ED 404 768 EC 305 192

AUTHOR	Sayler, Michael, Ed.
TITLE	Math, Science, and the Gifted Student.
INSTITUTION	Texas Association for the Gifted and Talented, Austin.
PUB DATE	96
NOTE	20p.; Includes only theme-related materials, extracted from serial issue.
AVAILABLE FROM	Dr. Michael Sayler, University of North Texas, P.O. Box 13857, Denton, TX 76203-6857; fax: 817-565-2089; telephone: 817-565-4699.
PUB TYPE	Collected Works - Serials (022) -- Guides - Non-Classroom Use (055) -- Reports - Descriptive (141)
JOURNAL CIT	Tempo; v16 n1 Win 1996
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Animal Husbandry; Curriculum Development; *Educational Strategies; Elementary Secondary Education; *Gifted; Inclusive Schools; Inventions; *Mathematics Education; *Science Education; Special Schools; *Student Development; *Talent; Talent Development
IDENTIFIERS	Texas Academy of Mathematics and Science

ABSTRACT

This theme issue of a Texas journal on gifted education contains articles focusing on math and science instruction for gifted students. "Science Education for Gifted Students" (Joyce VanTassel-Baska) discusses what a science curriculum for gifted students should include, what teachers can do to make reform efforts successful, and how to teach mathematics to talented learners. "Young Math Whizzes: Can Their Needs Be Met in the Regular Classroom?" (Ann Lupkowski-Shoplik) provides options for educating mathematically talented students in the regular classroom and discusses issues that regular classroom teachers might encounter. "Nurturing Future Edisons: Teaching Invention to Gifted Students" (Johnathan Plucker and Michael Gorman) describes a project to develop gifted college students' inventive skills. In "Raising Cattle: Gifted Education Comes Alive" (Elaine Gray, Scott Barton, and James Coffey), a middle school program that combines gifted education with the latest practices in modern cattle husbandry is reviewed. "Is it Worth Leaving a Good High School and a Good Home To Go a Long Distance to TAMS?" (Colleen Elam) describes a parent's decision to send her daughter to the Texas Academy of Mathematics and Science (TAMS) and the daughter's experience at TAMS. Some articles include references. (CR)

Tempo

TEXAS ASSOCIATION FOR THE GIFTED AND TALENTED
Member, National Association for Gifted Children (NAGC)

VOLUME XVI ISSUE 1
WINTER 1996

REGULAR FEATURES

MATH, SCIENCE, AND THE GIFTED STUDENT

SCIENCE EDUCATION FOR GIFTED STUDENTS

Joyce VanTassel-Baska, Ed. D.
The College of William and Mary
jlvant@facstaff.wm.edu

In this time of great concern about the continuation and continuity of programs for gifted students in many parts of the country, perhaps it is appropriate to focus on fundamental areas of learning in which they participate in regular classrooms. It is relatively uncommon to find pullout science programs at the elementary level and also somewhat rare to find separate science programs for gifted students in middle schools. Consequently my suggestions for looking at science curriculum will be made from the assumption that these students are being served in regular classrooms. If we are interested in finding a curriculum base that is highly appealing to gifted students, that offers a good point of departure for interdisciplinary learning, and that is highly relevant to efforts toward curriculum reform for all students, science is clearly the most appropriate area we could find.

What Should a Science Curriculum for Gifted Students Include?

In our work at *The Center for Gifted Education* at The College of William and Mary, we have spent the past six years addressing issues of appropriate science curriculum and instruction for high-ability students as well as melding those ideas to the template of curriculum reform for all students in science. Consequently, the elements essential for high-ability learners also have saliency for other learners as well. The most important include the following elements.

An Emphasis on Teaching Concepts

By restructuring science curriculum to emphasize those ideas deemed most appropriate for students to know and grounded in the view of the disciplines held by practicing scientists, we allow students to learn at deeper levels the fundamental ideas central to understanding and doing science in the real world. Concepts such The use of technology to teach science offers some exciting possibilities for connected

(See VanTASSEL-BASKA, p. 14)

FROM THE PRESIDENT

Mary Seay

Once again it is my pleasure to speak to the members of TAGT and readers of *Tempo*. It is with a feeling of great honor and humility that I am privileged to serve this year as your president. I am tremendously aware of the weight of the responsibility for protecting the interests of our gifted children in Texas and, by extension, gifted children all over the world. And to that end, I would like to begin this year by addressing a pressing concern in this time of misunderstanding of the nature of the gifted child and of the homogenizing of our programs.

The most eminent researcher in this area today, Karen Rogers of the University of St. Thomas, has written that many reformers are arguing for the elimination of most forms of ability grouping. The suggestions are that children of like ability working together in a group be replaced by mixed-ability classrooms in which whole group instruction and cooperative learning are the major pedagogical delivery systems. Keep in mind that "cooperative learning" means a group in which one "high" child, one "low" child, and two or more "average" children work together.

Some of these folks are calling for the elimination of gifted programs in the name of reform. This effort was originally sponsored by the parents and supporters of special education students to place them in a "least-restrictive" environment. It is daunting to realize that most reformers are not aware that the least-restrictive environment for gifted children *is* working together in a mental peer grouping. Any other reasoning is manifestly non-sequitur.

In the 1990 *Communicator*, Barbara Clark discusses erroneous claims calling to return gifted children to the classroom full-time. Though these claims were supposed to have been based on research, they were not valid studies of gifted children. "Conclusions are being drawn and practices recommended from research which has specifically omitted gifted populations (p. 11)." In fact, she writes, of the three most recent researchers, only one – Harry Passow in 1988 – investigated grouping effects on gifted children. Both Kulik & Kulik and Robert Slavin use disclaimers at the beginning of their reviews of the literature waiving the two groups who would be excluded from their work: those who are low achievers and the gifted, because they are "fundamentally different from comprehensive ability grouping plans" (Slavin, 1987, p. 297). (That's Robert Slavin from Johns Hopkins University.)

The Kuliks (1984) found that when you design a program especially for talented students, there are positive effects. They had already found in 1982 that high-ability students benefit quite apparently from the stimulation provided by either special curriculum designed for them and accommodations for their being grouped together part of the

(See PRESIDENT, p. 12)

Tempo

VOLUME XVI ISSUE 1
WINTER 1996

The Texas Association for the Gifted and Talented (TAGT) is a nonprofit organization of parents and professionals promoting appropriate education for gifted and talented students in the State of Texas.

TAGT *Tempo* is the official journal of the Texas Association for the Gifted and Talented. It is published four times a year in January, April, July, and October. The cost of a subscription is included in the association's annual membership dues of $25.

Opinions expressed by individual authors do not necessarily represent official positions of TAGT. Material appearing in *Tempo* may be reprinted if not protected by copyright or reprinted already from another source. Please use the entire article, credit *Tempo* and TAGT, and send a copy of your publication containing the reprint to the *Tempo* editor.

TAGT does not sell its membership list to advertisers or other parties; however, membership names and addresses are made available for approved research requests. If you do not wish your name to be made available for G/T-related research, please write TAGT.

Address all correspondence and inquires concerning *Tempo* to, Dr. Michael Sayler, P. O. Box 13857, University of North Texas, Denton, TX 76203-6857. Telephone: 817/565-4699; Fax: 817/565-2089; TENET: sayler@unt.edu

Address correspondence concerning the organization to: TAGT, 406 East 11th Street, Suite 310, Austin, Texas, 78701-2617; 512/499-8248; FAX 512/499-8264. Address specific questions about the association to this address.

ADDRESS CORRECTION REQUESTED: Please notify TAGT if you are moving or if your mailing address has changed. TAGT publications are sent via third-class mail and are NOT forwarded by the Post Office. Also, please note the date at the top right of your mailing label. You will NOT receive TAGT mailings or information after this date UNLESS your membership is renewed. We value our members; please keep your membership current.

EXECUTIVE DIRECTOR UPDATE

Connie McLendon

1995 was a good year for TAGT. We have a great deal for which to be thankful and proud.

At the end of November, membership had reached an all time record high of 8,100, with continuing growth in special interest areas such as the G/T Coordinator's Division, the Research and Development Division, Parent and Community Affiliate groups statewide, and in the Institutional Membership category. TAGT's steady growth is a strong indicator of the value that educators, parents, and other advocates receive as TAGT members.

An attendance of 5,500 at TAGT's Eighteenth Annual Professional Development Conference on November 15-18 at the George R. Brown Convention Center in Houston broke the record set in 1994 at the Fort Worth conference.

TAGT's exemplary scholarship grants and awards program benefited nearly 200 children, youth, and educators during 1995 for awards totalling $56,390.

As a result of the active involvement of TAGT's 32 Parent and Community Affiliates, help from the Government Relations Advisory Council, and assistance from a vocal TAGT membership, the Association was able to steer gifted education through the storm of educational reform and budget cutbacks which took place during the 74th Session of the Texas Legislature. As part of the governmental affairs initiative, TAGT continued its efforts to keep members informed about legislative and regulatory issues affecting gifted students via the monthly publication of the *Capital News Update*.

One of the most important achievements of the past year was spearheaded by the Education and Training Committee chaired by Dr. Susan Johnsen, TAGT president-elect. Dr. Johnsen and the Education and Training Committee provided the leadership and initiative to launch TAGT's Professional Development Level 1 Awareness Certificate. A recipient of this certificate must complete 45 clock hours of awareness in gifted education balanced among the five areas of endorsement: (1) nature and needs, (2) identification and assessment, (3) creativity, (4) curriculum, (5) counseling. This important Level 1 Certificate will begin the process of developing higher quality professional development within the state-mandated 30 clock hours and the current endorsements offered by Texas universities. It is an important first step in a cycle of education, experience, and examination for teachers of gifted and talented students.

Key to TAGT's ongoing success is its strong Executive Board and volunteer committees — dynamic, visionary individuals whose untiring efforts and commitment to gifted and talented youngsters move the organization toward its mission. Important also to TAGT's success are the capable headquarters staff and service contractors who as a team provide strategic guidance in legislative and regulatory matters, support for the annual conference, association publications, and membership development and services.

New SBOE Rules for Gifted Education

A set of proposed rules, Chapter 89, related to gifted and talented education is scheduled for discussion by the State Board of Education on January 11-12, 1996 at the board's meeting in Austin. A set of rules recommended by the Division for Advanced Academic Services was disseminated by Evelyn Hiatt at a meeting of the Commissioner's Advisory Council for the Education of Gifted Students on December 6. Commissioner Mike Moses met with members of the Advisory Council to hear recommendations for the proposed rules and other issues relating to the education of gifted students. The set of recommended rules, (see page 24) was developed from suggestions received from TAGT parent affiliates, TAGT members, and other educators and community members attending the regional meetings co-sponsored by TAGT's regional directors and the Regional Education Service Centers across the state.

The State Board of Education schedule for the discussion and adoption of rules recommended for educational programs for gifted and talented students follows:

January 10-11	Discussion
February 15-16	First reading
April 11-12	Second reading and final adoption

TEA Division of Gifted and Talented Gets New Name

As a result of the recent reorganization of the Texas Education Agency, the Division of Gifted and Talented Education has been renamed the Division for Advanced Academic Services. The Division is still located at 1701 North Congress Avenue, Austin, TX 78701 and is under the direction of Evelyn Hiatt.

Letter from Commissioner Mike Moses

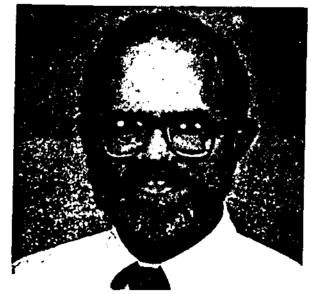
Education Commissioner Mike Moses cancelled his scheduled welcome to participants attending TAGT's 18th annual conference, November 15-18 in Houston, due to a meeting with Governor George W. Bush. The Commissioner sent his regrets via a letter read by Evelyn Hiatt at the Second General Session and disseminated to 5,500 conference attendees. The Commissioner's letter articulates his support and commitment to providing challenging programs for Texas' most advanced students. The letter is reprinted on page 25 of this issue of *Tempo*.

Governor Appoints New SBOE Member

Governor Bush has appointed Jose Garcia de Lara of San Antonio to fill the unexpired term of former board member Esteban Sosa. Mr. Sosa retired in June due to ill health. De Lara is a member of the Christian Coalition and brings a conservative view to the increasingly conservative State Board of Education. Mr. de Lara is reported to support a state voucher program for private and religious schools as an effective means of reforming the public education system. He is the ninth republican on the fifteen-member SBOE.

OUR EDITORIAL FOCUS

Michael Sayler, Ph. D.



Over the past three issues of *Tempo*, the TAGT Editorial staff has worked to create a refined and consistent format for the journal. You may have noticed some changes to the masthead, type faces, page layout, and organization of the issues. We hope that these changes make *Tempo* easier for you to read and use. We hope to provide the best, most professional publication possible.

The Spreadsheet section of *Tempo* has changed also. It is one way the Association office in Austin can provide you with timely information. The format was changed to make it easier for you to find and use. Each Spreadsheet contains announcements, information, awards, and a calender of important events. It includes items of significance that are occurring in gifted education in Texas.

Tempo continues to supply you with sound information on current and timely topics. It contains ideas and guidance for understanding gifted children, improving gifted programs, and better addressing the diverse needs of these children and youth in our schools and homes. Sometimes you may need this information to understand your children, sometimes to suggest ways to improve the things we do for and with them, and occasionally to defend the continuing presence or format of gifted education in your district's schools. To accomplish this, *Tempo* solicits and accepts submissions from international, national, and local authors. This issue on Science and Mathematics for the Gifted is a good example of our success in finding key individuals with worthwhile information.

In this issue, you will find an excellent discussion of what science for the gifted should be like. Joyce VanTassel-Baska is the leading voice in this area of curriculum planning. The work done at the College of William and Mary has helped define the "state-of-the-art" in gifted curriculum. Ann Lupkowski-Shoplik points out many useful strategies, and a few strategies to be avoided, when working with mathematically talented children. Jonathan Plucker and Michael Gorman describe an excellent project that allows gifted children to experience a deep sense of accomplishment through involvement in inventing. They also offer a World Wide Web connection where schools and families can get more information and the actual lessons on inventing and a great cross-link to a site on Alexander Graham Bell. Elaine Gray, Scott Barton, and Jim Coffey have a wonderful article about a unique gifted program in Schleicher County, Texas. Where else could you learn about a junior-high gifted program that scientifically breeds and carefully monitors their own cattle herd? Colleen and Corey Elam provide a candid and insightful look into the decision-making process of parents of the gifted when their child considers a program like the Texas Academy of Mathematics and Science. In this pair of articles, the reader shares in the joys and frustrations of a very gifted teenager and her family.

Finally, be sure to read Connie McLendon's column and the associated pages in the Spreadsheet. We have a noteworthy letter of support from the new Texas Commissioner of Education and an important first draft of the proposed Texas State Board of Education rules concerning gifted education.

We also invite each of you to consider writing for *Tempo*. Our editorial office will work with you to get your writing published. You should think of the editorial office as providing mentoring and supporting services and not as adversaries to get past. There are many great programs, competent program options, useful parenting ideas, successful stories of community building, and excellent teaching practices in Texas. Please consider sharing your successes with others through *Tempo*. Look at the back cover of each *Tempo* for the themes of the next two issues.

We hope you find useful information in *Tempo*. Neither the Texas Association for the Gifted and Talented nor the *Tempo* claim copyright on the articles and announcements published in the journal. You have our permission to copy the articles and distribute them. We do ask that you include the name of the Texas Association for the Gifted and Talented *Tempo* on any reprints you make. If you copy a page from *Tempo*, the needed information is in the page footer. If you retype an article, please include *Tempo* and the Texas Association for the Gifted and Talented. You may also reprint articles without specific approval from us. If you reprint an article in a newsletter, for a class, or other format, we do appreciate seeing a copy. Send reprints to the editorial office. Our address is in the sidebar on the inside cover.

Young Math Whizzes: Can Their Needs Be Met in the Regular Classroom?

Ann Lupkowski-Shoplik
Carnegie Mellon University

Elementary school classrooms contain students with varying levels of mathematical ability. Perhaps one or two students are *exceptionally* talented in mathematics and need radical acceleration or individualized programs. Two or three others are quite mathematically talented, but do not need such drastic interventions. These students usually enjoy math, and they usually do well in class. They are often the first ones finished with their seat work, so their teachers have to find things for them to do.

What can teachers do to challenge and to enrich the education of these students? This article addresses that question for mathematically talented students in third through sixth grade, although the principles delineated here can be adapted for older or younger students or for other content areas. Three main concerns are discussed: (1) common options for educating talented students in the regular classroom, (2) issues important to the regular classroom teacher, and (3) techniques appropriate for the regular classroom.

Options for Educating Mathematically Talented Students in the Regular Classroom

Tutoring Other Children

We've all heard that you never really learn something until you teach it to someone else. Consequently, it may seem like a good idea to ask our gifted students to tutor others in the class who have difficulty in math. Why isn't it a good idea? First, we are asking the students to do the teacher's job. Second, these students already know the material with which their classmates are struggling. For example, they do not need more practice in two-digit addition because they mastered that concept years ago. Put simply, it is not a good use of talented students' time to tutor others instead of learning something new. Therefore, this option is not recommended for more than occasional and short-term use.

Working Ahead in the Textbook, at His or Her Own Pace

This is one of the easiest ways in which to fill a student's time. The student is allowed to work ahead at his or her own pace. The student approaches the teacher with questions, but spends most of the time learning the material independently. Although permitted to move ahead at a faster pace, the student might experience feelings of isolation, and probably will not learn the material well or to any great depth. Indiscriminate use of this option is also not recommended.

Working on an Independent Study Project

After students have completed their regular work, they can use their time to investigate a mathematical topic on their own with the teacher's guidance and perhaps the help of a community mentor. This option is recommended as a supplement to the regular curriculum, but it is not meant to be a substitute for curriculum compacting or proper pacing.

Work on the Same Material as Other Students, only in Greater Depth

The advantage of this approach is that it avoids the problem of students being given more of the same work (also known as "busy work"). Instead, the students have a more in-depth experience at each level of instruction. For example, if all students in the class are expected to do computations, the gifted students could spend their time doing the computations in bases other than base ten (Pratscher, Jones, & Lamb, 1982). This model is relatively simple for the regular classroom teacher to deliver, because it does not require the development of a totally separate program for the gifted. Instead, the teacher matches in-depth activities with each level of the existing curriculum (Lupkowski & Assouline, 1992). A potential problem with this option is that the student might see the additional activities as "punishment" for being talented in math. For example, if Susan is required to do the same set of 50 practice problems as the rest of the students and is also expected to do an additional activity or problem set, she will probably resent the additional work.

Instead, it makes sense for Susan's teacher to permit her to do fewer practice problems (maybe just 10) to demonstrate mastery before encouraging her to do the extensions. A good strategy for selecting the 10 problems is to choose an assortment of the most difficult problems in the set. If the child does well on those, she knows the material (Winebrenner, 1992).

Exploring Enrichment Topics in the Regular Classroom

This option could be provided using centers, where students choose a center at which to work. For example, most of the students in the regular classroom are expected to complete Centers A, B, and C, while Centers D and E are available to students who have the time, interest, and motivation to work on additional materials. Examples of appropriate enrichment topics for these centers include probability and statistics, estimation, mental arithmetic, spatial visualization, algebra, geometry, and discrete mathematics (Wheatley, 1988). The disadvantage to this approach is the same as that mentioned in the previous option: the enrichment topics might be seen as "punishment" for completing the other activities early. A good solution to this problem is to offer students the option of substituting a higher-level activity for one the student has already mastered (e.g., substitute completing Center C for completing Center A).

Working on Mathematics Assignments in Small Groups with Other Advanced Students

This option is also known as "homogeneous grouping." Homogeneous grouping can occur when an entire classroom is composed of students of similar abilities, or when a diverse classroom of students is divided into several small groups (perhaps three or four groups) based on current skills or abilities. When this grouping arrangement occurs in the regular classroom, it requires careful planning by the teacher. It can be a marvelous way to meet individual students' needs because the pace of the curriculum is matched to the pace of a small group of learners rather than to the whole class. Thus, talented students are given challenging activities, and they are not forced to wait for everybody else to catch up.

Homogeneous grouping is not popular in the United States today, primarily due to concerns about tracking students. Ability grouping is one of the preferred options for mathematically talented students, however. The advantages of this approach include: grouping students with similar interests and abilities, giving them assignments at an appropriate level of difficulty, and allowing them to work at a pace matched to their abilities.

"...[W]hen gifted students are in class with other students of similar ability, curriculum can be designed that goes well beyond the regular content in both depth and breadth. The syllabus for average learners can be compacted and the topics elaborated, but most importantly, the thinking can be on a higher plane with topics unified and synthesized. No other grouping model offers such potential." (Wheatley, 1988, p. 253)

Moving up a Grade Just for Math

This can be another good option for students who are talented in just one content area. Whole-grade acceleration can also be considered. One disadvantage to this acceleration would be that the pace of the class a grade higher might still be too slow for these quick learners.

Participating in Mentor-Paced Programs Instead of the Regular Classes

This option is ideal for those students who are *exceptionally* talented in mathematics and need much more challenge and acceleration than the regular curriculum offers. These students are typically capable of working at least two grade levels above their age-group. Students work with a mentor in a program designed for the individual student. A detailed explanation of this approach was offered in the Winter 1995 issue of *Tempo* by Michael Sayler. This is the preferred option for students *extremely* talented in mathematics.

Issues

Now that we have considered some of the options for educating mathematically talented elementary students, let us turn to the some of the issues that the regular classroom teacher might encounter.

Varying Abilities in Mathematics

Since students' abilities vary, programs offered to them should be varied; the curriculum can be matched to the abilities of students by adjusting the pace and the depth at which the material is presented. Skipping a grade in math might be the most appropriate option for one student, while doing enrichment activities and independent study projects might be most appropriate for another.

Gifted in Math but Not in Other Subjects

Many students are quite gifted in mathematics, but do not have equal strengths in other academic areas. Consequently, these students are often not placed in their district's gifted program. It is important not to deny mathematically talented students opportunities because they are not labeled "gifted." For example, one school district refused to accelerate a student in mathematics because she had not been identified for the gifted program. This student demonstrated mastery of material presented to students one or two years older than she, yet she was not permitted to move ahead in mathematics or to leave the regular classroom.

The Gifted Program Does Not Address the Needs of the Mathematically Talented Students

The gifted program in many schools is verbally-oriented, and little time during the academic year is devoted to the study of mathematics. The mathematics that is studied might be covered in a random or superficial fashion. For example, students might receive challenge problems or enrichment sheets to complete. While these problems are interesting, they do not compose a systematic program of study in mathematics. The gifted program will meet mathematically talented students' needs only if the students are permitted to move ahead in the mathematics curriculum at an appropriate pace and depth, not if they are given random enrichment activities.

A False Dichotomy: "Acceleration Versus Enrichment"

Good acceleration contains some enrichment, while good enrichment is accelerative. The two approaches are not a dichotomy, but a continuum. Some parents put a lot of pressure on educators to accelerate their children into a higher grade for mathematics, while not realizing that an appropriately challenging program composed of enrichment, ability grouping, and subject-matter acceleration can occur in the regular classroom. On the other hand, some educators incorrectly assume that accelerated students will not experience mathematics in great enough depth. Proper pacing and the opportunity to study mathematics in great depth are both needed for the curriculum to be correctly matched to students' abilities.

Acceleration Doesn't Necessarily Produce Gaps

Students who accelerate in mathematics have already demonstrated mastery of most of the topics taught at their current grade level. The task is to determine where the gaps are and to fill them in before the student moves ahead. This can be accomplished quite simply, through the use of teacher-made tests, tests provided by textbook publishers, and/or standardized tests. Students first complete the test under standardized conditions, with one important change: they are asked to put a question mark next to the items of which they are unsure. After the test is completed, the examiner grades the test and hands the students a list of items they missed, skipped, or marked with a question mark. The students are then asked to try those problems again in unlimited time, while showing all work. This is a powerful diagnostic tool for teachers, and it helps point out misunderstandings and gaps in a student's background. It is rather simple to explain to the student the correct approach, fix misconceptions, and allow the student to move ahead. This approach is useful for mentoring students individually, and it can also work well in the larger classroom situation (Lupkowski, Assouline, & Vestal, 1992).

Students Extremely Talented in Mathematics May Make Computation Mistakes

Many mathematically talented students demonstrate imperfect computational skills. In fact, one study demonstrated that mathematically talented youth scored significantly higher on mathematics Basic Concepts tests than on Computation tests (Lupkowski-Shoplik, Sayler, & Assouline, in press). Some of these students have extremely strong abilities in mathematics and show a great intuitive grasp of mathematics concepts, yet they do not show the same high level of skill in computations. Talented students might make mistakes in computations because they are bored or have learned bad habits such as not writing down their thought processes as they solve problems. They may also have advanced in their conceptual understanding of mathematics because of their strong reasoning abilities, and their computational skills have not caught up yet because they have not learned the appropriate terminology or algorithms. These students should not be held back because of their relative weakness in computations. Instead, concepts and computations should be taught concurrently. These students can be challenged by learning new concepts while polishing their computational skills.

Classroom Techniques

Once the regular classroom teacher has an understanding of the educational options for mathematically gifted students and the issues that educating them creates, the teacher can employ techniques useful in educating these students.

Questioning, Justifying Answers, and Providing Alternate Solutions

When students are given challenging mathematics problems to try, asking them to discuss possible approaches before beginning the problem and asking them to defend their answer after solving it are both powerful learning strategies. Students should be able to explain their answers and justify their approaches. Some mathematically talented students in our programs are surprised by this approach. It seems as if they had never been questioned about their answers to a problem. Asking them to justify their answers has the added benefit of increased awareness of their own thinking, rather than feeling as if the answer just appeared to them. Encourage students to offer several different approaches to the same problem. They benefit from hearing different points of view on how to approach a problem.

Problem Solving

Teachers should provide challenging problems for the students, but also teach the students strategies and approaches to use when solving those difficult problems. Problem solving strategies include: Make a List, Make a Table, Guess and Check, Work Backwards, and Finding a Pattern. Lenchner's (1983) book offers some excellent challenging problems for mathematically talented students in third through sixth grades. Krulik and Rudnick (1980, 1984) offer several books for teachers on using problem solving strategies in the regular classroom. The National Council of Teachers of Mathematics encourages teachers to use real-world problems, such as those that "allow students to experience problems with 'messy' numbers or too much or not enough information or that have multiple solutions, each with different consequences; [these real-world problems] will better prepare them to solve problems they are likely to encounter in their daily lives" (NCTM, 1989, p. 78).

Journals

Another way to encourage students to think about their approaches to mathematics is to ask them to keep a mathematics journal and to write down their approach to a problem. Asking students to write about their mathematical thinking is a new experience for many students; they usually think of mathematics as being numbers, not words.

Portfolios

Keeping individual student portfolios in mathematics is becoming more and more popular. Portfolios are useful in tracking students' mathematical development, and they can also be helpful in identifying students for differentiated instruction. Students are asked to keep copies of their best work in their portfolios from year to year. Teachers might also designate specific assignments as "portfolio work." Comparing students' responses to these assignments might be useful in selecting students for differentiated programming. Portfolios can be an excellent diagnostic and evaluation tool for discovering mathematically talented students who do not test well or who are hesitant to respond in class.

Compacting the Curriculum

If gifted students in the regular classroom are to be given enrichment topics, it is essential that the regular curriculum be compacted, so that students will have more time for the enrichment topics and also so that they aren't bored by the pace of the regular classroom. The three basic questions asked during the compacting process are (1) What does the student know? (2) What does the student need to learn? and (3) What differentiated activities meet his or her needs? (Starko, 1986). Using tests provided by textbook publishers, standardized tests, or teacher-made tests, we can address the first two questions. Wheatley (1988) provides the answer to the third question with his list of appropriate enrichment topics for mathematically gifted students: problem solving, estimation and mental arithmetic, spatial visualization, computer problem solving, probability, statistics, ratio, proportion, percent, and intuitive algebra.

Starko (1986) and Winebrenner (1992) provide thorough explanations of how to compact the curriculum. For example, after a group of students have completed pretesting, they are given a list of activities to be completed for each unit. The teacher checks the tasks to be completed by individual students. On the occasions when the group is covering material already mastered by a particular student, that student is free to pursue enrichment or acceleration options such as completing logic puzzles or taking notes for an independent study project.

Summary

The goal for educating mathematically talented students in the regular classroom is to properly pace and enrich their study of mathematics. The roadblock educators, students, and parents encounter is the "problem of the match"—matching the curriculum to the abilities and achievements of these students. This match can be accomplished through ability grouping, enrichment activities in mathematics, and subject-matter acceleration.

Selected Resources Used in Programs for Mathematically Talented Elementary Students

Erickson, T. (1989). *Get it together*. Berkeley, CA: EQUALS. University of California at Berkeley.

Krulik, S., & Rudnick, J. (1980). *Problem solving: A handbook for teachers*. Boston: Allyn & Bacon.

Krulik, S., & Rudnick, J. (1984). *Problem solving: A sourcebook*. Boston: Allyn & Bacon.

Lenchner, G. (1983). *Creative problem solving in school mathematics*. Boston: Houghton Mifflin.

Lenchner, G. (1990). *Mathematical Olympiad contest problems for children*. East Meadow, NY: Glenwood Publications.

Phillips, E., Lappan, G., Winter, M. J., & Fitzgerald. W. (1986). *Middle grades mathematics project: Probability*. Menlo Park, CA: Addison-Wesley.

Pentagram Design Ltd. (1989). *Puzzlegrams*. New York: Simon & Schuster.

Serra, M. (1989). *Discovering geometry*. Berkeley, CA: Key Curriculum Press.

Seymour, D. (1982). *Favorite problems*. Palo Alto, CA: Dale Seymour.

Winebrenner, S. (1992). *Teaching gifted kids in the regular classroom*. Minneapolis, MN: Free Spirit Press.

Winter, M. J., Lappan, G., Phillips, E., & Fitzgerald, W. (1986). *Middle grades mathematics project: Spatial visualization*. Menlo Park, CA: Addison-Wesley.

Sources of Enrichment Materials

Creative Publications, 5040 West 111th St., Oak Lawn, IL 60453. Telephone: (708)425-1440.

Dale Seymour Publications, 1100 Hamilton Ct., Menlo Park, CA 94025. Tel: (415)324-2800.

Mathematical Olympiads for Elementary Schools, 125 Merle Ave., Oceanside, NY 11572. For 6th graders and younger students.

National Council of Teachers of Mathematics. 1906 Association Dr., Reston, VA 22091.

References

Lupkowski, A. E., & Assouline, S. G. (1992). *Jane and Johnny love math: Recognizing and encouraging mathematically talented elementary students*. Unionville, NY: Trillium.

Lupkowski, A. E., Assouline, S. G., & Vestal, J. (1992). Mentors in math. *Gifted Child Today, 15*(3), 26-31.

Lupkowski-Shoplik, A. E., Sayler, M. F., & Assouline, S. G. (In press). Mathematics achievement of talented elementary students: Basic concepts vs. computation. *Roeper Review*.

National Council of Teachers of Mathematics (NCTM). (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: NCTM.

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

Sayler, M. (1995). Mentoring students who are highly talented in mathematics. *tempo, 15*, 5-7.

Starko, A. J. (1986). *It's about time: Inservice strategies for curriculum compacting*. Mansfield Center, CT: Creative Learning Press.

Winebrenner, S. (1992). *Teaching gifted kids in the regular classroom*. Minneapolis, MN: Free Spirit Press.

Wheatley, G. H. (1988). Mathematics curriculum for the gifted (pp. 252-274). In J. VanTassel-Baska, J. Feldhusen, K. Seeley, G. Wheatley, L. Silverman, & W. Foster. *Comprehensive curriculum for gifted learners*. Boston: Allyn & Bacon.

About the Author

Ann Lupkowski-Shoplik received her Ph.D. in Educational Psychology from Texas A&M University. After a postdoctoral fellowship with Julian Stanley at Johns Hopkins University and three years as an assistant professor at the University of North Texas, she moved to Carnegie Mellon University. She has been conducting research and directing summer programs and weekend workshops for mathematically gifted elementary students at Carnegie Mellon since 1992. She can be reached at: C-MITES, 4902 Forbes Ave., Box 6261, Carnegie Mellon University, Pittsburgh, PA 15213. Telephone: (412)268-1629.

Correction

The following is clarification for the article, "Identifying and Serving Gifted Kindergartners," by Dr. Joyce Miller, East Texas State University, which appeared in the fall 1995 issue *Tempo*, volume XV, issue 4.

Paragraph four, second sentence should read:

"Level 1 screening consists of five assessment items: a cognitive abilities test, an achievement test, a reasoning activity, Modern Curriculum Press's Visual-Motor Integration Test, and a parent nomination/interview."

For further information, please contact Marta Mountjoy, Garland ISD.

NURTURING FUTURE EDISONS: TEACHING INVENTION TO GIFTED STUDENTS

Jonathan A. Plucker, Ph. D.
University of Maine

Michael E. Gorman, Ph. D.
University of Virginia

The Invention Project at the University of Virginia is attempting to fill the void in what we know about invention and how to teach it to students. Although the Project began three years ago by focusing on the development of college students' inventive skills (Gorman et al., 1995); current efforts focus on secondary students because material on invention helps them understand how science and math are applied to real-world problems and may affect their career choices.

The result of our ongoing efforts is a course developed and piloted with nearly three dozen children who attended a residential summer program for gifted students. The purpose of this article is to describe the activities of the Invention Project, discuss how what we have learned can be useful for educators of the gifted, and summarize the various, easily accessible resources that the Invention Project provides.

How the Invention Project is Different from Previous Efforts

The instructional techniques developed in the Invention Project are an extension of case-based (Fitzgerald, 1995) and problem-based learning (Stepien & Gallagher, 1993), which are used quite frequently in medical, engineering, and business schools. Students work in small, diverse groups on problem-based simulations. They are presented with general objectives, provided a significant amount of background material, and asked to meet several deadlines for creating and presenting patents and prototypes. For example, the objectives deal with activities as diverse as (1) designing a telephone based on technology that was state-of-the-art in 1876 and (2) developing solar technology to power the medical and refrigeration needs of an isolated, third world community.

Our research (Gorman & Plucker, in press; Plucker & Gorman, 1994, 1995) provides evidence that the strengths of this type of unit include:

- recognition that diverse skills and talents are valuable when working in a group
- more accurate beliefs about scientific processes, especially with respect to invention
- increased emphasis on the value of reflection during the invention process
- belief that science and technology are accessible to people with diverse talents and interests
- realization that "success" can be based on process and not necessarily on completion of a product
- awareness that frustration and "failure" can be temporary and constructive

We believe that these findings are a result of the format of the course: Students are presented with an applied, real-life problem that is only loosely defined and are then required to solve unexpected problems as they arise using a variety of media, technological, and human resources. By requiring students to build prototypes and defend their innovations in front of a "patent examiner" and their peers, the student-inventors are exposed to the process of scientific and technological creativity as it exists in modern society.

A "Typical" Unit: The Telephone

Students were assigned to three or four person groups based on their stated interests and abilities. Although most of the students were interested in science, many considered themselves to be more talented in verbal/linguistic areas. We assigned these students to groups with mathematically and scientifically talented peers to create teams characterized by diverse skills, again mirroring the process of technological creativity as it exists in today's research and development laboratories.

The groups were then presented with a general problem statement similar to: "It is 1876, and Alexander Graham Bell is about to patent his telephone. Create a prototype and patent for a telephone that would be innovative in 1876." They were given significant resources, including Bell's patent, access to copies of Bell's notebooks, Elisha Gray's caveat (a formal intent to file a patent), instructions for creating four different phone prototypes that existed in 1876 (i.e., the "state-of-the-art"), tools and additional building materials (e.g., wires, pliers, nails, wood), and numerous videos, books, and articles on Bell and/or the invention of the telephone. Additionally, the teacher of the course — a physics teacher from an area high school — taught mini-lectures to the entire

The Invention Project is supported at the secondary level by grants from the Geraldine R. Dodge Foundation. Documents developed through the Invention Project are available via the World Wide Web at: **http://jefferson.village.edu/~meg3c/id/id_sep.html.**

class or to specific groups on pertinent topics. For example, during the telephone unit the teacher noticed that most groups lacked knowledge of electric circuitry, so he provided a whole-class mini-lecture on circuits. During the solar energy unit, one group encountered an aerodynamics problem that was specific to their project, so the teacher directed his mini-lecture to that group and allowed the other teams to keep working with their respective inventions.

Students were given approximately 10 days to file and defend a patent. The first few days were used for background research and initial experimentation. After the fifth day, they were asked to file a caveat that included drawings and descriptions of their various ideas. Prototype-building began in earnest between the fourth and sixth day, and most groups were tinkering with their phones and preparing their patents by the eighth day. The final step of each unit was the presentation of the patent to the rest of the class. An educator with patent and content area expertise served as a patent examiner and asked the students questions that required them to defend the utility and novelty of their inventions.

The last stage of the presentations allowed students in the audience to ask questions of the presenting inventors. Many of the student queries centered on the presenters' reactions to specific problems (which the inquiring students also encountered). Several student questions were more direct than those asked by the patent examiner. Surprisingly, many students felt that their group was successful even though they were not able to create a sound-transmitting phone by the end of the unit. We attribute this to the emphasis placed upon creative/inventive processes during the course.

A second unit involved the development of solar technology that would allow the introduction of electricity to isolated communities in equatorial rain forests. This unit differed from the phone unit in that students had to consider environmental problems (e.g., little sunlight reaches the forest floor due to the extensive canopy formed by the trees), ethical issues (e.g., does the community want electricity?), and the need to conduct research on prototypes. Since most groups constructed working prototypes within a couple of days, the emphasis moved from creating a working model to fine-tuning the prototype in order to increase its efficiency. One group established the exact angle of their solar panels that would cause water to boil in their solar oven at the quickest rate, while another team determined the most cost efficient way to insulate their hot water heater. Groups also estimated the overall financial cost of their inventions, which required many of them to call supply houses and other companies. The emphasis on research necessitated that students consider a variety of costs: environmental, ethical, financial, and aesthetic.

Modifying the Units

Teachers who actively participated in or observed the course suggested ways in which the modules could be incorporated into existing programs for secondary students. The educators thought that the units could be easily incorporated into existing summer or afterschool programs for the gifted, since little modification would be necessary. Most of the materials are inexpensive and readily available, leading several people to suggest the use of a similar format in high school physics laboratories. In this format, the units could be broken into several stand-alone lab activities or implemented as an activity that spans several lab periods.

Other possible applications include independent study for talented students or students with a special interest in technology and science, a whole-class activity that develops creative and interpersonal skills, and a curriculum for students in gifted and talented pullout programs.

Invention on the World Wide Web

The Internet is an excellent way for educators to share materials. As such, we are using the World Wide Web to disseminate the products we have developed through the Invention Project. At the URL provided below, teachers will find:

- pilot-tested modules similar to the unit described above,
- extensive background material, teachers' notes, and outlines of the mini-lectures, and
- complete copies of evaluation reports and additional research on the course for secondary students.

The documents can be accessed via the Web at:

http://jefferson.village.virginia.edu/~meg3c/id/id_sep.html

While a growing number of school districts are gaining access to the Web, we realize that computers with entry into the Internet are not a common sight in many schools and classrooms. The materials available at the Web site can also be obtained on a 3.5" computer disk to be run on either PC- or Macintosh-based computers by writing to the project director.

Conclusion

Why have no attempts been made to teach inventing in the schools? Why should it not be possible to train people to invent? These questions are extremely interesting and of great social importance (Rossman, 1964, p. 216).

Plucker

continued from page 11

While the Invention Project's continuing efforts to teach invention are addressing Rossman's timeless questions, our experiences lead us to believe that educators are able to facilitate the development of inventive and creative skills in secondary students. The experiences of educators who are training our society's future inventors will add significantly to what we currently know about the psychology and education of inventing.

References

Fitzgerald, N. (1995, March). Teaching with cases. *ASEE Prism*, 16-20.

Gorman, M. E., & Plucker, J. A. (in press). Teaching invention as critical creative processes: A course on technoscientific creativity. In M. A. Runco (Ed.), *Critical creative processes*. Norwood, NJ: Ablex.

Gorman, M. E., Richards, L. G., Scherer, W. T., & Kagiwada, J. K. (1995). Teaching invention and design: Multi-disciplinary learning modules. *Journal of Engineering Education*.

Plucker, J. A., & Gorman, M. E. (1995). Group interaction during a summer course on invention and design for high ability secondary students. *Journal of Secondary Gifted Education, 6*, 258-272.

Plucker, J. A., & Gorman, M. E. (in press). *One year follow-up evaluation of a secondary course on invention and design*.

Plucker, J. A., & Gorman, M. (1994). *An evaluation of a course on invention and design for gifted high school students: Report submitted to the Dodge Foundation*. Charlottesville, VA: University of Virginia School of Engineering and Applied Sciences.

Rossman, J. (1964). *Industrial creativity: The psychology of the inventor*. New Hyde Park, NY: University Books.

Stepien, W., & Gallagher, S. (1993). Problem-based learning: As authentic as it gets. *Educational Leadership, 50*(7), 25-28.

About the Authors

Jonathan Plucker is an assistant professor in the College of Education at the University of Maine. Michael Gorman is director of the Invention Project and an associate professor in the School of Engineering and Applied Sciences at the University of Virginia. He can be reached at TCC, School of Engineering and Applied Sciences, University of Virginia, Thornton Hall A217, Charlottesville, VA 22903 or via e-mail at meg3c@virginia.edu.

Are your students interested in invention? For information on starting an inventing club in your school, contact: Houston Inventors Association, c/o Charles F. Mullen, 204 Yacht Club Lane, Seabrook, Texas 77586, (713) 326-1795.

President

continued from page 2

schoolday. Here's something else you should know: they found the effects of grouping in average and below average students to be near zero on the achievement of those students. They did not find it to be negative.

The study concluded with the finding that all children liked their school subjects more when they studied with peers of abilities comparable to their own, and that some students in similar groupings developed more positive attitudes about themselves and about school than they had had before.

No one who has read what I have written in the past doubts that I believe that all babies are born with gifts. That is not in question. I also think that we parents and we teachers should be working as hard as we possibly can every day to develop those gifts in all children. However, this is *not* the same thing as programs for and the nurturing of the gifted child. The work "gifted" annoys and confuses those who do not understand who and what these children are. The name gifted came from the Marland report which sort of officially labeled these children with the word "gifted" and gave us the federal definition. You all know, too, that I think "gifted" is the wrong word for our children and, further, I believe that semantic problems are where a *great* deal of the trouble lies.

I have called these children "cognitively needy." Maybe "challenge needy" would be better. Whatever we call them, these children are the reason TAGT exists. Our mission is advocacy for these specially endowed children. While every pre-service training program in the world is a support group for our regular and special education children, the 8,000 members of the Texas Association for the Gifted and Talented have accepted the charge to serve the cause of the gifted child. And 1996 is going to be a vintage year.

RAISING CATTLE: GIFTED EDUCATION COMES ALIVE

Elaine Gray and Scott Barton
Schleicher County ISD

James Coffey
Region XV Education Service Center

In Schleicher County, a ranching community in southwest Texas, our middle-school students are, for the most part, just like average teenagers everywhere. They are preparing for the TAAS test, playing football and cheerleading Thursday nights, and generally acting like teenagers most of the time. There is one exception, however. On any given day, you will find a group of students from the Eldorado Middle School Gifted Program recording data concerning cattle weights on a computer or monitoring newly born calves and their mothers in a local pasture.

These students are part of an innovative and unusual gifted and talented program. It combines gifted education with the latest practices in modern cattle husbandry. The program was the brainchild of the Schleicher County ISD Superintendent, Scott Barton, while he was the middle-school principal.

"I knew the bright kids could handle the mental challenges, but I felt that many of them were lacking practical experience when it came to working with their hands and using fine motor skills. I believed that if we could combine both challenging mental activities and the hands-on experiences in a real-life situation, the students would gain so much more."

So, with the help of Dr. Wayne Williams, a local physician and rancher, and Martha Spinks, the middle-school teacher of the gifted and talented, Mr. Barton developed a unique gifted program. The project outcome was not a series of written papers or oral reports but selection and breeding of a premiere cattle herd. The program was given the name, *Bovine Reproduction with Artificial Interference.*

Initially, the students researched artificial insemination and cattle genetics with Dr. William Edmiston, a local veterinarian. There was much to learn about this process, and even more to learn about the qualities that determined a "good cow." Students learned about diseases, herd management, estrogen cycles, and choosing a sire of quality. All of which were necessary to master if the artificial insemination (A.I.) process was to be successful. The students visited the Medina Valley Genetics Center in Castorville, Texas, and the School of Veterinary Medicine at Texas A & M University. These visits have continued now as yearly field trips for the gifted students. It is during these visits that students gained firsthand knowledge of the A.I. process. They received specific and technically accurate instruction in genetics and in the implication of sire characteristics on individual cattle and the health and prosperity of the entire herd.

The program participants were about ready to begin husbandry of their own herd of cattle. While the students continued learning specific technical skills and developing an extensive knowledge base in this subject area, Mr. Barton was securing needed help from local ranchers. A rancher agreed to provide a healthy mother cow that the students could breed. This arrangement benefited both the school and the rancher. The students could use their newly acquired skills. The rancher would have a cow pregnant from an excellent sire. She would receive close attention and all the necessary medical treatments to insure a healthy pregnancy.

The program and the cattle were a great success. After two years, Mr. Barton realized that the middle-school students could gain even more skills if they owned their own herd of cattle. The school district would provide up to $5,000 for buying cows. This provided another unique experience for the gifted class. The students, along with Mr. Barton and Mrs. Spinks, attended a cattle auction in San Angelo. Their goal was to purchase the best breeding herd they could with the funds available.

Today, the herd continues to prosper. They pasture it on local ranches and the students continue to be responsible for its maintenance. Detailed records are kept on the weight gain or loss of each pregnant cow. Students record any injections that they give and why they were necessary. They closely monitor the herd's feed program and they have continually updated and recorded gestation information.

The cattle herd has become a self-sufficient undertaking for the school district. Since keeping a large herd of cattle would not be easy, they decided to maintain a small herd. Therefore, they sell some calves each year; this provides the funds needed to purchase feed, medications, semen straws, and other related veterinary supplies.

This program might not work in a large city, but it has been very successful here. The students enhance their computer skills and gain hands-on experiences in ranching and animal husbandry. They also learn about the anatomy and the reproductive systems of other animals as they help Dr. Edmiston in actual surgical veterinary procedures.

At Eldorado Middle School, making gifted education come alive has new meaning for the students who have worked with the cattle herd. Although most of the students who participate in this program will not choose ranching or veterinary medicine as a career, they have gained many skills and much confidence. The experiences, diverse knowledge, and skills learned in this project should translate into success in whatever fields they eventually pursue.

VanTassel-Baska

continued from page 1

as systems, change, reductionism, and scale all provide an important scaffold for learning about the core ideas of science that do not change, although the specific applications taught about them may.

An Emphasis on Higher-level Thinking

Just as students need to learn about important science concepts, they also need to manipulate those concepts in complex ways. Having students analyze the relationship between real world problems, like an acid spill on the highway, and the implications of that incident for understanding science and for seeing the connections between science and society provides opportunities for both critical and creative thinking within a problem-based episode. Such an emphasis is crucial in a science curriculum that purports to be engaging learners in "minds-on" experiences.

An Emphasis on Inquiry Approaches, especially Problem-based Learning

The more that students can construct their understanding about science for themselves, the better able they will be to encounter new situations and employ appropriate scientific processes to them. Through guided questions by the teacher, through collaborative dialogue and discussion with peers, and through individual exploration of key questions, students can grow in the development of valuable habits of mind found among scientists, such as skepticism, objectivity, and curiosity (VanTassel-Baska, Gallagher, Bailey, and Sher, 1993).

An Emphasis on the Use of Technology as a Teaching Tool

The use of technology to teach science offers some exciting possibilities for connected real world opportunities for students. Access to the world of scientific papers through CD-ROM databases offers new avenues for exploration. Moreover, Internet access provides teachers wonderful connections to well-constructed units of study in science as well as ideas for teaching key concepts. Using Gopher Jewels as a basis for quality materials provides further assistance in selecting appropriate resources. The use of e-mail allows students to communicate directly with scientists as well as other students around the world on questions related to their research projects.

An Emphasis on Teaching the Scientific process, using Experimental Design Procedures

In our experience in having teachers all over the world implement the William and Mary science units, one of the realities we have uncovered is how little students know about experimental design and its related processes. Typically, basal texts will offer canned experiments where students follow the steps to a preordained conclusion. Rarely are they encouraged to read and discuss a particular topic of interest to them in science, come up with a problem about that topic to be tested, and then follow through in a reiterative fashion with appropriate procedures, further discussion, a reanalysis of the problem, and communication of findings.

What Can Teachers Do to Make These Reform Efforts Successful?

While the inclusion of the elements cited above will go a long way in enhancing science education in our schools, especially for high-ability learners, it is folly to think that these major emphases can be effected without the appropriate support structures in place to nurture them along. In order to ensure that science reform has a chance, administrators, teachers, and parents need to consider the following resource tools to help the reform effort succeed.

The Selection of Modular Materials Rather than Basals for Classroom Use

Our work (Johnson, Boyce, and VanTassel-Baska, 1995) has demonstrated that there are excellent science materials available that will promote the teaching described above. However, districts must be willing to turn to the use of such materials rather than insisting on the purchase of basals which do little to promote the desired kind of science learning. Moreover, there are excellent supplementary materials also attuned to the new science agenda that can augment any school science program.

The Training of Teachers in Content-based Pedagogy

Our research evidence would suggest that if we wish to improve teaching and focus on student learning, then teachers need help in teaching for understanding (Cohen, D., McLaughlin, M., Talbert, J., 1993). In order to do that, we need to emphasize strategies and instructional approaches in the context of content rather than separate from it. One good way to approach such training is to use high-quality materials as the basis for the training sessions to ensure the integration of content and pedagogy.

The Employment of Curriculum Monitoring Processes in Schools

No matter what new emphasis schools wish to see implemented, there is a need to ensure that the innovation has been implemented faithfully. Where that is not happening, suitable measures are employed to ensure that such change will occur appropriately in the near future. Research on staff development as well as effective teaching demonstrates the need for systematic follow-up procedures to ensure teacher action. Whether such monitoring occurs through peer coaching programs, supervisory procedures of the principal, or curriculum specialists is not as important as the fact that it occurs at all.

Conclusion

Appropriate science curriculum for high-ability and gifted learners implies the need to emphasize some elements at the expense of others. It implies a need to focus on a few concepts that are taught deeply and well. It implies an emphasis on the real world act of doing science. It implies the infusion of technology as a resource. It implies making the experience in science classrooms learner-centered and dynamic. If we can accomplish such an integrated agenda, then our students are far more likely to be able to function at higher levels of scientific literacy than is currently the case.

References

Cohen, D., McLaughlin, M. and Talbert, J. (1993). *Teaching for understanding*, San Francisco, Ca.: Jossey Bass.

Johnson, D., Boyce, L. and VanTassel-Baska, J. (1995). Evaluating curriculum materials in science. *Gifted Child Quarterly, 89*(1), 35-43.

VanTassel-Baska, J. , Gallagher, S., Bailey, J., and Sher, B. (1993). Scientific experimentation. *Gifted Child Today, 16*(5), 42-46.

Recommendations Concerning Mathematics for Talented Learners

1. Teachers should use a variety of measures to identify mathematically talented students, tapping skills beyond computation. These students need to have a wide range of exciting math classes, math clubs, and contests where they can demonstrate and hone their mathematical abilities.
2. All students should be provided with a wide variety of rich, inviting tasks that require spatial as well as analytical skills. Talented students should explore topics in more depth, draw more generalizations, and create new problems and solutions related to the topic.
3. Students should be encouraged to persist in solving mathematical problems. Fewer problems need to be tackled, but in far greater depth. Talented students need the challenge of new and more complex problems. They need to experience the joy of solving difficult problems and to be able to share that joy with others.
4. Teachers should encourage students to construct their own mathematical understanding, and talented students should be encouraged to reach the highest levels of construction.
5. Teachers should engage in the use of technology and manipulatives to aid in their construction of math concepts. Talented students should use these materials to explore even further and to create and display quality mathematics.
6. Students need to be shown examples of superior student work in order to challenge them to ever-increasing levels of mathematical achievement.
7. Teachers need adequate resources and support to obtain the materials, technology, and training they need to assist in the development of mathematically talented students.
8. Parents, students, teachers, and others in our society must be encouraged to believe that all students can learn mathematics and that our talented students are capable of greater mathematical power than we have ever asked of them.
9. Teachers should use a wide variety of assessment tests beyond standardized achievement tests which limit mathematics to low-level computation. Teachers must expect the highest levels of achievement on several types of assessment from mathematically talented students.

Recommendations from Linda Jensen Sheffild for the National Research Center on the Gifted and Talented, University of Connecticut.

PROFILES OF THE GIFTED

Is it Worth Leaving a Good High School and a Good Home to go a Long Distance to TAMS?

Parent Response

Colleen Elam
Sugar Land, Texas

This question has no easy answer. Each individual family must resolve a series of hard questions. What do we want for our children? What must we do to obtain those things? Are we willing to make the sacrifices involved?

We who advocate for gifted education profess to support an educational environment where highly gifted children are able to proceed at their own speedy pace, to pursue their own intellectual quests, and to reach their own potentials. The Texas Academy of Mathematics and Science is built on that principle. The Texas Legislature made a commitment to the future of our nation and to the future of the highly gifted children of Texas. They are to be commended. Advocates for gifted are always seeking legislative support for gifted education. But are we supporting the options for which we pleaded?

How many of us encourage our most gifted high school students to investigate TAMS? How many of us would prefer to keep them in our local schools and in our homes? We have a plethora of excuses—in our heads and in our hearts. The hard fact is that if we advocate for this environment for gifted and we want this opportunity now for our children in high school today, TAMS is an excellent option. The desirability of the option must be determined on a case-by-case basis by the individuals involved.

Upon reading a brief description of the Texas Academy of Mathematics and Science in TAGT Annual Conference literature, Corey, my ninth-grade daughter, was intrigued. TAMS is designed as a program where gifted students who are focused in math and science can complete their last two years of high school and their first two years of college concurrently. Corey requested that I attend an information session during the conference. I did. As I sat in the dimmed room watching the initial video presentation, I cried. I knew in those first moments that this academy would be great for Corey and that Corey was the type of student the academy was seeking. The problem was the academy was located on the campus of the University of North Texas and we lived 300 miles away in the Houston area. It was too far away. Ideal as TAMS seemed, I could not imagine allowing our daughter to go so far away to college two years early. Corey is a gem. We, her family, were entitled to a full 18 years with her.

During the verbal information session that followed, I took copious notes and asked pointed questions. I listened for some policy with which I disagreed or some angle I felt was inappropriately addressed that would allow me to dismiss this whole idea. Alas! For every question asked, the director of admissions, Dr. Stream, gave the right answer.

He was forthright in stating that each student was admitted according to the same criteria. Admittance was based on the applicant's academic performance in high school, SAT scores, teacher recommendations, evidence of interest in science and mathematics, a student essay, math diagnostic test scores, a personal interview, and parental support and commitment. There were no quotas that had to be met. Enrollment was limited by dorm space because all the academy students lived in one dorm on campus. The dorm was coed by floor with limited hall visitation hours and a security system. Dr. Stream firmly stated there was a student code of conduct and no behavior problems would be tolerated. The successful students were those who liked structure. Parents were warned not to send students who were disciplinary problems, who did not follow rules, or who caused disturbances because those students would not be successful and would be sent home. The academy had a commitment to protect and maintain the safety and learning environment of the students who did abide by the

Texas Academy of Mathematics and Science

Located at the University of North Texas, the Texas Academy of Mathematics and Science was created by the Texas Legislature in 1987 to provide an opportunity for talented students to complete their first two years of college while earning a high school diploma. Students enroll in the academy after their sophomore year in high school, live in a UNT residence hall, and attend regular UNT courses. Their classmates are UNT undergraduate and graduate students.

At the end of two years, academy students receive a high school diploma and at least 60 college credit hours. Academy graduates stay at UNT or transfer to other universities to complete their bachelor's degrees. (1-800-241-TAMS) academy code of conduct, who did respect others, and who were eager to seize this opportunity.

The curriculum and course work were described as challenging to gifted students. The academy students were required to complete a core curriculum to graduate: two semesters each of biology, chemistry, and calculus-based physics; the companion labs for each of these courses; three semesters of math through Calculus II; four semesters of English; two semesters of history; one semester of political science; and at least one elective. The designated science courses were those recommended by the university for science majors. The designated English, history, and political science courses were those in the university's most challenging "Classic Learning Core" program. With the exception of calculus, the classes were university classes with regular university students. All math and science classes were taught by Ph.D. professors. At graduation the students would receive a high school diploma from the Texas Academy of Mathematics and Science plus have 60-80 hours of college credits transferable to any Texas public university and many other universities in Texas and across the nation.

All of this sounded like an answer to our dreams except that it was located so far from home. Students would come home one weekend a month during the "closed weekends." The rest of the time students must live in the residence hall. The policy made perfect sense. But I could not imagine only seeing my 16 year old once a month!

Following the session, I told Dr. Richard Sinclair, the Director of TAMS, that I had one of the students he was seeking but he could not have her because we were not giving her up. His response was they had found that the students who were most successful at TAMS were those whose parents were interested in the high-level opportunities but who had some concerns about sending them. As I continued in session after session through the rest of that conference, thoughts of TAMS haunted me.

Once home, my husband's reaction to TAMS was the same as mine. Other parents complain about their teenagers. We had a super one. We did not want to give her up until the time prescribed by today's mores which is college, after high-school graduation. If the academy had been located in Houston, we would be elated. The University of North Texas was too far away. But as the school year progressed, Corey broached the subject more and more frequently. I, too, was attracted by the opportunities TAMS offered yet at the same time repelled by the distance from home. The more I thought of the possibility of Corey leaving home at 16, the more I cherished every moment spent with Corey and with Kindel, our daughter two years younger than Corey.

Lured by the TAMS opportunity and implored by Corey, the following fall our family of four drove to Denton for a preview day to investigate the program and facilities firsthand. The drive was long, but the TAMS program, the promise, and the possibilities softened us. In the next weeks I contacted teachers, G/T administrators, parents of current TAMS students, and Denton friends to determine the reputation TAMS held in the area and the state. Meanwhile Corey began the application process.

Many an evening at our dinner table, our family discussed the positives and negatives of going to TAMS. On the positive side, since Corey was contemplating the pursuit of both an M.D. and a Ph.D., TAMS might save her some time. Second, the TAMS students have access to the resources of a large university. What a great high school! Third, the chance of having excellent teachers is high. Fourth, there is no pressure of class rank so the TAMS students are free to focus their energies on pursuit of knowledge rather than pursuit of grades. Fifth, the opportunity to do research was appealing because Corey wanted to be a research biologist. Sixth, we had high hopes that if there were other students who shared Corey's passion for learning and quest for knowledge, TAMS is where they would abound. There she could not only interact with such peers but live with them and make lifelong friends and contacts. Seventh, TAMS had a dedicated student-life staff who provide a caring atmosphere and creative, fun student activities. Certainly the academy students are minimally supervised compared to parental supervision at home, but they are nurtured much more than students are at college. We viewed TAMS as a stepping stone into college and total independence.

And the negatives... We would miss her. She knew no one there. She would miss us. She would be so far away. She would be leaving a good 5A school with a strong honors and AP program. Kindel would find it harder to use her sister as a confidant and best friend, and would, in effect, become an only child. Corey had a small group of good friends at her current high school. These friends were the proverbial bird in hand. A group of TAMS students spoke at the preview day. We could tell that many of these particular young people were not like Corey. They spoke mainly of the social aspects of TAMS. Last but not least, we questioned the expense. As with any public high school, the state paid all of the TAMS tuitions and books, but the families paid room and board for two years (about $3500 to $4000). This was an unplanned expense when we were trying to save for college and medical school and post graduate work for two children. In addition, we would have the monthly travel expenses and a dramatically increased long-distance bill.

Late at night, my husband and I pondered additional pros and cons. We were cautious. Being parents, we would agree to enroll her only if we were convinced she would be happy and successful. We were not concerned about Corey mastering the academic content. Corey was a gifted, self-motivated hard worker who thrived on challenge. We were not worried about Corey's ability to manage independently. She was mature, self-reliant, and self-confident. She always took the world in stride and with a smile. Our nagging worry was that Corey was a night person who had difficulty waking in the morning. Would she sleep through morning classes?

In the end the opportunity of TAMS outweighed the security of home. We committed and Corey accepted the academy's invitation to enroll.

During her first year at TAMS she experienced ups and downs but she made it work. Occasionally, she did miss her earliest morning class because she turned off her alarm in her sleep. But on other occasions when she woke just five minutes before a class, she would pull on her jeans, slip into shoes, grab a pair of glasses and her backpack, and run. She accepted that if she was ungroomed, without contact lenses, and hungry, it was her own fault but not an excuse to miss class.

She continued to seek challenge. When her calculus teacher assigned the easy and medium problems, Corey also completed the difficult problems. When she determined another teacher was teaching in more depth and covering more material, Corey audited that class in addition to taking her own. She even secured permission to take the final exam "for fun." That is Corey.

And we missed her! I missed her! We obtained a private 800 number. Corey called daily. Sometimes more than once a day. Sometimes for just a minute to exclaim, "Guess what!..." Sometimes for long conversations. I cherished the calls. Still, I missed her terribly. For self therapy I selected our favorite snapshots from family photo albums and had them enlarged. I covered our refrigerator with those family moments and placed them throughout the house. They were a constant reminder that our family had had much time together through many good years.

Now beginning her senior year with a 4.0 cumulative average, Corey is allowed and encouraged to schedule any courses she wishes. This semester she is taking 21 hours in challenging university classes: Organic Chemistry and Lab, Physics and Lab, Calculus II, U.S. History, Political Science, English, and a math problem-solving course. A rigorous, demanding schedule. Yet, Corey would not enjoy it any other way. This year she could not wait to return to TAMS, her classes, and her TAMS friends. She is busy and beaming. TAMS was a good choice for her.

Still, we miss her. We love her. We respect her. We trust her. We wish her the best. Regardless of what college she chooses, regardless of whether she receives scholarships, regardless of whether that college accepts any of her credits, she has had a positive, challenging experience at TAMS. Yes, it was worth it — for all of us in this family.

Is it Worth Leaving a Good High School and a Good Home to go a Long Distance to TAMS?

Student Response

Corey Elam
Denton, Texas

The decision to attend the Texas Academy of Mathematics and Science is an individual and personal one. Each student must weigh the pros and cons to determine the best path to follow.

Let me introduce myself. I am a senior at TAMS. I love biology, history, math, and trivia, and want to be a research biologist. My personality could probably be described as obsessive. My favorite color is red, and I wear it every day. I am a Trekkie (Vulcan alias T'Para) and a chocoholic. I love reading books and watching PBS. I value learning for its own sake and believe that the most challenging teacher is the best teacher.

My decision to attend TAMS was difficult. My old high school offered several honors and AP classes and had some good teachers. I had a group of friends with whom I enjoyed associating. I was not a teenager who was itching to get away from my parents and be out on my own. So why was TAMS even an option, especially since I live 300 miles away? There are many reasons. In general, TAMS offered more than my high school — more choices, more opportunities, and more people like me. At my high school, I would not have been able to take organic chemistry or microbiology. I would not have had the opportunity to conduct research in a university laboratory within walking distance of my room, or to go to England and Ireland over the summer to study and explore with friends.

TAMS concentrates on the needs of students who are motivated and focused. My home school district concentrated on motivating the less focused. The schools had more incentives and rewards to encourage the students with poor attitudes and poor academic performance than they had for the students who worked continually and succeeded regularly. They were eliminating ability levels in some disciplines, forcing more classes to be heterogeneously grouped. Also, they were increasingly stressing cooperative learning over advanced content. The high school I attended was old and in need of renovations. However, because the district was growing so quickly and new schools needed to be built every year, the district repeatedly neglected the old school. Over time, many of the good teachers had left to go to the newer schools.

I was attracted to a school where the students shared my values about education, where students were allowed and even encouraged to move quickly through the curriculum, and where the best students received incentives and rewards. An additional factor favoring TAMS was the possibility of my receiving more scholarship money if I did well. Just getting two years of college credit was itself quite a scholarship.

I gave up a lot to come to TAMS, though. One big sacrifice for me was not competing in academic tournaments like UIL and Academic Decathlon. This was how I used to spend my weekends at home. Okay, I admit I am crazy to want to pay money so I can get up early on the weekend and go take tests. Crazy or not, I like the challenge and I miss it. At my old high school I was practically guaranteed a position on the Decathlon team as a junior because I had done so well on Octathlon for two years. TAMS students are not allowed to enter UIL competitions because of objections from other Texas high schools. However, TAMS participants are gradually being accepted in other academic competitions. Of course, I also gave up my friends. I did make new friends and did not completely lose contact with my old friends, but it is not the same.

TAMS is not exactly as I expected it would be. First, it was much easier than I expected, probably because I came from a good 5A high school. Second, my favorite class at TAMS was English which is ironic since TAMS is a math and science school. The English teacher I had was superb because he really made us think and interpret the literary selection based on the language of the text. He certainly was not an easy "A", but the grade did not matter because I was challenging my brain. Third, there is such a variety of people at TAMS. We have more than our share of geniuses, but it is more than that. We have some students who study all the time and others who never seem to study and do just fine; some students who are very social and others who are loners; and some who are wild and others who are conservative. TAMS has a large group of students who are addicted to Jeopardy (including me) and who do better than the actual contestants. TAMS also has a large group of Monty Python fans. Most of the academy students are much more computer literate than I am. There are quite a few Star Trek fans. TAMS is the type of community where someone will know the answer to almost any question you ask in any subject. It can be intimidating to be suddenly surrounded by so many people like this when you were used to being one of a few at your high school. But for me, it is a phenomenal experience. At TAMS, no one has ever told me I can not take a certain class or I am taking too many hours. This semester students are taking as many as 22 hours and as few as 13. I am taking 21. The TAMS advisors guide us, but do not limit us academically as long as our grades are good. The administrators are more likely to say "try it" than "no."

Many people want to know about the ratio of TAMS to UNT students in our classes. Our math classes are specifically made all TAMS. They are more challenging than the regular university classes. Biology is about half and half in a class of 225. My English class was mostly TAMS students because it was part of the university's Classic Learning Core program. The ratio in chemistry varies by course section. I took the honors chemistry, so the class was almost all TAMS students. In the regular chemistry classes, the ratio favors the UNT students. As far as senior-year classes, so much depends on the electives you are taking. Most of my classes are about half TAMS students and half university students.

One disappointing change at TAMS between my junior and senior year is that the University of North Texas is phasing out the Classic Learning Core program. CLC is a UNT program of integrated English, history, and political science. Previously, TAMS students were required to take these classes. The CLC also attracted some students to the University of North Texas because of the quality of the program and the challenge involved. The CLC classes involve more discussion and writing than the traditional lecture format. This semester TAMS students were discouraged from taking the few CLC classes available. I was among the few who squeezed into one of the two remaining CLC English classes because I was in the right place at the right time. This change was not made by TAMS, but it certainly does effect the quality of our classes. Needless to say this change is quite a disappointment to many TAMS students. A friend and I have started a literary discussion group to take up some of the slack and plan to talk with the university administrators as well. Access to CLC classes is not something that makes me wish I had not come to TAMS, but it was a factor in my decision to attend.

On the positive side, Mu Alpha Theta (a mathematics society) at TAMS has started a problem-solving math class specifically for TAMS students to work on contest problems. So far that class is enjoyable and challenging. Our teacher was nominated last year by TAMS students, and later honored as one of the top 22 math teachers in the United States and Canada.

Socially, TAMS has a diversity of clubs and sponsors numerous activities including dances, symphony trips, and intramural sports teams. Also, TAMS students may join any of the UNT groups or clubs on campus except for the Greek system. I do not feel that a student's social activities are cut back in any way upon coming to TAMS. TAMS students do have stricter rules than the university students, but in my mind they are reasonable. Some parents are stricter than others, so the TAMS rules may seem lax to one family and strict to another. Without the rules though, I know I would not have come. The rules keep out many of the discipline problems and troublemakers who plague high schools. Conduct code violations are on a point system escalating with severity. Any student who accumulates a certain number of points is sent home. The system is fair and it works.

The ultimate question, of course, is: am I glad I came to TAMS? I am happy and challenged here. I have been able to select some interesting high-level classes. I have become close friends with students of varied interests and personalities who share my value of education. These bonds will last a lifetime and I am very glad I had the opportunity to make them. Many people here will be famous one day and it is an honor to have known them. However, I can not answer that question absolutely for a while. So much depends on this year with my college search — where I am accepted for college and how much scholarship money I am awarded. I sincerely believe, though, that in the long run I will be glad I came to TAMS. This was the choice for me.

Live long and prosper.

NOTICE

REPRODUCTION BASIS

- [x] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

- [ ] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").