DOCUMENT RESUME

ED 480 361 CE 085 345

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TITLE	The 1996 High Schools That Work Assessment: Science. Good News, Bad News and Actions. Research Brief.
INSTITUTION	Southern Regional Education Board, Atlanta, GA.
REPORT NO	No-4
PUB DATE	1997-06-00
NOTE	10p.; For related Briefs, see CE 085 342-350.
AVAILABLE FROM	For full text: http://www.sreb.org/programs/hstw/publications/briefs/97brief4.as p.
PUB TYPE	Guides - Non-Classroom (055) -- Information Analyses (070)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Blacks; Educational Policy; Educational Trends; Enrollment; Enrollment Trends; Females; *High School Students; High Schools; *Instructional Improvement; Longitudinal Studies; Males; Racial Differences; *Science Achievement; *Science Instruction; Sex Differences; *Student Evaluation; Teacher Expectations of Students; Teacher Role; *Vocational Education; Womens Education
IDENTIFIERS	African Americans; *High Schools That Work; Work Based Learning

ABSTRACT

The science achievement of career-bound students at High Schools That Work (HSTW) sites in 1996 was compared to performance levels at HSTW sites in 1993 or 1994. HSTW sites studied in 1993 improved their average science scores from 270 to 283 in 1996. Vocational students at HSTW sites scored higher in science (average score, 283) than did the national sample of vocational students in the National Assessment of Educational Progress (average score, 267). Fifty-three percent of the 260 sites studied showed improvement in science in 1996, and 39% of students completed the HSTW-recommended science curriculum in 1996 with an average score of 289 compared with a score of 279 for the 61% who did not complete the curriculum. The bad news is that there was no improvement in science scores from 1994 to 1996. The following were among the recommendations for further improving students' science performance: (1) set high expectations and get students to meet them; (2) have students complete a challenging program of study consisting of an upgraded academic core and a major; (3) increase access to science studies that teach the essential content from the college preparatory curriculum; (4) engage students actively in the learning process; and (5) provide a structured system of work-based and school based learning. (MN)

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Research Brief
No. 4
June 1997

HIGH SCHOOLS THAT WORK

Research Brief

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The 1996 *High Schools That Work* Assessment: SCIENCE Good News, Bad News and Actions

By Gene Bottoms and Caro H. Feagin

The 1996 *High Schools That Work* Assessment report on science contains good news, bad news and implications for action. The report shows that the achievement of career-bound students improved when science departments enrolled more of them in college-preparatory science courses; when science teachers used methods that motivated students to work harder in and out of class; when teachers used open-ended, real-world problems in teaching science; and when teachers used writing and oral presentations to get students to reflect on what they had learned.

This report reflects data gathered in the 1993, 1994 and 1996 *HSTW* Assessments. Sites that assessed students in 1993 did not assess in 1994; therefore, there are two sets of data, 1993-96 and 1994-96.

The good news about science achievement is apparent in four ways:

1. *HSTW* sites that participated in the assessment in 1993 and again in 1996 showed significant improvement in average science scores. The scores improved from 270 in 1993 to 283 in 1996. (See Figure 1.)
   - The mean science score of students assessed in 1996 was greater than that of students assessed in 1993.
   - Male students scored higher in 1996 (288) than in 1993 (269). Male students also improved slightly from 1994 (285) to 1996 (288). (See Figure 2.)
   - Female students improved in science from 1993 (270) to 1996 (278).
   - All ethnic groups improved in science from 1993 to 1996.
2. Vocational students at *HSTW* sites scored higher (283) in science than did the national sample of vocational students (267) in the National Assessment of Educational Progress (NAEP).
3. Fifty-three percent of the 260 sites participating in the 1993 and 1994 assessments showed improvement in science in 1996. Students who completed the *HSTW*-recommended curriculum of high-level academic courses and a vocational concentration almost met the *HSTW* goal (292) with a score of 289.
4. Thirty-nine percent of students completed the *HSTW*-recommended science curriculum in 1996 with an average score of 289 compared to a score of 279 for the 61 percent who did not complete the curriculum.

The bad news is that there was no improvement in science scores from 1994 (282) to 1996 (283). (See Figure 1.)

More bad news is that the science achievement of female students stayed the same between 1994 and 1996. (See Figure 2.)

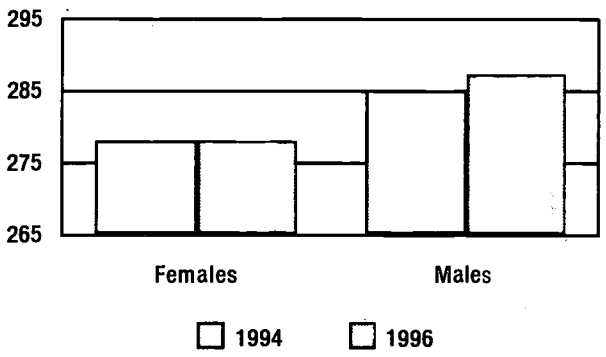
Figure 1

Mean Scores for 1993, 1994 and 1996

Science	1993	1994	1996
HSTW Goal: 292	270	282	283

Figure 2

Comparison of Science Achievement by Gender



The science achievement of African American youth did not improve from 1994 to 1996. Caucasian youth scored slightly lower in 1996 (287) than in 1994 (289). These students will be handicapped in getting and advancing in a good job and pursuing further studies.

Why did science achievement increase between 1993-1996 and decline between 1994-1996?

Sites in both groups (1993-1996 and 1994-1996) increased the percentage of students taking college-preparatory biology, chemistry, life science and physics or Principles of Technology. However, the 1993 sites had greater gains in the percentage of career-bound youth who took college preparatory-level science courses. (See Figure 3.) In addition, the 1993 sites increased the percentage of students taking college-preparatory courses and actually raised the average science achievement of career-bound youth. (See Figure 4.) In comparison, the 1994 sites increased the percentage of youth taking college-preparatory courses but showed a decline in the average science achievement for three of the four courses.

High school science chairpersons and teachers can take a number of actions to advance the science achievement of career-bound students. Successful schools:

- **Set high expectations and get students to meet them.**

The good news is that science achievement was significantly higher if students completed at least one hour of homework daily. Students who were encouraged to take more science courses and who took science in the senior year had significantly higher science achievement. Further good news is that high-achieving schools set higher expectations in science and got students to work harder to meet them. Ten percent more students at high-achieving schools did one or more hours of homework; 10 percent more took a science course in the senior year; 70 percent more were encouraged to take more science courses.

The bad news is that 66 percent of the students did not take science their senior year. Further, 38 percent of students scoring below the basic level in science said they did not have homework or failed to do it.

- **Have students complete a challenging program of study consisting of an upgraded academic core and a major.**

The upgraded academic core con-

Figure 3

Comparison of Course-Taking Patterns Between 1993-96 and 1994-1996

	Percentage of Students		Percentage of Students	
	1993	1996	1994	1996
College-Preparatory Biology	17%	40%	22%	39%
Chemistry	31%	45%	35%	42%
Physics/Principles of Technology	25%	50%	27%	42%
College-Preparatory Life Science	17%	27%	22%	28%
Taking Three or More Science Courses	57%	73%	64%	73%
Taking Science in the Senior Year	31%	38%	29%	32%

Figure 4

Comparison of Science Achievement Scores
1993-1996 and 1994-1996

College-Prep Course	1993	1996	1994	1996
Biology	284	289	293	289
Chemistry	280	289	290	288
Physics/Principles of Technology	276	288	285	289
Life Science	284	291	293	292

sists of at least four years of college-preparatory English and three years each of mathematics and science, including at least two courses in each area equivalent in content to college-preparatory courses. A major includes at least four Carnegie units in a broad technical field or further academic studies and two additional units in related or academic courses.

The good news is that students who complete the *HSTW*-recommended curriculum of high-level English, mathematics and science courses and a career major have science achievement that greatly exceeds the *HSTW* goals. In fact, career-bound students completing the recommended academic core scored 14 points higher in science in the 1996 *HSTW* Assessment than students who completed a less-demanding program of study.

The bad news is that 83 percent of students at all *HSTW* sites and 63 percent at high-achieving sites did not complete an upgraded academic core and a career concentration. Yet, 64 percent of the students at all sites and 84 percent at high-achieving sites completed the *HSTW*-recommended curriculum in mathematics.

It is evident that the problem is with "the system" rather than with the students. **This means that science teachers and counselors are willing to continue a system that gives only the most advantaged students access to high-quality, better-taught science classes while relegating most career-bound students to science courses of lower quality and expectations.** Thus, many high schools continue 0to produce graduates who lack the problem-solving skills and scientific literacy needed in an information-centered economy.

What can science teachers do to raise expectations and get students to meet them?

- Have students read, write and present information.
- Make science a "hands-on" subject with frequent inquiry-based lab projects.
- Give thought-provoking, problem-solving homework daily.
- Grade students on solving complex problems.
- Use cooperative learning techniques with students.
- Develop course syllabi that list exactly what students must do to be successful in each grading period.
- Encourage all students to take a minimum of three high-level science courses.
- Develop common end-of-unit and end-of-course exams.
- Have students redo work until it meets standards.

■ **Increase access to science studies that teach the essential content from the college-preparatory curriculum.**

The good news is that the 1993 *HSTW* sites continue to make progress in the percentage of career-bound youth taking higher-level science courses. (See Figure 3.) Students who take such courses have significantly higher science achievement than those who take lower-level courses. Twenty-three percent more students at high-achieving sites than at other *HSTW* sites completed a sequence of demanding science courses. These students had a significantly higher mean science score. (See Figure 5.)

What can administrators do?

- Encourage the local board of education to require career-bound students to complete three high-level science courses.
- Get business, industry and higher education representatives to stress the need for higher content knowledge and skills in science.
- Abolish all low-level science courses.

Figure 5

Students Completing or Not Completing the *HSTW*-Recommended Science Curriculum in 1996

	All Sites		High-Scoring Sites	
	Percentage	Score	Percentage	Score
Completing the *HSTW*-Recommended Science Curriculum	39	289	62	295
Not Completing the *HSTW*-Recommended Science Curriculum	61	279	38	286
HSTW Science Goal		292		292

The bad news is that science teachers at *HSTW* sites still have not made the commitment to teach career-bound youth a science curriculum benchmarked to the standards of the college-preparatory curriculum. No progress was made between 1994 and 1996 in getting career-bound students to complete a more rigorous science sequence. **It is time to "close down" low-level, non-lab science courses and enroll career-bound youth in courses taught to college-preparatory standards.**

The more quickly science teachers decide to do this, the faster they will learn how to teach high-level content to these students. The problem is not that students lack ability; rather, it is the unwillingness of teachers to switch from a curriculum that accommodates some students to low achievement to one that increases student achievement and motivation.

What can science teachers do?

- Teach all classes to college-preparatory standards.
- Teach the same content and skills; change the methodology.
- Encourage students to take more higher-level science courses.
- Benchmark standards to those of high-scoring sites.

School leaders who support science teachers with staff development and time to do collaborative planning can do for 85 to 95 percent of career-bound youth what is presently being done for only 39 percent. (See Figure 5.)

■ Engage each student actively in the learning process.

The good news is that students learn more science when they are engaged in completing challenging assignments such as applying scientific knowledge to a new situation, designing and carrying out an experiment, explaining orally and in writing their reasons for taking certain actions and describing the results. Activities associated with higher science achievement include:

- Making presentations in class about a science project;
- Reading assigned books and articles on science;
- Preparing a written report on a science subject or project;
- Completing a science experiment concerning a problem in the community or work setting.

The bad news is that most career-bound youth at *HSTW* sites do not remember having to complete intellectually challenging assignments in their science classes. For example, 59 to 77 percent of these students said they seldom or never completed the four activities listed above. Science achievement seems to increase if students are engaged in learning activities that involve them in connecting science knowledge and processes with specific problems and experiments that have meaning to them.

It appears that science classrooms are not places where career-bound youth are actively engaged with others in attempting to understand and interpret scientific concepts and to link them to authentic problems. In too many classrooms, career-bound youth are being taught science from a textbook rather than being allowed to ex-perience science and to link it to their vocational and other academic studies.

What changes can science teachers make in how they teach?

- Have students do open-ended lab problems designed to help them construct understandings of scientific concepts. Students need to act like scientists in the discovery of scientific knowledge.
- Provide open-ended problems so students can learn that more than one answer may be true. Have students defend their findings.
- Arrange for students to use and apply scientific concepts and processes in finding alternative solutions to real-life problems.

- Use relatively concrete, pragmatic models that help students internalize abstract and theoretical knowledge.
- Provide opportunities for students to interact and learn from each other. In many cases, science reflects a group effort.

■ Offer intellectually challenging occupational studies.

The good news is that students from two vocational programs had average science scores that met or exceeded the *HSTW* goal of 292: electronics (292) and drafting and design (296). At high-achieving *HSTW* sites, students graduating from several additional fields of study had average science scores that exceeded the *HSTW* goal. (See Figure 6.)

Students also had significantly higher science achievement if their vocational teachers often stressed science and if they had to use scientific principles daily or weekly to explain particular systems in their vocational studies.

The bad news is that the average science scores of students in vocational programs that should require in-depth knowledge of science did not meet the *HSTW* goal of 292. These programs include agriculture—285, health—281, family and consumer sciences—270, technical—290, and trade and industrial—284. The bad news continues: 64 percent of students said they did not remember or their vocational teachers never or seldom stressed science. Worse news is that there was almost no change from 1993 and 1994 to 1996 in the percentage of students who said their vocational teachers often stressed science.

What can state and local leaders do to promote the integration of science and vocational studies?

- Arrange in-depth science and technology workshops for science and vocational teachers to expand the vocational teachers' knowledge of scientific concepts and processes and help the science teachers discover "real-life" problems and issues that can be used as a vehicle for teaching science.
- Support academic and vocational teachers in working together to encourage students to take the challenging science courses that are coherently linked to their career concentrations.

■ Provide time and incentives for academic and vocational teachers to plan together.

Schools and society have changed. It is no longer enough for students to learn facts in isolation. Rather, teachers must help students understand connections among subject areas and how the knowledge and skills acquired in school will fit the needs and demands of the workplace and postsecondary education. To do this, teachers must plan together to integrate learning. The good news is that in the 1996 Assessment, 63 percent of students said their vocational and science teachers worked together.

What can science and vocational teachers do?

- Review national standards and select those that overlap to develop joint integrated lessons and projects for achieving the standards.
- Seek support from school administrators for a common planning time.
- Develop an end-of-program exam on science facts, concepts, processes and problems that graduates of a given vocational program should know and understand.
- Ask groups and/or individual students to design and conduct experiments on problems germane to their vocational studies and to report their findings orally and in writing.

The bad news is that 70 percent

Figure 6

Scores at High-Scoring *HSTW* Sites

	Scores
Agriculture	305
Transportation	294
Construction	298
Industrial and Manufacturing	297
Communications	301
Community Protection	311

of career-bound students in 1996 said they never had a science assignment for which they also received a grade in another class. In 1994, the percentage was 73.

Administrators, counselors and teachers must change their philosophy and primary strategy from "sort and divide" to "plan and integrate." Linking subject matter to experience helps students learn. All science concepts can be linked to experience.

■ **Strengthen guidance programs so that counselors, science teachers, parents and students understand the value of taking high-level science courses.**

The good news is that 67 percent of students said they had help from a counselor or teacher/advisor in planning a high school program of study, and 67 percent said they had help from a teacher or counselor in reviewing that plan each year.

The bad news is that science achievement was not affected by whether or not the student received help in planning a program of study or had the plan reviewed annually. In some instances, students had slightly higher science achievement if they did not receive any help from a counselor or teacher in choosing their science courses. Further bad news is that only 21 percent said their parents met with them and a counselor or advisor to plan their high school program of study. This is compelling evidence that our current high school system of curriculum and guidance is aimed at serving the most advantaged students in the most challenging science classes and accommodating the most disadvantaged students in low-level classes that fail to motivate students to work hard to meet high standards. This concept of sorting and accommodating students results in low performance by career-bound youth who need more rather than less rigor.

What can counselors do?

Counselors must "rethink" the purpose of schooling, counseling and advising so that they place students in classes based on the future rather than the past. There must be a great philosophical change from exclusion to inclusion, from "you can't" to "you can." What is needed is a conscious breaking and bending of old parameters.

- Pay as much attention to career-bound as to college-bound students.
- Work with parents and the community to learn about today's and tomorrow's needs in the workplace and the world.
- Use future plans/careers, desire for further study and willingness to work hard as a basis for placing students in high-level science classes.
- Involve parents in the advisement process so they will understand the need for high-level science courses.

The bad news is that many schools have guidance and curriculum systems that sort and place students based on past performance, past test scores and perceived ability rather than students' plans for the future and ability to change. Advisors need to help career-bound youth and their parents understand what is required for successful transition to postsecondary studies or a primary job. This failure to provide information and to confront youth with the "realities of life" is one of the major weaknesses in improving the quality of learning for career-bound youth. Counselors must be willing to place career-bound students in high-level science courses. Science teachers must decide to give all students access to high-level courses and to use authentic problems and strategies as a vehicle for teaching high-level content.

■ **Provide a structured system of work-based and school-based learning for students.**

The good news is that students who work 15 to 20 hours per week have higher science scores than students who do not work at all or who work more hours.

The bad news is that only 35 percent of career-bound students work up to 20 hours per week while 36 percent work 21 or more hours per week. Further bad news is that youth who work and earn school credit have significantly lower average science achievement than youth who work and do not earn school credit. Youth who earn school credit tend to work longer hours and are less likely to take a science course in their senior year; 34 percent fit in this category. Science teachers should join with other academic teachers to insist that youth who earn school credit for employment in their junior and senior years should take at least three high-level academic courses, including one in mathematics or science.

Additional bad news is that only 22 percent of career-bound youth

say their school-based instruction is sometimes related to their work-site learning experiences. Science teachers need to know the work-site experiences in which their students participate and to draw upon those experiences in helping students understand major science concepts and processes. Further, science teachers need to establish a close working relationship with vocational teachers who have placed youth in organized work-site learning experiences.

What can science teachers do?

- Promote and achieve the learning goals outlined in the Benchmarks for Science Literacy and the National Science Education Standards.
- Place science learning in real workplace contexts. Identify problems or issues commonly faced in the workplace that involve science concepts included in national standards.
- Provide hands-on, inquiry-based learning opportunities that create scientific habits of mind.
- Assess student achievement through individual projects that draw on both classroom and workplace learning.
- Help students make sense of how science contributes to solving real-world problems.
- Develop workplace activities, classroom activities and suggested student projects that require students to understand and use science concepts.

Summary

While there was definite improvement in the science scores of career-bound students at *HSTW* sites between 1993 and 1996, this was not true from 1994 to 1996. Science teachers need to work with vocational teachers, business and community leaders, and parents to provide a science curriculum for career-bound students that is fast-paced, lab-based and closely related to the workplace and home. Philosophically and practically, science teachers need to consider science a gateway course to success. Sorting and accommodating students to low standards will never produce citizens who can make decisions, use research data, solve problems and think critically. Quality science instruction cannot be geared to only the "top" students.

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