1987

Providing for exceptionally able mathematics students at the local school level

Linda M. Dober
University of Northern Iowa

Providing for exceptionally able mathematics students at the local school level

Abstract

With the renewed Interest In gifted education, more and more students are being Identified In special talent areas. Our use of current technology Increases the need for leadership in mathematics and science. Unfortunately, economic constraints are reducing the size of teaching staffs while increasing class size. Elementary classroom teachers realize that mathematics and science are extremely important in contemporary society and that the development of talent in these areas ls often unintentionally slighted. Wheatley (1979) reports a decline in favorable attitudes towards mathematics from Grade 4 to Grade 6 which ls perhaps more apparent among gifted students.

Providing for Exceptionally Able Mathematics Students at the Local School Level

A Graduate Project
Submitted to the
Department of Curriculum and Instruction
In Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Education
UNIVERSITY OF NORTHERN IOWA

by
Linda M. Dober
November 1987

This Research Paper by: Linda M. Dober

Entitled: Providing for Exceptionally Able Mathematics Students at the Local School Level

has been approved as meeting the research paper requirement for the Degree of Master of Arts in Education.

7/27/87
Date Approved

Mary Nan Aldridge
Director of Research Paper

7/27/87
Date Approved

Mary Nan Aldridge
Graduate Faculty Adviser

11/19/87
Date Approved

Marvin Heller
Graduate Faculty Reader

11/20/87
Date Approved

Greg Stefanich
Head, Department of Curriculum and Instruction

Table of Contents

Introduction

With the renewed interest in gifted education, more and more students are being identified in special talent areas. Our use of current technology increases the need for leadership in mathematics and science. Unfortunately, economic constraints are reducing the size of teaching staffs while increasing class size. Elementary classroom teachers realize that mathematics and science are extremely important in contemporary society and that the development of talent in these areas is often unintentionally slighted. Wheatley (1979) reports a decline in favorable attitudes towards mathematics from Grade 4 to Grade 6 which is perhaps more apparent among gifted students.

The most recent statement by the National Council for the Teachers of Mathematics (NCTM) in 1986 addressed the importance of appropriate programs for the gifted. The recommendation is

> all mathematically talented and gifted students should be enrolled in a program that provides a broad and enriched view of mathematics in a context of higher expectation. Acceleration within such a program is recommended only for those students whose interests, attitudes, and participation clearly reflect the ability to

persevere and excel throughout the entire program (NCTM 1986).

Stanley (1976) contends that providing for the mathematically and scientifically talented is not expensive. Commitment is required by school personnel along with ingenuity and persistence, but eventually this provision will, most likely, save schools and parents considerable funds.

Statement of the Problem

This study will attempt to answer the following questions: What direction can teachers take as they face the challenge of dealing with gifted students? How can a teacher meet the needs of these exceptional individuals while serving the majority of students adequately? What instructional modifications, alternative practices, and supplementary resources are available if there is not a special gifted and talented program?

Design of the Study

This paper deals with four specific areas in which teachers may wish to concentrate their efforts. These include:

1. Goals: In order to plan for other than a computationally oriented curriculum, goals must be set by each teacher. This aids in skills development

decisions that will be included in the program. Students may be encouraged to provide input.

2. Organization: What options are available in attempting to reach the stated goals? Teachers need suggestions for structuring the classroom setting in order to provide these students with the appropriate atmosphere and the flexibility to complete projects; the setting must accommodate a wide variety of learning styles.

3. Teacher's role in designing a program: The teaching of mathematics to gifted elementary students is not an easy task and requires certain teacher characteristics and competencies.

4. Evaluation: Because of the current heavy emphasis on grades, gifted mathematics students must have freedom to attempt high level investigations without concern for punitive evaluations.

Procedures in Obtaining Research Literature

To obtain the related literature, the researcher made extensive use of both the Educational Resources Information Center (ERIC), Education Index, and the Microcomputer Information Services databases. This involved use of the Iowa Network for Obtaining Resource Materials for Schools (INFORMS), undertaken through the facilities of Area Education Agency Seven, and ERIC computer searches, undertaken through the facilities of the University of Northern Iowa Library. The printed counterparts of these computer databases are Current Index to Journals in Education (CIJE), Resources in Education (RIE), and Education Index. The materials were obtained at the University of Northern Iowa Library, the Area Education Agency Seven Media Center, the National Council of Teachers of Mathematics, and the U.S. Department of Education.

Review of Related Literature

Goals

Programs for gifted and talented students should allow them to use their strengths to maximum advantage. The intellectual and personal growth provided is unique to the capabilities of bright children but inappropriate for their less able classmates.

Programs must provide opportunities to develop abstract thinking, to sharpen higher cognitive processing, to practice creative problem posing and solving, and to expand individual approaches and styles of inquiry. A solid program requires long-term planning and long-range commitment by professional staff, parents, and the students themselves.

Gifted students need appropriate support and direction as many have no sense of how to address problems that are new to them. They may simply withdraw if presented with a problem that cannot be answered immediately. Programs will hopefully generate enthusiasm and foster independent investigation as gifted students are not necessarily self-motivated.

Students should be expected to write well, think well, and speak well in both standard English and the language of mathematics.

The mathematical content of these programs should include standard topics in great depth, additional nonstandard content, and early study of more advanced content. The importance of process should be stressed along with the expanded dimensions of mathematics that are generally too sophisticated and subtle to be understood and appreciated by less able classmates.

The program should have academic integrity. The curriculum must communicate significant mathematical concepts in an interesting and effective way. Students can, not only learn more mathematics, but also develop thinking skills that are essential for productive efforts and continued intellectual and personal growth (House, 1987).

Hersberger and Wheatley (1980) listed the following as goals of a gifted mathematics program:

-development of problem-solving skills
-development of thinking-learning skills
-stimulation of intellectual curiosity
-exploration of advanced topics
-participation in determining problems to be investigated
-development of spatial ability
-development of visuo-intuitive thinking

> Many programs for gifted pupils emphasize logical and analytical thinking at the expense of visual-intuitive thought.
>
> -development of logical-analytic ability
>
> -development of healthy self-concepts
>
> -development of computational ability
>
> (Computation skills are necessary to study higher mathematics, e.g. computing with simple and complex fractions.

While raising some salient questions, Osborne (1981) suggested some goals for gifted mathematics education. He indicates the need to question the roles of memory, intuition, and experience in the design and selection of activities designed to nurture mathematical talent. If the goals of a mathematically gifted program encompass processes of thinking and problem solving, then children need experience manipulating variables while processing cognitive data. Memory and natural access to that memory are important if children use their cognitive structures efficiently.

Teachers have been conditioned to believe that it is best to keep bright children busy with constant activities or acceleration. Osborne also ponders the role and effects of daydreaming in the development of mathematical creativity.

Problem solving is an important goal although its role in the mathematically talented program is not completely clear. What is the relative contribution of process learning (such as problem solving) and acquisition of knowledge (such as facts and structure), to the development of mathematical talent? Osborne's view is that the problem solving experiences are very important in talent development in the mathematically gifted because, at times, a selection of a problem solving strategy can be stimulated by a stray bit of information.

Wavrik (1980) lists five underlying themes and philosophical bases for establishing goals for nonstandard instruction.

1. Math is more a subject of ideas than a subject of facts.
2. Students can best understand an idea when, in some measure, they thought of it themselves.
3. Understanding of ideas must be created in the student's mind rather than transmitted from the teacher's mind. "Ideas must be born in the student's mind and the teacher can act only as midwife." (Socrates)

4. Learning takes place in a stimulating environment that encourages and supports thinking.
5. The main goal of mathematics instruction is to produce students who can solve problems. In the context of nonstandard instruction, this means that they can analyze the problem, use their understanding of mathematical ideas to devise one or more plan of attack, and continue to work interactively with the problem until a method is devised to solve it.

Vertically accelerating computational skills while encouraging the use of manipulative materials and the development of problem-solving skills can often be done in an enjoyable game setting. Instruction for gifted students should also provide students the opportunity to encounter topics not ordinarily available in an elementary school (Sirr, 1984).

The major program models for gifted math students seem to include some variation of two distinct categories: acceleration and enrichment. The extent of implementation of either model depends on student population and available qualified staff with associated funding (Shufelt, 1981).

Parkhurst (1981) posits that the system should allow for time to expand mathematical horizons. The program should help the student to become a more self-reliant, independent learner.

In a pull-out program for mathematically capable children described by Bloomstrand (1984), the main goal was to offer math enrichment in addition to regular classroom work. The idea is to enrich the child's mathematical experiences without accelerating their basic skills development. One mathematics topic needing enrichment is the historical development of mathematics concepts and related tools and machines mankind uses in solving problems. Machines are helpful and appealing, but human minds first created, refined, and produced these tools.

A basic program suited to the abilities and needs of the majority of pupils must be established. (Vance, 1983) This curriculum should then be extended for those students who can progress faster, wider, or deeper.

Pratscher (1982) writes that goals for the development of a gifted mathematics program should answer the following questions:

-How is the gifted student best identified?

-How are the gifted students different from their peers?

-What kind of program is most suitable for a given youngster?

-How is that program best implemented and evaluated?

In order to be effective, programs must be carefully planned and developed.

The following was taken from an official NCTM position statement, developed by the Council's Instructional Issues Advisory Committee and adopted by the Board of Directors (NCTM 1986).

> All students deserve the opportunity for achievement of their full potential. School districts have the fundamental responsibility to identify mathematically talented and gifted students. Programs to meet their needs are to be designed and implemented. Mathematics educators have the responsibility of providing appropriate instruction for these students. The needs of these students cannot be met by programs of study that merely accelerate students through the standard school curriculum or by programs that allow students to terminate their study of mathematics before high school graduation.

> The school curriculum will provide areas of study for these students each year they are in school. Areas in this enriched and expanded curricula will emphasize higher-order thinking skills, nontraditional topics, and applications of skills and concepts in a variety of contexts.

According to Payne (1981), talented students, along with demonstrating good performance in the regular math content, should explore topics in the regular curriculum at greater depth and engage in explorations of math not ordinarily taught to all students. Greater insight and understanding is the aim of instructional efforts in the gifted classroom. Gifted students need to be challenged to use their full intellectual potential.

Most of the usual topics in the math curriculum can be expanded to include new, but closely related, ideas. Estimation and mental arithmetic are particularly important for talented students because of their frequent use in math and science. These topics appeal to talented students because of their superior memories. Geometric concepts, calculators, and microcomputers can also be used to challenge able students. Other topics which are appropriate for

gifted students to study are the history of mathematics, unit fractions, and formal logic.

Mathematics knowledge should include the ability to perceive patterns and relationships (Johnson, 1983). He suggests students must be taught to form concepts and generalizations about these perceived relationships. Quantitative and qualitative strengths of mathematically gifted elementary children must be considered when planning a special program in the classroom.

Organization

A class for the gifted needs to be more individualized than most school mathematics classes to be successful (Hersberger and Wheatley, 1980). In the beginning, emphasis should be on total group and small group investigations planned with input from the pupils. Together the instructors and students should decide how students will be grouped for the investigation, what will be investigated, and when projects will be completed. The amount of teacher input in the decision making process can decrease as the students take a more active role. In this way the students feel a greater degree of responsibility and become more proficient problem-sensers because they determine what constituted the problem and worked on their own toward a solution.

Osborne (1981) questions the need for extensive group attention to mathematics. Group interaction may provide an important stimulus for some children. However, many adult mathematicians, who were powerful problem solvers in their childhood or youth, had extended periods of intensely personal, private encounters with mathematics. In a gifted program, the teacher must maintain an appropriate balance between

the personal encounter and the group attack on mathematics problems.

Fourth through sixth grade is an appropriate time to begin expecting students to assume control of their own learning (Wavrik, 1980). The program should be taught by someone who is actively working in mathematics because of the flexibility and knowledge base that will be required in case progress takes unexpected turns. Allowances should be made to allow for fairly wide differences in ability and interests. Not all students need to do everything; they just need to accomplish something worthwhile. When developing activities, the instructor should have a clear idea of the purpose to be served and a rationale for expecting that the activity will accomplish the purpose. Feedback from the group will determine if activities require modification.

The utilization of learning centers is suggested by Sirr (1984) for the following reasons: Teachers expressed the need for help in finding material outside the textbook. There is a need to keep costs low. Excellent resources are available for existing plans of learning centers in math.

Shufelt (1981) discusses methods for accelerating and enriching the mathematics curriculum. In the

acceleration model she describes, three instructional methods are presented. One method is independent study using a textbook. The limitations of this type of acceleration seem obvious; the classroom teacher has little time to do more than make an occasional check of the written work of the accelerated student.

Another method of accelerated study uses individualized programmed materials, either print or computer generated. This method is only slightly better than the method mentioned above. The gifted student still completes all material but merely does so at a faster rate.

The third method, grouping across grade lines with instruction provided by a mathematics specialist, is common in upper elementary or junior high school levels. When properly implemented, this type of acceleration seems to offer the greatest promise of success. Educators, however, caution that additional care must be taken to ensure that the accelerated student is accommodated appropriately at the high school level as well. Careful records must, therefore, be kept of the mathematical content to which each student is exposed so that students aren't asked to repeat content already learned.

Two methods are listed in the enrichment model. Supplementary enrichment materials can be provided in the regular classroom by the teacher. In order to meet this need, some schools have incorporated the use of cross-grade grouping by subject areas (math being one of them). This works well if teachers are willing to undertake this kind of specialization. Using the computer and ability grouping in math are other possibilities.

Enrichment can also be provided outside the regular classroom by a specialist, often in a laboratory setting. The teacher and the specialist must work together to ensure that competition does not surface with regard to amount of personal time and attention given to the shared students. The topics chosen by the specialist should be extensions of the regular classroom content.

The three acceleration and the two enrichment models described above contain elements which can be incorporated into almost any program. The critical factor leading to success of the plan is, however, the specialist-teacher who is well prepared in mathematics and knowledgeable about materials appropriate for instruction of the mathematically able student.

The following stipulations are important elements of mathematical contracts (Parkhurst, 1981).

1. At the end of first grading period, students who receive A's and B's are invited into the contracts program although anyone who wishes to participate is welcome.
2. Students sign up for a specific number of math sections to complete. A specified length of time is given to determine if the number of chosen sections is too numerous.
3. Students are held responsible for checking work.
4. Achievements are recorded on individual achievement charts. Letters are sent to parents and a master copy is included in the cumulative file.

In the pull-out program described by Bloomstrand (1984), first and second grade students were grouped together and third through sixth were grouped together. Students were chosen on the basis of tests indicating academic ability in math and on teacher recommendations. The curriculum included history of mathematics, field trips, in-depth study of computers and calculators, and problem solving.

In a heterogeneously grouped whole-class situation, differentiated assignments can be given in which assignments for the mathematically able include challenging questions and open-ended problems. These problems can be formulated and answered at different levels of difficulty. Students can be grouped according to diagnostic test results after introduction to the unit. Students can then be rejoined at the unit's culmination (Vance, 1983).

The following was taken from an official NCTM position statement, developed by the Council's Instructional Issues Advisory Committee and adopted by the Board of Directors in October of 1986.

> Talented and gifted students should be identified on multiple assessment measures. Teachers, counselors, administrators, and other professional staff should be cooperatively involved. The evaluators must consider the student's total educational development as well as mathematical ability, achievement, and aspirations. Acceleration within a program is recommended only for those students whose interests, attitudes, and participation clearly reflect the ability to persevere and excel throughout the entire program (NCTM, 1987).

For the highly talented student, acceleration is necessary because of the voracity of their intellectual appetites (Payne, 1981). For acceleration beyond a given grade level, there must be a school plan and school district policy. However, there are degrees of acceleration. Within a grade level, talented students can work ahead so as to cover later chapters usually not covered. Records of independent work time must be kept. Talented students should have opportunities to discuss mathematics with peers. It is essential that talented students have regular and systematic contact with an adult person knowledgeable about the reasoning and logic of mathematics. These students need this intellectual exchange to help them check their own reasoning, conjectures, and conclusions.

House (1987) contends that a productive approach to providing for mathematically gifted elementary school children is to combine the best elements of both acceleration and enrichment. This type of enrichment could investigate topics normally studied in the respective grade, but do so to a greater depth or by using a more comprehensive approach. The students may study topics that are not a part of the normal school curriculum, or may begin to explore topics ordinarily reserved for higher grades.

Recently published mathematics programs include enrichment activities for more advanced students. These materials must be screened and selected carefully with consideration for their value as an integral part of a well-planned mathematics program. The focus of enrichment should always build a foundation for further study and generate enthusiasm for, and understanding of, mathematics.

An enrichment triad model with adaptations that provide useful guidelines for elementary teachers is offered by Renzulli (1977). The three types of enrichment included in this model are: general exploratory activities to stimulate interest, group training activities, and individual or small-group investigations of real problems. Teachers need to be able to orchestrate these in order to provide the variety and flexibility which are necessary.

Classroom teachers need to employ flexibility when making assignments. For example, after demonstrating mastery of the current concept, students can be encouraged to work on alternative assignments. Teachers need to find problems which employ varied approaches and many levels of solutions. They should obtain additional resources for supplementing the basic program. This can include mathematics contests,

interaction with other mathematically-talented adults, and challenging computer software. Gifted students need to be allowed to pursue special projects and investigations. They should plan their own investigations and learn to make their own time allocations. Time needs to be spent discussing their projects. In these discussions, students can be stimulated to consider alternatives or extend their thinking. Gifted students need to communicate with others about their work. Communication with parents is also important in that their assistance is needed in planning and in relating in-school activities to out-of-school activities (House, 1977).

Providing for the exceptionally talented mathematics student within a regular class setting presents additional challenges and requires additional efforts.

Teacher's role and characteristics

In addition to an effective organizational plan, the program for mathematically gifted children needs a teacher with special characteristics. Several authorities discuss teacher attitudes and desired characteristics that contribute to effective programs. Hersberger (1980) offers the following four positive characteristics:

1. The teacher must be confident of his/her ability as a teacher.
2. A healthy self-concept is needed.
3. This teacher needs to be able to work without being threatened when his/her limits of math knowledge are taxed or exceeded.
4. The teacher must know how to function as a resource manager rather than a giver of answers.

These characteristics are important because sometimes the teacher has to rely primarily on personal, professional judgment when designing programs and activities for the mathematically talented (Osborne, 1981; Wavrik, 1980).

Teachers of gifted students need to remember that they are helping students develop successful attitudes and personality characteristics. The goal of some

lessons may, for example, be simply to show students that it's possible to learn by participating in math's creation. Teachers need to know how to help students develop their ability to think mathematically rather than to simply increase their store of mathematical information. Teachers need to provide an environment in which students are encouraged to teach themselves (Wavrik, 1980).

Sirr (1984) also emphasizes this need for a cooperative effort and adds that effective teaching of the gifted requires the teacher to assess the needs of parents, students and teachers by surveys and standardized test results. If learning centers are used, the teacher must carefully design and place them; they should be easily self-managed. A year-end evaluation is also necessary.

Teachers need to be sensitive to the affective as well as to the academic development of students (Shufelt, 1981). In acceleration, the teacher must carefully monitor students to avoid frustrations that may lead to distaste for math. In a plan of organization that employs cross-grade grouping, the teacher develops expertise in a particular subject and assumes responsibility for its instructional content. However, he/she must continue to have an active

interest in what students are doing outside the classroom. If the students are involved in special math classes, the regular classroom teacher ought to be interested and involved. Parkhurst (1981) notes that in the contract program, the teacher's role is to make resources available; this includes record-keeping.

There is little argument among mathematics educators; virtually all agree that teachers of academically gifted students should be competent in subject area content. The teacher should have a deep understanding and appreciation of mathematics and be able to communicate their enthusiasm for the subject. This includes the confidence and flexibility to encourage and permit pupils to ask questions and examine areas with which they may not be familiar. The teacher needs to have enough math knowledge to challenge the students. The teacher needs to know how to create activities that pull students deeply into mathematics. The teacher must demonstrate a mastery of the content and should be able to handle math at the level appropriate to the students' needs. He/she should be open-minded and flexible. They should possess a high degree of self-confidence and be capable of encouraging gifted students both to accept themselves and to respect the talents of other students

(Vance, 1983; Kurtz, 1983; House, Gulliver, Knoblauch, 1977).

There seems to be three aspects of expert teaching which differentiate good teachers of math from novices (McKinney and Paulu, 1986). First, expert math teachers use almost all of the class time for math. Time is stolen from blank spaces in the day. Useful homework is assigned. Second, organization and routines are established. Tightly organized demonstrations are used that relate to the content being taught. Finally, good math teachers know their subject and provide guidance throughout the lesson. They can extend and enrich lessons or reinforce concepts easily without personal anxiety or confusion.

Students, too, have described the characteristics of successful teachers of the gifted. Their descriptions include:

1. These teachers are characterized by high achievement needs - they attempt to do their best.
2. Effective teachers have more favorable attitudes toward students than other teachers.
3. Effective teachers tend to be more student centered in their teaching approach.

4. Their classroom approaches are more systematic, orderly, and businesslike.
5. Teachers who are effective with gifted students are more stimulating and imaginative in the classroom.
6. They support special educational provisions for gifted students (Bishop, 1968).

It is true that more boys than girls exhibit exceptional mathematical ability during adolescence. However, enough girls show real ability so the gap between the sexes, relative to achievement and career attainment in math and science, cannot be explained solely in terms of differences in aptitude. Many girls simply do not develop their skills fully, because of a stereotype that math is more appropriate for men than for women (Fox, 1981).

Mathematically able girls need encouragement from their teachers regardless of the support that is received at home. It is important for schools to identify, at an early age, those girls who have great potential. One of the most reliable indicators of talent are high scores on standardized tests. Some highly able girls enjoy toys and games that are often considered masculine and may be considered "tomboys".

This may be an indication of a budding interest in science.

It is also important to make a girl's parents aware of the fact that she is mathematically able. This may lead to further encouragement from them when the student makes career plans involving mathematical preparation programs.

Telling girls that they are very good at math and helping them to view this as appropriate for them, as well as for boys, may have both long and short term effects on their self-confidence, career, and educational aspirations. It is important to encourage girls to study mathematics on their own and to explore the world of recreational mathematics materials. Girls should be urged to take advanced math and science courses in high school.

Teacher expectations need to be the same for girls as for boys. Don't help girls any sooner and don't expect them to be neater, less noisy, and more polite than boys. Highly able boys and girls both need moral and intellectual role models who can exhibit the heights that talented people can achieve. Having exposure to women who use the full range of their talents and gifts may be crucial to girls.

Educators must face the challenge of identifying mathematically able girls and helping them discover their potential and realize the maximum effect of schooling during their adolescence.

Teachers of children, both boys and girls who are mathematically advanced, must know how to cultivate a student's mathematical interests. They need to encourage students to make higher-level generalizations and abstractions since many problems can be solved on several different levels of sophistication. They need to encourage students to explain the reasons for their procedures and monitor the development of basic concepts and computation skills. They need to keep a balance between the logical and reasoning parts of mathematics, including problem-solving activities, and the essential computational skills. They must encourage creative extensions of content by being sensitive to the students' interests and encouraging them to pursue their ideas further (Payne, 1981).

A primary goal of any special program for gifted youngsters is to start with the unique characteristics of these talented students (Fleming and Takacs, 1983). To work effectively with gifted children requires a full range of intellectual and psychosocial abilities

and requires the teacher to function in a wide range of roles.

Intellectual Qualities

One role a teacher must expect to assume is the role of scholar; gifted learners require complexity and higher-level abstraction to engage their attention and to foster their concentration. The teacher must also be a generalist and have a variety of interests in order to respond to these students who are searching for understanding and mastery of their environment. One of the key factors in motivating gifted children is to allow them to discover patterns for themselves. The teacher, in the role of facilitator, provides opportunities for students to manipulate materials, ideas, tools, and structures.

As originator/creator, a teacher helps gifted students play with ideas and problems that forces serious mind activity. In the role as liberator, the teacher helps to channel energies brought about by task persistence, on the student's part. Of course, the teacher must assume the role of instructor; this requires superior teaching ability, good communication skills, and abstract thinking ability. Finally, the teacher must serve as a guide, helping students discover their personal interests. They need to be

able to direct each student toward appropriate life goals, including both vocations and avocations.

Psychosocial Qualities

The teacher needs to be a friend who is sensitive to problems, considerate of others, and shows respect for the goals and dreams of youngsters. The role of liberator is important because it provides the flexibility needed to support the high level of responsibility gifted learners like to take for their own learning. Learning goals and strategies must sometimes be their choice. The originator/creator model enables teachers to encourage the use of the imagination for fantasy and novel approaches to problem solving.

The teacher as a wit/enthusiast responds to the balance between a gifted learner's sense of justice and sense of the ridiculous and the incongruous. Because gifted students are especially anxious for perfection, the teacher as evaluator must help students understand their own abilities, talents, and limitations as well as those of others. The teacher needs to be a psychologist and have a special understanding of students. The roles of counselor and facilitator are fulfilled when the teacher helps students put their talents together for genuine productive outcomes.

According to House (1987), teachers have a responsibility to continue to interact at appropriate times during the process of solving a problem or the development of a project. This includes a challenge to defend, clarify, and generalize their thinking.

In summary, a successful teacher of the mathematically gifted must be able to work successfully with these students, help them learn according to their high potential, and motivate them to feel good about themselves and their ability. The ideal teacher of the gifted mathematics student, therefore:

-is emotionally healthy, honest and sincere;

-is energetic and vital;

-has experience and maturity;

-has a strong background in mathematics;

-an effective leader, motivator and communicator who demonstrates enthusiasm for mathematics and for teaching;

-is confident of personal abilities and fosters cooperative pursuits including exploring new knowledge together.

Evaluation

Because many gifted students are overly concerned with grades, Hersberger and Wheatley (1980) stress that such judgments should not be made regarding all endeavors. Sometimes the process is more important than product and grades may discourage the exploration that is necessary. The "A, B, C" system seems in order for final grades but should only be based on total effort. Ongoing feedback should consist of written comments or a check system. Task commitment is a major attribute of a gifted math class and therefore calls for a flexible, nonpunitive grading system.

Wavrick (1980) also suggests no tests or grades. He does, however, suggest that students be expected to turn in reports on self-selected independent projects. These can then be read and commented upon; this fosters introspection.

When making a long range evaluation of the program, the following questions should be considered:

1. Does the program encourage more students to take mathematics at the high school level?
2. Has the decline in attitude towards mathematics from Grade 4 to Grade 6 reversed?
3. Has the national trend, the loss of female students taking mathematics, been counteracted?

4. Has the average grade level results of the school's chosen standardized test been raised? Hopefully the system adopted and continually modified will be in effect until at least one set of students has experienced the program during their entire school career. This provides the continuity necessary for program evaluation (Sirr, 1984).

Shufelt (1981) in discussing both acceleration and enrichment models, explained that the success of the method usually depended upon how well prepared the specialist-teacher was in math and their awareness of materials appropriate for enhancing instruction of mathematically able students.

If a teacher's enrichment materials are truly challenging, the average student will not choose to use them (Kurtz, 1983). When average students regularly ask to perform the enrichment activity, a teacher should question whether the tasks truly challenge and extend to the degree appropriate. Since there can be various levels of enrichment for students who finish their basic assignments, the enrichment activities for the gifted student should be planned with great care.

Evaluation needs to be a continuous process, one that makes the students aware of their strengths and weaknesses, interests and abilities, in a positive and

nonthreatening way (House, 1987). Alternatives to traditional letter grades include weighted grades for honors classes, teacher observations, conferences, self-evaluation, and self-diagnosis by means of a contract, checklist, or essay. Other methods include specially constructed tests and rating scales, student interviews, parent and student questionnaires, student self-reports, and group visitations. Gifted students are perceptive and can provide information about whether a program is meeting their needs. They can also provide valuable suggestions for improvement.

Evaluation methods for mathematically gifted programs should place an emphasis on creativity and higher-level thinking skills. Unfortunately, the development of instruments to measure these outcomes is still in its infancy. One approach includes having the students keep a record of their problem-solving efforts in a notebook and to submit these records periodically for evaluation. This provides a record of progress over a period of weeks or months. Teachers and students together can discuss and assess progress after studying these records.

Evaluation will usually be of the formative type aimed at collecting data to monitor student progress and to guide program improvements. In order for this

to happen, there needs to be a clearly articulated statement of the program's philosophy and goals. The program must have the needs and characteristics of the students in mind and recognize that there is no one single way to assess progress or achievement. A supportive environment is needed when assessing student performance and when communicating to students and parents the results of this assessment. Opportunities should be provided for all parties affected by the evaluation to have appropriate input into the process. Lastly, a carefully designed and implemented ongoing system for collecting comprehensive data about both student achievement and program effectiveness is needed.

After this, the crucial question is: What do <u>you</u> as a classroom teacher do with the information at hand?

Summary

A mathematics curriculum for talented students reflects their individual characteristics and the nature of mathematics. It allows students to develop to their full potential and to explore new domains of knowledge. The curriculum includes in-depth treatment of basic content, extensions of basic content, and enrichment topics.

Goals

Authorities agree that the overall goal is for higher level cognitive thinking and higher order reasoning skills to be developed as much needed supplements to the mastery of the basic mathematics curriculum. The experience of manipulating thinking and problem solving skills is imperative. Goals for program development are carefully chosen so they are suitable (i.e. meet students' ability and needs) for the students involved. Long term planning and a long range commitment to such programs are required of professionals, parents, and students. The content should include expansion of mathematical horizons; mathematical topics not ordinarily available in an elementary school are included. In this way, mathematical experiences are enriched beyond the basic skills required of regular students.

Organization

Small group interaction and individualization seem to be two preferred methods of organization proposed by authorities. Teachers must decide on appropriate balances between these two areas as group interaction provides an important stimulus for some children. However, some students prefer private encounters when problem solving.

There are various methods of grouping in acceleration and enrichment. The critical factor is the teacher in charge. This person must possess a strong background in mathematics and have knowledge of, or access to materials appropriate for the instruction of able math students.

Teacher's Role

Authorities concur that teachers of mathematically able students must have a strong background in mathematics and confidence in their ability. In addition, since they must fill the role of resource manager, they must have a knowledge of appropriate materials, record keeping, and evaluation techniques.

These teachers must develop the inward sense of knowing when it's appropriate to intervene and interact in the learning process of these students. These teachers must know how to instill enthusiasm and

motivation for mathematics and how to develop effective leadership skills in the mathematical field. Hopefully, these are qualities that the teachers themselves possess.

Evaluation

Because of the heavy emphasis on letter grades, students may be discouraged from exploration in the various mathematical areas. Positive feedback must be provided in order to encourage the students to participate actively in process-oriented curriculum in which they are engaged. Evaluation needs to be a positive and continuous process.

In the articles explored for this paper, very little was written about direct methods of evaluating gifted mathematics programs. Many mentioned difficulty in directly evaluating planned activities. One reason for this lack of guidance could be that limited funding for research has caused practitioners to rely primarily on personal professional judgment in designing such programs. Because of growing demand for school and teacher accountability, it is imperative that schools develop methods for evaluating such programs.

Recommendations

Gifted mathematics students are an important resource whose needs are not adequately met in most elementary school programs. Administrators should give careful consideration to the proper selection and placement of teachers for these students. Attempts should be made to identify those teachers who will provide the optimum educational experiences for gifted students.

Alternatives for enrichment within the regular classroom should be incorporated into the in-service education for classroom teachers. Instructors should be aware of the importance and availability of testing programs in order to define, more precisely, the characteristics and needs of gifted students. More effort needs to be put into inservice for the classroom teacher. This can help math instructors become aware of resources and testing programs which help to define characteristics and needs of gifted students.

Classroom teachers would welcome information about the gifted and about specific curriculum materials that can be used with gifted students. Instructors with training and experience in mathematics education should be considered valuable resources in the development of

programs for the gifted and can contribute to preservice and inservice education.

Mathematics for gifted students needs planned developmental activities and not just worksheets. The teacher of these students must have knowledge of the field and appropriate resources which can be used to extend the mathematics curriculum. Along with these materials, ways to evaluate effectively must be developed.

Classroom teachers should examine enrichment and acceleration techniques in their mathematics curriculum. What steps are needed to locate, acquire, or build resources for enrichment and acceleration in the mathematics curriculum? Commitment and funding areas could be explored along with specific methods of evaluation used for mathematically gifted students.

> It seems uncomfortably probable that much of the intellectual alienation of brilliant high-school graduates is due to their having been educated at a snail's pace too many years. It is time for...schools to do feasible, sensible things to prevent this atrophy of intellectual motivation (Stanley, 1976).

References

Bishop, W. E. (1968). Successful teachers of the gifted. Exceptional Children, 34(5), 317-325.

Bloomstrand, N. L. (1984). Kids with computers: an enrichment program for elementary schoolchildren. Arithmetic Teacher, 31(5), 12-15.

Borenson, H. (1983). Mathematical research in the honors classroom. Mathematics Teacher, 76(4), 328-244.

Chang, L. L. (1985). Who are the mathematically gifted elementary school children? Roeper Review, 31(3), 76-79.

Fleming, E. S., Takacs, C. (1983). A model for educating teachers of the gifted and talented. Roeper Review, 6, 22-26.

Fox, L. (1981). Mathematically able girls: a special challenge. Arithmetic Teacher, 28(6), 22-23.

Hersberger, J., Wheatley, G. (1980). A proposed model for a gifted elementary school mathematics program. Gifted Child Quarterly, 24(1), 37-40.

House, P. A., (Ed.) (1987). Providing opportunities for the mathematically gifted. Reston, VA: National Council of Teachers of Mathematics.

House, P. A., Gulliver, M. L., Knoblauch, S. F. (1977). On meeting the needs of the mathematically talented: A call to action. Mathematics Teacher, 70(3), 222-227.

Johnson, M. L. (1983). Identifying and teaching mathematically gifted elementary school children. Arithmetic Teacher, 30(5), 25+.

Kurtz, R. (1983). Mathematics for elementary and middle school gifted students. School Science and Mathematics, 83(7), 576-586.

McKinney, K., Paulu, N. (1986). How the experts teach math (Report IS 86-210bc). Washington D.C.: United States Department of Education.

National Council of Teachers of Mathematics, (1986). A position statement on provisions for mathematically talented and gifted students. An Agenda for Action. Reston, VA: NCTM.

National Teachers of Mathematics, (1987). Provisions for mathematically talented and gifted students. NCTM News Bulletin, 23(7).

Osborne, A. (1981). Needed research mathematics for the talented. Arithmetic Teacher, 28(6), 24-25.

Parkhurst, R. E. (1981). An enrichment system for any classroom. Arithmetic Teacher, 28(6), 45-46.

Payne, J. (1981). The mathematics curriculum for talented students. Arithmetic Teacher, 28(6), 18-21.

Pratscher, S. K., Jones, K. L., Lamb, C. E. (1982). Differentiating instruction in mathematics for talented and gifted youngsters. School Science and Mathematics, 82(5), 365-372.

Renzulli, J. A. (1977). The enrichment triad model: A guide for developing defensible programs for the gifted and talented. Wethersfield, CT: Creative Learning Press.

Shufelt, G. (1981). Providing for able students at the local school level. Arithmetic Teacher, 28(6), 44-46.

Sirr, P. M. (1984). A proposed system for differentiating elementary mathematics for exceptionally able students. Gifted Child Quarterly, 28(1), 40-44.

Stanley, J. (1976). The student gifted in math and science. NAASP Bulletin, March, 28-37.

Trafton, P. (1981). Overview: Providing for mathematically able students. Arithmetic Teacher, 28(6), 12-13.

Vance, J. H. (1983). The mathematically talented student revisited. Arithmetic Teacher, 31(1), 22-25.

Wavrick, J. J. (1980). Mathematics education for the gifted elementary school student. Gifted Child Quarterly, 24(4), 169-173.