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AUTHOR	Bottoms, Gene; Creech, Betty
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ABSTRACT

The mathematics achievement of career-bound students at High Schools That Work (HSTW) sites in 1996 was compared to performance levels at HSTW sites in 1993-1994. Forty-nine percent of the 260 HSTW sites improved their average mathematics scores over the period, with the percentage of career-bound students meeting the HSTW mathematics goal of 295 increasing from 36% to 44%. Although male students' performance improved significantly over the study period, that of female and African-American American students did not. The gap continued to widen between HSTW sites' career-bound students and vocational students in the National Assessment of Educational Progress. Students taking the challenging HSTW-recommended mathematics curriculum had an average score of 294, which nearly meets the HSTW performance goal of 295. The bad news is that over half of students at HSTW sites did not score at the mathematics goal level. The following were among the recommendations for further improving career-bound students' mathematics performance: (1) raise expectations and get students to work harder; (2) take the lead in getting other school teachers to use data and numbers to advance learning; (3) work with vocational teachers to increase the application of mathematics concepts in vocational courses; and (4) use instructional methods that connect mathematical concepts and procedures to experiences in students' lives. (MN)

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Gene Bottoms
Betty Creech

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Mathematics Performance of Career-Bound Students: Good News and Bad News from the 1996 *High Schools That Work* Assessment

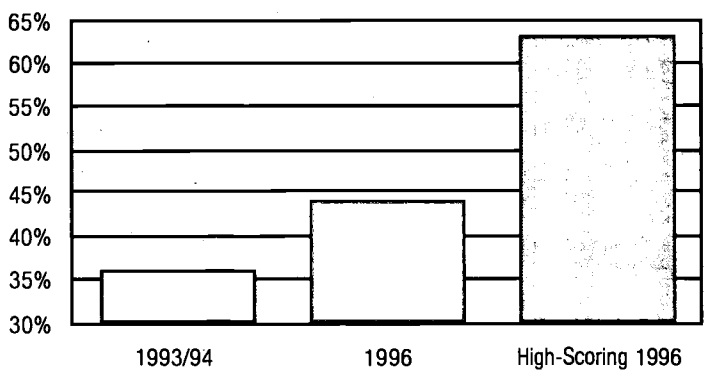
By Gene Bottoms and Betty Creech

The 1996 *High Schools That Work* Assessment contained good news and bad news about the mathematics achievement of career-bound students at *HSTW* sites. The commitment by some *HSTW* sites to move students into more challenging mathematics courses and teach a more complex curriculum through a meaning-oriented approach appears to be working. The good news is apparent in a number of ways:

1. Forty-nine percent of the 260 sites that tested students in 1993 or 1994 and again in 1996 improved their average mathematics scores. Also, the percentage of career-bound students meeting the *HSTW* mathematics goal of 295 increased from 36 percent in 1993/94 to 44 percent in 1996. At high-scoring sites—where students have ethnic, racial and socioeconomic backgrounds similar to those of students at all sites—63 percent met the mathematics goal. (See Figure 1.)
2. The performance of male students improved significantly between 1993/94 and 1996.
3. *HSTW* sites continued to widen the gap between their career-bound students and vocational students in the National Assessment of Educational Progress (NAEP) national sample. The average mathematics score was 283 in 1993/94 and 285 in 1996. These scores significantly exceed the average score of 277 for vocational students nationally.
4. Students taking the challenging *HSTW*-recommended mathematics curriculum had an average score of 294, which nearly meets the *HSTW* performance goal of 295. (See Figure 2.)

Figure 1

Percentage of Students Meeting the *HSTW* Mathematics Performance Goal



The bad news is that over half of students at *HSTW* sites did not score at the mathematics goal level. These students lack the mathematics skills needed for further study in postsecondary education and for entering and advancing in the workplace. Mathematics achievement at the time of high school graduation has a much bigger impact on the careers of 24-year-old high school graduates today than in the late 1970s.

Students are taking more mathematics courses and more higher-level mathematics courses; yet, the

Figure 2

Mathematics Performance of Students Completing Challenging Mathematics Courses at All Sites and High-Scoring Sites

	1996 All Sites		1996 High-Scoring Sites		1993/94 All Sites	
	Percent	Score	Percent	Score	Percent	Score
Students Completing the *HSTW*-Recommended Curriculum	64	294	84	308 *	42	297 *
Students Not Completing the *HSTW*-Recommended Curriculum	36	270	16	284	58	273

* These scores exceeded the *High Schools That Work* goal of 295.

average scores for female students and African American students are not improving. With the exception of high-achieving *HSTW* sites, most high schools are simply emphasizing more higher-level mathematics courses but are failing to teach the content in relevant ways. Students may pass the courses, but they do not appear to retain and understand the content well enough to apply it in solving open-ended, real-world problems.

There may be several reasons why too little progress is being made in advancing the mathematics achievement of career-bound youth. Observations in mathematics classrooms during technical assistance visits to *HSTW* sites over the past three years reveal a very common pattern in mathematics instruction for career-bound youth:

1. Most instruction is textbook-centered; mathematics teachers seldom enrich the textbook with materials and problems enabling students to construct meaning with mathematics concepts and connect mathematics knowledge to other classes and the outside world.
2. Mathematics instruction most often consists of a teacher working a few textbook problems on the board and then having students repeat the procedures with drill sheet problems for which there is no context.
3. Students seldom discuss a mathematical concept and link it to an experience beyond the school or in another class. Doing so would help them understand and retain the concept.
4. Most mathematics instruction teaches students how to perform a function or follow a set of procedures and to remember them long enough to pass a test, rather than to use mathematical concepts and procedures to solve open-ended problems that provide a context for understanding and retention.
5. The belief persists that, based on past performance, students considered disadvantaged in mathematics will not make an effort to do mathematics assignments outside of class; therefore, these students are seldom assigned mathematics homework. However, extra work for credit is routinely expected of the more advantaged mathematics students.

Some possible explanations for the lack of progress by female and African American students between 1993/94 and 1996 include:

- Male students are usually enrolled in vocational programs that offer a richer base of mathematics experiences and require more frequent use of mathematics to complete vocational assignments. Female students are more likely to be enrolled in vocational programs that have a weaker base of mathematics experiences. Thus, vocational programs are not an accelerating factor in the mathematics learning of many female students. Career-bound females who take higher-level mathematics courses have lower average scores than males, because many mathematics courses emphasize learning mathematical procedures rather than understanding mathematical concepts. Little is being done in mathematics or vocational courses to help female students connect and apply mathematics to challenging problems that will engage them in learning mathematics.
- Little progress has been made in enrolling African American students in a more advantaged mathematics curriculum. Many African American students are being tracked into lower-level algebra, geometry and pre-algebra. When this is coupled

with instruction that is limited to in memorizing procedures to the exclusion of understanding and application, it is not surprising that the mathematics achievement of African American youth is stagnant.

Embedded in the 1996 assessment are clues about what can be done to advance the mathematics achievement of career-bound youth. Mathematics teachers and mathematics departments in collaboration with other teachers can:

■ **Raise expectations and get students to work harder.**

The good news is that students who take more mathematics courses and more demanding courses have higher mathematics scores. Further, career-bound students who were encouraged to take more mathematics courses and who took a mathematics course in their senior year had significantly higher mathematics achievement than did career-bound students who were not encouraged to do so. (See Figure 3.)

Under bad news is the fact that the percentage of students enrolled in mathematics in their senior year has increased very little. In 1996, fewer than half of the students took a mathematics course in the 12th grade, despite the need to build problem-solving skills that will be used in postsecondary education and high-tech employment.

The good news is that career-bound students who averaged one hour or more of mathematics homework had significantly higher mathematics achievement than career-bound students who did little or no homework.

The bad news is that 40 percent of youth who scored below the basic level did not do homework. Further, nearly 60 percent of career-bound youth said they finished high school despite doing little if any (one-half hour or less) homework outside of class.

There are three reasons why mathematics teachers have difficulty getting career-bound students to do homework:

1) They don't expect them to do it.

2) They don't count it even if they assign it.

3) When they do assign it, the homework consists of meaningless drills instead of ways to use mathematics concepts to solve real problems.

Mathematics teachers report that career-bound youth will do homework when it means something to them. Some successful mathematics teachers require students to find a problem at work or in a vocational course, apply mathematical concepts to solve the problem, write a description and present it to other students in class. Teachers report that this type of assignment gets good response from students.

Mathematics teachers also get better results if they encourage students to work together but hold each student accountable for knowing and understanding the homework.

■ **Take the lead in getting other high school teachers to use data and numbers to advance learning in academic, vocational, art, music and health education disciplines.**

The good news is that opportunities for academic and vocational teachers to plan together accelerates student progress in mathematics. At 15 *HSTW* sites where mathematics teachers worked as a team with other academic and vocational teachers, the percentage of students who met the mathematics goal increased from 35 percent in 1993/94 to 49 percent in 1996, while at experienced *HSTW* sites, the increase was from 36 percent in 1993/94 to 44 percent in 1996. There is more good news at the 15 *HSTW* advanced integration sites where mathematics and vocational teachers worked together in cross-curriculum teams:

- More students completed the *HSTW*-recommended mathemat-

Figure 3

Students Taking More Mathematics Courses and Taking Mathematics in the 12th Grade

	Percent	Mathematics Score
Took Mathematics as a Senior		
Yes	46	290
No	54	281
Number of Mathematics Courses Taken		
Two or Less	15	271
Three	49	282
Four or More	37	295

Figure 4

Comparison of Course-Taking Patterns and Mathematics Performance at All *HSTW* Sites and High-Scoring Sites Testing in 1993/94 and 1996

	1996 All Sites		1996 High-Scoring Sites		1993/94 All Sites	
	Percent	Score	Percent	Score	Percent	Score
Lower-level mathematics courses (basic, consumer, general and business mathematics)	55	266	23	288	68	277
Technical Mathematics I	22	271	11	280	21	275
Basic Algebra	31	278	21	297 *	54	284
Algebra I (regular or advanced)	56	294	69	308 *	50	294
Algebra II	51	301 *	75	312 *	38	299 *
Geometry	63	296 *	86	309 *	49	295 *

* These scores met or exceeded the *High Schools That Work* goal of 295.

ics curriculum and more enrolled in upper-level mathematics courses such as Algebra II and geometry.

- All groups of students—females, males and African Americans—made advances in mathematics achievement.
- More teachers expressed support for setting high expectations for students, for having students use academic skills in completing vocational assignments, for using hands-on projects to make content more concrete and for having students use high-level academic content to solve authentic problems. Yet, the percentage of minority youth was higher at the 15 advanced integration sites than at the experienced sites.

The bad news is that the organizational structure and daily schedule at most high schools prevent teams of academic and vocational teachers from doing the planning necessary to engage students in completing challenging assignments that will develop their mathematics and problem-solving skills to a level needed in today's economy.

The further bad news is that more than 50 percent of career-bound youth do not remember having to use mathematics daily or weekly to complete assignments in their vocational classes, and 90 percent do not remember having to use mathematics more than twice a year to complete a learning activity assigned by a mathematics teacher or another teacher. Too little effort is being made in mathematics classrooms to connect mathematics with learning in other academic, fine arts and practical arts classes.

Like reading and writing, mathematics and data can become tools for advancing learning in other disciplines. It is incumbent upon mathematics departments and mathematics teachers to take the lead in helping vocational, science, social studies, health and fine arts teachers develop assignments that cause students to apply mathematics and data to better understand the content of their courses.

■ Work with vocational teachers to increase the application of mathematics concepts in vocational courses.

The good news is that vocational students in 1996 who reported that they had to use mathematics concepts to complete vocational assignments daily or weekly had significantly higher mathematics achievement than did students who lacked such experiences.

The bad news is that only four percent more students in 1996 than in 1993/94 reported that they had to use mathematics daily or weekly to complete vocational assignments. Mathematics teachers can take the lead in reaching out to vocational teachers. They can identify the major mathematics concepts they will be teaching during the year and ask vocational teachers to identify the mathematics concepts students will apply during each grading period. Aligning mathematics topics with their application in vocational classes can:

- Raise mathematics teachers' awareness of the mathematics skills needed to complete challenging vocational assignments;
- Create a dialogue between the mathematics department and the vocational department;
- Produce a major mathematics assignment in each grading period that requires students to

apply the mathematics topics being studied to problems in the vocational lab and then return to the mathematics classroom to share the information with other students. Such experiences will enhance the worth of these students in the eyes of their peers and provide a rich context for connecting mathematics to events beyond the classroom.

■ **Continue to enroll more career-bound students, including minority students, into advantaged mathematics classes.**

The good news is that *HSTW* sites enrolled more career-bound youth into advantaged mathematics classes—college-preparatory Algebra I, geometry, Algebra II and trigonometry—in 1996 than in 1993/94. The percentage of career-bound youth completing two mathematics credits equivalent to college-preparatory Algebra I, geometry and Algebra II increased from 42 percent in 1993/94 to 64 percent in 1996 at all *HSTW* sites. Students scored near the goal level if they had taken Algebra I and well above the goal level if they had taken Algebra II and geometry. At high-achieving sites, 84 percent of career-bound students completed a high-level mathematics curriculum. The higher percentage of students completing the advantaged mathematics curriculum at high-achieving schools scored significantly higher than did the smaller percentage who completed the curriculum at all *HSTW* sites—308 versus 294. High-achieving sites appear to have stopped over-sorting students into too many levels of courses and are requiring their students to work harder than students at other sites. (See Figures 2 and 3.)

As *HSTW* sites increased the number of students taking advantaged mathematics courses, the average achievement scores of these students stayed about the same despite the more difficult courses. (See Figure 3.)

There are several items of bad news. Career-bound seniors who took lower-level mathematics courses had average scores nearly 30 points below the mathematics goal in 1996. Even with the increased number of students enrolling in advantaged mathematics courses, the average achievement of females and African American students did not improve.

The further bad news is that there was a significant decline in achievement for students enrolled in technical mathematics, pre-algebra and basic algebra—often referred to as regular algebra, general algebra, basic algebra or Algebra A and B. This decline occurred at all *HSTW* sites and at high-achieving sites. It appears that less effort in and out of class is expected of students enrolled in these courses. Teachers with the least experience are often assigned to teach these classes, and they tend to teach in traditional ways that fail to excite students about mathematics. They do not use a meaning-oriented approach that allows students to connect mathematics topics to other classes and to other events in their lives.

While Applied Mathematics has content equivalent to Algebra I and geometry, many schools elect to teach it at a slower pace. They assign teachers who are not trained in applied, contextual teaching strategies and who do not require work from students outside of class. Rather than present Applied Mathematics as a difficult course that requires extensive work in and out of class, some schools consider Applied Mathematics a course for "dummies" in which students and teachers are destined for low-level results—a self-fulfilling prophecy. At some *HSTW* sites, students taking Applied Mathematics performed at about the same level as students taking regular algebra, but these sites assign the best teachers, prepare them and encourage them to work students hard in and out of class. Student achievement data and observations during *HSTW* technical assistance visits suggest that this approach is the exception rather than the norm at *HSTW* sites.

■ **Use instructional methods that connect mathematical concepts and procedures to experiences in the lives of students.**

Engaging students in completing more authentic, challenging assignments that involve them emotionally in mathematics leads to higher mathematics achievement. When students are actively engaged in the learning process, they learn more. Students earned higher mathematics scores when they:

- Completed mathematics projects using mathematics as it would be used in a work setting;
- Used mathematics to complete vocational assignments frequently;
- Used a computer to complete mathematics assignments once or twice a year;
- Made presentations in class about a special mathematics project once or twice a year;

Adapting Instructional Practices to Teach Algebra to All Students

Mathematics teachers at Gloucester High School in Virginia are demonstrating how to adapt instructional practices to teach algebra to all students. Faced with large numbers of unsuccessful students, the algebra teaching team decided that it was no longer acceptable to allow students to take Algebra I, minimally pass the course, or fail and repeat it. They wanted all students to get a good foundation. Working as a team, the teachers believed they could teach a high-level course and expect all students to do well if they provided good instruction, developed a program of extra help and accepted the fact that some students would need extra time to learn and master concepts.

In 1994, the team began developing Mastery Algebra I after hearing about a similar program at another *HSTW* site. The teachers determined that they would meet weekly to plan instruction, pace the classes alike, develop end-of-unit mastery tests, share data, monitor results and communicate with parents. After three years of Mastery Algebra, student success rates have soared.

Percentage of Students Earning A's, B's or C's in Algebra I at Gloucester High School

	1994 Traditional Algebra	1996 Mastery Algebra	1997 Mastery Algebra
First Semester	49%	94%	95%
Second Semester	47%	82%	88%

As the algebra team refined the program over three years, they learned several things:

- Expectations are the key. Students are expected to master all of the content with at least a C average—and they are doing it.
- A support system is necessary. The re-teaching and tutoring services provided during and after school do not allow students to give up or coast through the course.
- Monitoring each student's progress and maintaining data are critical activities for program evaluation and course revision.
- Working closely with middle schools has allowed the high school to increase content.
- Developing end-of-unit and end-of-course exams used by everyone has brought consistency to the curriculum.
- Working as a team has generated a positive attitude that helps the faculty strive for continuous program improvement. Veteran teachers say this program has been the most rewarding of their career.
- Used mathematics frequently to solve actual problems encountered in vocational classes or at work.

The bad news is that career-bound students in the majority of classrooms observed during *HSTW* technical assistance visits were experiencing textbook-focused learning. Mathematics teachers seldom enriched the textbook with authentic problems. The majority of career-bound students at *HSTW* sites in 1996 never used mathematics in completing an authentic project, described the project in writing, nor made an oral presentation about it in class. Few students said they were asked to apply mathematics concepts and skills to solve problems that had value to them. Mathematics teachers need to do more planning to bring challenging real-world problems to the classroom.

Mathematics teachers can adopt a new framework in which:

- Teachers pose complex, authentic, thought-provoking problems;
- Students struggle with the problems individually and in groups;
- Various students present ideas or solutions to the class;
- The class discusses various solutions;
- The teacher summarizes the students' conclusions.
- The teacher assigns similar open-ended problems as homework.

■ **Join with counselors to advise career-bound students and their parents about the need to complete more demanding mathematics courses.**

The good news is that more students at *HSTW* sites reported in 1996 than in 1993/94 that they were encouraged to take more mathematics courses. More than two-thirds of these students said they were encouraged to take a combination of academic and vocational courses.

The bad news is that 43 percent of students at all *HSTW* sites did not receive encouragement to take more mathematics courses, and the performance of these students was 16 points lower than that of students who received such encouragement. The further bad news is that 34 percent of career-bound youth reported that they either did not have a four-year program of study or that no one assisted them in developing one. Yet, these students had slightly higher mathematics scores than students who said they received such assistance from counselors, teachers or a combination of counselors and teachers.

Students who did not get help from a counselor or teacher in reviewing a program of study each year had slightly higher scores. This suggests that the predominant advisement strategy in high school is to sort and divide students into mathematics classes based on their past performance rather than to place them in courses designed to give them the mathematics skills needed in continued learning and the workplace.

The fact that only one in five career-bound students could recall meeting with their parents and a teacher-advisor to help plan a high school program of study suggests that high school mathematics teachers are doing little to join with guidance counselors to become proactive in educating parents and students about the importance of advantaged mathematics classes—real algebra, geometry, Algebra II and trigonometry.

■ Arrange extra help to assist students in mastering specific mathematical concepts.

Research continues to show that focused extra tutorial help aimed at aiding career-bound students in understanding and applying specific mathematical procedures improves mathematics learning. The good news is that 78 percent of career-bound youth said they received extra help from their mathematics teachers.

The bad news is that only 15 percent said they received special tutoring and only 12 percent received special help from a resource teacher in learning a specific mathematical concept.

Mathematics departments and teachers can:

- Stop sorting career-bound students into mathematics courses based on past performance, place them into advantaged mathematics courses, and arrange for extra time and help.
- Encourage mathematics teachers to do collaborative planning with each other and with other teachers aimed at enriching mathematics instruction with problems and events that enable youth to connect mathematics with things they have experienced.
- Join with counselors to educate students and parents about the need for career-bound students to complete an advantaged mathematics curriculum of Algebra I, geometry, Algebra II and trigonometry.
- Encourage mathematics teachers to work together to develop common end-of-unit and end-of-course exams for applied algebra and college-preparatory algebra. At least half of the exam items should require youth to apply mathematical concepts to new situations. Use these exams to hold students in applied algebra courses and college-preparatory classes to the same standards. Students who fail the exams should be required to attend extra help sessions before taking a different version of the exam.
- Re-think the school schedule. Give academic and vocational teachers time to plan together. Consider giving groups of students common classes so that they can have more integrated mathematics learning experiences.
- Plan staff development to help teachers learn how to use engaging instructional strategies such as manipulatives and hands-on projects.
- Provide extra help to students who are not prepared to master a more challenging mathematics curriculum when they enter high school. Work with feeder middle schools to help them better prepare students to meet the demands of an upgraded mathematics curriculum in high school.

Gene Bottoms is Vice President for Education and Work and Betty Creech is Director for Advanced Integration Model for High Schools That Work *at the Southern Regional Education Board.*

Southern Regional Education Board
High Schools That Work
592 Tenth Street, N.W.
Atlanta, Georgia 30318-5790
(404) 875-9211
fax (404) 872-1477
http://www.peach.net/sreb

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