Are We Missing Anyone?

Identifying Mathematically Promising Students

BY M. KATHERINE GAVIN

Albert Einstein was four years old before he could speak and seven before he could read anything. He was considered "dull" by both his parents and teachers. Might you have an Albert Einstein sitting in your math class?

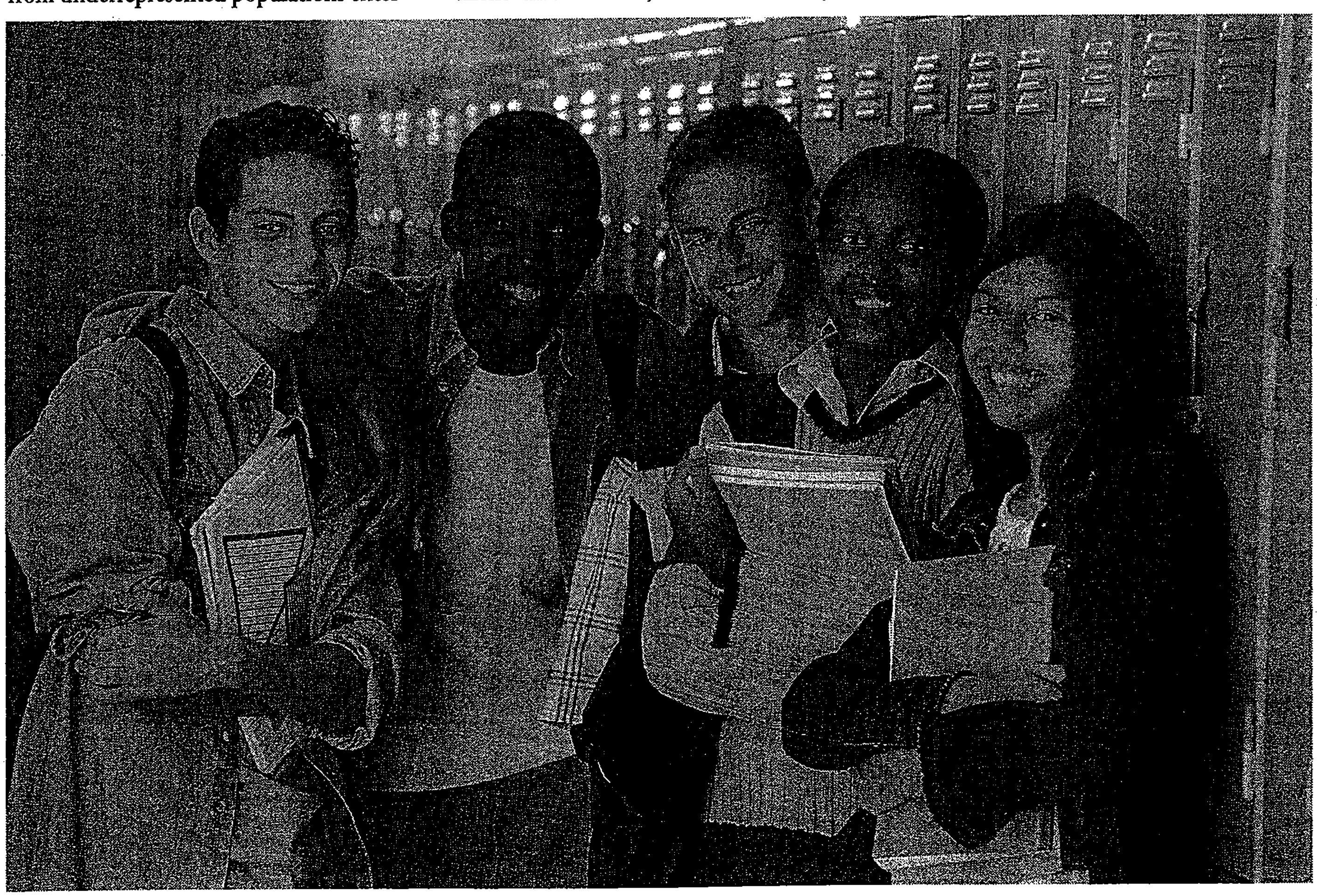
Today, more than ever, there is a need for the United States to produce top mathematicians in order to maintain its leadership as a world power. Yet, the numbers are shrinking and the projections of rising stars in the field are not promising. Recent statistics show that at the post secondary level, less than one-half of 1% of students chooses mathematics as their major field of study (National Center for Educational Statistics [NCES], 2005). Moreover, there are even fewer students from underrepresented populations entering the field with only one-fourth of 1% of Black or Hispanic students majoring in mathematic. (NCES, 2005). Clearly we need to do a much better job of identifying students with math talent and then nurturing this talent by providing challenging curriculum and instruction that ignites a desire to pursue mathematics. But, how can we ensure that we no longer miss opportunities to identify and serve students with mathematical promise?

Identification of Mathematical Talent: A Process vs. a Procedure

It is time to take a close look at identification and redefine it as a process rather than a procedure. Identification should be fluid and ongoing. It should be influenced by the definition of mathematical talent and in turn, identification must influence and be influenced by the instructional services that the district is able to provide to students.

The Definition of Mathematical Talent

First we need to step back and examine what is necessary to establish an effective identification process. To identify students with talent we need to be able to define what it means to be mathematically talented. But how many teachers and administrators really stop to consider what this talent is? What are they actually looking to identify in students when they consider results on an IQ test, an achievement test, or performance in math class? Are the instruments they are using for identification of math talent really able to find students who have mathematical



promise and who have the potential to become our next generation of creative mathematicians? Grappling with this definition of mathematical talent is an important and necessary first step. This is not an easy task and becomes more complicated when we broaden our definition to include students who have mathematical promise but may not be displaying their talent in conventional ways.

In 1994, the National Council of Teachers of Mathematics (NCTM) appointed a Task Force on the Mathematically Promising to examine issues on the development of talented students and to make recommendations regarding identification and programming. The task force purposely chose the word *promising* rather than *gifted* or *talented* to emphasize the goal of including students who have previously been excluded because of lack of opportunity or experience. Their definition was an outgrowth of the broadened definition of giftedness issued by the federal government after the passage of the Javits Gifted and Talented Education Act in 1988. The task force defined promising students as "those who have the potential to become leaders and problem solvers of the future" (Sheffield, 1999, p. 310). More specifically, they specified mathematical promise as a function of:

- ability
- motivation
- belief, and
- experience or opportunity

This definition includes the students who have been traditionally identified as gifted, talented, precocious, and so on, and it adds students who have been traditionally excluded from rich mathematical opportunities. This definition acknowledges that students who are mathematically promising have a large range of abilities and a continuum of needs that should be met. (Sheffield, 1999, p.310)

Moreover, the task force stated that:

> "...traditional methods of identifying gifted and talented mathematics students, such as standardized test scores, are designed to limit the pool of students identified as mathematically promising.... To avoid bias in the selection process, identification procedures should include a wide variety of measures to identify the broadest number of both females and males from diverse cultural and socioeconomic backgrounds. (Sheffield, 1999, p. 311)

Each of these variables—ability, motivation, belief, and experience—needs to be considered when identifying students with mathematical promise. If we focus only on mathematics achievement scores, we may miss those students who possess creative problem-solving ability. If we don't consider motivation, we may miss students who with the right mentor and mathematics that is relevant to their lives and interests can display talent far beyond what their test scores reveal. If we ignore students who lack self-confidence or who have traditionally been overlooked as a group who perform well in mathematics, we will miss an opportunity to find students with mathematical promise. And finally there are many students for whom experiences have not been available to them to demonstrate their math talent. This holds true both for students of poverty as well as students who have been exposed to mathematics as a set of procedures and rules to memorize and never had the opportunity to solve interesting non-routine problems. We need to seek out these students and nurture their potential.

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Instructional Services

The ultimate goal of identification should be to provide services to students to nurture their talent. In providing services to gifted and talented students, it is very important to make sure that the identification process is linked to instruction. This certainly holds true for serving mathematically talented students. Although this seems logical and in fact almost too obvious to mention, it is sometimes not given serious consideration. For example, some programs use identification instruments that focus only on standardized math tests that rely on speed and accuracy in computational skills or traditional problem solving, yet the enrichment instruction provided students requires high-level reasoning using analytical and creative thinking.

How can we provide the right match between identification and instructional services? There are three important tenets to adhere to no matter what services are being offered. First, mathematical talent is not a single construct, and different students display different types of mathematical talent at different times. Ideally, services for talented math students should be as varied as the variety and extent of talents students display.

Take for example, Raphael, a third grader. He enjoys "playing with numbers" and shines at algebraic reasoning. He is always amazing his teacher at how fast he can find the general pattern in a number sequence. He comes up with sophisticated explanations that sometimes leave her scratching her head. It is only when she has more time to really think about his

Student's Name (or Assigned Code No.) ______________________________
(please fill in)

MATHEMATICS CHARACTERISTICS

The student:	Never	Very Rarely	Rarely	Occasionally	Frequently	Always
1. is eager to solve challenging math problems (A problem is defined as a task for which the solution is not known in advance)	☐	☐	☐	☐	☐	☐
2. organizes data and information to discover mathematical patterns	☐	☐	☐	☐	☐	☐
3. enjoys challenging math puzzles, games, and logic problems	☐	☐	☐	☐	☐	☐
4. understands new math concepts and processes more easily than other students	☐	☐	☐	☐	☐	☐
5. has creative (unusual and divergent) ways of solving math problems	☐	☐	☐	☐	☐	☐
6. displays a strong number sense (e.g., makes sense of large and small numbers, estimates easily and appropriately)	☐	☐	☐	☐	☐	☐
7. frequently solves math problems abstractly, without the need for manipulatives or concrete material	☐	☐	☐	☐	☐	☐
8. looks at the world from a mathematical perspective (e.g., notices spatial relationships, finds math patterns that are not obvious, is curious about quantitative information)	☐	☐	☐	☐	☐	☐
9. when solving a math problem, can switch strategies easily, if appropriate or necessary	☐	☐	☐	☐	☐	☐
10. regularly uses a variety of representations to explain math concepts (e.g. written explanations, pictorial, graphic, equations)	☐	☐	☐	☐	☐	☐
Add Column Total:	☐	☐	☐	☐	☐	☐
Multiply by Weight:	1	2	3	4	5	6
Add Weighted Column Totals:	☐	☐	☐	☐	☐	☐
Scale Total:						☐

ideas that she realizes how truly talented he is.

On the other hand, we have Emery, a bright fifth grader who loves to work with shapes. She can transform a shape using reflections and rotations in her mind and predict images faster and more accurately than her classmates can do using physical models. Her joy and talent lie in the area of spatial visualization and geometry. Both of these students exhibit mathematical promise, yet each needs a different kind of mathematical experience to nurture particular talent.

Finally, there is Tonya, a first grader, who can multiply with ease, estimate with very large numbers, and reason quantitatively far beyond her grade level. Clearly, she needs to move well beyond the first grade curriculum and should be provided with an accelerated challenging program.

Rather than considering themselves gatekeepers to the gifted math program, teachers should view themselves as math talent scouts always on the lookout for new students.

Second, multiple measures, both quantitative and qualitative, should be used that provide a variety of sources of information to ensure students from all backgrounds and experiences are given the opportunity to demonstrate mathematical promise. Third, students should be given the opportunity to demonstrate their talent at different times over multiple time periods. Mathematical talent can be nurtured and students can demonstrate interest and talent at various stages in their development. Again, identification should be a process and not a procedure. It needs to be ongoing with multiple entry points into enrichment programs and opportunities for acceleration.

Quantitative Identification Measures

Quantitative measures include standardized achievement tests, specific math ability tests, reasoning ability tests and nonverbal ability tests. Some of these quantitative instruments are designed specifically to identify talented students (e.g. The *Test of Mathematical Abilities for Gifted Students (TOMAGS)*). Other measures are often used out-of-level for identifying students with talent. For example, The Johns Hopkins Center for Talented Youth has successfully identified seventh- and eighth-grade students with math talent for their accelerated program using the *Scholastic Aptitude Test (SAT)* and the *American College Test (ACT)*. Using out-of-level tests allows us to identify the most precocious math students who easily top out on measures that are standardized for their own particular age group. However, a word of caution is necessary regarding the use of standardized testing as identification instruments. Some students from disadvantaged backgrounds and some students with learning disabilities do not perform well on these measures even though they may be quite talented. It is always wise to use multiple measures for identification that allow students to display their talent in varied ways.

At the local level, using an end-of-grade-level mathematics achievement test can help identify students who place out of this curriculum and should be accelerated to the next grade level curriculum. On a smaller scale, pretesting a particular unit of instruction can identify students who have already mastered the objectives for that unit and need to be compacted out of the unit and provided with advanced math instruction.

One commonly held belief, especially at the elementary level, is that students who excel at reading and language arts excel in all subject areas including mathematics. There is a line of reasoning that assumes "gifted in one area...gifted in all areas." This is often not the case. For example, in a third-grade classroom of 20 students in an urban setting composed of all the top readers at the grade level, the teacher was quite surprised to discover that 14 of them were not identified to participate in a math program for talented students. Even more surprising to the third-grade teacher, was the fact that 12 students who were not identified as the better readers in the class were invited to join the program based on a variety of identification measures specifically designed to seek out students with mathematical promise.

Qualitative Measures

Whether identifying mathematically promising students for possible acceleration, a self-contained math class, or for a math enrichment program, teachers need to look at the mathematics being learned and the mathematical thinking that students will be doing. We should consider these students as budding mathematicians. Not only do their analytical talents need to be developed, but it is also especially important to nurture their mathematical creativity. Looking at standardized test results or end-of-grade level tests that typically are composed of questions with multiple-choice answers does not reveal the creative potential in students.

Moreover math grades and class test scores often do not give insight into either analytical or creative reasoning, especially at the elementary level. Despite the emphasis on problem solving by the National Council of Teachers of Mathematics (NCTM) and the recommendations put forth in their *Principles and Standards for School Mathematics* (NCTM, 2000), most math programs especially at the elementary level still focus on computation skills and algorithms.

Students, especially those with math talent, come to school loving mathematics. They love to count, to build, to find patterns in the world around them. They are curious about numbers and shapes and enjoy making sense of the mathematics they encounter. However, a diet of drill and practice can soon lead to boredom; the joy of discovery turns to disillusionment with mathematics and a careless attitude toward their work. Thus their grades in mathematics are not always appropriate indicators of their mathematical promise. This is complicated even more so with students who have little or no support in developing their mathematical inquisitiveness at home. A lack of home support is often the reality in the lives of students from disadvantaged backgrounds, but it is also the case in homes where parents have high levels of anxiety and low levels of self-confidence with regard to mathematics.

Qualitative measures including teacher recommendations, solutions to open-ended problems, and the observation of students in the problem-solving process can shed additional light on mathematical talent and should be used in conjunction with quantitative measures. These measures lend themselves to a qualitative methodology in gathering data different from standardized testing, one that involves teacher observation of the behavioral characteristics of students.

Behavioral Characteristics of Talented Students

Considerable attention has been given to determining the characteristics of mathematically gifted students (Waxman, Robinson, Mukhopadhyay, 1996; Sheffield, 1994; House, 1987; Heid, 1983; Lester and Shroeder, 1983; Greenes, 1981; Osborne, 1981). These researchers emphasize that their enumeration is descriptive rather than definitive or exhaustive. Much of what is found in the literature regarding these characteristics can be attributed to the Soviet psychologist and researcher, V.A. Krutetskii whose work was translated and published in 1976. He actually observed students in the process of problem solving much as Piaget did when studying cognitive development. From his observations, he believed that students who are mathematically gifted see the world through a mathematical lens, "a mathematical cast of mind" (Krutetskii, 1976, p. 302). In other words, these students see mathematics in a wide variety of situations that on the surface might not seem mathematical. Through his research, he found that gifted students actually think about mathematics in qualitatively different ways. Krutetskii argued that the way to identify mathematically gifted students was by observing them as they solved problems.

Teacher Rating Scales

Teacher rating scales can help identify behavioral characteristics of students who are mathematically promising and, in fact, help teachers think differently about the possibility of mathematical talent in many of their students. There are a variety of rating scales on the market for teachers to identify students with gifted characteristics. The Scales for Rating the Behavioral Characteristics of Superior Students (SRBCSS; Renzulli, Smith, White, Callahan, & Hartman, 1976) was one of the earliest of these sets. It has undergone several revisions and is still one of the most widely used rating scales.

Using Krutetskii's model as a basis, a new mathematics scale has been developed and is among four new scales recently added to the Scales for Rating the Behavioral Characteristics of Superior Students (Renzulli, Smith, White, Callahan, & Hartman, Gavin, Reis, Siegle, & Systma, 2004).

This scale builds on the lists of characteristics cited by leading mathematics educators and researchers for this age group, yet also has the strength of statistical testing. The scale was evaluated by content experts in the fields of gifted education, mathematics education, and mathematics, including resource teachers and university faculty in gifted and math education and university mathematicians. It was piloted by teachers rating over 735 students in grades 4-6 in urban, suburban and rural settings. The reliability (Chronback alpha = .97) and confirmatory factor analysis (X^2[14] = 45.94, *RMSEA* = .06, *TLI* = .99, *CFI* = .99) for this new scale are compelling. There is also a teacher-training component that helps to insure reliability for individual administration.

Anna has made great strides. In class, she frequently raises her hand to offer her ideas and can clearly explain her thinking in writing.

To use the math scales effectively and appropriately, teachers should recognize that mathematical talent is multidimensional and unique. As observed by Krutetskii, some talented students tend to view the world analytically, using verbal-logical reasoning; others see the world geometrically from a visual, spatial perspective; and still others see the world using a combination of the two (Krutetskii, 1976, pp. 315-329). In addition, there is a continuum of mathematical talent from those students who learn quickly to the extremely precocious. Thus the ratings of individual characteristics on the scale may differ among talented students, yet the holistic score will be within a range that shows mathematical talent. In fact, examining the scores on the individual characteristics can help teachers in nurturing the specific talents of students by using their mathematical strengths to frame their continued study of the subject.

It is important to point out that the

list of characteristics does not include speed and accuracy in computation or the ability to memorize rules or formulas easily. Although these characteristics may be helpful, they are neither necessary nor sufficient for a student to be considered talented in mathematics. In fact, as mentioned earlier, many talented students are bored with computation and make careless errors. At other times their superior reasoning ability is so predominant that it may overshadow their computational accuracy. It is important for teachers to realize that they may lose opportunities to identify talented students if their curriculum focuses heavily on computational strategies and algorithms rather than on problem solving and mathematical discovery.

These mathematics scales are currently being used in a U.S. Department of Education Javits research grant project at the University of Connecticut, Project M3: Mentoring Mathematical Minds in 10 economically diverse schools in Connecticut and Kentucky. They are one instrument along with standardized nonverbal ability and achievement tests and classroom performance that are used to identify a pool of students with mathematical promise in grades three, four, and five to take part in field testing new curriculum units. These units focus on developing critical and creative problem solving using advanced math content. The scales have added an important dimension to the identification process. This project now in its fourth year has not only identified students with mathematical promise but has also been able to nurture this talent in students who might have gone unnoticed, or even worse, labeled as not able to perform in school.

A profile of one our students, Anna, attests to the power of using multiple means of identification and coming with an open mind in search of students with mathematical promise in nontraditional ways.

Anna is a Hispanic student in an urban school who was "quiet and withdrawn." She was almost held back in second grade due to poor reading scores and was rated as one of the lowest students in her class in terms of math performance. Her IEP states she cannot memorize math facts.

Yet at the end of the first year in the project, Anna's teacher reported the following:

Anna has made great strides. In class, she frequently raises her hand to offer her ideas and can clearly explain her thinking in writing. This confidence has also affected her test scores. Her scores on unit tests have been consistently high. In addition, her mom is now working with her at home and she was the second student to master her math facts. I anticipate that Anna will only continue to succeed!

Conclusion

Identification of mathematically promising students is a complex process. It is important to take into account all factors outlined by the NCTM task force on mathematically promising students: ability, motivation, belief, and experience. We must err on the side of being too inclusive in order to make sure we are not missing students with talent potential from all backgrounds. To do this, teachers must be aware that mathematical giftedness cannot be captured in a single number or with a single instrument. To this end, multiple measures of identification should be used. Talent can and does manifest itself in unusual ways and at unusual times. Rather than considering themselves gatekeepers to the gifted math program, teachers should view themselves as math talent scouts always on the lookout for new students. And most importantly, once identified, students' mathematical talents need to be nurtured and their enjoyment of mathematics kept alive so that they will continue to pursue this field and become our next generation of creative mathematicians. ■

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