work towards establishing the resulting mathematics improvement action plan.*

School leaders should be able to rely on the central office as a facilitating partner. In several ways the partnership is of particular importance. Support for logistical planning is necessary in the earliest stages, but is a significant asset throughout. As the process proceeds, there may be need to resolve inconsistencies between the district's existing curriculum and the recommendations of the school assessment team. Finally, and significantly, the district office should be able to offer information and additional expertise to the team as it designs strategies for implementing the assessment recommendations.

Step 2: Plan Assessment Process; Conduct a Site-Based Implementation Workshop.

Two days before school begins or early in the school year, and periodically during the school year, as each new phase of MAP begins.

Staff Development Workshops For Team Members

Learning to use MAP is a staff development process that takes place in two phases. Phase one occurs at the outset of MAP planning. The second phase starts once data are in hand, when the analysis begins. Team members participate together in a workshop that provides two days of intensive preparation for leading the MAP team. After the assessment has begun, team leaders and members schedule any additional workshops they determine are necessary.

Team co-leaders conduct the initial workshops. The major topics discussed are:

- **The project's research-based framework.** This includes a review of the research underlying the MAP Criteria and Ideals, and recommended program changes for middle-grades mathematics.

- **Techniques of data collection and analysis.** This offers experience using interview and observation methods, procedures for summarizing data, and procedures for analyzing and identifying findings from the data analysis process.
- **Action planning approaches.** This better equips the team to generate program options, learn action planning procedures, and to lead change.

Appropriate workshops and supplemental assistance in specialized areas should be scheduled throughout the assessment process by team leaders with appropriate assistance from their consultant.

The Mathematics Supervisor's Role

Ideally, the assessment team should include a consultant from the district's mathematics office—usually the mathematics director or supervisory—who is respected both by the school's mathematics and non-mathematics staff. Along with other on-site team members, the district office person provides the following kinds of support:

- *Expertise* and *experience* in mathematics curriculum and in teaching young adolescents;
- *Knowledge of resources* on young adolescent development and on middle-grades mathematics teaching and learning;
- *Information about how to access* resources; and
- *Skills in coordinating the logistics* associated with curriculum analysis and planning process.

Throughout the assessment process, this person attends team meetings and, upon the team's request, helps facilitate planning sessions and meetings. Teachers may have limited prior experience with some of the activities the MAP team, will undertake, especially data analysis, report writing, and strategies for recommending instructional changes. Central office supervisory staff often have this expertise and can assist team members in determining the implicatins of their assessment findings and suggest proposed plans of action, program strategies, new curriculum offerings, or the names of technical experts. Of particular importance is the supervisor's knowledge about program assessment procedures and innovation in middle-grades mathematics.

Finally, as the district's facilitator of MAP within schools, the supervisor shares with the principal the important responsibility for maintaining connections among school and district policy makers, especially with the mathematics curriculum leaders, the superintendent, and the school board.

Step 3: Collect and Organize Data

Three to six days over a three to five month period

Assembling and organizing the assessment data for analysis occurs in two steps over three to six months, depending upon the plan each school decides to follow. The decision is influenced by such factors as:

- whether interviews are conducted with individuals or in groups,
- the length of the individual interviews and observations,
- the number of parents and students interviewed,

MAP Instruments

The assessment instruments are a central ingredient in the MAP program, the tools that enable the assessment work to be done. By using these instruments, data are gathered through interviews, observations, and surveys of faculty, staff, administrators, parents, and students. Training for those using the instruments is offered early in the program, ensuring reasonable consistency and increasing validity of assessment results. All data and other information obtained in the assessment process is held in confidence, and is maintained with complete anonymity for those responding to or observed in the program. The MAP instruments include:

- **Mathematics Teacher Interview.** Interviews, conducted by members of the Mathematics Teacher Cluster, are far-ranging—seeking expressions of teaching philosophy pertinent to middle-grades students as well as specific information on course content.
- **Administrator Interview.** A member of the Interdepartmental Faculty Cluster solicits information about awareness of and support for mathematics instructional practices.
- **Faculty Interview.** Members of the instructional staff and other school-site faculty who do not teach mathematics focus on interdisciplinary awareness of and support for infusion of mathematics principles throughout the middle-grades curriculum
- **Parent Interview.** A sampling of approximately 10 percent of parents is questioned about involvement in and support for the school's mathematics program and expectations for their children's competence and understanding in mathematics.
- **Student Interview.** A sampling of approximately 10 percent of students has an opportunity to express their opinions about the relevance of their mathematics instructional programs to their present lives and to their academic career objectives.
- **Mathematics Classroom Observation.** A member of the Mathematics Teacher Cluster looks at teaching processes, environments, and procedures. Observation of teaching among colleagues is a rewarding method of exchanging ideas and broadening teaching perspectives. To promote such an exchange, MAP observers and their observed colleagues are encouraged to discuss the observation process with one another at a convenient time soon after it takes place.
- **Schoolwide Observation.** The Interdepartmental Faculty Cluster is responsible for conducting schoolwide observations of all classes and student and faculty work areas to determine the extent to which mathematics teaching and learning are promoted schoolwide

  Each cluster member observes a designated portion of instructional classes and, in addition, observes informally in other student and staff work areas. Other faculty members may join the observation process after receiving training in the procedures from a team member.
- **Mathematics Teacher Survey.** All mathematics teachers are asked to complete the Mathematics Teacher Survey, a supplementary instrument that documents information about their training, instructional approaches, the materials and resources they use, evaluation procedures, and special mathematics activities and programs.
- **Materials and Facilities Survey.** Mathematics teachers also extensively review the materials and facilities available for teaching mathematics, ranging from teachers' resources (such as a photocopy machine or computers), to student resources (such as calculators and computers), to resources in the media center/library (such as filmstrips and VCRs). Also sought is a detailed list of mathematics reference materials, displays, and manipulatives that are available to teachers, and information about how frequently they are used.
- **Statistical Profile.** The final instrument used in the MAP program, the Statistical Profile, summarizes schoolwide achievement data and demographic background information about the school population. It is used by the MAP team as part of the overall data-gathering process to obtain a statistical portrait of students in the school

- decisions about how much emphasis to place on gathering survey data on curriculum activities,
- and the availability of specialized mathematics resources and facilities.

A more comprehensive assessment, conducted slowly over the course of the school year, will provide more information and, ultimately, will increase the quality and credibility of the team's recommendations. Nevertheless, schools vary in the amount of flexibility and planning time they can procure from a school-year calendar, and teams should be practical about planning their data gathering.

Conducted over a three- to five-month period, data analysis spans the school year, avoiding the beginning and end periods. Data gathering is most effective when team members work in pairs. In some cases, teams may want to seek the assistance of colleagues who are not on the team. Interviews and observations can be conducted by any interested faculty, as long as they receive directions and follow procedures that are consistent with those the team is using. Following data collection, team members individually compile their data immediately after it has been gathered so it can be examined by the entire team and other faculty colleagues.

Step 4: Analyze Data and Report Findings

Two to three days over a two-month period

This significant phase of data examination is, ideally, a schoolwide function. The team turns to others in the faculty and community to help analyze the data. In consultation with other team members, the mathematics department, and the principal, "study groups" are formed to review the data summaries and identify themes that emerge from the assessment process. If possible, three study groups are created, one for each cluster; in some cases, one or two study groups divide the entire analysis task. Assessment team members serve as study group co-leaders. The study groups review the information gathered in their designated cluster, matching it to the Criteria and Ideals. Through this process, the ways the program meets the Criteria for Excellence, and the ways that it falls short, come into sharp relief. *(See chart on following page.)*

Members of the mathematics teaching staff, whether or not they serve on the assessment team, have a vital role in study groups. Ideally, all mathematics faculty participate in one of the groups. This distributes the responsibility for program analysis and ownership of planning at an early stage in the data review. This level of involvement makes it far more likely that all members of the mathematics teaching faculty will engage in the overall change process. Smooth working collegial relationships within the mathematics department enable a school to realize the potential of MAP for promoting program improvement. Involvement in the initial review of the MAP data and participation throughout the development of the improvement proposals ensures that the entire mathematics staff has an important role in the outcome of the year-long assessment effort.

Study group leaders can turn to the assessment team's co-leaders and to the consultant as their groups begin their investigation of the data. District-level administrators, members of the parent and business communities, and students are also potentially valuable contributors to the study groups' analysis and planning. The study group structure will work most effectively if it is open-ended, adaptable to the unique talents, needs, and opportunities of each school.

Study Group Data Analysis Framework

Cluster or Study Group	Instrument (Abbreviation)	Who Responds?
Mathematics Teacher (MT)Cluster	◆ Mathematics Teacher Interview (MTI)	◆ Mathematics Teachers
	◆ Mathematics Classroom Observation (MCO) and Observation Feedback (OBF)	◆ Team Member Observers of Mathematics Classrooms
	◆ Mathematics Teacher Survey (MTS)	◆ Mathematics Teachers
Interdepartmental Faculty Cluster (IF)	◆ Administrator Interview (ADM)	◆ Administrators
	◆ Faculty Interview (FI)	◆ Other School Site Faculty and Professional Support Staff (e.g., Counselors, Librarians, etc.)
	◆ School-Wide Observation of Mathematics Related Activities (SWO) and Observation Feedback (OBF)	◆ Team Member Observers of Non-Mathematics Classes
Administrative Support and Community Cluster (ASC)	◆ Parent Interview (PARI)	◆ Parents, Community Members
	◆ Student Interview (STI)	◆ Students
	◆ Mathematics Materials and Facilities Survey (MFS)	◆ Assessment Team
	◆ Statistical Profile (SP)	◆ Assessment Team

INTERVIEWS:
Mathematics Teacher Interview (MT)
Administrator Interview (IF)
Faculty Interview (IF)
Parent Interview (ASC)
Student Interview (ASC)

OBSERVATIONS:
Mathematics Classroom Observation (MT)
School-Wide Observation of Mathematics-Related Activities (IF)
Observation Feedback Form (MT and IF)

STATISTICAL PROFILE:
(Assessment Team)

SURVEYS:
Mathematics Teacher Survey (MT)
Mathematics Materials and Facilities Survey (MT and ASC)

Study Group Responsibilities

Study groups analyze the same data that their cluster team members collected. Mathematics teachers, for example, join the Mathematics Teacher Cluster to explore the findings from the mathematics department. Other faculty participate with the Interdepartmental Faculty Cluster and review their interviews and observation results. Finally, members of the community, support staff, and possibly, business partners assess the results of the data from the Administrative, Support, and Community Cluster.

Developing data summaries spans several months and entails scrutiny of the entire assessment findings. Led by the assessment team members, the analysis involves the following major activities:

- Examining the data summaries to learn the community's perspectives on the school's mathematics program;
- Comparing the views that emerge with the Ideals within the Criteria for Excellence;
- Generating a description of the mathematics program strengths and a list of the areas that are candidates for improvement.

Through the analysis, study group members seek to thoroughly understand the varying views of the mathematics program. As they work, they should be aware of the suggestions for adjusting the program offered in the data. Whenever possible, new ideas should be recorded for later reference and, eventually, used as the basis of the strategies for improving the program content and organizational structure.

When the study groups have completed their work, they submit their reports to the assessment team as a whole. It is the team's job to unify the findings of the three team clusters. The team reviews and integrates the three separate study group reports, summarizing the consistencies or inconsistencies the groups saw with the MAP Criteria and Ideals. With the data pooled, the team begins to examine program alternatives and to design an action plan. The action plan will propose changes to bring the mathematics program in line with the Criteria for Excellence that the team and study groups found were in most urgent need of attention.

Step 5: Design an Action Plan for Program Renewal

Two to four days over a two-month period

Identify Strategies

At this final, critical stage, the assessment team begins to consider strategies for capitalizing on the program's existing strengths and to recommend modifications where the program falls short of Ideals within the Criteria for Excellence. Team members, working with their colleagues in the mathematics department and, at times, with the district supervisor, explore how the school can lead teachers to greater awareness of their program's achievements and their students' learning needs.

Establish Priorities for Mathematics Improvement

The Criteria for Excellence that served as the assessment's conceptual framework now become the guidelines for defining a new plan that meets the accepted national and local standards of middle-grades mathematics instructional practice.

Strategies for program improvement will range widely, depending on the school. They may include new summer or school year planning to match the local curriculum with the recommendations of NCTM, or the initiation of teacher-directed staff development for sharing expertise and specialized interest. Sometimes, recommendations will encourage procedures for teachers to observe and analyze their own teaching more closely. Requests for additional professional development may also surface, but the content of staff development will now be determined by the assessment data, not by central office or university personnel who are removed from the classroom and school. Another possible outcome will be to incorporate new teaching approaches that more actively engage students in learning to apply mathematics to complex, non-routine problems typically encountered in real-life situations.

The final phase of the assessment consists of completing and prioritizing, in the form of an action plan, the strategies the team has discussed and identified through their months of analysis and thinking together.

Complete an Action Plan

The action plan is a framework for achieving short- and long-range goals, defined in the context of each of the nine MAP Criteria for Excellence. At this critical juncture, the assessment team narrows its focus. Emphasis is on a few key areas within each Criterion that represent the agreed-upon starting point for the school as it begins improvement of its mathematics program.

Members of the assessment team, after working together for nearly a year, are well-positioned to direct a practical and responsive program improvement plan. The process benefits enormously from the fact that it is locally designed and created by the staff who will implement it.

Step 6: Approve the School Mathematics Improvement Plan

Two to three days at the conclusion of the action planning process

The final action plan incorporates the perspectives of colleagues who participated in the many previous stages of the assessment and data review. Thus, the MAP team is ready to seek faculty-wide approval of their recommended plans.

The action plan will include short-term, no-cost and low-cost changes, as well as long-term strategies that require new funds or school or district policy adjustments or approvals. The important achievement of this process is that the school's teaching faculty owns the plan and the implementation process. Such shared ownership for the plan and for the proposed action agenda require continuing collaboration among the mathematics department and other departments, and with the community.

The principal, the faculty team, and the school district top administrators must now use the school's plan to make a case for the fiscal and other support they need to implement it.

Section 4

Using the Assessment Tools

Using the Assessment Tools: Teams, Instruments, Analysis, and Planning

The substantial work of MAP involves collecting the data, organizing it to analyze its implications, and designing action stra*gies to implement a new mathematics program. The process is a complex and demanding one. Th ward is increasing collegiality and program improvement led by the faculty, not by an outside group.

The following sections describe in detail the assessment team's work flow—from convening the team through to finalizing the improvement plan. A summary is presented on the next page.

This section guides the team through the following tasks::

- Working in cluster groups.
- Collecting data: interviewing, observing, and surveying procedures.
- Organizing the data for study group review.
- Reporting Study Group findings
- Designing and approving a Mathematics Improvement Plan

Collecting Data

Working in Cluster Groups

The process of collecting and analyzing data will go more smoothly if team members work in at least three clusters or working groups. This cluster arrangement enables assessment team members to specialize in using the various instruments, and in this way to better understand the status and needs of the school's mathematics program from the point of view of a particular group of significant "stakeholders"—such as teachers, parents, or students. Furthermore, by sharing the responsibility for data collection in this way, the team also benefits from the special perspectives and abilities of each of its members. No one or two people carry the weight of the process; it is, indeed, a truly collaborative effort, a process "owned" by the many participants.

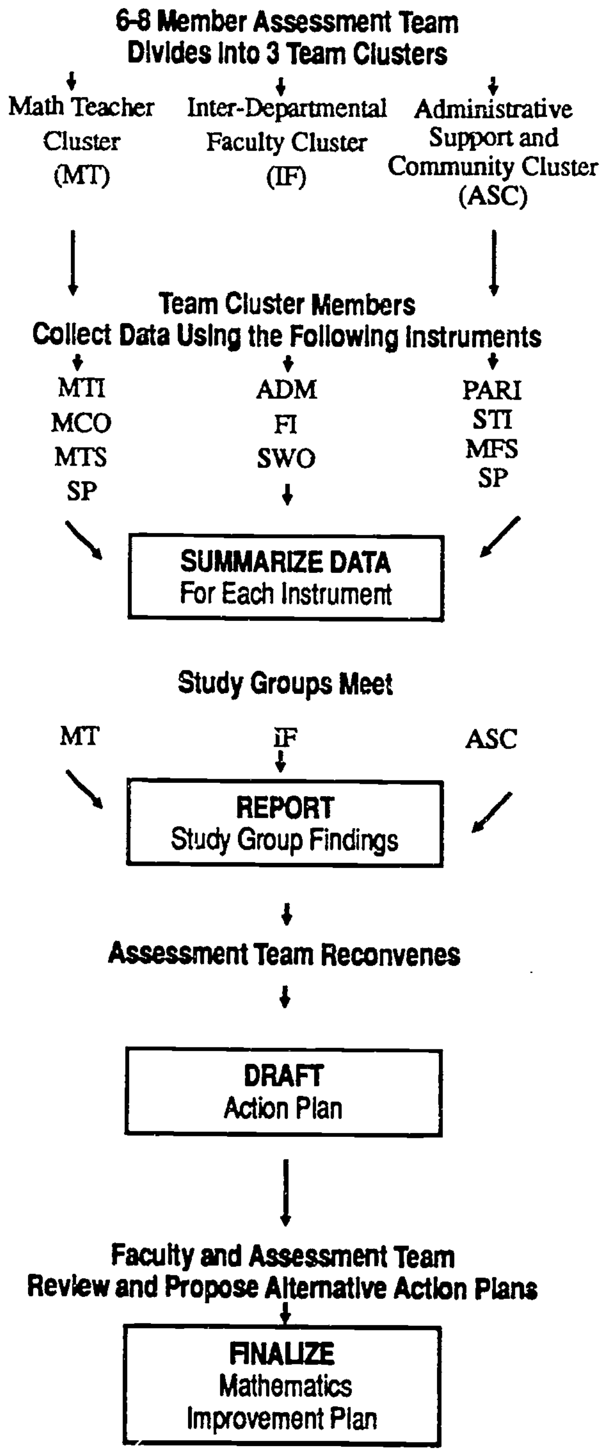
The following three-tiered cluster structure is a guide for organizing the team's work.

Mathematics Teaching Cluster (MT): includes all team members who teach mathematics. They will be responsible for conducting the Mathematics Teacher Interviews and Mathematics Classroom Observations, and summarize the data from the Mathematics Teacher Surveys completed by their mathematics colleagues. This cluster may also be called upon by their colleagues in the ASC (see below) to assist with several of the surveys.

Interdepartmental Faculty Cluster (IF): includes team members who teach all subjects other than mathematics. It conducts the Administrator and Faculty Interviews and the Schoolwide Observations.

61

Assessment Team Work Flow



Assessment Team

- Informs faculty about Assessment
- Participates in training to use MAP
- Organizes in team clusters to collect data
- Demonstrates interview and observation processes to colleagues
- Coordinatedwith the school administration and the district office

Team Cluster Members

- Collect data
- Summarize data from interview, observation and survey instruments
- Lead Study Groups in data analysis process (below)

Study Groups

- Analyze each data summary
- Identify consistency and inconsistency with ideals
- Report Study Group findings to the Assessment team

Assessment Team

- Reviews and analyzes the Study Groups' findings
- Summarizes and prioritizes all findings
- Designs Action Plan
- Distributes proposed plan to faculty for discussion

Faculty and Assessment Team

- Review and discuss Assessment team's action plan
- Faculty proposes alternative plans
- Faculty and team agree upon and prioritize actions
- Facu'ty and team finalize the school's Mathematics Improvement Plan

Administrative/Support/Community Cluster (ASC): includes all remaining team members, that is, those who are not classroom teachers. This group conducts Parent and Student Interviews and the Mathematics Facilities Survey. Administrative and support members of this cluster also gather the demographic data called for in the School Statistical Profile. Finally, since this cluster includes administrative and support personnel, its members should be prepared to assist the MT cluster, as needed, in summarizing their information.

Organizing Data Collection

Clusters distribute the data collection responsibilities among their members. Team members may work in pairs or threes, if that is comfortable, to collect and summarize the information they gather throughout the assessment, making sure that notes preserve the anonymity of those interviewed or observed.

Team co-leaders should maintain a record of who conducts the various interviews and summarizes the other instruments. *It is important to remember that no individual names or identifying details should ever be included in the data-gathering instruments.* Any data collected should be reported anonymously and individual observations or responses to any questions are confidential information. Maintaining confidentiality is a vital ingredient that enables colleagues, parents, and students to be candid and constructive.

While data collection will be organized differently in each school, the following provides guidelines to standardize and facilitate the process of conducting interviews, observations, and surveys.

Conducting Interviews

Conducting interviews allows colleagues to share their ideas and perceptions with those conducting the interview, enabling them to learn a great deal about another's perspective. This creates the opportunity for those conducting the interviews to broaden their own perspective and understanding. The interview is an opportunity to exchange ideas, concerns, and feelings. Confidentiality, confidence, and sincerity are qualities that will improve the exchange with the person being interviewed, helping to assure that the information given is candid and accurate.

To determine a good match between interviewers and those interviewed, be sensitive to individual preferences. Whenever possible, honor preferences about who interviews or observes a colleague. Mathematics department members who are not on the assessment team certainly should be encouraged to participate as interviewers or observers. Prior review by an informed team member of the procedures to follow is advised to assure continuity and accuracy of the data gathered. Parents make good interviewers of other parents and students, and students also are insightful interviewers.

Interviews are likely to be most comfortable and people will be most candid in individual interview sessions. However, under some circumstances, other arrangements can be made. Some groups or teaching teams may find it valuable to participate in the interview together. It may be unavoidable to have to interview parents or students in groups. Team members should plan the process they use with full awareness of the gains and losses of using a group instead of an individual interview process. The important guideline to remember at this stage in data collection is that teams should strive to obtain objective information about *individuals'* perspectives about the mathematics program. If group interviews are conducted, interviewers should remind the groups that they are seeking *individual* points of view—they are at this juncture recording any differences of opinion that exist. This is not the time to obtain group consensus. Only if the individual's firm opinions and viewpoints are recorded initially can the broadest consensus—one that reflects varying ideas—be achieved.

To be most effective, every interviewer needs to become familiar with the instrument before initiating interviews. It is helpful to practice both interviewing and listening skills with a partner before beginning.

Tips for Effective Interviews

- Be able to explain why you are conducting the interview and how the information will be used.
- Know your own biases before going into the interview. Remember that your purpose is to gain information about the school's mathematics program, not to discuss what you think it should or should not be.
- Be thoroughly familiar with the interview forms.
- Read the introductory section of each interview at the beginning of your exchange. This will help establish the flow of the interview by formally structuring its opening and insuring consistency across all interviews the team conducts.
- Help the interviewee feel at ease and ready to talk. Be at ease yourself by being informal, natural, and tactful. If the interviewee does not know you (especially if you interview parents or students), introduce yourself and clearly state the general purpose of MAP. Answer any questions the interviewee may have about the interview itself, especially about how the information will be used by the assessment team.
- Ask the questions as they are posed on the form and avoid asking any additional leading questions. However, if you do not understand the interviewee's response, ask for clarification. Encourage the interviewee to elaborate on any statements that are not clear to you.
- Listen well to the person you are talking with, using the "listening skills" presented in the next section.
- During the interview, reserve your own judgement and point of view. Avoid disagreeing with or challenging the interviewee, and avoid giving advice. Sharing your own perspective in an interview may inadvertently antagonize some people, making them more hesitant to talk.
- Allow the interviewee enough time to think and respond to your questions. Allow yourself time to listen and reflect on the answers. Some silence—allowing time for thought and active listening—can be supportive and helpful.
- Pace your interview carefully, noting when you begin and end. Anticipate that interviews will take about 45 minutes. Depending on the individual, the length will vary greatly. The mathematics interviews require at least two sessions of 45 minutes each, so consider scheduling two sessions at the outset. If your interview is longer than you expected, feel free to come to a logical

stopping point and re-schedule a mutually convenient time to conclude. Be sure to note how far you got on the interview form.

- Direct the interview comfortably and clearly. Be assertive but not aggressive. Stay on the topic. Try not to get "stuck" on one question, but move on to another question as soon as the response is complete and you understand it.
- During the interview, write down just enough of what the interviewee says to remind you of important points. It is unnecessary to write down everything at this time if you record key words to indicate what the interviewee said. Immediately following the interview, however, it is a good idea to review your notes and expand on them by writing more detailed information to clarify the key words you indicated earlier. Carefully avoid making inferences.

At the close of the interview, it is helpful to thank the interviewee for talking with you and offer to answer any final questions the person may have.

Tips for Effective Listening

Effective listening contributes to a successful interview. Keep in mind the following suggestions for sharpening your listening.

- Think of listening as an active process. It involves being physically alert, constantly aware of your emotions, affirming the other person's feelings, and thinking clearly.
- Be thoroughly familiar with the interview forms, and know your purpose for listening.
- Your interview form will be easy to follow; it structures the interview so you can attend fully to the person you are talking with. Concentrate, instead, on the speaker's ideas, and do not worry about what *you* are going to do or say next.
- Try to put each thing you hear into the total context of what the person or group has said. Look for important ideas and listen for the meaning behind the spoken words.
- Listen with an open mind. Try to put your personal opinions aside and remember that your purpose is to gather as much information and insight as possible.
- Maintain eye contact as you listen. Be warm, pleasant, and relaxed.
- Try to avoid these common barriers to effective listening:
  - evaluating what you hear based on your own biases
  - interrupting
  - not responding to the speaker at all
  - taking too many notes, doodling, fidgeting

Enjoy your interview! It is a wonderful opportunity for collegial exchange.

Conducting Observations

There are two purposes of the MAP observations:

- To determine the extent to which a school's mathematics teaching and its students' learning processes reflect the Criteria and Ideals of the mathematics assessment; and
- To initiate a professional exchange among teachers regarding the consistency of their teaching practices with the MAP Criteria for Excellence and the accompanying Ideals.

The first purpose is achieved by using the Mathematics Classroom Observation (MCO) to obtain a randomly collected series of "snapshots" of the teaching and learning in mathematics classes. A similar observation is also conducted of mathematics activity that occurs throughout the school using the Schoolwide Observation of Mathematics-Related Activities (SWO). *The emphasis of all observations is on what is observed, not on what is missing.*

The second purpose for conducting observations is achieved by scheduling a post-interview or debriefing between the observer and the observed teachers. This may not always be possible, and in some cases teachers may choose not to participate in such a dialogue. Keep in mind, however, that understanding of teaching practices among a faculty is enhanced by the sharing that occurs between colleagues after observing one another's classes.

The purposes of the observations are achieved by obtaining a composite schoolwide picture. As a result, it is not necessary to describe any one classroom or lesson extensively. Observations may last 15 to 20 minutes, or as long as it takes to observe and record the range of activities and the context of a given class segment (beginning, middle, or end). A wide range of sample data, collected as often as possible throughout the assessment data collection period, provides the most complete and reliable picture of the school's mathematics program.

The school and classroom observations are *not* to be used to evaluate any individual teachers or their teaching. Instead, the observations, together with the interview and survey data, assess the degree to which the entire school community supports a mathematics program that is consistent with the assessment's Criteria and Ideals. ***It is important to repeat that no information identifying any individual teacher is requested, nor should it be recorded.***

Instructions to individual observers are included with the observation instruments in the MAP supplementary volume on instruments. Also, procedures for teams to use in developing an interview schedule are provided in the appendix, Making Logistical Decisions.

The observation instruments have been subdivided into three sections. Items in the first section must be marked, if observed, while the observer is in the classroom. These items require recording what teachers or students are doing or saying. The second two sections can be recorded in the classroom, if time permits, or immediately upon leaving the classroom. Each observation should be fully completed before beginning another observation. Observers should record any notes to themselves or to the data reviewers without reference to individual teachers. Notes can be maintained on the observation sheet, wherever there is space available, or on a supplementary page.

Using Effective Observation Techniques

- Understand the Criteria and Ideals to assure your observations reflect their meaning and intent.

66

- Situate yourself in classrooms so you can see both the students and the teacher easily and fully.
- Become accustomed to the room and its activity before recording your observations.
- Avoid making judgments on the basis of your initial reactions or your personal preferences about the observed teacher's or students' personal style or approach.
- Go beyond your biases, recording only what you actually see or hear.
- Watch people closely, observing and noting their expressions, and try to understand meaning behind their actions.
- Listen for the meanings and ideas exchanged among students and teachers, and record them accordingly.
- Look beyond the surface behavior observed.
- Focus on and record what *is* observed, not on what you did not see. This is a procedure for identifying and recording positive teaching practices, not for evaluating or criticizing teachers.
- Before leaving the classroom, leave an Observation Feedback Sheet with your colleague and suggest a time and place for a debriefing session.

After observing classes, be certain to informally express your appreciation to your colleague for anything you saw or experienced of particular interest. Often when we observe one another's classes, we come away with good ideas or suggestions for improving on something we are doing with students. Be sure to share these positive benefits—few of us tire of praise or credit for a good idea!

Completing Surveys

Surveys provide additional data that fill in some of the basic information about the mathematics program that cannot be readily observed or described in interviews. The Mathematics Teacher Survey is an especially important data supplement for MAP. The responsibility of summarizing the surveys' data can be shared with colleagues in the mathematics department. As long as the respondents' names are not associated with the instruments, the extra hands in the summary process ease the burden of the data collection and assure that knowledge from colleagues is shared within the department.

The purpose of each survey and a suggestion about summarizing the information is summarized below.

Mathematics Teacher Survey (MTS)

This survey is designed to elicit information from classroom teachers about details of their teaching process. It helps the team develop a perception of the mathematics program without requiring a more lengthy interview. In addition, using the Mathematics Teacher Survey, teachers can express their opinions directly and confidentially.

At the beginning of the assessment, the MT cluster should distribute to each of their colleagues a copy of the Mathematics Teacher Survey, indicating when and to whom the survey must be returned for analysis.

Teachers should be encouraged to take the time to complete this survey in depth since the requested data provide significant background information about the needs of the school's mathematics teachers. In addition, this information informs the assessment team of approaches, philosophies, and perspectives of the staff with respect to the Criteria for Excellence.

Mathematics Facilities Survey (MFS)

This survey is completed by members of the ASC cluster through a combination of observation and informal interview. Since some of the items on the survey may be unfamiliar to individuals who do not teach mathematics, parts of the survey can be completed with groups that include mathematics teachers.

The cluster may wish to distribute responsibility for completing the survey, or the team can complete the survey instrument several times (as with the observation instruments) to assure that it obtains a complete picture of facilities that are both available and used in the mathematics program. Once the survey is complete, additional information, if needed, can be obtained by interviewing individual staff. The cluster may designate a member to supplement survey data in this way.

Statistical Profile

This survey is designed to summarize significant demographic data about teachers and students that affect the way the mathematics program can be organized. The information about the teacher's specialized training and prior experiences teaching mathematics, along with the data on how the mathematics programs serves special populations of students enables the school to match existing teaching talents and student needs. Where there are gaps between needs and teachers' experiences, the assessment team will want to work with its staff, the principal, and the district's central office to plan additional opportunities for staff development or to bring extra resources into the school.

There are also several ways for recording basic demographic information about students. Schools and school districts vary on the accessibility of this information, so administrators and support personnel in the cluster may need to look hard for the records. The search is worth the effort. Each of the items contributes to understanding fully the demographic factors in the school that should be considered in laying plans for revising and updating the mathematics program.

Organizing and Summarizing the Data for Study Group Review.

A simple tally or summary procedure is used to transfer data collected in interviews, observations, or surveys to a form the group can use to report their findings.

The summary procedure will vary slightly for each of the three kinds of instruments. Teams are encouraged to agree upon the summary procedure that is appropriate for their needs and convenient for all team members. District supervisors may offer direction on how to establish expedient procedures.

In organizing the data for review, teams should keep in mind the following principles for summarizing and organizing the information they collect:

- Data should be tallied so that it **summarizes** the original information obtained. However, the summary should accurately reflect the original ideas of interviewees and the context of the observations.
- Each individual should organize the information he or she collects into a format that is convenient for tabulation with the information collected by other team members.
- Data tabulations must maintain the confidentiality and anonymity of the original sources.

General suggestions for initially tabulating results follow.

Interviews

Each team member summarizes the answers to the questions in the interviews he or she conducts by searching for and highlighting (using a bright marking pen) common themes across the interviews, noting the number of people who offered a response that reflects that theme. Themes are the ***general notions or ideas that were expressed or "teased out" of the facts or opinions offered*** during interviews. On a clean interview form, these highlighted various ideas can be restated in short phrases that capture the main ideas of those interviewed. If a number of people reflected the same idea, simply indicate so with a check mark each time the idea was repeated.

Individual team members within a cluster should then combine the results of all the interviews their group conducted on a **single blank instrument form**—one that has additional pages added as necessary. This more lengthy summary represents the cluster's results, and the data are ready to be turned over to study groups for analyzing and reporting preliminary findings.

Observations

Each observer tallies the results of his or her Mathematics Classroom Observations (MCO) and the Schoolwide Observations (SWO) on forms for this purpose. Simple frequencies (the number of times each item was observed) can be tabulated on an unused observation form. After the observations for the entire cluster are tabulated together, the teams should **figure a group frequency** and determine the **percentage** of times each observation item was recorded. By determining the percentages for each observation item, it will be readily apparent what teaching behaviors are most common across the school. Later, the study groups will use this information to recommend teaching processes that should be encouraged to bring the school in closer alignment with the MAP Criteria for Excellence.

Surveys

Designated cluster members summarize the results obtained on the Mathematics Teacher Survey (MTS) by using a clean MTS as a summary sheet.

The survey serves primarily as a balancing device for expanding and confirming themes and conclusions arrived at through interviews and observations. Unlike the observation and interview forms, the survey items do not directly correspond to a particular Criterion or Ideal. This is because so many of these items reflect multiple aspects of the Criteria for Excellence. Thus, the study groups will use the information from the surveys to produce the most accurate composite portrait of the overall mathematics program.

The Mathematics Facilities Survey (MFS) provides information about the facilities that support a well-rounded mathematics program. It records what is in the school and the degree to which those materials are used. The team members responsible for gathering the data with this instrument tally their notes regarding available materials and facilities and the extent to which they are used. They note if the absence of certain facilities impedes teachers from implementing a mathematics program that best serves their students. It is useful for team members also to note strengths. With the other survey instruments, the Mathematics Facilities Survey contributes to the overall record of the school's consistency with the MAP Criteria for Excellence.

Finally, in summarizing the Statistical Profile data, special attention is given to examining whether the school's program provides access to mathematics for girls, minority students, and developing English language speakers. This information enables the assessment team to consider the unique talents and needs of special education populations, both gifted and handicapped students.

A goal of several of the MAP Criteria for Excellence is that the school's mathematics program prepare *all* its students, regardless of prior experience and entering achievement, for success in mathematics. This demographic information provides a check on this issue. The demographic background information enables the team to verify that students are not "stuck" in remedial groups and have access to the kind of teaching that uses and develops the full range of their thinking and conceptualizing capacities. It also means examining group achievement test scores to determine how well the school's existing program supports students' learning beyond the traditional "basic" skills. It examines how well students perform on standardized achievement tests of mathematics concepts, problem solving, and applications. Most summaries of standardized test scores will need to be separated into the categories of information requested in this Statistical Profile to get a full picture of this range of students' mathematics achievements and needs.

Reporting Preliminary Findings

A booklet by the National Association of Secondary School Principals (NASSP), *Assessing Excellence: A Guide for Studying the Middle Level Schools* (1989) is an outstanding reference for assessment teams that are beginning to examine their MAP data. Since school teams vary in their experience as data analysts, this section includes only specific procedures for using MAP study groups. Teams that need additional guidance about analyzing data should refer to the NASSP report described above. It is available from most libraries and from the National Association of Secondary School Principals, 1904 Association Drive, Reston, Virginia 22091. The third volume of MAP—*Staff Development Guidelines*—also suggests detailed procedures for analyzing the school's data.

The authors of *Assessing Excellence* remind readers how difficult and emotionally charged are aspects of any program evaluation that involve analysis and interpretation of data, offering the wise adage as a warning: "Where you stand depends largely on where you sit!" In trying to figure out the answer to "What do all these data mean?" most people who have a stake in the answer to the question also have an opinion about what the answer is.

Because this is a critical aspect of the assessment process, the MAP procedures invite broad schoolwide participation in the review and interpretation of the data. Just as the assessment itself has been a collaborative group process, so must be the analysis. It will involve negotiation, consideration, argument, evidence, and ultimately, consensus building and compromise. In the end, the goal is to make the analysis of the data as complete as possible, and to present it simply. Most importantly, the analysis and the accompanying findings should focus only on the points team members agree are central to designing a quality program for the school's students.

The data analysis and report of findings is conducted by cluster-designated study groups. The three assessment team clusters—mathematics teachers, interdepartmental faculty, and the administrative/support/community group—recruit two or more additional colleagues from the faculty and the community. Joining as members of the clusters' study groups, these individuals review the raw data summaries the team members completed when they concluded their data collection.

The major responsibilities of the study groups are to "reduce" the raw data, putting it together to make it meaningful to others; identify the assets and needs of the current mathematics program; and, finally generate a preliminary report of the findings of the MAP study. The study group reports will, in the end, be submitted to the assessment team. With these reports of study group findings, the full assessment team will be in a position to develop an action plan for improving the mathematics program.

The following are the basic tasks in this phase of the assessment process:

- Form a study group for each cluster
- Use the analysis to identifying assets and needs of the current mathematics program.
- Generate and report findings.

This section, along with the suggestions in the *Staff Development Guidelines*, shows how to form study groups, analyze the MAP data, and report the findings.

Forming Cluster Study Groups

Each of the three assessment team clusters (MT, IF, and ASC) recruit from the faculty or school community working groups to assist them in reducing and analyzing the data compiled from the interviews, observations, and surveys. The two or three assessment team members in the cluster serve as leaders of the study groups; provide the raw data to work with; plan, announce and structure meetings; keep records; and write the reports of findings of the study groups.

The analysis process should take place in several meetings, probably occurring after school over a period of several months, or in release time that the school can make available to study group participants. Cluster leaders can organize the meetings in advance to increase their efficiency by having the data prepared in a readable and organized format and convening in a place where there will not be interruptions.

If the analysis process is open, it encourages a lively exchange of ideas about the data and their implications. Some team leaders may find it useful at this stage to call upon the team's consultant to initiate the meetings, set the tone, and to offer advice on how to make best use of the limited time available.

Identifying Assets and Needs of the Current Mathematics Program

Following summary of the raw data gathered from the instruments, and its "reduction" by those who collected it, further analysis by the study group will likely be necessary. Its purpose: to further summarize the findings by Ideal, indicating the extent to which the information demonstrates the mathematics program is consistent or inconsistent with each Ideal. This is most often accomplished by closely reading the findings reported and, as a group, determining what they imply. These judgments should be made on the basis of the actual information before the study group, not on personal opinions or hearsay. If additional information is needed, return to those who collected the data for interpretation.

Using chart paper, clusters should summarize the overall findings for each Ideal and each instrument. Divide the charts by Criterion and Ideal. Indicate a place to list examples of how the program is "consistent with Ideals," and, next to it, a place to indicate ways in which the data indicate the program is "inconsistent with the Ideals." Using large paper sheets for this initial summary process makes it easy to see at a glance the program's strengths and weaker areas.

Generating and Reporting Findings

Cluster study groups conclude their work when they agree on a series of summary statements that reflect the findings from the data collected on all the instruments assigned to their cluster. The group should list their findings in terms of the evidence showing how the program is consistent with those various Ideals within the Criteria for Excellence. The group should also generate a parallel list that specifies how the program is inconsistent with certain Ideals. Statements written positively, focusing on goals and aims, can be more useful than can statements cast in negative terms. Finally, the cluster leaders summarize their group's work in a report of the findings. Along with the instrument summaries on which they are based, each group's report of findings will be returned to the assessment team and, ultimately, combined with the other cluster group reports.

Summarizing Cluster Group Findings

Merging Data

When the three team clusters and their study groups complete their reports of findings, the original math assessment team reconvenes to continue the final stage of the process. At this session, team members report the results of their study groups' work and together they merge the findings from the study groups. At this juncture, the team will generate a list of Ideals within each Criterion that have been largely met and a second list that indicates the Ideals that need attention.

The following procedure can be used to summarize the cluster study groups' findings:

- Team members simultaneously review the three preliminary reports of findings, starting with Criterion A. Each set of instruments the clusters use vary in the degree to which they collect information about any given Criterion or its Ideals. As a result, there may be quite a range of information, from very little to a great deal, from any one group.
- Itemize the Ideals addressed by the three reports, making note of whether the findings from the study groups are consistent or inconsistent with each Ideal. Next to each Ideal indicate the

number of reports which mention a particular Ideal or finding. An Ideal that was stated only by one cluster may not be given as high a priority for action as one that was indicated on all three reports.

- If several reports mention the same Ideal but disagree as to whether school practices were consistent or inconsistent with the Ideal, members should refer back to the original data and discuss possible reasons for the lack of agreement on the finding, keeping notes on the discussions and conclusions.
- When all the reported Ideals for each Criterion have been listed, and related thoughts and considerations have been noted next to each Ideal, the team should proceed in a similar manner for all the succeeding Criteria.

One or more team members may be assigned to take notes for this process. While the format for completing this aspect of the assessment vary from team to team, the purpose of this phase of the process is to integrate the conclusions and findings from the three cluster reports. It may be that the team's consultant would be a good facilitator of the discussion, suggesting ideas and possibilities to help the group focus on innovations and alternative ways of interpreting and resolving issues that arise.

Generating and Reporting a Preliminary Action Plan

Working from the notes taken in the working sessions described above, team members are now prepared to complete the assessment team report, in preparation for designing an action plan. To complete this important aspect of the assessment process, the team should consider several significant issues. First, from the results of the data-gathering process, two questions are relevant:

- To what degree is each Criterion *already met* by the mathematics program?
- For Criteria that have not been met or have only partially been met, what Ideals do the data suggest should be recommended for priority action?

After some discussion and debate regarding these issues, the team should reach a consensus regarding the Ideals to emphasize within each Criterion. This consensus acknowledges those Ideals with which the program is consistent and describes as priorities for action those Ideals with which the program is inconsistent. Regardless of how many Ideals have been listed as not being met, the group is responsible for establishing priorities at this point. In addition, it is best to *focus upon only 2 or 3 Ideals within each Criterion* for initial action.

Once the team has identified the "consistent" and "inconsistent" Ideals, it has an indication of how its own mathematics program compares and contrasts with that envisioned in the assessment Criteria. This enables team members to focus on recommending actions for change.

Now the team is challenged to determine where the school should focus its energy. This is a step that requires an open review of potential strategies and options that will respond to the priority needs defined to that point. Thus, the team may take several sessions to brainstorm and research what they will include in this final important aspect of the assessment.

While members will want to keep in mind realistic constraints that can impede accomplishing ideal solutions, the team should also encourage new ideas, including those that might once have met resistance from the faculty or that require special funding. This is an open, exploratory part of the assessment process, and team members should allow themselves the freedom to suggest imaginative, creative, and novel solutions to the program improvement target areas.

Considering Action Alternatives

The last step in MAP entails planning to restructure or further develop the mathematics program on the basis of the results of the assessment. At this stage, the team should consider these questions:

What instructional and organizational changes will bring our school's mathematics program into alignment with the assessment's Criteria and Ideals?

- To accomplish these changes, what specific aspects of our current program do we want to recommend our colleagues restructure, add to, or revise?
- What alternatives were suggested during the assessment process and what are some approaches to determining new ways of tackling old problems?

During the sessions devoted to making action recommendations, the team writes an action plan that eventually will be submitted to the faculty for review, comment, and suggested revisions. For each Criterion and related Ideals with which the program was determined to be inconsistent, the team should propose program revisions that bring the program into better alignment with the Criteria. At all times, team members should retain their commitment to developing a program from the data gathered. Proposals that are particularly controversial should be tabled for future attention. Focus at this stage on concrete actions the staff believes it can reasonably take.

The assessment team should open its final discussions to all members of the mathematics department. Most important, the action plan that goes to the faculty should be one that has been carefully considered and discussed by teachers in the mathematics department. If the report is, indeed, one that reflects the sense of those teachers, department members may wish to help present the proposed recommendations.

Disseminating Assessment Team's Proposed Action Plan to the Faculty

The assessment team co-leaders confer with the school principal regarding a suitable time to present the team's proposed action plan at a regular faculty meeting. In preparation for the faculty review of the implementation goals and plans, team co-leaders should distribute to the entire faculty copies of the team's draft report.

The main purpose of this meeting is to lead an informal discussion and debate among colleagues regarding the findings of the assessment, to confirm or extend its recommendations for actions, and to agree upon the priorities the assessment team proposes.

Adopting a Mathematics Improvement Plan

Reviewing Recommendations for Action

Several weeks after the initial presentation to the faculty of the assessment team's report, the faculty should convene to discuss its merit and feasibility and to consider alternative recommendations for action. If possible, ask volunteers from each department represented on the team to serve as spokepersons or to lead parts of this discussion. Since actions to be taken will be assigned priority in the next step, there is no need at this stage to limit discussion only to the "practical." Welcome and encourage idealistic activities and dreams.

After the faculty discusses and brainstorms modifications in the team's findings and suggested actions, the assessment co-leaders seek a "sense of the group" or consensus about their list of action proposals. Rather than using a "majority rules" approach, it is preferable for this process to be one of reaching a mutually agreed-upon point of view. In cases where there is debate or strong disagreement, items can be tabled for later consideration.

Confirming an Improvement Plan

The school should feel free to devise its own approach to action planning. The important achievement of this phase of the assessment is to define clearly workable goals and plans *within each* Criterion, that the mathematics department, collaboratively with colleagues and school community, can expect to achieve.

The MAP Criteria for Excellence provide a framework for these decisions. The data-gathering process and discussions held in analyzing the data guide a school in developing its own unique vision from within its ranks. Having used MAP, including its team approach to data gathering, analysis, and planning, we expect that there will be widespread ownership of the overall mathematics program. The challenge of turning that vision into reality, one that reflects the initial objectives of the *Mathematics Assessment Process for the Middle Grades*, stated by the school's assessment team in the first stage of the process, belongs to the school.

Implementation

Implementation will be an uneven process, taking several years. It will require continuing examination, analysis, creativity, and unified action. Extensive staff development about new expectations, curriculum materials, and instructional approaches may be a significant part of the proposed agenda for improvement. Continuing faculty leadership is essential. Changes will be most likely to take root if there are leadership roles for many colleagues, both in and outside of the mathematics department.

Most important, the process of implementing a new kind of mathematics education for the school's young adolescent learners must be one that continues to focus on students. It must respect their complexity, vibrancy, and potential. This should be in the forefront of the school's agenda at all times.

Any successful middle-grades mathematics program begins with the needs of young adolescents and it ends there, as well. It is the students who will demonstrate the wisdom and efficacy of the process.

Section 5

Responsive Mathematics Learning Environments for Young Adolescents

What Is a Responsive Learning Environment for Young Adolescents?

Because early adolescence is a period of such profound growth, the middle grades are a critical time for enhancing mathematical thinking. Emerging cognitive processes complement the physical and social changes that occur during these years, making available significant new abilities to organize, create, and analyze one's own (and others') thoughts and actions.

This period of awakening enables young people to form and understand concepts and ideas that previously were inaccessible to them. The greater range and complexity of thinking, combined with rapid physical development, encourages new relationships and achievement needs. Moving from a "here and now" orientation into a novel world with a wider panorama deepens young adolescents' desire for personal competency and commitment. These changes give new breadth and intensity to the struggle to find meaning in their life and in their future.

Young adolescents bring great energy to the search for new self-definition and the peer group becomes an increasingly powerful influence. Nevertheless, parents and teachers retain importance as role models, leaders, and guides because young adolescents are not yet ready for full independence. Thus, to make the smoothest transition, middle-grades students continue to require flexible, adult-established influences and structure in their lives. When there are sufficient opportunities to make real choices about how to use time and interests within reasonably adaptable boundaries, 10- to 15-year olds are free to test safely their limits of competence and potential.

The natural trajectory of young adolescent development fits well with a mathematics program that emphasizes creativity, problem-solving, and applied thinking. Making connections is an important theme of mathematics during the middle years, and, as young adolescents' decisions begin to affect their futures, mathematics can be a tool for analyzing and exploring options. Collaborative projects encourage peer interaction and strengthen peer connections. Technology, too, is an especially well-suited tool that supports the development of individual and group competency as it teaches the value of learning to reason and communicate mathematically.

Acknowledging the significance of these middle years, the NCTM *Curriculum and Evaluation Standards for School Mathematics* emphasizes the importance of a caring environment where students freely explore mathematical ideas, ask questions, and make mistakes they can learn from. When assignments are demanding intellectually, socially, and physically—requiring group work, model-making, diagramming, writing, and dialogue and debate—students learn to apply their knowledge and experience to increasingly complex challenges.

As a school embarks on MAP, it is useful to bring together as many members of the community as possible to reflect upon the opportunity of these early adolescent years and to consider how the mathematics program can contribute more fully to student development. The following exercise, ***Puzzling and Problem Solving***, encourages educators and parents alike to envision creatively a different kind of mathematics program. With a clearer vision, the school is well-positioned to plan a mathematics program that is fully responsive to the unique needs of students in a mathematics-and science-based technological age.

Puzzling and Problem Solving

An Exercise in Creating Responsive Mathematics Programs for Young Adolescents

Puzzling and Problem Solving is simple a exercise to conduct, and it reliably sparks lively discussion among participants. It is an excellent way to invite into the assessment process colleagues, administrators, and parents who do not ordinarily think of themselves as "math people." Often, parents and teachers from other disciplines have very original ideas about how the mathematics program can connect more successfully with students' changes and expanding interests.

This exercise is designed to be conducted with adults from many sectors of the school community: mathematics and nonmathematics colleagues, school administrators, central office staff, school board members, and community or parent groups. The exercise clarifies the changes young adolescents experience and establishes a rationale for making the school more responsive to middle-grade students.

Beginning with the question, *Do you wonder why young adolescents .. ?*, the worksheet describes familiar adolescent behavior. The final column, "*The school's mathematics program can help by . .* " opens the discussion for group suggestions. By including the perspectives of people who are not teaching mathematics every day, new insights and alternative approaches come quickly.

Discussion Goal

To build a united vision of the characteristics and needs of young adolescents and to identify ways that mathematics programs can be designed to respond.

Discussion Format

The exercise should be conducted in an informal atmosphere that lends itself to an open-ended exchange of ideas. It may take from an hour to an hour and a half to complete. A leader can be designated to direct the discussion, or a small group can decide together to read and talk through the exercise. Discussion is most dynamic and informative when groups are small, including three to ten people. When the group is larger than ten, it may be divided into subgroups of three or four.

Materials Needed

1. Chart paper, a chalk board, or notebook paper to record examples of how a mathematics program can help young people make a smooth transition into adolescence.
2. Transparencies (provided at the end of this section):
   - Characteristics of Young Adolescent Development
   - Characteristics of Emergent Adolescent Thinking
3. Copies of the "*Puzzling and Problem Solving*" exercise and accompanying "Puzzling and Problem Solving: Recording Sheet" for each participant.

Instructions for Conducting the Discussion

1. Use the two transparencies provided at the end of this section, "Characteristics of Young Adolescent Development" and "Characteristics of Emergent Adolescent Thinking," as an introduction to the normal characteristics of young adolescent development. Ask groups to consider how these characteristics can influence students' responses to school, especially to the unique challenges of mathematics.

2. Review the first three columns of the *"Puzzling and Problem Solving"* exercise. Read and discuss (within small groups) three or four of the items, sharing with one another reactions to the statements in the first three columns. Do not try to discuss the fourth column, "How mathematics programs can help . . . " until completing the exchange about the characteristics and needs of young adolescents. *This portion of the exercise should take from 15 to 20 minutes* for each group to discuss in depth three to four of the characteristics.

3. Once participants understand the characteristics of 10- to 15- year olds, discuss (again, in small groups) the implications of typical adolescent behavior for mathematics classes and identify specific ways the mathematics program can be responsive. Within each group, one person should record ideas on the *"Puzzling and Problem Solving: Recording Sheet"* or on blank chart paper so the suggestions can be reported back to the larger group. *This portion of the exercise should take about 15 to 20 minutes.*

   Hint: To stimulate an open discussion, use the rules of brainstorming that assume the following:

   - Begin the discussion of each item with an idea-generating period that last several minutes; encourage every small group member to suggest one or more ideas;
   - Accept each idea initially, recording it without discussion;
   - When the idea-generating period is complete, discuss each person's idea in some depth. Record the most workable suggestions for making the mathematics program more responsive to the characteristics of young adolescents.

4. Convene the larger group for a concluding feedback session, *lasting about 20 - 30 minutes.* Members representing each subgroup report their suggestions about how mathematics programs can better respond to the characteristics of young adolescents. These ideas can be recorded and used in the final stages of MAP action planning.

5. Type the suggestions that emerged from the discussion and distribute them with several articles from the annotated resource lists (Section 6) that the MAP team thinks workshop participants would find informative.

Transparency 1: Characteristics of Young Adolescent Development

Young Adolescents Are . . .

1. Moving (in uneven spirts) from experience-centered thinking to more flexible, abstract thought
2. Developing primary and secondary sex characteristics
3. Self-conscious and subject to bouts of low self-esteem
4. Seeking understanding of their place in their community through ties with their family and their social and ethnic group
5. Strengthening their competencies and beginning to see themselves as contributors to home, school, and community
6. Vulnerable to natural uncertainty and much in need of strong parental and adult associations
7. Identifying with peers and developing friendships and affiliations that are independent of family
8. Physically, socially, and intellectually changing faster than in any other period of human development
9. Comparing their own lives to an ideal and thinking about the adults they will become
10. Developing new capacities for complex thinking and problem solving
11. Seeking independence and guidance, often both at the same time
12. Testing new social experiences, uncomprehending of real potential dangers and risks

Transparency 2
Characteristics of Emergent Adolescent Thinking

Young Adolescents Are Learning to...

Think About Possibilities

- No longer rely on what is directly observed
- Consider alternative possibilities that are not Immediately or physically present

Think Ahead

- Systematically consider the future — the critical immediate (i.e. summer) *and* long term — (i.e., career)
- Take responsibility that requires planning

Think Through Hypotheses

- Generate and test hypothetical options that are contrary to fact
- Consider multiple scenarios

Think About Their Own Thoughts

- Capable of "metacognitive thinking"—analyzing, reflecting upon, considering their own mental processes
- Develop rules about rules; think more systematically
- Hold two disparate rule systems in mind while weighing and considering their options

Think Beyond Conventional Limits

- Rethink fundamental social issues, morality, politics, religion
- Recognize discrepancy between ideals of their community and the behavior of the people around them
- Strong idealism, and search for heroes

Revised from Daniel Keating. "Thinking Processes in Adolescence." In J. Adelson (Ed.), *Handbook of Adolescent Psychology*. New York: Wiley, 1980.

Puzzling and Problem Solving: Creating Responsive Mathematics Programs for Young Adolescents

Most middle-grades educators are doing more than they realize to assure their mathematics programs are responsive to their young adolescents' developmental characteristics. To think about the responsiveness of mathematics in your school, and to extend your thinking about matching mathematics opportunities with young adolescents' developmental needs, please review the following chart.

The first column provides examples of young adolescents' behavior. This section lists things young adolescents say, do, and feel that show us they are experiencing developmental changes. The second column lists things we know about 10- to 15-year-olds from research and experience. The third column lists conclusions about what young adolescents need from us, based on what we know about them. The fourth column provides space for you to list ideas about how mathematics programs can be responsive to young adolescents' characteristics and developing needs.

Do You Wonder Why Young Adolescents...	It's Because They Are...	Therefore They Need...	The School's Mathematics Program Can Help By...
1) ... may be certain at one moment but seem to contradict themselves with equal vehemence a few minutes later.	... moving away from concrete, experience-centered thinking to more flexible, abstract thought.	... to discuss/debate their ideas with their peers and adults, and both practical and concrete experiences to develop their logical and abstract thinking.	
2) ... compare their physical changes with those of their friends; often look into mirrors and sometimes retreat to a place where they can be alone; worry, "Am I normal?"	... changing and growing at different rates, according to highly individual internal "clocks." ... developing secondary sex characteristics and the capacity to reproduce.	... time to absorb and reflect upon their new "look;" time to explore new ways of thinking and new reactions from others; opportunities to try out and define their developing identities.	

This exercise was modified for *the Mathematics Assessment Process for the Middle Grades* from a similar activity in *Living With 10- to 15-Year-Olds: A Parent Education Curriculum*. Both curricula are available from: Center for Early Adolescence, University of North Carolina-Chapel Hill, Suite 211, Carr Mill Mall, Carrboro, NC 27510, 1989.

Do You Wonder Why Young Adolescents...	It's Because They Are...	Therefore They Need...	Mathematics *Can Help* By...
3)... can be very sensitive to criticism and failure; ask for frequent feedback on school work and other activities; may be embarrassed by public praise, but enjoy receiving recognition for a job well done.	... often painfully self-conscious and self-critical and vulnerable to bouts of low self-esteem.	... many varied opportunities to try out newly developing abilities, to be successful, and to have their achievements recognized by peers, parents, and teachers.	
4)... seek the company of other adults such as teachers, coaches, and family, friends, and relatives.	... identifying more maturely with their race, gender, and future occupations; and seeking understanding of new roles they may want to take on as adults.	... dependable role models of their own race and gender who care about them, talk with them, and share their interests.	
5)... volunteer for service projects; become concerned about problems such as poverty, hunger, discrimination, and war; want to help plan events and contribute to making rules.	... living in a world that expands as they become more capable, mastering new social skills and beginning to see themselves as contributors to their home, school, and community.	... opportunities to meaningfully contribute to their home, school, and community, so they can experience being responsible collaborators who can make a difference in their world.	
6)... look to parents and teachers for affection, guidance, and deeply held values.	... at a uniquely vulnerable, rapidly changing time in their lives, when the stable, reassuring presence of parents and teachers is especially important.	... relationships with parents, teachers, and other adults who like, respect, enjoy, and appreciate being with them.	
7)... sometimes prefer to spend time with friends rather than family; insist on being like their friends.	... identifying with their peer group and want to belong; developing deepening, mutual friendships.	... time to be with their friends; opportunities to make friends with others their age who share their interests.	

83

Do You Wonder Why Young Adolescents...	It's Because They Are...	Therefore They Need...	Mathematics *Can Help* By...
8)... fidget or squirm when sitting; have unbounded energy at times, but seem unduly tired or lazy at other times.	... growing very rapidly and developing new physical and social, emotional and intellectual abilities.	... lots of physical activity—not intense competition—and time for relaxation and for reflection, too.	
9)... argue about whether rules are reasonable and fair; question parents' and teachers' beliefs and values.	... sharpening new thinking skills that enable them to ask "What if . . . ?" questions; comparing their own lives with an imagined ideal and thinking about the adults they will become.	... to have a voice in the family and at school about decisions that affect them; opportunities to discuss values.	
10)... become very excited about a new hobby or activity, and then seem to lose interest right after they have started lessons or purchased materials.	... developing new thinking skills and have an increasing capacity to think abstractly.	... varied experiences in creatively expressing these new interests, thoughts, and emotions, without making long-term commitments.	
11) ... test and question limits set by teachers and parents; push to help make rules and decisions about dress, recreational activities, and responsibilities at home and in school.	... seeking limited independence, but still need adult support and guidance.	... to make real choices for themselves, within safe limits; opportunities to create new rules and plans that affect their lives.	
12)... experiment with new social experiences and behaviors, some of which may have unexpected, even dangerous consequences.	... yearning to test new social experiences, yet imagining themselves to be invulnerable—unaware they can be hurt.	... significant adults who model appropriate behavior and set safe, clear limits, within which they can make choices that limit risks.	

Puzzling and Problem Solving: Recording Sheet

Young Adolescents Are	*Mathematics Programs Can Help By*
1. Moving (in uneven spirts) from experience-centered thinking to more flexible, abstract thought	
2. Experiencing dramatic and rapid physical changes, including the development of primary and secondary sex characteristics	
3. Self-conscious and self critical	

Young Adolescents Are	*Mathematics Programs Can Help By*
4. Seeking same gender and ethnic group adult role models	
5. Mastering new social skills and see selves as contributors to the community	
6. Feeling vulnerable and uncertain, needing greater adult support	

86

Young Adolescents Are	*Mathematics Programs Can Help By*
7. Seeking identity with peers, valuing deeper friendships	
8. Simultaneously changing rapidly in social, emotional, and intellectual spheres	
9. Questioning and challenging adults, rules, and organizational systems	

Young Adolescents Are	Mathematics Programs Can Help By
10. Expanding personal interests that use their widening abilities to think abstractly	
11 Seeking from adults both independence and guidance	
12. Testing new experiences without regard to potential dangers	

Section 6

Annotated Resource Lists for Middle-Grades Mathematics Educators

Annotated Resource Lists for Middle-Grades Mathematics Educators

As the information age enables the ever-accelerating production of valuable educational resources, it often takes longest for them to reach teachers, the individuals who could benefit most directly from their use. This annotated bibliography was compiled with the aim of putting up-to-date books and articles into the hands of educators who are leading mathematics improvement efforts in their schools.

Subdivided by topics, the first list of references is especially useful to teachers for planning classroom instruction. It is followed by five lists emphasizing specialized areas of theory and research that support mathematics teaching and learning among middle-grades students. The last three lists itemize pertinent journals, organizations, and distributors of educational materials. Using these references, MAP teams have at their fingertips reliable information and practical suggestions for creating responsive mathematics programs for young adolescents.

LIST OF ANNOTATED RESOURCES LISTS

NOTE: The letters following each annotation indicate the MAP Criteria to which the resource is most relevant.

SELECTED REFERENCES FOR MIDDLE-GRADES MATHEMATICS TEACHERS

A Mindset for Math: Techniques for Working With Math-Anxious Girls. Newton, MA: WEEA Publishing Center, 1987.

Describes a program designed for eighth- to tenth-grade girls which first determines their mathematics anxiety and mathematics-achievement levels then designs a plan to reduce anxiety and improve attitudes toward and achievement in mathematics. (D, E)

Activities for the Junior High School and Middle School Mathematics: Readings from The Arithmetic Teacher and The Mathematics Teacher. Reston, VA: National Council of Teachers of Mathematics, 1981.

A compilation of activities selected from *The Arithmetic Teacher* and *The Mathematics Teacher* including are classroom activities on the following: major mathematical strands; counting and place value; whole numbers and integers; number theory; decimals, fractions, and percents; ratio and proportion; probability and statistics; geometry; measurement and estimation; logic and problem solving. (B)

Averbach, Bonnie, and Orin Chein. *Mathematics: Problem Solving Through Recreational Mathematics*. San Francisco: W. H. Freeman and Company, 1980.

A mathematics textbook designed to help readers become better problem solvers, think critically, and apply mathematical concepts to a wide range of situations. (C, E, F)

Baroody, Arthur J. *Children's Mathematic Thinking: A Developmental Framework for Preschool, Primary, and Special Education Teachers*. New York: Teachers College Press, 1987.

Presents educators with a framework for understanding children's learning of elementary mathematics; uses this psychological framework to generate guidelines for teaching; and provides specific activities, often in the form of games, to promote the learning and teaching of elementary mathematics. (D)

Beyer, Barry K. *Practical Strategies for the Teaching of Thinking*. Boston: Allyn & Bacon, Inc., 1987.

Reviews current research, theory, and exemplary classroom practices, then collects and describes the strategies, techniques, and principles necessary to improve student thinking in the classroom. Gives specific examples and techniques suitable for use at any grade level with students of any ability level. (C)

Bray, Judy and Jane Armstrong. *What's Wrong With Mathematics Textbooks? Views From the Field*. Denver, CO: Education Commission of the States, 1986.

Discusses problems with current mathematics materials, provides criteria for the selection of materials, and suggests uses for new technology in the mathematics curriculum. (A)

Bright, George W. "Teaching Mathematics With Technology: Numerical Relationships." *Arithmetic Teacher* 36, no. 6 (February 1989): 56-58.

Shows teachers how to use calculators and computers to help students understand numerical relationships. Covers fractions, decimals, and circle approximations. (D)

Brooks, Jacqueline G. "Teachers and Students: Constructivists Forging New Connections." *Educational Leadership* 47, no. 5, (1990) 68-71.

Clearly outlines the concept of "constructivist" teaching, a frequently discussed approach to teaching that enables students to learn through the creation and testing of increasingly complex rules and hypotheses.

Brown, Stephen I., and Marion I. Walter. *The Art of Problem Posing*. Philadelphia, PA: The Franklin Institute Press, 1983.

Presents the significance of problem posing in mathematics and offers strategies for doing so. Based on the premise that problem posing can lead to deeper understanding of a standard topic and cast it in a new light. (A, B, C)

Brush, Lorelei R. *Encouraging Girls in Mathematics: The Problem and the Solution*. Cambridge, MA: Abt Books, 1980.

Presents the results of a longitudinal study on gender differences in students' desire to participate in mathematics. Clearly presents the problem of girls in mathematics and provides practical suggestions designed to help mathematics teachers. (E)

Burns, Marilyn. "Teaching `What to Do' in Arithmetic vs. Teaching `What to Do and Why'." *Educational Leadership* 43, no. 7 (April 1986): 34-38.

Describes one teacher's experience in letting children explore and problem-solve. Includes reasons for teaching arithmetic in the context of meaning and application. (C, E, F)

Burns, Marilyn. *The I Hate Mathematics! Book.* Boston: Little, Brown, 1975.

A book for kids (and adults, too) full of activities, puzzles, games, and tricks to show that mathematics is fun and can be understood by someone other than the class genius. Humorous illustrations and graphics. (E)

Burton, Leone, ed. *Girls Into Maths Can Go*. London: Holt, Rinehart and Winston, 1986.

A British collection including chapters written by academics and practitioners for a general readership. Presents a picture of the current state of thinking about gender issues in mathematics education. An appendix discusses significant women in the history of mathematics. (B, C, E, F)

Campbell, Patricia F., and James T. Fey. "New Goals for School Mathematics." In *Content of the Curriculum*, edited by Ronald S. Brant. Alexandria, VA: Association for Supervision and Curriculum Development, 1988.

Describes traditional mathematics programs and elaborates on the programs' weaknesses. Presents suggestions for much-needed program revisions at both the elementary and secondary levels. (A)

Chambers, Donald. *A Guide to Curriculum Planning in Mathematics*. Madison, WI: Wisconsin Department of Public Instruction, 1986.

A state curriculum guide designed to assist school districts in developing their curriculum guides. Presents discussions and objectives in seven strands of mathematics, in addition to discussions of more general topics, including curriculum development and issues in mathematics education. (A, G)

Charles, Randall, Frank Lester, and Phares O'Daffer. *How to Evaluate Progress in Mathematical Problem Solving*. Reston, VA: National Council of Teachers of Mathematics, 1987.

Provides guidelines and specific ideas for teachers on evaluating student progress in problem solving. Examples are abundant. (C, I)

Coburn, Terrence. *How to Teach Mathematics Using a Calculator*. Reston, VA: National Council of Teachers of Mathematics, 1987.

Provides elementary and middle school teachers with directions on how to use calculators as instructional tools. Includes such topics as multiplication and division, decimals, problems and applications, pre-algebra, measurement, geometry, percent, and student evaluation. (B)

Cohen, Elizabeth G., and Joan Benton. "Making Groupwork Work." *American Educator* 12, no. 3 (Fall 1988): 10-46.

Discusses some of the benefits of group work, such as more time on task and more active learning and gives specific guidelines for teachers to follow when planning group activities. (B, D)

The College Board. *Get Into The Equation: Math and Science, Parents and Children*. New York: The College Board, 1987.

A pamphlet encouraging parents, especially minority parents, to be actively involved in their children's mathematics and science education. Discusses what students need and what parents can do to help their children succeed in science and mathematics. (H)

Corwin, Rebecca B., and May C. Reinhardt. "Mathematics Education: Learning From the Process Approach to Writing." Paper presented at The National Educational Computing Conference, Boston, June 1989.

Uses the writing process to show how students learn. Contends that an emphasis on process in the mathematics classroom enables students to enjoy the doing of mathematics just as students of writing can enjoy doing writing. Highlights the three following themes: respect for the learner, new roles for teachers, and taking enough time. (A)

Curriculum and Evaluation Standards for School Mathematics. Reston, VA: National Council of Teachers of Mathematics, 1989.

The long awaited and highly acclaimed Curriculum and Evaluation Standards for School Mathematics is here! Contains the standards for mathematics curriculum and for evaluation of the curriculum and student achievement proposed by NCTM. An executive summary edition is available. (A-I)

Davis, Robert B. *Learning Mathematics: The Cognitive Science Approach to Mathematics Education*. Norwood, NJ: Ablex Publishing Corporation, 1984.

Following a discussion of mathematics education and what mathematics actually is, presents an in-depth study of how people learn mathematics. (A-H)

Dick, Thomas. "The Continuing Calculator Controversy." *Arithmetic Teacher* 35, no. 8 (April 1988): 37-41.

While results of mathematics education research overwhelmingly support calculators in the classroom, their use continues to be limited and debate is widespread. (B)

Dickson, Linda, Margaret Brown, and Olwen Gibson. *Children Learning Mathematics: A Teacher's Guide to Recent Research.* Oxford, England: The Alden Press, Ltd., 1984.

A British book which summarizes the findings of research pertaining to the learning and teaching of mathematics in children (ages 5-16), including findings on low-achieving children. Topics include: spatial thinking, measurement, number, language-words, and symbols. (A, D)

Didactics and Mathematics: The Art and Science of Learning and Teaching. Palo Alto, CA: Creative Publications, 1978.

One of the five topical resources developed by the Mathematics Resource Project. Although developed some years ago, still answers many basic questions asked by classroom teachers and presents best-known teaching practices and alternatives. Especially useful for promoting interdisciplinary teaching that is relevant to the lives of young adoldescents. (A, B, C, E)

Dillon, J. T. *Questioning and Teaching: A Manual of Practice.* New York: Teachers College Press, 1988.

Helps classroom teachers understand the elements of questioning and its relationship to educational processes. Chapters examine student questions, teacher questions, questioning and recitation, and questioning and discussion. (C, G)

Downie, Diane, Twila Slesnick, and Jean Kerr Stenmark. *Math for Girls and Other Problem Solvers.* Berkeley, CA: Lawrence Hall of Science, 1981.

A collection of problem-solving activities requiring both physical and mental ability. These activities were developed as part of Math For Girls, a Lawrence Hall of Science program designed to give students hands-on experiences in logical thinking and problem solving to stimulate their curiosity and interest in doing mathematics. (B, C, E)

Driscoll, Mark, and Jere Confrey, eds. *Teaching Mathematics: Strategies that Work, K-12.* Chilmsford, MA: National Regional Exchange, 1985.

A collection of innovative strategies for teaching mathematics, written by enthusiastic classroom teachers who have used them successfully. (B, E, F)

Driscoll, Mark. *Research Within Reach: Secondary School Mathematics: A Research-Guided Response to the Concerns of Education.* St. Louis, MO: CEMREL, (n.d.).

Reports on the National Institute of Education's research studies concerning effective methods for teaching and learning mathematics. Estimation, calculator use, and problem solving are some of the topics covered. (A, B, C, E)

Duckworth, Eleanor. *"The Having of Wonderful Ideas" and Other Essays on Teaching and Learning.* New York: Teachers College Press, 1987.

A collection of ten delightful essays written by a teacher on subjects such as children's thinking and language, Piaget's place in the curriculum, and teacher education. (C, D, E)

"Family Math." *Equity and Choice* 1, no. 2 (Winter 1985): 37-38.

Briefly discusses EQUALS and its program, Family Math. (E, F, I)

Forte, Imogene, and Sandra Schurr. *Science Mind Stretchers*. Nashville, TN: Incentive Publications, Inc., 1987.

Contains science activities based on Bloom's six stages of cognitive development: knowledge, comprehension, application, analysis, synthesis, and evaluation. Mini-units of science activities and accompanying reproducible pages in the areas of life, earth and physical science have been developed to stretch students' minds when learning basic science concepts while reinforcing reading, writing, and thinking skills. (B, C)

Gardner, April L., Cheryl L. Mason, and Marsha Lakes Matyas. "Equity, Excellence, and 'Just Plain Good Teaching.'" *The American Biology Teacher* 51, no. 2 (February 1989): 72-77.

Discusses how "equity" and "excellence" in science teaching encourage *all* students (men, women, and minority students) to participate and learn in the science classroom. Provides selected teaching strategies and activities designed to improve student achievement and motivation in the classroom. (E,F)

Gardner, Martin. *aha! Insight*. New York: W. H. Freeman Company, 1978.

Six sets of mathematical puzzles (combinatorial, geometry, number, logic, procedural, and word) designed to exercise and improve the readers ability to creatively solve problems, not in the traditional, linear fashion but in an insightful, 'aha!' method. (C, E)

Ginsburg, Herbert. *Children's Arithmetic: The Learning Process*. New York: D. Van Nostrand, 1977.

Shows how children learn, do, and understand elementary mathematics, especially arithmetic, then demonstrates how this knowledge can be used to improve mathematics education and resolve children's difficulties in learning. Emphasizes the significant mathematics learning that takes place outside the school setting. (A, B, D)

"Girls' Math Achievement: What We Do and Don't Know." *Harvard Education Letter* 2, no. 1 (January 1986): 1-5.

Discusses sex differences in achievement in mathematics, including: (1) when and where they appear, (2) biological factors, (3) differences in experiences in the classroom, and (4) intervention strategies. (D)

Goldberg, Dorothy. "Integrating Writing into the Mathematics Curriculum." *Two-Year College Mathematics Journal* 14 (November 1983): 421-424.

Discusses why we should teach writing in the mathematics class, how to get started, and how to give feedback to students on how well they are communicating their ideas. (A)

Good, Thomas L., et al. "Using Work-groups in Mathematics Instruction. *Educational Leadership* 47, no. 4 (1990) 56-62.

Describes research findings on the benefits of heterogeneous "work-groups" for teaching mathematics. Lessons using work-groups promote active learning, variety of mathematics lessons, peer interaction, and opportunities for more flexible mathematical thinking.

Sample lessons point to the benefits and challenges involved in effectively implementing the work-group teaching strategy. (B)

Grossnickle, Donald R., and Frank P. Sesko. *Preventive Discipline for Effective Teaching and Learning.* Reston, VA: NASSP, 1990.

A brief, concise guide reviewing basic concepts and principles that can help teachers and administrators, as a team, support the school and classroom environment. Focuses on setting conditions that bring about the best in students' potential for learning. (D)

Harvey, Wayne, and E. Paul Goldberg. "Rethinking the Teaching of Algebra: New Opportunities Using New Tools." Newton, MA: Education Development Center, Inc., Center for Learning Technology, March 1988.

Discusses the use of computer software in the teaching of algebra concepts with particular emphasis on materials developed by the Education Development Center, Inc. (A, B)

Heibert, James, and Merlyn Behr, eds. *Number Concepts and Operations in the Middle Grades.* Reston, VA: National Council of Teachers of Mathematics, 1988.

This second volume of research papers by the NCTM Research Advisory Committee focuses on middle-grade students' competence with numbers, conventional and experimental classroom techniques, and number content in the middle grades. (A-C)

Heiman, Marcia, et. al. *Teaching Thinking Skills: Mathematics.* Washington, DC: National Education Association, 1987.

Presents a variety of instructional and learning strategies designed to assist students in developing thinking skills. One chapter focuses on the instructional implications of Piaget's research. (B, C)

Hirsch, Christian R., ed. *Activities for Implementing Curricula Themes from the Agenda for Action.* Reston, VA: National Council of Teachers of Mathematics, 1986.

Presents thirty activities for grades seven through twelve which originally appeared in *Mathematics Teacher.* Each activity fulfills one or more of the NCTM curricula recommendations from Agenda for Action, particularly problem solving; basic skills; and using calculators, computers, and manipulatives. Student worksheets and teacher guides are included. (A, B)

Hope, Jack A., Barbara J. Reys, and Robert E. Reys. *Mental Math in Junior High.* Palo Alto, CA: Dale Seymour Publications, 1988.

Designed for seventh through ninth graders, Mental Math in Junior High contains a collection of 50 lessons in mental calculation. This is the third in a series of three books on mental computation. The other two include Mental Math in the Middle Grades (grades four through six) and Mental Math in the Primary Grades (grades one through three). (A, C)

Hord, Shirley M., et al. *Taking Charge of Change.* Washington, DC: Association for Supervision and Curriculum Development, 1987.

A highly readable and practical guide for school practitioners to use as a supplement in planning and implementing school program innovations. Useful for both team members and team leaders who are participating in school change. (I)

Horsley, Susan Loucks, and Leslie F. Hergert. *An Action Guide to School Improvement*. Alexandria, VA: Association for Supervision and Curriculum Development and The NETWORK, 1985.

Presents a seven-step process to school improvement which is based on research as well as practical experience. A clearly written, practical guide to action-oriented school improvement. (I)

Immerzeel, George, and Melvin Thomas, compilers. *Ideas from The Arithmetic Teacher, Grades 6-8, Middle School*. Reston, VA: National Council of Teachers of Mathematics, 1982.

A collection of middle-grade mathematics activities compiled from the "Ideas" section of *Arithmetic Teacher*. Student worksheets appear on the front of each page while teacher directions are presented on the reverse. (A, B)

Jacobs, Harold R. *Mathematics: A Human Endeavor*. San Francisco: W.H. Freeman and Company, 1982.

A delightful mathematics textbook for "those who think they don't like the subject" which provides a broad view of mathematics in an exciting and fun format. Some of the chapters include Mathematical Thinking, Number Sequences, Mathematical Curves, and An Introduction to Statistics. (E, F)

Johnson, David W., Roger T. Johnson, E.J. Hollubec, and P. Roy. *Circles of Learning: Cooperation in the Classroom*. Alexandria, VA: Association for Supervision and Curriculum Development, 1984.

A broad look at cooperative learning, discussing teachers' roles, the teaching of cooperative skills, and misconceptions about cooperative learning.

Jones, Beau Fly, et al. *Strategic Teaching and Learning: Cognitive Instruction in the Content Areas*. Alexandria, VA: Association for Supervision and Curriculum Development, 1987.

Draws on research to describe specific teaching and learning strategies which emphasize learning as the primary goal of instruction. (A, E, F)

Juraschek, William. "Piaget and Middle School Mathematics." *School Science and Mathematics* 81, no. 1 (January 1983): 4-13.

Briefly examines Piaget's theory of cognitive development and discusses its relevance and application to middle school mathematics teaching. (A-D)

Kagan, S. *Cooperative Learning Resources for Teachers*. Riverside, CA: University of California, 1988

Contains ideas and resources on team learning, Jigsaw, and "Co-op Co-op" (Kagan's version of Group Investigation). (B, D)

King, Barbara. "Using Writing in the Mathematics Class: Theory and Practice." In *Teaching Writing in All Disciplines*, edited by C. Williams Griffin. San Francisco: Jossey-Bass, December 1982.

Outlines how students can learn mathematical skills and how to confront their mathematics anxiety by writing in a variety of modes. (A)

Kochman, Thomas. *Black and White: Styles in Conflict*. Chicago: University of Chicago Press, 1981.

Unveils the differences in Black and White cultural styles that lead to miscommunication and conflict. (D)

Kogelman, Stanley, and Joseph Warren. *Mind Over Math.* New York: McGraw-Hill, 1979.

Premise is that mathematics anxiety can be overcome and performance improved by the "Mind Over Math" method focused on approaching mathematics rather than on solving problems. Argues that the removal of an apparent deficiency in thinking leads to improved self-concept and self-image. Changes in attitude show up in increased assertiveness in both daily and job-related activities. (B, E)

Kunjufu, Jawanza. *Developing Positive Self-Images and Discipline in Black Children.* Chicago: African American Images, 1984.

A manual for teachers, parents, and educational researchers on providing a relevant, stimulating, and enabling education for Black children. Advocates an holistic approach. (D)

Kunjufu, Jawanza. *To Be Popular or Smart: The Black Peer Group.* Chicago: African American Images, 1988.

Provides a sophisticated analysis of the belief system wherein intellectual achievement is equated with whiteness. Chapters directed at students, parents, teachers, and community members offer suggestions for battling the crisis of low academic success among African-American Youth. (D)

Lappan, Glenda, and Ruhama Even. "Similarity in the Middle Grades." *Arithmetic Teacher* 35, no. 9 (May 1988): 32-35.

A study of the geometric concept of similarity revealed that many students do not understand it nor can they use its properties. Activities to assist students in developing this concept are included. (A)

Lappan, Glenda, William Fitzgerald, Mary Jean Winter, and Elizabeth Phillips. *Middle Grades Mathematics Project: Similarity and Equivalent Fractions.* Menlo Park, CA: Addison-Wesley, 1986.

One in a series of five teacher source books in the Middle Grades Mathematics Project (MGMP). Funded by the National Science Foundation, MGMP is a curriculum program developed at Michigan State University designed to develop students' problem-solving skills via activity-oriented mathematics. The remaining four in the series include Mouse and Elephant: Measuring Growth, Factors and Multiples, Spatial Visualization, and Probability. Each book contains exciting activities complete with worksheets and materials, review problems, tests, answer sheets, and answer keys. (A, C)

Learning by Doing: A Manual for Teaching and Assessing Higher-Order Thinking in Science and Mathematics. Princeton, NJ: Educational Testing Service, 1987.

Citing the need of schools to teach higher-order thinking skills, NAEP developed and pilot tested a series of hands-on science and mathematics tasks to assist teachers in achieving that goal. This book is a selected compilation of examples of appropriate tasks. (A, B, C)

Leinhardt, Gaea. "Expertise in Mathematics Teaching." *Educational Leadership* 43, no. 7 (April 1986): 28-33.

Discusses research on what makes an expert teacher. Includes a profile of one "expert." (G, H)

Lindquist, Mary Montgomery, ed. *Learning and Teaching Geometry, K-12: 1987 Yearbook.* Reston, VA: National Council of Teachers of Mathematics, 1987.

Examines current perspectives on teaching geometry in the schools, how geometry is linked with problem solving, some proven teacher activities, how geometry relates to other mathematical areas, and how to prepare teachers to teach geometry. (A)

Litwiller, Bonnie H., and David R. Duncan. *Activities for the Maintenance of Computational Skills and the Discovery of Patterns.* Reston, VA: National Council of Teachers of Mathematics, 1980.

Consists of field-tested, non-routine classroom activities that may be used to reinforce basic skills in addition, subtraction, multiplication, and the hundred square, as well as pattern development. Many activities are appropriate for calculator use. An answer key and brief discussion are included at the end of each chapter. (A)

Maletsky, Evan M., and Christian R. Hirsch, eds. *Activities from the Mathematics Teacher.* Reston, VA: National Council of Teachers of Mathematics, 1981.

A compilation of activities reprinted from the *Mathematics Teacher.* Appropriate for grades 7-12, activities include topics in computational skills, calculator use, geometry, measurement, and problem solving. Nice supplementary resource to have in the classroom. (A, B)

Maletsky, Evan M., ed. *Teaching with Student Math Notes.* Reston, VA: National Council of Teachers of Mathematics, 1987.

The *NCTM Student Math Notes* is a student periodical published five times a year with the *NCTM News Bulletin.* This book, highly recommended by teachers, provides reproductions of each four-page issue along with teacher notes, detailed solutions, suggested extensions, and additional worksheets. (A)

Mason, John, Leone Burton, and Kaye Stacey. *Thinking Mathematically.* Reading, MA: Addison-Wesley, 1982.

A manual for students exploring mathematical processes and thinking, not mathematical content. The reader is required to get actively involved with the material. The final chapter presents 100 questions to further stimulate growth and development in mathematical thinking. (C, E, F)

Math Matters: Kids Are Counting on You. Chicago: The National PTA, 1989.

A packet designed to get parents involved in their children's mathematics education (right on the kitchen table!). Contains a video, a calculator, planning guide, posters, stickers, and seventy home-helper activities. (H)

Meyers, Marcee J. and Grace M. Burton. "Yes You Can. Plan Appropriate Instruction for Learning Disabled Students." *Arithmetic Teacher* 36, no. 7 (March 1989): 46-50.

Helps teachers understand learning disabilities and provides instructional guidelines for teachers working with students who have visual-processing, auditory-processing, kinesthetic, and reasoning deficits. Ways to plan appropriate mathematics instruction for these students are also discussed. (D)

Middle Level Education's Responsibility for Intellectual Development. Reston, VA: National Association of Secondary School Principals, 1989.

Considers the contemporary and emerging issues involved in dealing responsively with young adolescent intellectual developmental needs. Asserts that the nurture and education of young adolescents must be an integrated venture since the physical, social, emotional, and intellectual realms are inexorably intertwined. (D)

Morris, Janet. *How to Develop Problem Solving Using a Calculator*. Reston, VA: National Council of Teachers of Mathematics, 1981.

A collection of 24 mathematics activities designed to help students develop problem-solving techniques and strategies using a basic four-function calculator. Each activity can be easily duplicated for use in the classroom, with either individuals or groups of children. Also describes the fundamentals of teaching problem-solving. (B, C)

National Council of Teachers of Mathematics. *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: 1989.

The product of a several-year study by an NCTM-sponosred Commission on Standards for School Mathematics, this volume establishes a broad framework to guide reform in school mathematics. It sets standards for kindergarten through twelth grade mathematics curricula and for evaluating the quality of the curriculum and of student achievement. It contains practical examples of activities teachers can use with students to meet the standards described. (All)

National Council of Teachers of Mathematics. *Professional Standards for Teaching Mathematics*. Reston, VA: 1991.

The *Professional Standards* describe a vision of teaching practice that complements NCTM's *Curriculum and Evaluation Standards for School Mathematics*, expanding alternative meanings and making explicit new images of mathematics teaching and learning. Models of practice are illustrated through annotated vignettes of classrooms in which teachers confront and analyze realistic challenges of implementing the goals and standards of the mathematics reform agenda. (All)

Newman, Joan. "Adolescents: Why They Can Be So Obnoxious." *Adolescence* 20 (1985): 635-645.

Describes a number of adolescent behaviors which parents and educators find obnoxious. Explains why normal adolescents engage in such behavior at certain periods in their development, taking into account inconsistencies in normal adolescent development. Offers suggestions for dealing positively with the sometimes difficult and exasperating behavior of adolescents. (D)

Oakes, Jeannie. *Keeping Track: How Schools Structure Inequality*. New Haven: Yale University Press, 1985.

Questions the pervasive practice of tracking students according to ability level. Clear differences exist between upper and lower tracks in regard to the content and quality of instruction, teacher-student, student-student relationships, the expectations of teachers for their students, the affective climate of classrooms, and other elements of the educational enterprise, all resulting in the likelihood that tracking limits students' opportunities to learn. (D)

Orton, Anthony. *Learning Mathematics: Issues, Theory, and Classroom Practice*. London: Cassell, 1987.

An introduction to the study of learning mathematics which addresses the following questions: (1) Do teachers of mathematics need theories? (2) What cognitive demands are made in learning mathematics? (3) Must we wait until pupils are ready? and (4) How should mathematics be taught? (A-I)

Pimm, David. *Speaking Mathematically: Communication in Mathematics Classrooms*. London: Routledge, 1987.

Examines the teaching of mathematics from the perspective of mathematics as a language. Claims that seeing mathematics and its teaching in linguistic terms can illuminate many events which occur daily in mathematics classes and can allow important questions to be asked which may not have been previously apparent or even seemed reasonable. (A)

Post, Thomas R., ed. *Teaching Mathematics in Grades K-8: Research Based Methods*. Boston: Allyn and Bacon, 1988.

Contributions from various writers integrate current research with ideas and activities that can be used by the elementary or junior high/middle school mathematics teacher. (A-I)

Presseisen, Barbara Z. *Thinking Skills: Research and Practice*. Washington, DC: National Education Association, 1986.

Reviews the large body of research on the teaching of thinking skills. Focuses on three topics: (1) various kinds of thinking, (2) influences on thinking and learning, and (3) teaching of thinking. Includes an extensive bibliography. (A, C)

Presseisen, Barbara Z., ed. *At Risk Students and Thinking Perspectives from Research*. Washington, DC: National Education Association, 1988.

Explores the difficulties and problems encountered in teaching thinking skills (problem solving, critical examination of issues, inventing solutions) to at-risk students. (A-D)

Prevost, Fernand J. "Algebra Isn't the Answer: Alternatives to Enrich Eighth Grade Mathematics." In *Schools in the Middle*. Reston, VA: National Association of Secondary School Principals, March 1988.

Examines the question, "Is algebra necessary for the enrichment of the eighth-grade classroom?" Reviews the studies that address this question and concludes that enrichment mathematics courses may provide a satisfying alternative to accelerated algebra courses in most eighth-grade classrooms. (B, F)

Resnick, Lauren B., and Leopold E. Klopfer. *Toward the Thinking Curriculum: Current Cognitive Research*. Alexandria, VA: Association for Supervision and Curriculum Development, 1989.

Combines the two major trends/concerns impacting the future of educational development for the next decade: knowledge and thinking. Integrates these two educational necessities rather than polarizing them. Contributions from theorists, practictioners, and scholars offer both research and practical ideas. (D)

Reys, Robert, Marilyn Suydam, and Mary Lindquist. *Helping Children Learn Mathematics*. Old Tappan, NJ: Prentice Hall, 1989.

A revised introduction to the challenges of using a developmental perspective to teach mathematics to young people. Summarizes the latest research on mathematics teaching and learning and suggests practical applications for this knowledge in the classroom. (A-D)

Rich, Dorothy. *Schools and Families: Issues and Action.* Washington, DC: National Education Association, 1987.

An easy-to-read guide describing programs and policies for anyone interested in helping families contribute to and support educational programs. (H)

Roberts, N., and M. Carter. *Integrating Computers into the Elementary and Middle School.* Englewood Cliffs, NJ: Prentice Hall, 1988.

Summarizes available software and suggests how it can be best integrated into language arts, mathematics, social studies, and science curricula. Includes creative uses teachers have found for commonly available spreadsheets and databases. (B)

Rubin, Nancy. "Math Stinks!" *Parents* 63, no. 6 (June 1988): 132-6, 207-8, 212.

Examines possible explanations for girls' being less likely than boys to excel in mathematics, citing in particular lack of encouragement and confidence. Offers parents suggestions for "taking the misery out of math." (D)

Russell, Susan Jo, Friel, Susan, and Corwin, Rebecca (Developers). *Used Numbers: Real Data in the Classroom.* Palo Alto, Calif: Dale Seymour Publications, 1990.

A new series of practical mathematics challenges designed to focus on the proccess of data analysis--collecting, organizing, repreesenting, and interpreting data. Incorporating experiences students typically encounter in their daily lives, the *Used Numbers* materials enable students to become critical and intelligent analysts and users of data-based information. (A-F)

Schoen, Harold. *Estimation and Mental Computation: 1986 Yearbook.* Reston, VA: National Council of Teachers of Mathematics, 1986.

Focuses on estimation and mental computation. Due to advances in calculator and computer technology, estimation and mental computation are more important than ever before in the teaching of mathematics. (A)

Schwartz, Wendy. "Teaching Science and Mathematics to At-Risk Students." *Equity and Choice* 4, no. 2 (Winter 1988): 39-45.

Discusses five factors that account for differences in student achievement as well as ways to promote higher achievement of at-risk students. (D)

Shalaway, Linda. "Technology: Promise Becomes Practice?" *R&D Notes* (November, 1985): 7-9.

Describes some of the many uses and advantages of calculators and computers in the classroom. (B, D)

Shockley, Robert. "A Few Instructional Practices You Can Trust." *Middle School Journal* 17, no. 4 (1986): 18-20.

After cautioning the reader that most studies on effective teaching have been done at the elementary and secondary levels, Shockley describes some strategies appropriate for teaching young adolescents. (B, E)

Singer, I. M. "Mathematics." In *The Joys of Research*, edited by Walter Shropshire. Washington, DC: Smithsonian Institute Press, 1981.

Singer discusses the influences of Albert Einstein on his life and the role of mathematics in his work. (B)

Skolnick, Joan, Carol Langbort, and Lucille Day. *How to Encourage Girls In Math & Science.* Englewood Cliffs, NJ: Prentice-Hall, 1982.

Provides both parents and educators with background on the extent to which sex role socialization affects girls' participation in mathematics and science. Also presents educational strategies and activities designed to encourage girls in mathematics and science. (D, E)

Smith, Michael K. "Why is Pythagoras Following Me?." *Phi Delta Kappan* 70 (February 1989): 446-454.

A controversial argument in favor of *decreasing* mathematics requirements in U.S. high schools. Smith believes existing courses often cause more harm than good by creating mathematics anxiety and that students who freely choose to take more than one year of basic mathematics will be motivated to succeed in a way that students "coerced" to take algebra, geometry, and trigonometry/precalculus will never be. (A)

Smith, Stuart C., and James J. Scott. *The Collaborative School: A Work Environment for Effective Instruction.* Reston, VA: NASSP, 1990.

Synthesizes much of the significant work on collaboration as a strategy for improving the instructional effectiveness of a school's faculty. (D, G)

Stenmark, Jean Kerr. *Assessment Alternatives in Mathematics: An overview of assessment techniques that promote learning*. Berkeley, CA: University of California, 1989.

A brief overview of current trends in assessment written for teachers, administrators, and parents. Clearly presents and illustrates some ways to assess authentic achievement. The implications are that students should be working on worthwhile investigations or tasks and that their success should be evaluated in ways that make sense. (I)

Stenmark, Jean Kerr, Virginia Thompson, and Ruth Cossey. *Family Math*. Berkeley, CA: Lawrence Hall of Science, 1986.

A collection of activities for parents to use with their children to help students improve their mathematics skills and gain an appreciation for mathematics. (E, F, H)

Stenmark, Jean Kerr. "Family Math." In *Out of School Mathematics Education*, edited, by Robert Morris. Paris: UNESCO, 1987.

A brief introduction to the Family Math program developed by the Lawrence Hall of Science at the University of California at Berkeley. The program gives parents, together with their children, opportunities to develop their problem-solving skills and to understand the mathematical concepts their children need to know. (E, F, H)

Stevenson, Harold W. "America's Math Problems." *Educational Leadership* 45, no. 2 (1987): 4-10.

In a study of the performance of first and fifth graders in Chicago, Stevenson found that American children were doing poorly in comparison to their peers in China and Japan. He concludes that Americans do not believe there is a mathematics problem, a situation that only worsens the issue. (A, I)

Stevenson, Harold. *Making the Grade in Mathematics.* Reston, VA: National Council of Teachers of Mathematics, 1990.

A monograph reporting on the same research outlined in "America's Math Problems" (above). Large differences between American students and their Japanese and Chinese peers led researchers to inquire about their lives at school and at home. They discerned differences in experience which may help explain the poor performance of American children. (A, I)

Summers, George J. *The Great Book of Mind Teasers and Mind Puzzlers.* New York: Sterling, 1985.

A collection of puzzles that require logic and reasoning to reach the correct solution. Provides a discussion and answer section to help the reader tackle the problems. (C, E)

Suydam, Marilyn. "Manipulative Materials and Achievement." *Arithmetic Teacher* 33, no. 6 (February 1986): 10, 32.

A review of the research supporting the use of manipulative materials to improve mathematics achievement. (B, D)

Tjart, Emerson S. "Questioning Skills Are Important - And They Can Be Improved." *American Middle School Education* 8, no. 4 (Fall 1985): 25-37.

Discusses the importance of using effective questioning skills in the classroom and cites significant studies to support that conclusion. Includes a list of nine effective questioning procedures with supporting research. (A, B)

Tobias, Sheila. *Succeed With Math: Every Student's Guide to Conquering Math Anxiety.* New York: The College Board, 1987.

Written for students who want to conquer mathematics anxiety and become proficient in mathematics. Concentrates on getting mathematics into focus, thinking about mathematics in new ways, and transferring school mathematics to the real world. (E, F)

Turkle, Sherry. *The Second Self: Computers and the Human Spirit.* New York: Simon and Schuster, 1984.

Addresses the complex interrelationships between people and computers, including how computers affect the way children grow up. Of particular interest is a chapter entitled "Adolescence and Identity: Finding Yourself in the Machine." (D,E,F)

Whimbey, Arthur, and Jack Lochhead. *Beyond Problem Solving: An Exploration of Quantitative Reasoning.* Hillsdale, NJ: Lawrence Erlbaum, 1984.

Explores aspects of quantitative reasoning the authors feel the educated citizen of the twenty-first century will need. Presents the pair problem solving method which involves two people working together on problems, with each person having a specific role as problem solver or listener. Helps readers analyze problems that frequently occur on educational tests such as the Preliminary Scholastic Aptitude Test and the Scholastic Aptitude Test. (C)

SUPPORTING STUDENT DIVERSITY IN MIDDLE-GRADES MATHEMATICS PROGRAMS

...And Justice for All. Washington, DC: National Education Association, 1987.

A collection of four reports by the NEA Executive Committee Study Group on Ethnic Minority Concerns investigating the educational needs of American Indians/Alaskan Natives, Asian and Pacific Islanders, Blacks, and Hispanics. Each report provides an overview of the minority's experience in American society and presents findings and recommendations in such areas as curriculum, parents/community, employment, and legislation. (D)

Beane, DeAnna B. *Mathematics and Science: Critical Filters for the Future of Minority Students.* Washington, DC: Mid-Atlantic Center for Race Equity, 1985.

A comprehensive presentation of factors influencing minority student participation and performance in mathematics and science courses. Provides a summary of the barriers to achievement along with practical, teacher-oriented suggestions for adjustments that can be easily made to support more sensitive and responsive mathematics and science programs. (D, I)

Bishop, Alan J. *Mathematical Enculturation: A Cultural Perspective on Mathematics Education.* The Netherlands: Kluwer Academic Publishers, 1988.

Examines mathematics education from a cultural perspective, applies this theory to today's mathematics curriculum, and describes implications for the teaching process and teacher preparation. (G)

Clark, Reginald. *Family Life and School Achievement.* Chicago: University of Chicago Press, 1983.

Reports on case studies of ten poor, urban, Black families of high and low academic achievers and reveals what aspects of family life influence children's success in school. Suggests strategies for teachers, parents, schools, and social policy makers. (D)

Cocking, Rodney R., and Jose P. Mestre, eds. *Linguistic and Cultural Influences on Learning Mathematics.* Hillsdale, NJ: Lawrence Erlbaum, 1988.

A collection of research bringing the study of mathematics learning into the real world of schools, culture, and bilingualism. Its diverse chapters, drawing on many scholarly disciplines, explore these and other factors that make the learning of mathematics so difficult in American schools. (D)

The College Board. *Get Into The Equation: Math and Science, Parents and Children.* New York: The College Board, 1987.

A pamphlet encouraging parents, especially minority parents, to be actively involved in their children's mathematics and science education. Discusses what students need and what parents can do to help their children succeed in science and mathematics. (H)

Comer, James P. "Educating Poor Minority Children." *Scientific American* 259, no. 5 (November 1988): 42-48.

Describes a successful Yale University school improvement program which was developed in a New Haven inner-city school. The program calls for winning the support of parents, responding to student needs flexibly and creatively, and comprehensive school planning. (F, H)

Cummins, Tim. "Empowering Minority Students: A Framework for Intervention." *Harvard Educational Review* 56, no. 1 (February 1986): 18-36.

Presents a theoretical framework for analyzing minority student school failure and the relative lack of success of previous attempts at educational reform such as compensatory education and bilingual education. Suggests ways in which educators can promote the empowerment of students and lead them to succeed in school. (D)

Delpit, Lisa. "The Silenced Dialogue: Power and Pedagogy in Educating Other People's Children." *Harvard Educational Review* 58 (August 1988): 280-298.

Uses the debate over process-oriented versus skills-oriented writing instruction in considering how to best meet the educational needs of Black and poor students. Examines the "culture of power" that exists in society in general and in the educational environment in particular. (D)

Dorsett, Beryl. "Knowledge of Science Vital for All Children." *Education Week* 8, no. 2 (Nov. 23, 1988): 21-22.

Sound instruction in mathematics, science, and technology must be part of every student's education due to the increasing number of jobs related to advanced computer and electronics technology. Demographic trends suggest the importance of drawing more women and minority students into science and mathematics. (F)

Education That Works: An Action Plan for the Education of Minorities. Cambridge, MA: Quality Education for Minorities Project, 1990.

Presents examples of education that work and lays out a series of strategies for institutionalizing these successful approaches. Argues that we know what the problems are and what to do about them; what is lacking is the leadership, commitment, resources, and wisdom to move forward. (D)

Edwards, Carol. "Project MiCRO: Integrating Theory, Research and Practice: How an Intervention Program in Educational Computing for Middle School Minorities and Females Meets the Challenge." Paper presented at the American Education Research Association Annual Conference, San Francisco, 1989.

Project MiCRO aims to: (1) develop a model to teach critical thinking skills through microcomputer-based activities to minority and economically disadvantaged seventh- and eighth-grade youngsters; (2) equitably deliver computer literacy skills to the target population; and (3) interest students in technology and science course selection in high school. (B, D)

Gardner, April L., Cheryl L. Mason, and Marsha Lakes Matyas. "Equity, Excellence, and 'Just Plain Good Teaching.'" *The American Biology Teacher* 51, no. 2 (February 1989): 72-77.

Discusses how "equity" and "excellence" in science teaching encourage *all* students (men, women, and minority students) to participate and learn in the science classroom. Provides selected teaching strategies and activities designed to improve student achievement and motivation in the classroom. (E, F)

Hart, Laurie, and George M.A. Stanic. "Attitudes and Achievement-Related Behaviors of Middle

School Mathematics Students: Views Through Four Lenses" Paper presented at the American Education Research Association Annual Conference, San Francisco, 1989.

Considers gender and race differences in mathematics success by examining the attitude of confidence and the achievement-related behavior of persistence. (D, E)

Heath, Shirley Brice. "Oral and Literate Traditions Among Black Americans Living in Poverty." *American Psychologist* 44, no. 2 (February 1989): 367-373.

Current changes in the need for language use in the workplace call for greater adaptability, collaborative skills, and individual responsibility and commitment. These changing workplace needs raise educational problems for both mainstream and minority populations. (D)

Jackson, Allyn. "Minorities in Mathematics: A Focus on Excellence, Not Remediation." *American Educator* 12, no. 1 (Spring 1989): 22-27.

From careful analysis of the study patterns of Black and Chinese mathematics students at the University of California at Berkeley, Uri Treisman developed the Mathematics Workshop, which has been highly effective in improving the performance of minority students in calculus. The success of the workshop, which is based on collaboration and emphasizes excellence rather than remediation, has far-reaching implications for all teachers. (D)

Jones, Reginald L., ed. *Black Adolescents*. Berkeley, CA: Cobb & Henry, 1989.

Looks holistically and eclectically at the Black adolescent. Includes historical perspectives on Black youth, physical and mental health, psychosocial development and socialization, educational issues and programs, and counseling and psychotherapy. (D)

Kochman, Thomas. *Black and White: Styles in Conflict*. Chicago: University of Chicago Press, 1981.

Unveils the differences in Black and White cultural styles that lead to miscommunication and conflict. (D)

Kunjufu, Jawanza. *Countering the Conspiracy to Destroy Black Boys Vols. I and II*. Chicago: African American Images, 1985, 1986.

Articulates the belief that the system of American racism and oppression begins to cripple African-American males during their childhood so that when they reach adulthood they are socially, physically, and politically impotent. Offers many examples suggestions for ensuring that African-American boys grow up to be strong, committed, and responsible adults. Volume II includes a chapter on "Female Teachers and Black Male Children." (D)

Kunjufu, Jawanza. *Developing Positive Self-Images and Discipline in Black Children*. Chicago: African American Images, 1984.

A manual for teachers, parents, and educational researchers on providing a relevant, stimulating, and enabling education for Black children. Advocates an holistic approach. (D)

Kunjufu, Jawanza. *To Be Popular or Smart: The Black Peer Group*. Chicago: African American Images, 1988.

Provides a sophisticated analysis of the belief system wherein intellectual achievement is equated with whiteness. Chapters directed at students, parents, teachers, and community members offer suggestions for battling the crisis of low academic success among African-American Youth. (D)

Locust, Carol. "Wounding the Spirit: Discrimination and Traditional American Indian Belief Systems." *Harvard Educational Review* 58 (August 1988): 315-330.

Argues that fundamental differences exist between the belief systems of American Indians and those of non-Indians, and that the lack of knowledge about these belief systems on the part of the U.S. educational system has led to discriminatory treatment of American Indian students. Concludes that educators must understand and respect American Indian belief systems before they can begin to improve the educational experiences of American Indian children. (D)

Making Mathematics Work for Minorities. Washington, DC: Mathematical Sciences Education Board, 1990.

The Mathematical Sciences Education Board convened six regional workshops at which leaders in specific areas addressed the problems of minorities in mathematics. Their recommended actions are compiled in this volume. (D)

Matthews, Westina. "Influences on the Learning and Participation of Minorities in Mathematics." *Journal for Research in Mathematics Education* 15, no. 2 (1984): 84-92.

Reviews the literature on minorities in mathematics and identifies three potential variables (parents, students, and school) that could influence how minorities learn mathematics. Suggests directions for future research. (D)

McCarthy, Cameron. "Rethinking Liberal and Radical Perspectives on Racial Inequity in Schooling: Making the Case for Nonsynchrony." *Harvard Educational Review* 58 (August 1988): 265-279.

Analyzes the mainstream and neo-Marxist explanations of racial inequality in schools, arguing that the theoretical stance of the former depicts racial factors as manipulable variables tied to beliefs, values, and psychological differences while the latter position subsumes issues of race relations into socioeconomic interests. Presents the alternative of a nonsynchronous theory of schooling that begins to explain the interaction of race, gender, and class within the economic, political, and social environments as they differentially function within the daily practices of schooling. (D)

Miller-Jones, Dalton. "Culture and Testing." *American Psychologist* 44 (February 1989): 360-366.

Examines the limitations of standardized tests in assessing the underlying cognitive processes of individuals not from mainstream Anglo-American backgrounds. (D)

Moses, Robert P., et al. "The Algebra Project: Organizing in the Spirit of Ella." *Harvard Educational Review* 59, no. 4 (November 1989): 423-443.

Analyzes the unique impact of civil rights organizing on the grassroots effort of a community activist parent, Robert Moses, to ensure that every student studies algebra at the middle-school level. (D)

Neira, Christian. "Building 860." *Harvard Educational Review* 58 (August 1988): 337-342.

Autobiographical piece relating a student's experience living in two worlds: a New York housing project and an elite preparatory school. In a single day he confronts the poverty of his neighborhood and struggles against stereotypic attitudes and beliefs at school. (D)

Neisser, Ulric. *The School Achievement of Minority Children: New Perspectives.* Hillsdale, NJ: Lawrence Erlbaum, 1986.

A compilation of classic articles that address the complex issue of minority achievement. Presents a range of ideas about group differences: what they are about, why they occur, and how they can be used beneficially for students' successful achievement in school. Although the chapters are based on papers originally written for a 1982 conference, they are a rich resource for understanding diverse issues that affect learning among minority students in American schools. (D)

Oakes, Jeannie. *Keeping Track: How Schools Structure Inequality.* New Haven: Yale University Press, 1985.

Questions the pervasive practice of tracking students according to ability level. Clear differences exist between upper and lower tracks in regard to the content and quality of instruction, teacher-student, student-student relationships, the expectations of teachers for their students, the affective climate of classrooms, and other elements of the educational enterprise, all resulting in the likelihood that tracking limits students' opportunities to learn. (D)

Orr, Eleanor Wilson. *Twice as Less: Black English and the Performance of Black Students in Mathematics and Science.* New York: W.W. Norton and Company, 1987.

Explores the relationship between language (specifically, Black vernacular) and success in mathematics and science. Written by a White school administrator, this controversial book is based on a premise considered racist by some critics. (D)

Pang, Valerie Ooka. "Ethnic Prejudice: Still Alive and Hurtful." *Harvard Educational Review* 58 (August 1988): 375-379.

Describes the existence of ethnic prejudice in the education community and examines the process by which the author became aware of such prejudice. Her reflection of how prejudicial beliefs are unintentionally reinforced in our classrooms uncovers the need for self-examination in the educational community. (D)

Perry, Imani. "A Black Student's Reflection on Public and Private Schools." *Harvard Educational Review* 58 (August 1988): 332-336.

A fifteen-year-old high school student, interprets her experiences in both public and private schools. Rich examples support the argument that, in her experience, public schools deny students their identities as intellectual beings, and repress the intellectual development of minority students in particular. Private schools, on the other hand, are culturally isolating for minority students. (D)

Powell, Gloria Johnson, ed. *The Pychosocial Development of Minority Group Children.* New York: Bruner/Mazel, 1983.

Provides educators and human service practitioners with an understanding of the social and emotional needs of minority children. Includes six sections: health issues, psychosocial development, family life patterns, mental health issues, educational issues, and research and social policy issues. (D)

Presseisen, Barbara Z., ed. *At Risk Students and Thinking Perspectives from Research*. Washington DC: National Education Association, 1988.

A collection of essays exploring the difficulties and problems encountered in teaching thinking skills (problem solving, critical examination of issues, inventing solutions) to at-risk students. (D)

Schwartz, Wendy. "Teaching Science and Mathematics to At-Risk Students." *Equity and Choice* 4, no. 2 (Winter 1988): 39-45.

Discusses five factors that account for differences in student achievement as well as ways to promote higher achievement of at-risk students. (D)

Strickland, Dorothy S., and Eric J. Cooper, eds. *Black Children: America's Challenge*. Washington, DC: Bureau of Educational Research, School of Education, Howard University, 1987.

The National Conference on Educating Black Children collected these essays which consider the effects of school policy, teaching methods, classroom experiences, and home environment on the education of African American children. (D)

Sue, Derald Wing. *Counseling the Culturally Different: Theory and Practice*. New York: John Wiley, 1981.

Part of an effort by the American Psychological Association to provide relevant counseling and therapy to all cultural groups in American Society. Discusses case examples and includes chapters on counseling Asian Americans, Blacks, Hispanics, and American Indians. (D)

Taylor, Orlando L. *Cross-Cultural Communication: An Essential Dimension of Effective Education*. Washington, DC: Mid-Atlantic Center for Race Equity, 1987.

Considering the communication problems between teachers and students that can develop due to cultural differences, this pamphlet helps teachers find classroom behaviors that affirm rather than devalue minority students' culture. (D)

Tharp, Roland. "Psychocultural Variables and Constants: Effects on Teaching and Learning in Schools." *American Psychologist* 44 (February 1989): 349-359.

Considers the following psychocultural variables in educational underachievement: (1) social organization, (2) sociolinguistics, (3) cognition, and (4) motivation. Reviews evidence for the effectiveness of culturally compatible education, finding it to be generally positive. (D)

SERVING GIRLS IN MIDDLE-GRADES MATHEMATICS PROGRAMS

A Mindset for Math: Techniques for Working With Math-Anxious Girls. Newton, MA: WEEA Publishing Center, 1987.

A program designed for eighth- to tenth-grade girls which first determines their mathematics anxiety and mathematics achievement levels then designs a plan to reduce anxiety and improve attitudes toward and achievement in mathematics. (D)

Brush, Lorelei R. *Encouraging Girls in Mathematics: The Problem and the Solution.* Cambridge, MA: Abt Books, 1980.

Presents the results of a longitudinal study on gender differences in students' desire to participate in mathematics. Clearly presents the problem of girls in mathematics and provides practical suggestions designed to help mathematics teachers address the problem. (E)

Burton, Leone, ed. *Girls Into Maths Can Go.* London: Holt, Rinehart and Winston, 1986.

A British collection including chapters written by academics and practitioners for a general readership. Presents a current picture of the state of thinking about gender issues in mathematics education. An appendix discusses significant women in the history of mathematics. (D)

Dorsett, Beryl. "Knowledge of Science Vital for All Children." *Education Week* 8, no. 2 (Nov. 23, 1988): 21-22.

Sound instruction in mathematics, science, and technology must be part of every student's education due to the increasing number of jobs related to advanced computer and electronic technologies. Demographic trends suggest the importance of drawing more women and minority students into science and mathematics. (F)

Downie, Diane, Twila Slesnick, and Jean Kerr Stenmark. *Math for Girls and Other Problem Solvers.* Berkeley, CA: Lawrence Hall of Science, 1981.

A collection of problem-solving activities requiring both physical and mental ability that were developed as part of Math For Girls. This Lawrence Hall of Science program was designed to give students hands-on experiences in logical thinking and problem solving to stimulate their curiosity and interest in doing mathematics. (B, C, E)

Frederick, Julie D., and Heather Nicholson. "'No Talking, Have Fun' and Other Mixed Messages: Naturalistic Research in Girls Clubs of America's Operation SMART." Paper presented at the American Education Research Association Annual Conference, San Francisco, 1989.

A valuable exploration of the affective factors in girls' experiences with mathematics and science and the covert messages from adults which inform them. From observations at Girls' Clubs and schools in three diverse geographic locations, researchers draw conclusions with wide implications for encouraging girls' pursuit of mathematics and science, particularly on the importance of viewing mistakes positively as opportunities for learning. (D, E)

Gardner, April L., Cheryl L. Mason, and Marsha Lakes Matyas. "Equity, Excellence, and 'Just Plain Good Teaching.'" *The American Biology Teacher* 51, no. 2 (February 1989): 72-77.

Discusses how "equity" and "excellence" in science teaching encourage *all* students (men, women, and minority students) to participate and learn in the science classroom. Provides selected teaching strategies and activities designed to improve student achievement and motivation in the classroom. (E, F)

"Girls' Math Achievement: What We Do and Don't Know." *Harvard Education Letter* 2, no. 1 (January 1986): 1-5.

Discusses gender differences in mathematics achievement, including: (1) when and where they appear, (2) biological factors, (3) differences in experiences in the classroom, and (4) intervention strategies. (D)

Oakes, Jeannie. *Keeping Track: How Schools Structure Inequality.* New Haven: Yale University Press, 1985.

Questions the pervasive practice of tracking students according to ability level. Clear differences exist between upper and lower tracks in regard to the content and quality of instruction, teacher-student, student-student relationships, the expectations of teachers for their students, the affective climate of classrooms, and other elements of the educational enterprise, all resulting in the likelihood that tracking limits students' opportunities to learn. (D)

Operation SMART. Indianapolis, IN: Girls Clubs of America, 1988.

Operation SMART (Science, Math, and Relevant Technology) is an after-school program for girls emphasizing career exploration, decision-making, problem-solving, and critical thinking. The program is designed to make science and mathematics fun and gives girls opportunities for participatory, hands-on experiences. (B, D)

Rubin, Nancy. "Math Stinks!" *Parents* 63, no. 6 (June 1988): 132-6, 207-8, 212.

Examines possible explanations for girls' being less likely than boys to excel in mathematics, citing in particular lack of encouragement and confidence. Offers parents suggestions for "taking the misery out of math." (D)

Skolnick, Joan, Carol Langbort, and Lucille Day. *How to Encourage Girls In Math & Science.* Englewood Cliffs, NJ: Prentice-Hall, 1982.

Provides both parents and educators with background on the extent to which sex role socialization affects girls' participation in mathematics and science. Also presents educational strategies and activities designed to encourage girls in mathematics and science. (D, E)

Tobias, Sheila. *Succeed With Math: Every Student's Guide to Conquering Math Anxiety.* New York: The College Board, 1987.

Written for students who want to conquer mathematics anxiety and become proficient in mathematics. Concentrates on getting mathematics into focus, thinking about mathematics in new ways, and transferring school mathematics to the real world. (E, F)

EARLY ADOLESCENCE: SELECTED REFERENCES ON DEVELOPMENT AND MATHEMATICAL COGNITION

Adelson, Joseph, ed. *Handbook of Adolescent Psychology*. New York: John Wiley & Sons, 1980.

A comprehensive volume of essays presenting ideas and findings from the research literature about adolescents. Discusses central processes common to adolescence in general, and examines significant variations in adolescence. Includes new information about values, moral development, biological research, and gifted adolescents. (D)

Baroody, Arthur J. *Children's Mathematic Thinking: A Developmental Framework for Preschool, Primary, and Special Education Teachers*. New York: Teachers College Press, 1987.

Presents educators with a framework for understanding children's learning of elementary mathematics; uses this psychological framework to generate guidelines for teaching; and provides specific activities, often in the form of games, to promote the learning and teaching of elementary mathematics. (D)

Bearison, David, and Herbert Zimiles, eds. *Thought and Emotion: Developmental Perspectives*. Hillsdale, NJ: Lawrence Erlbaum, 1986.

Addresses a broad range of general and specific issues offering new directions in our understanding of the developmental and reciprocal relationship between intelligence and affectivity. Suggests that neither intellectual nor emotional development can be studied independently of the other. (D)

Benson, Peter, Dorothy Williams, and Arthur Johnson. *The Quicksilver Years: The Hopes and Fears of Early Adolescence*. San Francisco: Harper & Row, 1987.

The Search Institute surveyed 8,000 fifth- to ninth-graders and 11,000 of their parents. This compilation of data deals with issues of adolescent development, behavior, social interaction, family communication, and parental influence, and contains many timely statistics and astute observations about young adolescents and their parents. (D)

Burton, Leone. "Mathematical Thinking: The Struggle for Meaning." *Journal for Research in Mathematics Education* 15 (1984): 35-49.

Adresses the questions: What is mathematical thinking? Can it be taught? What does it have to do with mathematical content? Emphasizes that mathematical thinking is not equivalent to thinking about the subject matter of mathematics. Presents a model of mathematical thinking with relevant questions and suggestions for an instructional approach using the model. (C)

Carpenter, Thomas P., James M. Moser, and Thomas A. Rombey, eds. *Addition and Subtraction: A Cognitive Perspective*. Hillsdale, NJ: Lawrence Erlbaum, 1982.

Presents theoretical views and research findings of a group of international scholars who are investigating the early acquisition of addition and subtraction skills by young children. Integrates psychology, educational psychology, and mathematics education. (D)

Cocking, Rodney R., and Jose P. Mestre, eds. *Linguistic and Cultural Influences on Learning Mathematics*. Hillsdale, NJ: Lawrence Erlbaum, 1988.

A collection of research bringing the study of mathematics learning into the real world of schools, culture, and bilingualism. Its diverse chapters, drawing on many scholarly disciplines, explore these and other factors that make the learning of mathematics so difficult in American schools. (D)

Collins, W. Andrew, ed. *Development During Middle Childhood: The Years from Six to Twelve*. Washington, DC: National Academy Press, 1984.

Examines middle childhood from the point of view of cognitive and physical development, focusing on three elements: distinctive characteristics compared with other age groups, new settings and changing relationships children this age encounter, and developmental difficulties. (D)

Csikszentmihalyi, Mihaly, and Reed Larson. *Being Adolescent: Conflict and Growth in the Teenage Years*. New York: Basic Books, 1984.

Presents the results of a survey wherein seventy-five teenagers carried beepers for one week and were asked to fill out questionnaires each time they were paged. Uses charts, graphs, and narrative material obtained from the questionnaires to portray the behavior, inner feelings, and daily activity of these adolescents. (D)

Davis, Robert B. *Learning Mathematics: The Cognitive Science Approach to Mathematics Education*. Norwood, NJ: Ablex, 1984.

Discusses mathematics education and what mathematics actually is, then presents an in-depth study of how people learn mathematics. (A-H)

Elkind, David. *All Grown Up & No Place to Go: Teenagers in Crisis*. Reading, MA: Addison-Wesley, 1984.

Discusses the consequences of rushing children into premature adulthood. Elkind describes the book as "child psychology for intelligent parents." (D)

Fuys, David, Dorothy Geddes, and Rosamond Tischler. *The Van Hiele Model of Thinking in Geometry Among Adolescents*. Reston, VA: National Council of Teachers of Mathematics, 1988.

Researchers conducted and analyzed interviews with sixth and ninth graders to investigate how they learn geometry in light of the Van Hiele model, in which learners, assisted by appropriate instructional experiences, pass through a fixed series of levels. (A)

Ginsburg, Herbert P., ed. *The Development of Mathematical Thinking*. New York: Academic Press, 1983.

Introduces the student and researcher in developmental and educational psychology, mathematics education, and cognitive science to the development of mathematical thinking. Approaches the subject from a variety of perspectives. (D)

Ginsburg, Herbert. *Children's Arithmetic: The Learning Process*. New York: D. Van Nostrand, 1977.

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Shows how children learn, do, and understand elementary mathematics, especially arithmetic, then demonstrates how this knowledge can be used to improve mathematics education and resolve children's difficulties in learning. Emphasizes the significant mathematics learning that takes place outside the school setting. (A, B, D)

Gunnar, Megan R., and W. Andrew Collins, eds. *Development During the Transition to Adolescence.* Hillsdale, NJ: Lawrence Erlbaum, 1988.

A collection of papers presented at the 21st Minnesota Symposium on Child Psychology which focused on child development during the transition to adolescence. Among the issues addressed are hormones and behavior at puberty, adapting to menarche, and the role of conflict in adolescent-parent relationships. (D)

Hill, John P. *Understanding Early Adolescence: A Framework.* Carrboro, NC: Center For Early Adolescence, University of North Carolina at Chapel Hill, 1980.

Helps the reader see young adolescents in the environments that are part of their daily lives -- schools, families, peer groups, and communities. In each of these settings, the young person undertakes vital developmental tasks that will lead to adulthood. Hill tells the concerned professional, parent, or policymaker what is known about the primary and secondary changes of early adolescence that lead to healthy growth and maturation. A bibliography is also included. (D)

Johnson, Mauritz, ed. *Toward Adolescence: The Middle School Years.* Chicago: University of Chicago Press, 1980.

A collection of essays exploring the wide spectrum of issues that affect adolescent growth and development. Covers the age group and their environment, discusses areas of intervention, and explains research methods. Also discusses the role of the middle school in adolescent development. (D)

Jones, Reginald L., ed. *Black Adolescents.* Berkeley, CA: Cobb & Henry, 1989.

Looks holistically and eclectically at the Black adolescent. Includes historical perspectives on Black youth, physical and mental health, psychosocial development and socialization, educational issues and programs, and counseling and psychotherapy. (D)

Juraschek, William. "Piaget and Middle School Mathematics." *School Science and Mathematics* 81, no. 1 (January 1983): 4-13.

Briefly examines Piaget's theory of cognitive development and discusses its relevance and application to middle school mathematics teaching. (A-D)

Lerner, Richard M. and Terryl T. Foch, eds. *Biological - Psychosocial Interactions in Early Adolescence.* Hillsdale, NJ: Lawrence Erlbaum, 1987.

An in-depth examination of the biological, psychological, and social changes that occur during the early adolescent period of development. Looks at both the theoretical and research-oriented issues of this period of life. (D)

Levine, Melvin D., and Elizabeth K. McAnarney, eds. *Early Adolescent Transitions.* Lexington, MA: Lexington Books, 1988.

A collection of presentations from a multidisciplinary symposium on Early Adolescent Transitions, representing a wide range of disciplines such as developmental psychology, pediatrics, education, public health, speech and language. Includes chapters on poverty, divorce and remarriage, maternal employment, reading disorders, and antisocial behavior. (D)

Middle Level Education's Responsibility for Intellectual De ·lopment. Reston, VA: National Association of Secondary School Principals, 1989.

Addresses the contemporary and emerging issues involved in dealing responsively with young adolescent intellectual developmental needs. Founded on the belief that the nurture and education of young adolescents must be an integrated venture since the physical, social, emotional, and intellectual realms are inexorably intertwined. (D)

Mosher, Ralph L., ed. *Adolescents' Development and Education: A Janus Knot.* Berkeley: McCutchan, 1979.

A collection of essays aiming "to present a summary of current developmental knowledge of adolescents and how they grow, as well as to describe and analyze some of the new educational programs intended to stimulate their growth." Later chapters describe the adolescent as student, and emphasize the role of education in the cognitive development of the age group. (D)

Newman, Joan. "Adolescents: Why They Can Be So Obnoxious." *Adolescence* 20 (Fall 1985): 635-645.

Describes a number of adolescent behaviors which parents and educators find obnoxious. Explains why normal adolescents engage in such behavior at certain periods in their development, taking into account inconsistencies in normal adolescent development. Offers suggestions for dealing positively with the sometimes difficult and exasperating behavior of adolescents. (D)

Powell, Gloria Johnson, ed. *The Psychosocial Development of Minority Group Children.* New York: Bruner/Mazel, 1983.

Provides educators and human service practitioners with an understanding of the social and emotional needs of minority children. Includes six sections: health issues, psychosocial development, family life patterns, mental health issues, educational issues, and research and social policy issues. (D)

Resnick, Lauren B. "Constructing Knowledge in School." In *Development and Learning: Conflict or Congruence?*, edited by L.S. Liben. Hillsdale, NJ: Lawrence Erlbaum, 1987.

Argues that the implied correlation between invention and understanding does not exist, that only certain errors are based on partial understanding that is en route to deep comprehension. Includes an interesting discussion on formal versus informal acquisition of knowledge, concluding that they are ultimately more alike than different. (D)

Resnick, Lauren B. "Developing Mathematical Knowledge." *American Psychologist* 4, no. 2 (1989): 162 - 169.

Outlines the development of mathematical concepts of number in infants and preschoolers, including implications for mathematics education. (D)

Resnick, Lauren B. *Education and Learning to Think.* Washington, DC: National Academy Press, 1987.

An exceptionally readable and comprehensive discussion of the illusive idea of "higher order" thinking, learning, and teaching. Based upon an exchange of ideas among leading cognitive psychologists, educators, scientists, and philosophers, it discusses what is variously meant by "higher order skills" and examines the implications of related issues for children's learning in schools. (C, D)

Resnick, Lauren B., and Wendy W. Ford. *The Psychology of Mathematics for Instruction*. Hillsdale, NJ: Lawrence Erlbaum, 1981.

Presents a history of psychologists' efforts to explain the development of mathematical thought processes and discussing how proper instruction can enhance mathematical learning. (A-D)

Resnick, Lauren B., and Leopold E. Klopfer. *Toward the Thinking Curriculum: Current Cognitive Research*. Alexandria, VA: Association for Supervision and Curriculum Development, 1989.

Combines the two major trends/concerns impacting the future of educational development for the next decade: knowledge and thinking. Integrates these two educational necessities rather than polarizing them. Contributions from theorists, practictioners, and scholars offer both research and practical ideas. (D)

Reys, Robert, Marilyn Suydam, and Mary Lindquist. *Helping Children Learn Mathematics*. Old Tappan, NJ: Prentice Hall, 1989.

A revised introduction to the challenges of teaching mathematics to young people from a developmental perspective. Provides easy-to-read summaries of the latest research on mathematics teaching and learning with practical suggestions of how to apply this knowledge in the classroom. (A-D)

Silver, Edward A., ed. *Teaching and Learning Mathematical Problem Solving: Multiple Research Perspectives*. Hillsdale, NJ: Lawrence Erlbaum, 1985.

A synthesis of the research on mathematical problem solving containing a set of papers presented at the San Diego State University conference on Teaching Mathematical Problem Solving: Multiple Research Perspectives. Summarizes the research, considers contributions made from fields other than education, and provides directions for future research. (C)

Simmons, Roberta G., and Blyth, Dale A. *Moving into Adolescence: The Impact of Pubertal Change and School Context*. New York: Aldine de Gruyter, 1987.

Compares psychosocial adjustment and school performance of young adolescents during the transition from childhood into adolescence. Examines gender and grade-level effects, the impact of pubertal timing and physical characteristics, the impact of the school environment, and the factors that mitigate or aggravate the early adolescent transition. Contains important information for anyone working with young adolescents. (D)

Skemp, Richard. *The Psychology of Learning Mathematics*. Hillsdale, NJ: Lawrence Erlbaum, 1987.

Explores in depth human intelligence and the learning of mathematics. Among the topics discussed in Part I are: concept formation, schema, symbols, intuitive and reflective intelligence and imagery. In Part II, a new model of intelligence is proposed. (A, G)

Steinberg, Laurence. *Adolescence (2nd ed.)*. New York: Knopf, 1989.

The newest edition of this popular textbook is divided into three main sections: the fundamental changes of adolescence, the contexts of adolescence, and psychosocial development during adolescence. Each chapter combines research and theory. (D)

Tanner, James M. *Fetus into Man: Physical Growth from Conception to Maturity.* Cambridge, MA: Harvard University Press, 1978.

Provides a comprehensive picture of physical growth to puberty along with a discussion of the psychological and sociological problems of early and late maturers. Tanner's growth charts are also included. (D)

Tanner, James M. "Issues and Advances in Adolescent Growth and Development." *Journal of Adolescent Health Care* 8, no. 6 (1987): 470-478.

An update from the author of the seminal text on the physical development of adolescents. Discusses tempo, a terms referring to the rate at which individuals mature. (D)

Tharp, Roland. "Psychocultural Variables and Constants: Effects on Teaching and Learning in Schools." *American Psychologist* 44 (February 1989): 349-359.

Considers the following psychocultural variables in educational underachievement: (1) social organization, (2) sociolinguistics, (3) cognition, and (4) motivation. Reviews evidence for the effectiveness of culturally compatible education, finding it to be generally positive. (D)

Archbald, Doug A., and Fred M. Newman. *Beyond Standardized Testing: Assessing Authentic Academic Achievement in the Secondary School.* Reston, VA: National Assocation of Secondary School Principals, 1988.

Offers a framework for systematically looking at educational assessment, reviews the uses and limitations of standardized achievement tests, and describes alternative methods of educational assessment. (I)

Assessing Excellence: A Guide for Studying the Middle Level School. Reston, VA: National Association of Secondary School Principals, 1988.

The third volume in the projected six-volume Agenda for Excellence at the Middle Level series. Describes the whole process of Middle School assessment, from asking the right questions to disseminating the results. (I)

Assessing Mathematics in 1990 by the National Assessment of Educational Progress. Washington, DC: Council of Chief State Officers, 1988.

In 1990, many states will participate in a nationwide assessment of mathematics that will allow state-to-state and state-to-nation comparisons. In anticipation of that event and the possible anxiety it may create, this report describes the mathematical abilities that the assessment will measure. (A, I)

Bennis, Warren, and Burt Nanus. *Leaders: The Strategies for Taking Charge.* New York: Harper & Row, 1985.

Contends that great leaders make great organizations. Provides 'new leaders' with the strategies necessary to create successful organizations. An easy-to-read guide for anyone interested in making an organization more effective. (I)

Berman, Paul, and Milbrey McLaughlin. *Federal Programs Supporting Educational Change: Vol. 8 Implementing and Sustaining Innovations.* Santa Monica, CA: Rand Corporation, 1978.

A study of federally-funded programs designed to introduce and spread innovative practices in public schools. Analyzes the institutional and project factors that promoted or deterred the continuation of the projects. This summary volume describes the process of change at the local level and discusses implications for federal policy.

Charles, Randall, Frank Lester, and Phares O'Daffer. *How to Evaluate Progress in Mathematical Problem Solving.* Reston, VA: National Council of Teachers of Mathematics, 1987.

Provides guidelines and specific ideas for teachers on evaluating student progress in problem solving. Examples are abundant. (C, I)

Crandall, David, and Susan Loucks. *People, Policies, and Practices Examining the Chain of School Improvement* Vol. X. Andover, MA: The Network, 1983.

Summarizes the Dissemination Efforts Supporting School Improvement project, a long-term study of the effects of federally-funded school improvement efforts. Suggests important considerations for both policy makers assisting schools change efforts and school people committed to effective and long-lasting improvement in their classrooms.

Curriculum and Evaluation Standards for School Mathematics. Reston, VA: National Council of Teachers of Mathematics, 1989.

The long awaited and highly acclaimed Curriculum and Evaluation Standards for School Mathematics is here! Contains the standards for mathematics curriculum and for evaluation of the curriculum and student achievement proposed by NCTM. An executive summary edition is available. (A-I)

Driscoll, Mark. *Stories of Excellence: Ten Case Studies from a Study of Exemplary Mathematics Programs.* Reston, VA: National Council of Teachers of Mathematics, 1987.

Describes programs chosen from 150 school programs noted for mathematics excellence, ranging from small, rural schools to large, urban schools, and elementary through high school grades. (A, I)

Editors. Special Education on Changing Mathematics in Schools. *Educational Evaluation and Policy Analysis 12*, no. 3 (Fall 1990).

This special edition on the impact of the national mathematics reform movement on changing classrooms teaching provides case studies and analyses of the dilemmas of mathematics improvement. The stories told, combined with the policy analyses presented, offer insight into the complexities teachers and change agents face as they seek to modernize mathematics teaching practice in American schools.

Fullan, Michael. *The Meaning of Educational Change.* New York: Teachers College Press; Toronto, OISE Press, 1982.

Establishes a theoretical framework for examining and describing the school change process based on extensive analysis of school change studies. Offers both practical and conceptual considerations for improvement.

Greenfield, William, ed. *Instructional Leadership: Concepts, Issues, and Controversies.* Newton, MA: Allyn & Bacon, Inc., 1987.

Twenty well-known educators write essays on successful instructional leadership and the creation of effective schools. (I)

Grossnickle, Donald R., and Frank P. Sesko. *Preventive Discipline for Effective Teaching and Learning.* Reston, VA: NASSP, 1990.

A brief, concise guide reviewing basic concepts and principles that can help teachers and administrators, as a team, support the school and classroom environment. Focuses on setting conditions that bring about the best in students' potential for learning. (D)

Hall, Gene E., and Shirley M. Hord. *Change in Schools: Facilitating the Process.*

The Concerns Based Adoption Model, or C-BAM, emphasizes the personal side of school improvement from the points of view of teachers, school administrators, and community participants. This book summarizes fifteen years of research and addresses the practical

questions of how educators and administrators can become more effective change facilitators. (G,I)

Hord, Shirley M., et al. *Taking Charge of Change*. Washington, DC: Association for Supervision and Curriculum Development, 1987.

A highly readable and practical guide for school practitioners to use as a supplement in planning and implementing school program innovations. Especially useful for both team members and team leaders who are participating in school change. (I)

Horsley, Susan Loucks, and Leslie F. Hergert. *An Action Guide to School Improvement*. Alexandria, VA: Association for Supervision and Curriculum Development and The NETWORK, 1985.

Presents a seven-step process to school improvement which is based on research as well as practical experience. A clearly written, practical guide to action-oriented school improvement. (I)

Johnson, David W., and Roger T. Johnson. *Leading the Cooperative School*. Edina, MN: Interaction Book Co., 1989.

Advocates demonstrating leadership by structuring work situations cooperatively, so that staff members work together to achieve shared goals. Contains a set of practical strategies for structuring cooperative teams. (D, G)

Joyce, Bruce, and Beverly Showers. *Student Achievement Through Staff Development*. White Plains, NY: Longman, Inc., 1988.

Describes a comprehensive staff development system for the support of educational personnel. (I)

Lieberman, Ann, ed. *Building a Professional Culture in Schools*. New York: Teachers College Press, 1988.

Selected articles by a group of influential practitioners and researchers involved in making schools places where teachers can work and teach more thoughtfully and collaboratively. Chapters examine research findings, policies, and practices that characterize school cultures where teachers serve as fully committed and involved professionals. (G)

Lieberman, Ann. "Teachers and Principals: Turf, Tension, and New Tasks." *Phi Delta Kappan* 69 (May 1988): 648-653.

Discusses school reform including the author's belief that while teachers need higher salaries and more recognition, they also need to be given more decision-making power and responsibilities if they are to become school leaders in the community. (G, I)

Little, Judith. "Teachers as Colleagues." In *Educator's Handbook: A Research Perspective*, ed. by Victor Richardson. New York: Longman, 1987.

Examines the effects of collegiality and collaboration on teachers' work satisfaction and sense of accomplishment. Juxtaposes the benefits of teaching in a collaborative environment with research findings and an assessment of why collegiality in schools is so difficult to achieve.

Louis, Seashore Karen and Matthew B. Miles. *Improving the Urban High School: What Works and Why*. New York: Teachers College Press, 1990.

Speaking to school administrators, teachers, district office personnel, and consultants, these two leaders in school improvement share lessons they have learned about what makes successful reform in secondary schools. A thoughtful, practical book, it provides change agents sound advice to what works any why. (I)

McLaughlin, Milbrey. "Learning from Experience: Lessons from Policy Implementation." *Educational Evaluation and Policy Analysis* 9 no. 2 (1987): 171-178.

Synthesizes the lessons of several decades of educational reform, highlighting the complexity of school reform. Presents guidelines to consider when initiating long-term change in public policy for schools. A theoretical, though useful, article for district level and local leaders of school improvement efforts.

Miller, Rima. *Team Planning for Educational Leaders: A Training Handbook.* Philadelphia: Research for Better Schools, 1987.

Provides educational teams with five techniques designed to facilitate team productivity: team building, prioritizing, problem solving, planning, and implementation analysis. (I)

Miller-Jones, Dalton. "Culture and Testing." *American Psychologist* 44 (February 1989): 360-366.

Examines the limitations of standardized tests in assessing the underlying cognitive processes of individuals not from mainstream Anglo-American backgrounds. (D, I)

Murnane, Richard, and Senta A. Raizen, eds. *Improving Indicators of the Quality of Science and Mathematics Education in Grades K-12.* Washington, DC: National Academy Press, 1988.

In response to national concern about the serious inadequacies in U. S. Science and Mathematics achievement, this report (the second one developed by the Committee on Indicators of Pre-College Science and Mathematics) presents some non-conventional indicators of the condition of science and mathematics education. (A-I)

Nelson, Barbara Scott. "Collaboration for Colleagueship: A Program in Support of Teachers." *Educational Leadership* 43, no.5 (February 1986): 48-52.

Describes the Ford Foundation's development of and rationale for the Mathematics Collaborative Projects. (F, G, H)

Oakes, Jeannie. *Keeping Track: How Schools Structure Inequality.* New Haven: Yale University Press, 1985.

Questions the pervasive practice of tracking students according to ability level. Clear differences exist between upper and lower tracks in regard to the content and quality of instruction, teacher-student, student-student relationships, the expectations of teachers for their students, the affective climate of classrooms, and other elements of the educational enterprise, all resulting in the likelihood that tracking limits students' opportunities to learn. (D)

Rich, Dorothy. *Schools and Families: Issues and Action.* Washington, DC: National Education Association, 1987.

An easy-to-read guide describing programs and policies for anyone interested in helping families contribute to and support educational programs. (H)

Rosenholtz, Susan. *Teachers Workplace: The Social Organization of Schools.* New York: Longman, 1989.

A comprehensive picture of life in schools for teachers. Examines and explains the differences between schools that work very well and those that do not. Discussing elements such as shared goals, collaboration, and teacher learning and commitment, the study identifies factors that contribute to and detract from sustaining a productive professional environment for teaching. (G)

Saxl, Ellen, Matthew B. Miles, and Ann Lieberman. *Assisting Change in Education: A Training Program for School Improvement Facilitators.* Alexandria, VA: Association for Supervision and Curriculum Development, 1989.

A comprehensive guide for facilitators of school change, the "*ACE Manual*" provides detailed chapters on theory and practice, highlights key skills required by facilitators working to improve schools, and offers directions in developing those skills. Based on a study of 17 successful facilitators working with different school improvement programs, this is a valuable resource for those working to improve schools. (G,I)

Sarason, Seymour B. *The Culture of the School and the Problem of Change.* Boston: Allyn and Bacon, 1972.

"The more things change the more they remain the same." This basic text for students of school change is devoted to understanding and analyzing why.

Sergiovanni, Thomas J., and John H. Moore, eds. *Schooling For Tomorrow: Directing Reforms to Issues That Count.* Needham Heights, MA: Allyn and Bacon, 1989.

Consists of chapters taken from a national conference on restructuring schooling. Teachers, administrators, and representatives from teacher unions and state departments, politicians, and academic leaders discuss both practical and effective school reform ideas to "carry the school improvement process into the twenty-first century." (G)

Smith, Stuart C., and James J. Scott. *The Collaborative School: A Work Environment for Effective Instruction.* Reston, VA: NASSP, 1990.

Synthesizes much of the significant work on collaboration as a strategy for improving the instructional effectiveness of a school's faculty. (D, G)

Stiggins, Richard J., Evelyn Rubel, and Edys Quellmaz. *Measuring Thinking Skills in the Classroom.* Washington, DC: National Education Association, 1986.

Defines workable categories of thinking skills, illustrates how these categories relate to the traditional modes of testing, and provides guidelines for developing classroom assessments that incorporate thinking skills. (C)

NATIONAL REPORTS IN MATHEMATICS AND SCIENCE EDUCATION

...And Gladly Teach. New York: The Ford Foundation, 1987.

Between 1985 and 1987 The Ford Foundation awarded grants to help establish urban mathematics collaboratives in eleven cities. This is a preliminary report on the first two years of that initiative. (G)

...And Justice for All. Washington, DC: National Education Association, 1987.

A collection of four reports by the NEA Executive Committee Study Group on Ethnic Minority Concerns investigating the educational needs of American Indians/Alaskan Natives, Asian and Pacific Islanders, Blacks, and Hispanics. Each report provides an overview of that group's experience in American society and presents findings and recommendations in such areas as curriculum, parents/community, employment, and legislation. (D)

Assessing Mathematics in 1990 by the National Assessment of Educational Progress. Washington, DC: Council of Chief State School Officers, 1988.

In 1990, many states will participate in a nationwide assessment of mathematics that will allow state-to-state and state-to-nation comparisons. In anticipation of that event and the possible anxiety it may create, this report describes the mathematical abilities that the assessment will measure. (A, I)

Dorsett, Beryl. "Knowledge of Science Vital for All Children." *Education Week* 8, no. 2 (Nov. 23, 1988): 21-22.

Sound instruction in mathematics, science, and technology must be part of every student's education due to the increasing number of jobs related to advanced computer and electronic technology. Demographic trends suggest the importance of drawing more women and minority students into science and mathematics. There is an urgent need for better teachers and higher priority should be given to these areas of instruction. (F)

Dossey, John A., et al. *The Mathematics Report Card: Are We Measuring Up?* Princeton, NJ: Educational Testing Services, 1988.

The results of four national assessments of mathematics conducted by NAEP are presented together with an analysis of the trends indicated by the data. (A, G)

Education That Works: An Action Plan for the Education of Minorities. Cambridge, MA: Quality Education for Minorities Project, 1990.

Presents examples of education that work and lays out a series of strategies for institutionalizing these successful approaches. Argues that we know what the problems are and what to do about them; what is lacking is the leadership, commitment, resources, and wisdom to move forward. (D)

Educating Americans for the 21st Century: A plan of action for improving mathematics, science, and technology for all American elementary and secondary students so that their achievement in the best in the world by 1995. Washington, DC: National Science Foundation, 1990.

Report by the Commission on Precollege Education in Mathematics, Science, and Technology. Rather than dwell on the problem, aims to recommend solutions. Outlines a plan of action, addresses the question of costs, and proposes a procedure to determine the methods of financing such a plan.

Lapointe, Archie E., Nancy A. Mead, and Gary W. Phillips. *A World of Differences: An International Assessment of Mathematics and Science.* Princeton, NJ: Educational Testing Service, 1989.

Results from a mathematics and science assessment of 13-year-olds from five countries and four Canadian provinces. (A)

Madison, Bernard L. *A Challenge of Numbers: People in the Mathematical Sciences.* Washington, DC: National Academy Press, 1990.

Second of three reports planned by the Mathematical Sciences Education Board (the first being *Everybody Counts*). Serves primarily as a reference, providing in one place a comprehensive set of data describing the demographic situation in the mathematical sciences. An executive summary is available. (A)

Making Mathematics Work for Minorities. Washington, DC: Mathematical Sciences Education Board, 1990.

The Mathematical Sciences Education Board convened six regional workshops at which leaders in specific areas addressed the problems of minorities in mathematics. Their recommended actions are compiled in this volume. (D)

Martinez, Michael E., and Nancy A. Mead. *Computer Competence: The First National Assessment.* Princeton, NJ: Educational Testing Service, 1988.

Presents the results from the National Assessment of Educational Progress survey of computer competence. Generally, the assessment showed that (1) computers are seldom used in the classroom, (2) there are clear racial/ethnic differences in computer competence favoring White students over Black and Hispanic youngsters, and (3) school personnel have little training in computer studies and little confidence in their ability to use computers. Discusses the implications of these findings. (B, D)

Mathematics, Science, and Technology Education: A Research Agenda. Washington , DC: National Academy Press, 1985.

A report of the National Research Council Committee on Research in Mathematics, Science and Technology Education. Assesses the current condition of precollegiate education in those disciplines and outlines strategies for future improvement through research and development. (A, I)

McKnight, Curtis C., et al. *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective.* Champaign, IL: Stipes, 1987.

Presents and analyzes the performance of U.S. students in the Second International Mathematics Study. (A)

Mullis, Ina V.S., and Jenkins, Lynn B. *The Science Report Card: Elements of Risk and Recovery.* Princeton, NJ: Educational Testing Service, 1988.

Examines student achievement on the National Assessment of Educational Progress science assessment from 1969 to 1986. (A, I)

Murnane, Richard, and Senta A. Raizen, eds. *Improving Indicators of the Quality of Science and Mathematics Education in Grades K-12.* Washington, DC: National Academy Press, 1988.

In response to national concern about the serious inadequacies in U. S. science and mathematics achievement, this report (the second one developed by the Committee on Indicators of Pre-College Science and Mathematics) presents some non-conventional indicators of the condition of science and mathematics education. (A-I)

National Research Council. *Everybody Counts: A Report to the Nation on the Future of Mathematics.* Washington, DC: National Academy Press, 1989.

Delineates the problem facing the Unites States regarding mathematics education. The report urges everyone (teachers, administrators, the community, parents, etc.) to get involved in the revitalization of mathematics education. A summary edition is available. (A)

National Research Council. *Reshaping School Mathematics: A Philosophy and Framework for Curriculum.* Washington, DC: National Academy Press, 1990.

Aims to focus growing national dialogue on the nature and goals of mathematics in this country. Presents fundamental issues which transcend particular details of current curricula or assessment results. (A-I)

Nelson, Barbara Scott. "Collaboration for Colleagueship: A Program in Support of Teachers." *Educational Leadership* 43, no.5 (February 1986): 48-52.

Describes the Ford Foundation development of and rationale for the Mathematics Collaborative Projects. (F, G, H)

Renewing U.S. Mathematics: A Plan for the 1990s. Washington, DC: National Academy Press, 1990.

Considers many components of the mathematical sciences community requiring action, focussing on university research departments. (A,I)

Science For All Americans. Washington, DC: American Association for the Advancement of Science, 1989.

A set of recommendations by the National Council on Science and Technology Education on what understandings and habits of mind are essential for all citizens in a scientifically literate society. Recommendations cover a broad array of areas such as mathematics, the living environment, human society, and historical perspectives. Also explores future steps to help ensure our society's scientific literacy. (A,B,C)

Stevenson, Harold. *Mathematical Knowledge of Japanese, Chinese, and American Children.* Reston, VA: National Council of Teachers of Mathematics, 1990.

In study of the performance of first and fifth graders in Chicago, Stevenson found that American children were doing poorly in comparison to their peers in China and Japan. Researchers inquired about their lives at school and at home, discerning differences in experience which may help explain the poor performance of American children.(A,H,I)

Travers, Kenneth J. "Opportunity to Learn Mathematics in 8th Grade Classrooms in the United States: Some Findings From the Second International Mathematics Study" In *Linguistic and Cultural Influences on Learning Mathematics*, edited by Rodney R. Cocking and Jose P. Mestre. Hillsdale, NJ: Lawrence Erlbaum, 1988.

Presents findings from the Second International Mathematics Study (SIMS) conducted by the International Association for the Evaluation of Educational Association. Provides examples to help explain achievement patterns in secondary school mathematics. (D)

U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning.* Washington, DC: U.S. Government Printing Office, 1988.

Examines developments in the use of computer-based technologies, analyzes key trends in hardware and software development, evaluates the capability of technology to improve learning in many areas, and explores ways to substantially increase student access to technology. (B)

Wilson, Beth. *Making Sense of the Future: A Position Paper on the Role of Technology in Science, Mathematics, and Computing Education.* Cambridge, MA: Educational Technology Center, 1988.

Summarizes the results of studies on the use of computers and other technologies to improve K-12 instruction in science, mathematics, and computing. Three categories of findings are supported: teaching and learning, technology, and implementation. (A-D)

JOURNALS AND NEWSLETTERS OF INTEREST TO MIDDLE-GRADES MATHEMATICS EDUCATORS

AMP-LINE
American Mathematics Project
359 University Hall
University of California
Berkeley, CA 94720

A quarterly newsletter featuring accounts of successful group projects in mathematics. Includes information about the organization, development and leadership of projects, plus ways of gaining recognition, support, and funding from state legislature, school administrators, parents, and local business communities.

ARITHMETIC TEACHER
1906 Association Drive
Reston, VA 22091

A journal published by the National Council of Teachers of Mathematics focusing on mathematics education through the middle grades. Contains articles with ideas and techniques for classroom instruction.

CONSORTIUM
COMAP
60 Lowell Street
Arlington, MA 02174

Like its counterpart *The Elementary Mathematician*, gives pull-out mathematics lessons, new and exciting mathematics uses, puzzles, and general ideas for enhancing mathematics teaching. Free to secondary-school mathematics teachers.

THE ELEMENTARY MATHEMATICIAN
COMAP, Inc.
60 Lowell Street
Arlington, MA 02174

A free journal to all elementary school teachers and educators (also applicable to the middle grades) that features practical activities to be used in the classroom.

HANDS ON!
Technical Education Research Center (TERC)
1696 Massachusetts Avenue
Cambridge, MA 02138

Informs educators about the latest technological items and activities for use in the classroom.

JOURNAL FOR RESEARCH IN MATHEMATICS EDUCATION
1906 Association Drive
Reston, VA 22091

Examines current research in the area of teaching and learning mathematics. Although its focus is on research, it is of use to teachers since it discusses current problems in mathematics education.

JOURNAL OF COMPUTERS IN MATHEMATICS AND SCIENCE TEACHING
The Association for Computers in Mathematics and Science Teaching
P.O. Box 60730
Phoenix, AZ 80582

Provides "a forum for the exchange of information about teaching mathematics and science with computers and the impact of computers on mathematics and science curricula." Published quarterly.

JOURNAL OF MATHEMATICAL BEHAVIOR
Ablex Publishing Corporation
355 Chesnut Street
Norwood, NJ 07648

Aims "to assist in interventions that improve the teaching and learning of mathematics, and to help develop a deeper understanding of how people learn and use mathematics." Also contains articles dealing with curriculum issues and technology use in the classroom. Published tri-annually.

MATHEMATICS TEACHER
1906 Association Drive
Reston, VA 22091

Devoted to improving mathematics instruction, this NCTM monthly publication contains articles, activities, project descriptions, and current publication reviews.

NCSM NEWSLETTER
Henry S. Kepner, Jr. - Editor
Dept. of Curriculum and Instruction
University of Wisconsin - Milwaukee #413
Milwaukee, WI 53201

Contains articles on curriculum and instruction, staff development, and effective change, as well as general NCSM news. Published quarterly.

NCTM NEWS BULLETIN
1906 Association Drive
Reston, VA 22091

Provides updates on NCTM activities, as well as other news in the world of mathematics.

SCHOOL SCIENCE AND MATHEMATICS
126 Life Science Building
Bowling Green State University
Bowling Green, OH 43403

The official journal of the School Science and Mathematics Association. Published monthly, October through May.

TEACHING AND COMPUTERS
Scholastic, Inc.
Mahopac, NY 10541-9963

A professional magazine for teachers with "ready-to-use lesson plans to help you instruct your students and to make the most of your computers in every classroom, every curriculum."

131

ORGANIZATIONS OF INTEREST TO MIDDLE-GRADES MATHEMATICS EDUCATORS

AMERICAN FEDERATION OF TEACHERS (AFT)
555 New Jersey Avenue, N. W.
Washington, DC 20001
(202) 879-4400

AFT is a professional union for teacher and educators. It offers assistance in educational issues, public relations, organization, and resource development. The AFT Educational Research & Dissemination program provides information about effective teaching through a "teacher-to-teacher" network. The AFT Center for Restructuring is directed by AFT's Educational Issues Department and explores school change across the curriculum. AFT is also working with the Learning Research and Development Center to design a number of research tools for middle-grades mathematics educators for direct use in the classroom.

PUBLICATIONS

American Educator
American Teacher
Radius, the AFT Center for Restructuring newsletter

ASSOCIATION FOR SUPERVISION AND CURRICULUM DEVELOPMENT
125 North West Street
Alexandria, VA 22314
(703) 549-9110

ASCD produces books and booklets, audio and video cassettes, and films for teachers, supervisors, administrators, and curriculum developers. The Association sponsors National Curriculum Study Institutes on various topics including "Thinking Skills Training: Teaching for Intelligent Behavior" and "Motivating Experienced School Personnel."

PUBLICATIONS

An Action Guide to School Improvement
Bilingual Education for Latinos
Circles of Learning: Cooperation in the Classroom
Educational Leadership, published monthly, October-May
Essays on the Intellect
Journal of Curriculum and Supervision, published quarterly

CENTER FOR EARLY ADOLESCENCE
University of North Carolina at Chapel Hill
Suite 211, Carr Mill Mall
Carrboro, NC 27510
(919) 966-1148

The Center for Early Adolescence works to increase the effectiveness of agencies and individuals that have an impact on the lives of 10- to 15-year-olds. The Center serves as a clearinghouse for information on the age group, and develops training programs for professionals and volunteers who work with young adolescents. The Center focuses upon school improvement, parent education, responsive community services, and a variety of other issues affecting young people.

PUBLICATIONS

After School: Young Adolescents on Their Own
Growing Up Forgotten: A Review of Research and Programs Concerning Early Adolescence
Improving Middle-Grade Schools: A Framework for Action
Living With 10- to 15-Year-Olds: A Parent Education Curriculum
Middle-Grades Assessment Program
Successful Schools for Young Adolescents
3:00 to 6:00 P.M.: Planning Programs for Young Adolescents
Understanding Early Adolescence: A Framework

EDUCATION WRITERS ASSOCIATION
1001 Connecticut Avenue, NW, Suite 310
Washington, DC 20036
(202)429-9680

Education Writers Association, an organization of journalists who write on education, reports on innovative educational activities. Its bimonthly report on urban middle-grades schools, *High Strides*, is available from EWA at the subscription rate of $45.00 for a two-year period.

PUBLICATIONS

High Strides

EQUALS
Lawrence Hall of Science
University of California
Berkeley, CA 94720
510-642-1823

EQUALS is a research and program development organization dedicated to promoting mathematics and science success among population groups that are underrepresented in mathematics and science professions. Best known for its *Family Math* and *Family Science* programs and workshops, EQUALS staff developers are available to schools and districts to conduct workshops, provide on-site consultations, and to train teams of educators in techniques that effective involve minority students and young women in mathematics and science successes. A wide variety of publications, newsletters, and conferences are available as resources for school site educators.

PUBLICATIONS

Family Math
Family Science
Assessment Alternatives in Mathematics
Various newsletters and papers upon request

MATHCOUNTS FOUNDATION
1420 King Street
Alexandria, VA 22314
(703) 684-2828

Sponsored primarily by the National Society of Professional Engineers, MATHCOUNTS is an accelerated coaching program and a series of competitions designed to produce high levels of mathematics achievement in junior high students.

PUBLICATIONS

MATHCOUNTS School Handbook

NATIONAL ASSOCIATION OF SECONDARY SCHOOL PRINCIPALS
1904 Association Drive
Reston, VA 22091
(703) 860-0200

NASSP is a membership organization of secondary school principals and other persons involved in secondary school administration and supervision. NASSP offers publications, films, and filmstrips on a wide variety of subjects, including management techniques and curriculum programs. The NASSP's Council on Middle Level Education develops materials and holds conferences and conventions specifically for Middle School Administrators. The newsletter Schools in the Middle discusses "issues, trends, and practices affecting middle level schools."

PUBLICATIONS

Assessing Excellence: A Guide for Studying the Middle Level School
How Fares the Ninth Grade
Love Me When I'm Most Unlovable: the Middle School Years
The Mood of American Youth
NASSP Bulletin, published monthly, September-May
Schools in the Middle, a quarterly publication

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS
1906 Association Drive
Reston, VA 22091
(703) 602-9840

NCTM is concerned with the advancement of mathematics teaching in elementary, junior and senior high schools, two-year colleges, and teacher education colleges.

PUBLICATIONS

NCTM Bulletin
Arithmetic Teacher
Mathematics Teacher

NATIONAL COUNCIL OF SUPERVISORS OF MATHEMATICS
1902 Whitney
Houston, TX 77006
(713) 522-2006

NCSM provides for the interchange of evolving ideas and current research involving the supervision and curriculum development of mathematics education. It cooperates with other organizations in the improvement of instruction, and in curriculum planning in mathematics.

PUBLICATIONS

NCSM Newsletter

NATIONAL EDUCATION ASSOCIATION
1201 16th Street, N.W.
Room 510
Washington, DC 20208
(202) 357-6147

NEA is a professional organization of elementary and secondary school teachers and others interested in American education. The Association develops in-service education programs; encourages practitioner participation in determination of standards for teacher certification; and identifies and disseminates information about programs that respond to the special needs of bilingual multicultural students.

PUBLICATIONS

Developing Social Responsibility in the Middle School, A Whole School Approach
Reading Instruction in the Middle School
Today's Education, published quarterly

NATIONAL MIDDLE SCHOOL ASSOCIATION

4807 Evanswood Drive
Columbus, OH 43229
(614) 848-8211

NMSA promotes the growth of the middle school concept in America and provides information on innovative programs and projects in middle schools. The Association is for teachers, administrators, supervisors, parents, students, and other individuals and agencies interested in the education of young adolescents.

PUBLICATIONS

Middle Schcol Journal
Developing Effective Middle Schools through Faculty Participation
Good Schools for Middle Grade Youngsters
Five R's for Middle Schools

NATIONAL RESOURCE CENTER FOR MIDDLE GRADES EDUCATION

University of South Florida
College of Education -- EDU 115
Tampa, FL 33620
(813) 974-2530

The Center serves as a clearinghouse for evaluation and dissemination of materials; provides staff development for teachers, counselors, and administrators; prepares a series of publications and instructional tools for middle-grade educators; and provides access to research and a variety of consulting services.

PUBLICATIONS

Why a School in the Middle? Reminders of the Needs and Characteristics of Transecents and the Organizational Patterns Perfect for this Age Group
Teaming the Heart of the Middle School: How-To Implement the Teaming Process Successfully
Everybody Gets an "A" in Affective Education: How to Set Up an Advisory Program or Keep One Going

TECHNICAL EDUCATION RESEARCH CENTER (TERC)

The Henderson Carriage Building
Cambridge, MA 02140
(617) 547-0430

TERC is a non-profit organization committed to improving the quality and accessibility of education for students with diverse skills and backgrounds. TERC develops educational microcomputer software, evaluates and develops mathematics and science curricula, and works with special populations, such as women, minorities, and disabled learners, to increase and encourage their participation in technical education.

PUBLICATIONS

Hands On!
Used Numbers
Kids Network

UNIVERSITY OF CHICAGO SCHOOL MATHEMATICS PROJECT
5835 S. Kimbark Avenue
Chicago, IL 60637
(312) 702-1560

UCSMP focuses on upgrading the school mathematics experience for the average student. They develop and evaluate curricula and programs for primary, elementary, and secondary schools. The Resource Development Component translates foreign mathematical texts for use in this country. UCSMP also holds summer institutes for educators interested in upgrading their teaching skills.

PUBLICATIONS

UCSMP Newsletter
Functions and Statistics with Computers
Transition Mathematics

DISTRIBUTORS OF TEACHING MATERIALS OF INTEREST TO MIDDLE-GRADES MATHEMATICS EDUCATORS

Free catalogs are available from each distributor.

Creative Publications
5040 West 111th Street
Oak Lawn, IL. 60453
(312)767-2374
(800)624-0822

Cuisenaire Company of America
12 Church Street, Box D
New Rochelle, NY 10802
(914)235-0900
(800)237-3142

Dale Seymour Publications
P.O. Box 10888
Palo Alto, CA 94303
(800)USA-1100

Educational Solutions, Inc.
95 University Place
New York, NY 10003-4555
(212)674-2988

Marilyn Burns Education Associates
21 Gordon Street
Sausalito, CA 94965
(415) 332-4181

Midwest Publications
P.O. Box 448
Pacific Grove, CA 93950
(408)375-2455
(800)458-4849

Mindscape, Inc.
Educational Division
3444 Dundee Road
Northbrook, IL 60062
(312)480-7667
(800)221-9884

National Council of Teachers of Mathematics
1906 Association Drive
Reston, VA 22091
(703)620-9840

Sunburst Communications
39 Washington Avenue
Pleasantville, NY 10570
(914)769-5030
(800)431-1934

V. J. Mortensen Company
P.O. Box 98
Hayden Lake, IN 83835
(208)772-4074
(208)667-1580

Appendices

Appendix 1
Making Logistical Decisions: Questions to Consider

I. Planning the Assessment Process

A. Sharing the assessment process with colleagues and the school community:

1. When and how will the rationale and plan for MAP be explained to the faculty?
2. Who will make the presentation(s)?
3. What precautions will you take to make the assessment process fully open, encouraging participation by as many teachers as want to participate?
4. What communication procedures will be established among the staff, as well as within the team, to keep everyone in the school informed of the progress of the assessment?
5. Questions will be asked about the rationale behind interviewing and observing teachers other than the mathematics faculty. How will you respond?
6. How will parents be informed and involved in the process?

B. Selecting and planning the team process

1. How many members of the assessment team will there be? How will you assure a wide representation of the faculty and community, including people with different philosophies and approaches?
2. How will you identify or select team members?
3. There will be many varying responsibilities throughout the assessment process; how will you share ownership for those responsibilities?
4. How will you structure your team meetings so they are informal but efficiently organized to accomplish as much as needed in short periods of time?

C. Team meetings and study groups

1. What are the team's plans for conducting the staff development workshops for team members and, later, for members of study groups?
2. How will the interviews, observations, and data collection responsibilities be divided among members of the team? (The "cluster" concept helps share the responsibility but further discussion of planning details among members may be necessary.)
3. How will you recruit members for each of the Cluster Study Groups?

D. Planning and organizing the Assessment

1. Substitute teachers:
   a. How will substitute teachers be used to facilitate the assessment process?
   b. What activities will be supported with substitute assistance?
   c. How many days will each teacher be released from classrooms and who will schedule the substitute teachers?
   d. Will substitutes be used to provide release time for *both* interviews and observations?

2. Study Groups:
   a. Which team members will lead the study groups for each cluster?
   b. Who will convene the study group meetings? When? Where?
   c. How much time should be allocated to study group discussions?
   d. How much time will be available for study groups to write their findings?
   e. When will cluster study group meetings be conducted (during the school day or after?) How will that time be supported by the administration, e.g. with stipends, substitutes, informal planning periods?
3. Summarizing and reporting findings:
   a. How much time will be available for the assessment team to share and summarize the findings of their study groups?
   b. Will substitutes be used during this time?
   c. Who will convene the meeting(s)? When? Where?

E. Time lines: What are the target dates for completing the following major activities of the Assessment?

MAP Team Activities	Target Completion Dates
◆ Inform faculty and community	______________
◆ Select team members	______________
◆ Conduct staff development workshops for team to learn to use MAP	______________
◆ Conduct interviews and observations	______________
◆ Complete staff surveys	______________
◆ Summarize individual data for study group analysis	______________
◆ Study groups examine findings	______________
◆ Study groups report findings to team	______________
◆ Team combines findings of study groups and determines priorities for action	______________
◆ Team generates preliminary action plan: strategies for program improvement	______________
◆ Team distributes preliminary action plan	______________
◆ Faculty discusses findings and action recommendations	______________
◆ Team finalizes the action plan	______________
◆ Faculty adopts action plan	______________
◆ School presents plan to central office	______________
◆ School disseminates action plan to community	______________

II. Interviews

A. Scheduling:

1. Who will conduct each set of interviews?
2. How will personal preferences for interviewees be handled?
3. Who will make and confirm appointments?
4. Which, if any, interviews will be conducted by pairs of team members?

Some schools have found it effective to have *pairs* of team members conduct interviews with individuals in key roles or positions, e.g. the principal, the curriculum director, the counselor, etc. While this is not required, it can be considered by the team.

Interviews will vary in length. The math teacher interviews will likely take two sittings, each about 45 minutes. The administrator interview will also likely take 45 minutes to an hour. Other interviews should take between 30 and 45 minutes.

Teams should encourage shared responsibility across the faculty for participating in the the data collection process. Interviewers or observers who are not members of the assessment team can learn the recommended procedures from co-leaders or colleagues, or it may be useful for one of the team members to conduct an informal review of procedures for a group of interviewing or observing volunteers.

Team members who have an exceptionally close relationship or personality conflict with a given individual should not interview or observe that person.

B. Students and Parents:

1. How many students and parents will be interviewed?
2. How many team members will conduct the interviews?
3. How will students and parents be selected?
4. How will you assure that all groups and subgroups of the school population — i.e., students and their families representing various achievement levels, interests, and strengths and weaknesses — are included in the interviews?
5. What arrangements will be made for notifying students and parents of the purpose and rationale behind the interviews?
6. How will you provide information about your findings to students and parents who are interviewed?

The number of students and parents to be interviewed will be determined by the Administrative/Support/Community cluster. This group can also work out selection procedures. The number to be interviewed depends on the size of the school and the number of staff available to conduct interviews. A five to ten percent sample is the goal. This sample should be carefully selected, however, so that interview assignments are manageable (no more than 8 - 10 interviews per team member). Also, team members should not interview the students or parents they know best, because their objectivity will be difficult to maintain. Care should be taken to include all segments of the student and community population in the interviews. An effort might also be made to interview business partners and other community representatives, as well.

C. **Individual Summaries of Data:**

1. How will you assist one another in summarizing the data obtained from the interviews?
2. What processes will you use to assure anonymity of all individuals as the data are summarized?

Before individuals begin to work in study groups, they will be asked to summarize the themes and identify ideals that the themes suggest. This process may not be an easy one. Thus, an additional training or discussion session may be necessary to agree on a procedure and to offer assistance as team members examine their data and summarize the ideas their colleagues provided.

III. Observations

A. **Scheduling Observations**

1. Which classes will be observed, on what schedule, and how frequently?
2. How many and which weeks will be designated for observations?
3. How many observations will each team member conduct?
4. How will you designate observers?
5. Matrices for scheduling observations are provided as a supplement to this logistics planning document.

B. **Including all members of the mathematics department.**

1. How will provisions be made to include all members of the math department as observers?
2. What training in observation techniques and in the use of these observation protocols will be provided to those who did not attend the Assessment training?
3. How will you promote and assist the feedback process, especially among mathematics teachers?

C. **Openness: What arrangements will be made for all staff to review observation forms and procedures, and to raise questions with team members, before they are observed?**

Observations will be conducted throughout the school. Detailed instruction on the procedures to follow in conducting observations accompany the observation forms in the Assessmentc Instruments volume. However, decisions will have to be made by team members regarding the logistics of implementing the observations, timing, and assignments.

Care should also be taken to allocate time for colleagues to conduct "debriefing conferences" with teachers they observe following the observation periods. The Assessment's observation forms provide a guide sheet for conducting follow-up meetings, "debriefings," to exchange information about the observation process. We strongly recommend they be used throughout the assessment so that data are not misinterpreted or misused.

The success of the observations is fundamental to the success of the assessment process as a tool for informing the assessment team about program needs in the school. Every effort should be made to honor individuals' preferences regarding observers and observation schedules, but to maintain the confidentiality of the observations themselves.

IV. Team-Determined Logistical Needs (list below).

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

143

Appendix 2
Scheduling Matrices: Mathematics Classroom Observation

List the names of the teachers to be observed on numbered lines on the top row. List the observers' names in the column on the left. Indicate the scheduled time of observers' visits to teachers' classes in the matrix on the appropriate week. Schedule observations to sample the beginning, middle, and end of each teacher's classes.

Names of Mathematics Teachers to be Observed

#1 ____________ #2 __________ #3 __________ #4 __________ #5 __________

OBSERVERS

Week #1: ____

1. ________ ____________ __________ __________ __________
2. ________ ____________ __________ __________ __________ __________
3. ________ ____________ __________ __________ __________ __________
4. ________ ____________ __________ __________ __________ __________
5. ________ ____________ __________ __________ __________ __________

Week #2: ____

1. ________ ____________ __________ __________ __________ __________
2. ________ ____________ __________ __________ __________ __________
3. ________ ____________ __________ __________ __________ __________
4. ________ ____________ __________ __________ __________ __________
5. ________ ____________ __________ __________ __________ __________

Week #3 ____

1. ________ ____________ __________ __________ __________ __________
2. ________ ____________ __________ __________ __________ __________
3. ________ ____________ __________ __________ __________ __________
4. ________ ____________ __________ __________ __________ __________
5. ________ ____________ __________ __________ __________ __________

Week #4 ____

1. ____	____	____	____	____	____
2. ____	____	____	____	____	____
3. ____	____	____	____	____	____
4. ____	____	____	____	____	____
5. ____	____	____	____	____	____

Schoolwide Observation

The work areas or classes to be observed are listed in the left column. **Section I** indicates the work spaces to be observed. In **Section II,** record the teachers and room numbers of the classes to be observed.

List the names of team members who will conduct observations in the top row of each column. Indicate under each observer's name, across from the area or class to be observed, the date and approximate time (a.m. or p.m.) the observation will take place. Schedule observations to sample the beginning, middle, and end of each teacher's classes.

SECTION I

	Week #1	Week #2	Week #3
Work Areas:	**Observer:** ____	**Observer:** ____	**Observer:** ____
1. Main office	____	____	____
2. Media center	____	____	____
3. Counseling center	____	____	____
4. Cafeteria	____	____	____
5. Faculty area	____	____	____
6. Student work rooms	____	____	____
7. Computer/math lab	____	____	____
8. Science lab	____	____	____
9. Gym	____	____	____
10. Music/art areas	____	____	____
11. Drama area	____	____	____
12. Other:	____	____	____

SECTION II

Teacher/ Room #	Week #1 Observer:	Week#2 Observer:	Week #3 Observer:
	______	______	______
1. ______	______	______	______
2. ______	______	______	______
3. ______	______	______	______
4. ______	______	______	______
5. ______	______	______	______
6. ______	______	______	______
7. ______	______	______	______
8. ______	______	______	______
9. ______	______	______	______
10. ______	______	______	______
11. ______	______	______	______
12. ______	______	______	______
13______	______	______	______
14. ______	______	______	______
15. ______	______	______	______
16. ______	______	______	______
17. ______	______	______	______
18. ______	______	______	______
19. ______	______	______	______

Appendix 3
Glossary

Abstract

Abstract concepts or ideas are constructed in a person's mind on the basis of personal experience with concrete objects or pictorial representations. An abstract mathematical concept is presented or explained using materials or pictures that exemplify the concept.

Algebra-related manipulatives

Algebra-related manipulatives are manipulative materials specially designed to bridge the gap between the concrete world of number and the more abstract, symbolic world of algebraic notation. These include Algebra Tiles, Algebra Lab, and Dienes' Algebra Experience Materials.

Algorithm

An algorithm is a routine procedure followed in order to solve straightforward mathematical problems. Different algorithms may be used to solve the same problem.

Alternative algorithms

Alternative algorithms are different methods for solving mathematical problems. Middle school students particularly appreciate having a choice of methods.

Applications

Applications use previously learned skills to solve problems based on concrete situations. These problems may be either routine or non-routine.

Arithmetic calculators

Arithmetic calculators are calculating tools that perform the four basic arithmetic operations, and may also find values of square roots, powers, and logarithms.

Assessment techniques

Assessment techniques vary widely, ranging from individualized to group-administered, criterion-referenced to norm-referenced, formal to informal, instrument-based to observational techniques.

Attribute blocks

Attribute, or logic, blocks are manipulative materials that are used for sorting and classifying activities. A basic set consists of sixty-four blocks of four shapes, four colors, two sizes, and two thicknesses.

Base ten blocks:

Base ten blocks are classroom materials modeling the base ten numeration system. Base ten blocks embody place value relationships and are used to model addition, subtraction, multiplication and division of whole numbers and decimals.

Chip trading sets

Chip trading sets are manipulative materials often used to demonstrate and work with concepts of place value. Chips, colored to denote denominations, are traded according to set rules.

Combinatorics

Combinatorial mathematics deals with the counting of selections (combinations) or arrangements (permutations) of elements from finite sets.

Cooperative learning

In cooperative learning, students work together in small groups to solve problems. The teacher constructs problems in which collaboration is helpful. Research suggests that girls and minority students especially benefit from working in cooperative learning groups.

Computer spreadsheets

Computer spreadsheets are computer programs set up to perform calculations on data. Spreadsheets can be used effectively in middle school mathematics and computer courses.

Concepts

Concepts are ideas which are abstracted from experiences. Concepts are acquired through activity and are based on repeated experience and reflection.

Concrete

Concrete understanding is based on physical models or real-world objects. A concrete experience is one which is real and palpable. In classrooms the use of concrete materials helps students understand the abstract concepts which underlie much of mathematics.

Constructivism

An educational philosophy and approach embodying the following three principles: (1) Essential knowledge does not consist of facts but of specific conceptual structures linked by specific relations. (2) Conceptual and relational knowledge is not a commodity that exists outside people's heads and can simply be transferred to students by means of telling; it is something that must be built up by each individual, and language can do no more than orient a student's thinking in a certain direction. (3) Knowledge, including scientific knowledge, is not a collection of timeless truths about the world but a way of approaching and seeing experience. And, in order to reflect upon experience, students must be given opportunities to have experiences.

Criterion-referenced test (CRT)

A criterion-referenced test evaluates an individual's performance with reference to specific objectives in various skill areas. Criterion-referenced tests compare an individual's performance with objectives rather than with a group.

Critical thinking

Critical thinking involves an understanding of the relationship of language to logic, leading to the ability to analyze, criticize, and advocate ideas, to reason inductively and deductively, and to reach factual or judgmental conclusions based on sound inferences and experiences.

Cuisenaire rods

Multicolored, multilength rods used for a variety of mathematical activities. Can be used to emphasize spatial reasoning skills, reinforcing such concepts as area, perimeter and volume, fractions, or whole number operations.

Data analysis skills

Data analysis skills involve the ability to analyze raw data in order to understand what the data show. These skills include the ability to interpret representations of data as well as the ability to collect and construct meaningful representations of data.

Data bases

Data bases are computer programs that manipulate stored collections of data by performing sorting or ordering operations according to specified characteristics.

Discrete mathematics

Discrete mathematics deals with ideas that can be modeled using distinct, countable objects. Topics in discrete mathematics include logic, combinatorics, networks, and basic principles of computer programming.

Drill and practice software

Drill and practice software is designed for the practice of particular computational skills. Generally such programs encourage automaticity of responses by regulating time and controlling the level of difficulty of presented problems.

Estimation

Estimation is the skill of making a sensible guess based on logical analysis of a situation. Estimation skills involve many judgments and higher order thinking. They can be applied in either the spatial or numerical domains.

Fraction bars

Fraction bars are cardboard strips colored to represent fractional parts of a whole. They are used to teach equalities, inequalities, addition, subtraction, multiplication and division of fractions in a relatively concrete mode.

Geoboards Geoboards are boards with nails inserted in a grid pattern at regular intervals. Used with elastic bands to construct 2- dimensional shapes, they are valuable tools for developing concepts of shape, angles, measurement, number patterns, area, geometry, and vectors.

Geometric construction materials The traditional tools for performing two-dimensional geometric constructions are the compass and straightedge. Protractors, for measuring angles, are also used in creating pictorial representations of geometric ideas.

Geometric models A wide variety of materials are available to illustrate geometric ideas such as shape, measurement, tessellation, space-filling curves, symmetry, congruence, similarity, and angle measure. These include geoboards, tangrams, polyhedron models, pattern blocks, and many others.

Geometry Geometry incorporates the study of objects, motion, and relationships in a spatial environment.

Higher order thinking skills Higher order thinking skills are used to develop, articulate, test, and compare the results of different strategies, and to generalize the use of concepts and strategies in various situations. They are contrasted with more routine skills, such as memorization.

Heuristics Heuristics are general strategies used for solving complex mathematical problems. Unlike algorithms, heuristics do not guarantee solutions. Rather, they are techniques, such as drawing a diagram or making a chart, that may be helpful in solving a problem.

Informal diagnosis Informal diagnosis of a student's mathematical understanding can be made from classroom observations, clinical interviews, or other anecdotal evidence, such as parental reports.

Interdisciplinary unit An interdisciplinary unit is a unit of study which draws from more than one academic discipline and develops thematic content related to more than one content area. An interdisciplinary unit might be simultaneously taught by teachers in two or more content areas.

Logic Formal logic is a science dealing with the rules of sound thinking and proof by reasoning. Before the rules of this science are learned, however, students learn to think logically based on their own interpretation of experience.

Manipulatives

Manipulative materials are concrete models useful in representing various mathematical concepts. They typically appeal to several senses, and can be touched and moved around by students as they experiment and explore various mathematical ideas.

Mathematical models

Mathematical models are concrete or pictorial representations of various mathematical concepts. For example, Cuisenaire rods are a model of the number system; fraction bars are a model of fractions. These representations are used as tools with which to think.

Mental computation

Mental computation is a method of thinking through a problem, performing an operation, or obtaining a result without using pen, paper, or other concrete aids.

Metacognition

Metacognition is thinking about thinking, in particular, the uses and limitations of various thinking strategies.

Multibase blocks

Multibase blocks are blocks which are structured to develop students' understanding of our base ten numeration system by generating different representations for the same number using different bases for numerations.

Nonroutine problem

A nonroutine problem is one for which a student does not have a previously established procedure for finding a solution. Some nonroutine problems have multiple solution strategies; some may not.

Norm-referenced tests (NRT)

Norm-referenced tests evaluate a child's performance with reference to the performance of a specific sample of students. Scores are often reported as a percentile figure, indicating that the child performed better than a given percentage of the students in the sample.

Open-ended question

A question is open-ended when it does not require a given, specific answer as the solution. By showing students that there may be several ways to arrive at a solution, these problems support and encourage creativity.

Overhead calculators

Overhead calculators are transparent calculators which project the display and keyboard onto a screen by use of an overhead projector. They allow an entire class to view the operation of the calculator simultaneously.

Pattern blocks

Pattern blocks are colored blocks that can by used to model geometric relationships such as patterns, symmetry, congruence and similarity. They are often used to develop fraction concepts.

Problem solving

Problem solving is the process of applying previously acquired knowledge to new and unfamiliar situations. The methods, procedures, strategies and heuristics students use for solution often form the focus of a problem-solving lesson.

Problem-solving software

Problem-solving software is computer software which facilitates and supports problem solving. This software is often developed to support higher order thinking skills.

Problem-solving strategies

See *heuristics.*

Recitation

Recitation is a form of classroom interaction characterized by repeated sequences of teacher questions followed by student answers, in which students respond with information they have committed to memory.

Simulations

Simulations represent abstractions of some properties of behavior of a physical system into a model. This model is often manipulated by means of computer operations. A simulation may be used to analyze the effect of actions on that system.

Spatial abilities

Spatial abilities encompass many aspects of interpreting our environment, such as interpreting and making drawings, forming mental images, and visualizing movement or changes in those images.

Standardized diagnostic test

A standardized diagnostic test is intended to reveal strengths and weaknesses in basic scholastic concepts and skills. Standardized tests are presented in the same format to each student who takes the test.

Statistics

Statistics is the branch of mathematics dealing with the collection, organization, interpretation, and evaluation of (usually numerical) information. Statistics is an important tool for the analysis of trends and the study of populations.

Technology

Technology is the application of scientific methods and materials to achieve industrial, commercial, or educational objectives.

Tessellation drawing paper

Tessellation drawing paper is drawing paper which is pre-ruled to facilitate students' exploration of the tessellation of shapes.

Thinking processes

Thinking processes that are essential in the learning of mathematics include such processes as generalizing, abstracting, reversing, unitizing, and transitivity.

Thinking software

Thinking software is software which encourages the development of thinking skills and problem solving.

Tiles

Tiles are square materials which help children explore counting and number concepts, number patterns, basic operations, and multiples.

Thanks go to Rebecca Borwn Corwin, Leslie College, for her contribution to the development of early drafts of this glossary.

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