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Table of Contents

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Sara, who is 5 years old, listens as her 32-year-old father comments that today is her grandmother's 64th birthday. "Grandma's age is just twice my age," he observes.

Although outwardly Sara does not seem to react to this information, her mind is whirling. A few moments pass, and then the young girl excitedly replies, "You know Dad, you will only be 54 when your age is twice mine!"

Sara has been intrigued by numbers and numerical relationships since she was very small. At first this could be seen in the way she liked to count things and organize groups of objects. She showed a fascination for calendars, telephone numbers, dates, ages, measurements, and almost anything else dealing with numbers. Sara learned and remembered this information quickly and easily, but what was even more amazing was the way she played with and manipulated the information she was learning. She would carefully examine each idea and eagerly search to discover new, interesting, and unusual relationships and patterns. Although Sara has had little formal instruction in mathematics, at the age of 5 she has acquired an incredible amount of mathematical knowledge and is amazingly sophisticated in using this knowledge to discover new ideas and solve problems.

Sara is an example of a young child who is highly talented in the area of mathematics. Like most individuals with this unusual talent, Sara exhibits characteristics and behaviors that are clues to her ability. Some mathematically talented people radiate many or obvious clues, others offer only a few, or subtle ones. Recognizing these clues is often an important first step in discovering an individual's high ability in mathematics. It is difficult to believe, but many people with a high degree of mathematical talent have their talent underestimated or even unrecognized. Their clues have gone unnoticed or ignored, and the true nature of their ability remains unexplored. If Sara's talent in mathematics is to be discovered and appropriately nurtured, it is important that her parents and teachers recognize the clues.

WHAT SHOULD PARENTS AND TEACHERS KNOW TO HELP THEM BETTER

RECOGNIZE MATHEMATICAL TALENT?Mathematical talent refers to an unusually high ability to understand mathematical ideas and to reason mathematically, rather than just a high ability to do arithmetic computations or get top grades in mathematics. When considering mathematical talent, many people place too much emphasis on computational skill or high ability in replicating taught mathematical procedures. Unless mathematical talent is correctly perceived, however, important clues can be overlooked and less important clues can be given too much significance.

Some characteristics and behaviors that may yield important clues in discovering high mathematical talent are the following:

- 1. An unusually keen awareness of and intense curiosity about numeric information.
- 2. An unusual quickness in learning, understanding, and applying mathematical ideas.
- 3. A high ability to think and work abstractly and the ability to see mathematical patterns and relationships.
- 4. An unusual ability to think and work with mathematical problems in flexible, creative ways rather than in a stereotypic fashion.
- 5. An unusual ability to transfer learning to new, untaught mathematical situations.

Terms such as mathematically talented, mathematically gifted, and highly able in mathematics are generally used to refer to students whose mathematics ability places them in the top 2% or 3% of the population. It is important to keep in mind the unusually high degree of talent that is being sought when looking for mathematically talented individuals.

Not all students who achieve the highest test scores or receive the highest grades in mathematics class are necessarily highly talented in mathematics. Many of the mathematics programs in our schools are heavily devoted to the development of computational skills and provide little opportunity for students to demonstrate the complex types of reasoning skills that are characteristic of truly talented students. The tests used and the grades given in such programs usually reflect that structure. Computational accuracy and conformity to taught procedures may be overemphasized, and the reasoning abilities associated with high ability in mathematics may be underemphasized. In this type of environment, test scores and grades of less able students who are good in computation, attentive in class, willing to help, and conscientious about completing all assignments carefully in the prescribed manner will often be as high as the test scores and grades of students who are genuinely talented in mathematics. While high achievement in school certainly can be a clue to high ability in

mathematics, additional information is needed. If care is not taken, students who are simply high achievers in mathematics can be mistakenly identified as mathematically talented. It is just as important to avoid such incorrect identification as it is to identify students who are truly mathematically talented.

Some mathematically talented students do not demonstrate outstanding academic achievement, display enthusiasm toward school mathematics programs, or get top grades in mathematics class. It is important to know that there are students like this, for their ability in mathematics is easily overlooked, even though they may exhibit other clues suggesting high ability in mathematics. There are many possible reasons why these students do not do well, but often it is at least in part because of a mismatch between the student and the mathematics program. Many of them refuse, or are unable, to conform to the expectations of programs that they see as uninteresting and inappropriate. For their part, educators may not recognize the true ability of these students or see a need for adjusting the existing mathematics program.

HOW CAN STANDARDIZED TEST RESULTS HELP IN RECOGNIZING

MATHEMATICAL TALENT?INTELLIGENCE TESTS. IQ test results often yield valuable information and may provide clues to the existence of mathematical talent. Used alone, however, these tests are not sufficient to identify high ability in mathematics. Mathematical talent is a specific aptitude, while an IQ score is a summary of many different aptitudes and abilities. An individual's IQ is made up of several different components, only some of which relate to mathematical ability. Suppose two students have the same IQ scores. One of them could have a high score in mathematical components and a low score in verbal components, while the other is just the opposite. The first student would be likely have to much greater mathematics ability than the second, even though they have the same overall IQ. Children with high IQ's--no matter how high the score--cannot be assumed to be mathematically talented. It could be a clue, but more information is needed.

CREATIVITY TESTS. There are differing opinions on how the results of creativity tests can be used to help identify high ability in mathematics. Although mathematically talented students display creativity when dealing with mathematical ideas, this is not always apparent in creativity test results. However, high creativity assessments, along with indications of intense interest in mathematics, do seem to be a significant clue of mathematical talent.

MATHEMATICS ACHIEVEMENT TESTS. Mathematics achievement tests also can provide valuable clues in identifying high ability in mathematics, but the results of these tests have to be interpreted carefully. Mathematics achievement tests are often computation-oriented and give little information about how a student actually reasons

mathematically. Also, the tests seldom have enough difficult problems to appropriately assess the upper limits of a talented student's ability or show that this ability is qualitatively different from that of other very good, but not truly mathematically talented, students. If these limitations are kept in mind, the results of mathematics achievement tests can be useful. Students scoring above the 95th or 97th percentiles on national norms may have high ability in mathematics, but more information is needed to separate the high achievers from the truly gifted. It should not be assumed that there are no mathematically talented students among those scoring below the 95th percentile; those students will have to be recognized from other clues.

MATHEMATICS APTITUDE TESTS. Standardized mathematics aptitude test results should be used in basically the same way that the results of mathematics achievement tests are used. Aptitude tests have some of the same limitations as achievement tests except that, because they are designed to place less emphasis on computational skills and more emphasis on mathematical reasoning skills, the results from these tests are often more useful in identifying mathematically talented students.

OUT-OF-GRADE-LEVEL MATHEMATICS APTITUDE TESTS. Many of the limitations associated with mathematics aptitude tests can be reduced by administering out-of-grade-level versions of the tests. This process should be used only with students who already have demonstrated strong mathematics abilities on regular-grade-level instruments or those who show definite signs of high mathematics ability. An out-of-grade-level mathematics aptitude test is a test that is usually designed for and used with students about one and one-third times the age of the child being tested. For example, a 9-year-old third grader would be tested using an abilities test normally written for 12-year-old sixth graders. This gives a much better assessment of mathematical reasoning skills because the student must find ways to solve problems, many of which he or she has not been taught to do. These tests have many difficult problems that will challenge even the most capable students, thus making it possible to discriminate the truly talented from others who are just very good in mathematics.

The out-of-grade-level testing procedure has been used successfully in several mathematics talent searches and school mathematics programs with junior and senior high school students over the past 15 years. More recently, there have been programs that have successfully used the procedure in the elementary grades.

WHAT SYSTEMATIC PROCESS CAN BE USED TO IDENTIFY

MATHEMATICALLY TALENTED STUDENTS?Correctly identifying mathematically talented students is not a simple task, and there is more than one way to go about it. Some common features of successful identification processes are combined in the following model. This model is intended to be implemented with a degree of flexibility in

order to give mathematically talented students every opportunity to have their talent discovered. This may be especially important when looking for mathematical talent in minority or disadvantaged populations.

PHASE ONE: SCREENING

The objective in phase one is to establish a group of students suspected of having high ability in mathematics. These students will be evaluated further in the next phase. In phase one, effort should be made not to miss potentially talented students.
STEP ONE. An identification checklist (Figure 1) should be set up to record the names of students thought to have high ability in mathematics along with the clues that suggest their talent. Students scoring above the 95th percentile on a mathematics aptitude test are entered first. Next, those scoring above the 95th percentile on mathematics achievement tests who are not already on the list are added. If a student's name is already on the list, the test score is simply added to that student's record. In a like manner, students who are mentally gifted; students who are creative and have high interest in mathematics; and students nominated by parents, teachers, self, or peers can be added.

STEP TWO. The checklist information for each student should be reviewed. If the information collected for a particular student suggests that out-of-grade-level testing is not advisable, that student's name should be removed, because phase two testing may damage the egos of students who do not really excel in mathematics. However, caution should be exercised not to eliminate talented students in this process. Parent involvement in these decisions is recommended.

PHASE TWO: OUT-OF-GRADE-LEVEL MATHEMATICS ABILITIES

ASSESSMENTThe objective in phase two is to separate the mathematically talented students from those who are merely good students in mathematics and to begin assessing the extent of the ability of the mathematically talented students.

STEP ONE. Students who are scheduled to take the out-of-grade-level test, along with their parents, should be informed about the nature of this test and the reason it is being given. The out-of-grade-level test would then be administered with student and parent consent. Figure 2 provides a sample schedule for such testing.

STEP TWO. The results of each student's out-of-grade-level test should be evaluated in conjunction with the results of phase one screening. Generally, the student's out-of-grade-level score will be an indication of degree of mathematical talent. Scores above the 74th percentile represent a degree of mathematical talent similar to that of students identified in regional talent searches such as the one conducted by Johns

Hopkins University. This level of talent places the student in the upper 1% of the population in mathematics ability. Scores above the 64th percentile denote a level of talent that most likely places the student in the upper 3% of the population. Students in these two groups would be identified as mathematically talented.

WHAT INSTRUCTIONAL APPROACHES BENEFIT MATHEMATICALLY

TALENTED STUDENTS?Students identified as mathematically talented vary greatly in degree of talent and motivation. No single approach is best for all of these students. The design of each student's instructional program in mathematics should be based on an analysis of individual abilities and needs. For example, students with extremely high ability and motivation may profit more from a program that promotes rapid and relatively independent movement through instructional content. Students with less ability or lower motivation may do better in a program that is not paced so quickly and is more deliberate in developing the mathematical concepts being taught. There are some common features, however, that seem to be important ingredients in the mathematics programs of mathematically talented students.

The program should bring mathematically talented students together to work with one another in the area of mathematics. Students will benefit greatly, both academically and emotionally, from this type of experience. They will learn from each other, reinforce each other, and help each other over difficulties.

The program should stress mathematical reasoning and develop independent exploratory behavior. This type of program is exemplified by discovery learning, looking for underlying principles, engaging in special projects in mathematics, problem solving, discovering formulas, looking for patterns, and organizing data to find relationships.

The mathematics program should deemphasize repetitious computational drill work and cyclical review. This type of work in mathematics should be minimal for all mathematically talented students. As ability in mathematics increases, the benefits to be gained from this type of activity decrease.

The scope of the mathematics curriculum should be extensive so that it will provide an adequate foundation for students who may become mathematicians in the future. In many programs the mathematics curriculum will have to be greatly expanded to meet this need.

The mathematics program should be flexibly paced. Flexibly paced means that students are placed at an appropriate instructional level on the basis of an assessment of their knowledge and skill. Each student is then allowed to progress at a pace limited only by his or her ability and motivation. Flexible pacing can be achieved in the following ways:

* Continuous progress. Students receive appropriate instruction daily and move ahead as they master content and skill.

* Compacted course. Students complete two or more courses in an abbreviated time.

* Advanced-level course. Students are presented with course content normally taught at a higher grade.

* Grade skipping. Students move ahead 1 or more years beyond the next level of promotion.

* Early entrance. Students enter elementary school, middle school, high school, or college earlier than the usual age.

* Concurrent or dual enrollment. Students at one school level take classes at another school level. For example, an elementary school student may take classes at the middle school.

* Credit by examination. Students receive credit for a course upon satisfactory completion of an examination or upon certification of mastery.

CONCLUSION

The fate of Sara and other mathematically talented students will be determined largely by the ability of their parents and educators to discover and nurture their special ability. The notion that these students will achieve their potential anyway is constantly refuted. For too many students like Sara, lack of appropriate mathematical nourishment seems to be the rule rather than the exception. At risk are the benefits that these children might gain from early advancement and the attitudes that these children will have toward mathematics, school, learning in general, and themselves. By discovering the

mathematical talent of these students and using that knowledge to provide appropriate academic nurture, we have the greatest chance to help these individuals reach their gifted potential.

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- Student Ability Ach. Parent Grade-Level??
- Name Test/ Test/Gifted/Creative/Nominations/ Test??
- Jones,John 97 yes/yes??
- Smith,Sally 95 yes??-----??Figure 2. Testing Schedule??
- Current Grade Out-of-Grade-Level??
- (Fall) Test??

1st 3rd grade - Fall??

2nd 4th grade - Fall??

3rd 5th grade - Spring??

4th 7th grade - Fall??

5th 8th grade - Fall??

6th 9th grade - Spring??

7th 11th grade - Fall??

8th 12th grade - Fall??&&

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