HIGH SCHOOLS THAT WORK

SREB

Research Brief

Project Lead The Way® Works:

A New Type of Career and Technical Program

by Gene Bottoms and John Uhn

Employers in the 21st century are seeking more workers with strong science, technology, engineering and mathematics (STEM) backgrounds. In response to this demand, schools must prepare more students in STEM-related fields and raise student achievement in mathematics and science. Schools can increase student achievement in STEM courses by providing continuous, rigorous mathematics and science curricula with applied technology courses based on real-world, hands-on projects. Project Lead The Way® (PLTW) provides such a curriculum with: a) a series of engineering courses organized around authentic, problem-centered projects that require students to apply mathematics, science and technical knowledge and skills; b) a sequence of mathematics and science courses through which students progress; c) two weeks of comprehensive training for educators teaching the PLTW courses; and d) a national end-of-course exam to assess whether or not students meet the course objectives and expected performance outcomes.

High Schools That Work (*HSTW*) and PLTW began working together in September 1999 to implement an engineering educational career pathway that holds the same objectives as *HSTW*[1] — to prepare more students to pursue postsecondary studies and to enter and advance in a career. PLTW provides schools and students with a well-developed curriculum that includes embedded mathematics and science content. Schools adopting the PLTW curriculum are asked to enroll their students into a sequence of college-preparatory mathematics and science courses and to meet key conditions, including:

- requiring teachers to attend an intensive two-week summer training program for each PLTW course they instruct to better understand what academic and technical content to teach, how to engage students in learning and how to effectively assess students' progress;
- creating school laboratories with the equipment, instructional materials and supplies essential for teaching the courses; and
- training counselors to comprehend how the PLTW program can help students prepare for further education in engineering-related fields and the workplace and how to advise students on essential academic courses to take.

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[1] HSTW *Presents a Pre-engineering Program of Study*. SREB, 2001. (01V56).

The 2005 *HSTW* report, *Project Lead The Way: A Pre-engineering Curriculum That Works*,[2] compared the performance of PLTW students with *HSTW* career/technical (CT) students on the 2004 *HSTW* Assessment. The report stated that the 264 students who took two or more PLTW courses at a *HSTW* school:

- achieved significantly higher scores in mathematics on the NAEP-referenced *HSTW* Assessment than *HSTW* career/technical students in comparable CT fields;
- achieved significantly higher scores in reading, mathematics and science on the NAEP-referenced *HSTW* Assessment than *HSTW* career/technical students from all CT fields;
- were more likely to complete at least four years of mathematics and at least four years of science courses during high school;
- were significantly more likely to experience engaging instructional practices in mathematics and science courses; and
- were significantly more likely to have a richer learning experience in their career/technical courses.

This report analyzes the 2006 *HSTW* Assessment results to determine if PLTW students have higher achievement and higher-quality learning experiences than other CT students in the *HSTW* network. *HSTW* verified that those participating in this study were PLTW students who had completed at least three PLTW courses.

This analysis of PLTW students poses the following questions derived from the 2005 report:

- Do PLTW students in the *HSTW* network achieve significantly higher scores in reading, mathematics and science on a NAEP-referenced assessment than other career/technical students from similar CT fields and all CT fields in the network?
- Are PLTW students more likely to take at least four years of college-preparatory mathematics and at least three years of college-preparatory science courses than other career/technical students?
- How do PLTW students who complete at least four years of college-preparatory mathematics or at least three years of college-preparatory science courses perform, compared with PLTW students who do not complete these courses?
- Do PLTW students experience more challenging and engaging classroom instruction than other career/technical students in the network in their core academic and CT courses?
- Are PLTW students more likely to have a goal of pursuing a postsecondary education than other career/technical students?

This report also poses two new questions:

- Are PLTW students more likely to complete the *HSTW*-recommended curriculum than other career/technical students?
- Do more PLTW students see a high school education as being important to their future than other career/technical students?

[2] Bottoms, Gene and Karen Anthony. *Project Lead The Way: A Pre-Engineering Curriculum That Works*. SREB, 2005. (05V08).

Key Findings:

- PLTW students achieved significantly higher scores in mathematics and science on the NAEP-referenced *HSTW* Assessment than similar *HSTW* career/technical students in comparable CT fields and in all CT fields.
- PLTW students were significantly more likely to:
  - complete at least four years of mathematics — including Algebra I, geometry, Algebra II and one higher-level mathematics course — and at least three years of lab-based science courses during high school than other *HSTW* career/technical students;
  - complete all parts of the *HSTW*-recommended curriculum — four college-preparatory English courses, four mathematics courses and three college-preparatory science courses — than other *HSTW* career/technical students;
  - experience engaging instructional practices in language arts, mathematics and science courses;
  - use academic knowledge and skills — reading, mathematics and science — to complete authentic assignments in their career/technical courses; and
  - perceive high school as important in preparing them for the future.

Because the PLTW student demographics were not comparable to those of all *HSTW* students, *HSTW* used a random sampling technique to create demographically matched groups of non-PLTW students to PLTW students. (See Table 1.) Two different comparison groups were used: 1) a sample of CT students from similar CT fields;[3] and 2) a sample of CT students from all CT fields. Due to the larger number of PLTW students surveyed in 2006 than in 2004, the number of credits *HSTW* used to define a PLTW student was increased to at least three credits completed. Two hundred ninety-two students met these credit requirements. *HSTW* verified this list of PLTW students with each high school. For the *HSTW* comparison groups — career/technical students from similar and all CT fields — random samples of 292 students were selected to match the demographics of the 292 PLTW students. For a more detailed description of the process used to verify the PLTW students and to create the sample groups, see the Appendix.

Table 1
Demographics for PLTW Students, *HSTW* Career/Technical Comparison Groups and All *HSTW* Career/Technical Students

	All PLTW Students	*HSTW* Career/Technical Comparison Groups	All *HSTW* Career/Technical Students
Gender			
Male	86%	86%	49%
Female	14	14	51
Ethnicity			
White	65	65	59
African-American	22	22	24
Other Races/Ethnicities	13	13	18
Parent Education Level			
Completed High School or Less	28	28	39
Pursued Postsecondary Education	72	72	62

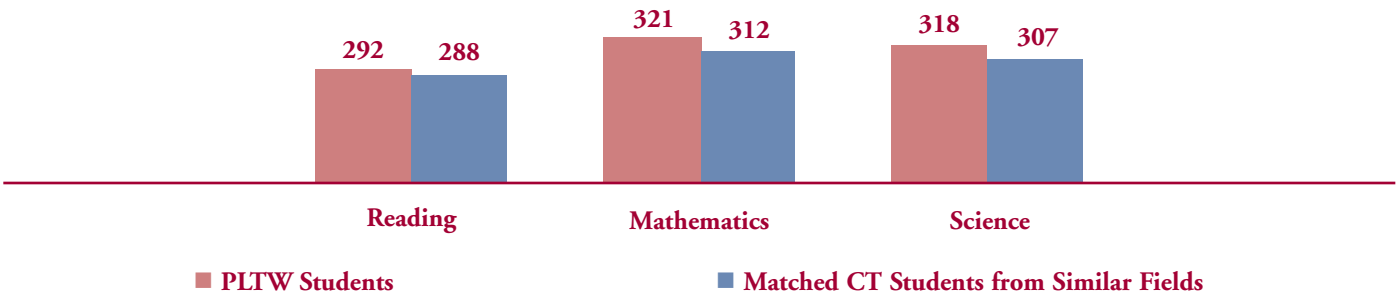
Source: 2006 *HSTW* Assessment
Note: Due to rounding, percentages may not equal 100 percent.

[3] Similar career/technical fields are students whose CT major is Information Technology, A/V Tech and Communications, Electricity and Electronics, Drafting and Design, or Technology and Engineering. Students who reported completing any PLTW credits at a high school without the PLTW program were removed from the pool.

Do PLTW students achieve significantly higher scores in reading, mathematics and science on a NAEP-referenced assessment than other career/technical students from similar CT fields and all CT fields in the network?

In 2004, PLTW students achieved higher scores on the NAEP-referenced *HSTW* Assessment than CT students from comparable fields and significantly higher scores in mathematics. In 2006, PLTW students scored significantly higher than CT students from similar fields in both mathematics and science. (See Figure 1.) PLTW students also achieved higher scores for reading in 2006. However, the difference in scores was not statistically significant at the same level. Both groups of students achieved average scores that exceeded all three of the *HSTW* college- and career-readiness performance goals.[4]

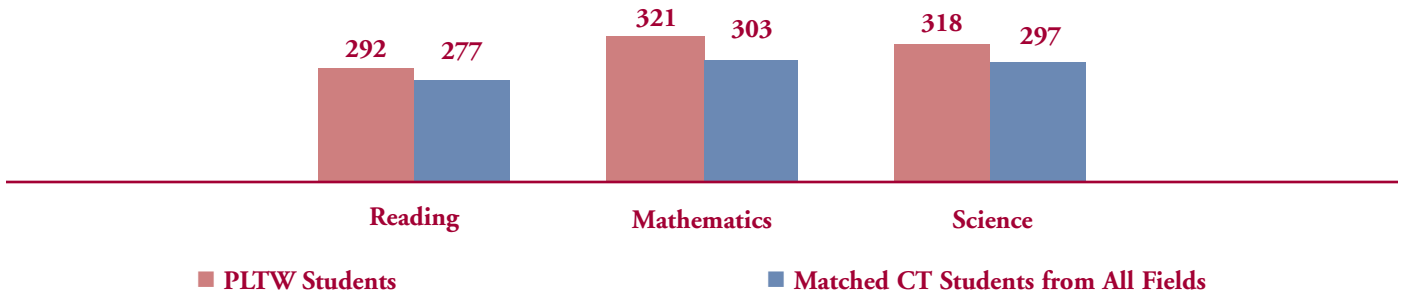
Figure 1
Comparison of PLTW Students' Mean Scores with a Random Sample of Career/Technical Students from Similar Fields



Source: 2006 *HSTW* Assessment
Note: Differences between mathematics and science scores were significant at $p < .01$ on the t test. Differences between reading were significant at $p < .10$ on the t test

When compared with a random sample of students from all *HSTW* career/technical fields, PLTW students scored significantly higher in all three assessment areas. (See Figure 2.)

Figure 2
Comparison of PLTW Students' Mean Scores with a Random Sample of Students from All Career/Technical Fields



Source: 2006 *HSTW* Assessment
Note: Differences between the assessment scores were significant at $p < .01$ on the t test.

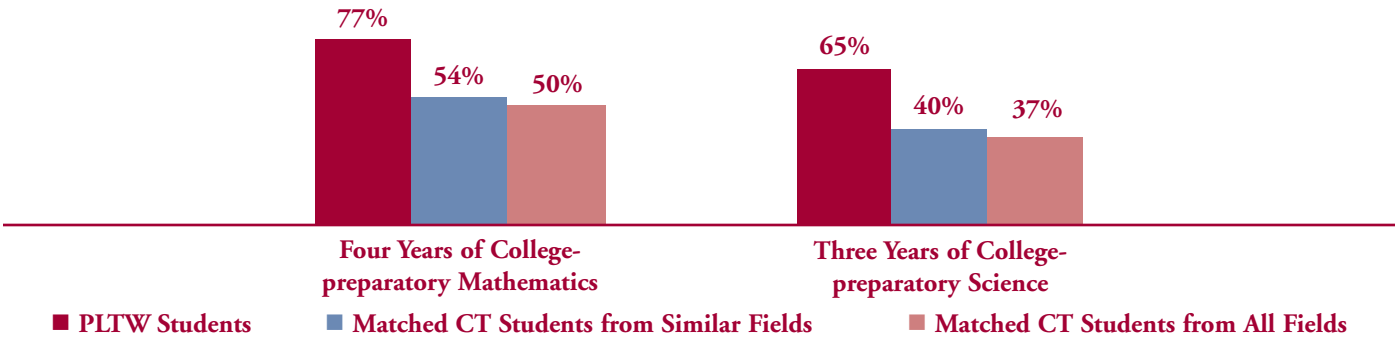
[4] *HSTW* performance goals are set at the Basic proficiency level in mathematics (297) and science (299), and between the Basic and Proficient levels in reading (279) on the NAEP-referenced *HSTW* Assessment.

The differences in scores between PLTW students and *HSTW* career/technical students can be explained by the courses students were encouraged to take and their classroom experiences. After 20 years of research, one piece of high school data has been consistent: **The best way to improve achievement of all student groups is to enroll more students in a challenging and well-taught academic curriculum.** PLTW students are encouraged to enroll in such curricula, leading to higher student achievement.

Are PLTW students more likely to take at least four years of college-preparatory mathematics and at least three years of college-preparatory science courses than other career/technical students?

When compared with students enrolled in similar CT fields, an additional 23 percent of PLTW students completed at least four years of mathematics, Algebra I and higher, and an additional 25 percent completed at least three years of science courses taught at the college-preparatory level. (See Figure 3.) **It appears that schools that use printed materials, teacher encouragement and counselor training to purposely encourage students to complete a challenging engineering program with a recommended mathematics and science sequence have more students enrolled in challenging academic courses.**

Figure 3
Comparison of PLTW Students' Course-taking Patterns to Other Career/Technical Students



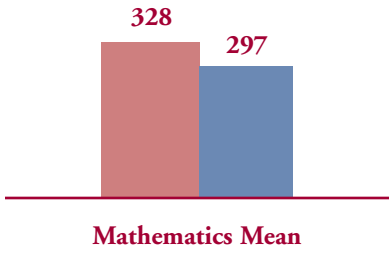
Source: 2006 *HSTW* Assessment
Note: Differences in students' course-taking patterns were significant at $p < .01$ on the chi-square test.

How do PLTW students who complete at least four years of college-preparatory mathematics or at least three years of college-preparatory science classes perform, compared with PLTW students who do not complete these courses?

PLTW students who completed at least four years of college-preparatory mathematics or at least three years of college-preparatory science achieved significantly higher scores in mathematics and science than those who did not. The 77 percent of PLTW students who completed at least four credits of college-preparatory mathematics achieved an average score of 328, at the Proficient level, compared with 297, at the Basic level, for those PLTW students who did not complete the curriculum.[5] (See Figure 4.)

[5] Proficiency Levels for Mathematics: Below Basic (0–296), Basic (297–327), Proficient (328–348) and Advanced (349–500)

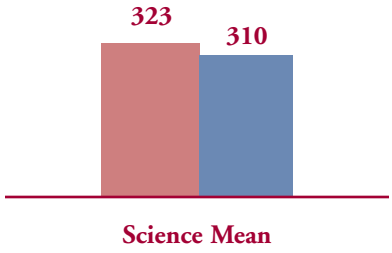
Figure 4
PLTW Students' Mean Mathematics Scores by College-preparatory (CP) Mathematics Courses Completed



Source: 2006 *HSTW* Assessment
Note: Difference in the mean scores between the two groups is significant at $p < .01$ on the t test.

The 65 percent of PLTW students who completed at least three years of college-preparatory/lab-based science classes achieved an average science score of 323, compared with 310 for those PTLW students who did not complete at least three years of college-preparatory science. (See Figure 5.) A 10-point difference in the *HSTW* Assessment score is considered equivalent to a difference in one grade level, meaning **PLTW students who completed at least three years of college-preparatory science were a grade-level higher in science[6] than PLTW students who did not complete three or more courses.**

Figure 5
PLTW Students' Mean Science Scores by College-preparatory Science Courses Completed



Source: 2006 *HSTW* Assessment
Note: Difference in the mean scores between the two groups is significant at $p < .01$ on the t test.

A coherent sequence of mathematics and science courses, complete with special CT courses that blend academic and technical content, can produce graduates with the mathematics and science skills necessary for further study in STEM-related fields. Fifty-three percent of students who completed at least four years of college-preparatory mathematics achieved at the Proficient level and above, compared with 12 percent of the students who did not complete at least four years of college-preparatory mathematics. (See Table 2.) Fifty-seven percent of PLTW students who completed at least three years of college-preparatory science courses were at the Proficient level and above, compared with 39 percent who did not complete three years of college-preparatory science.

[6] Proficiency Levels for Science: Below Basic (0–298), Basic (299–325), Proficient (326–351) and Advanced (352–500)

Table 2
Percentage of PLTW Students Scoring at Each Achievement Level on the *HSTW* Assessment

	Below Basic	Basic	Proficient/ Advanced
Completed Four Years of College-preparatory Mathematics	8%	39%	53%
Did Not Complete Four Years of College-preparatory Mathematics	43	45	12
Completed Three Years of College-preparatory Science	21	23	57
Did Not Complete Three Years of College-preparatory Science	31	29	39

Source: 2006 *HSTW* Assessment
Note: Differences in the percentages for the level of performances between groups are significant at $p < .05$ on the chi-square test. Due to rounding, percentages may not equal 100 percent.

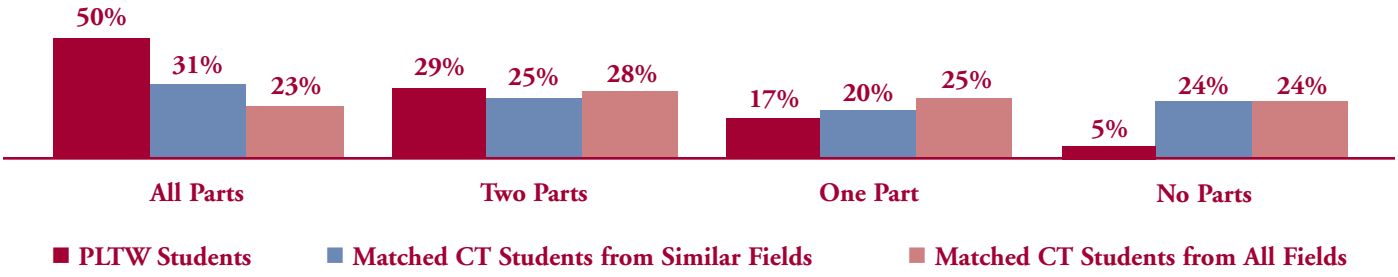
Are PLTW students more likely to complete the *HSTW*-recommended curriculum than other career/technical students?

The single most important predictor of student scores on the *HSTW* Assessment is the degree of completion of the *HSTW*-recommended academic curriculum.[7] Students who completed the recommended curriculum achieved significantly higher scores on all three sections of the 2006 *HSTW* Assessment than students who did not.[8] PLTW students were significantly more likely to complete the *HSTW*-recommended curriculum than *HSTW* career/technical students from similar and all CT fields. (See Figure 6.) One-half of the PLTW students surveyed completed all three curricula — English, mathematics and science — compared with 31 percent of CT students from similar fields and 23 percent of CT students from all fields. Only 5 percent of PLTW students did not complete at least one part of the *HSTW*-recommended curriculum, compared with about one-fourth of *HSTW* career/technical students. **It is evident that the PLTW program encourages more students to complete a sequence of rigorous, college-preparatory mathematics and science courses such as the *HSTW*-recommended curriculum.**

[7] *HSTW*-recommended curriculum is composed of: four credits in college-preparatory English; four credits in mathematics — including Algebra I, geometry, Algebra II and one higher-level mathematics course; and three credits in college-preparatory science.

[8] Young, John and Fred Cline. *Validity of the* HSTW *Student Survey Indices for Predicting* HSTW *Assessment Scores*. Center for Validity Research, Educational Testing Service, 2007. Unpublished Work.

Figure 6
Comparison of *HSTW*-recommended Curriculum Completed by PLTW Students with Other Career/Technical Students



Source: 2006 *HSTW* Assessment
Note: Differences in students' course-taking patterns were significant at $p < .01$ on the chi-square test.

Do PLTW students experience more challenging and engaging academic classroom instruction than other career/technical students?

Engagement in challenging assignments influences students' achievement. On the 2006 *HSTW* Assessment Student Survey, PLTW students reported completing engaging activities related to literacy, numeracy and science in their academic and PLTW courses.

HSTW Indicators for Emphasis on Literacy Across the Curriculum

Students reported that:

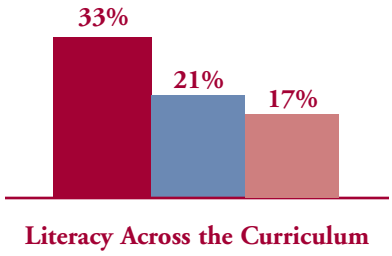
- They used word processing software to complete an assignment or project **often**.
- They revised their essays or other written work several times to improve the quality **often**.
- They were asked to write in-depth explanations about a class project or activity **sometimes** or **often**.
- They discussed or debated with other students about what they read in English/language arts classes **at least monthly**.
- They read an assigned book outside of English class and demonstrated that they understood the significance of the main ideas **at least monthly**.
- They read non-school-related materials outside of class for **two or more hours** in a typical week.
- They completed short writing assignments of one to three pages for which they received a grade in their English classes **at least monthly**.
- They completed short writing assignments of one to three pages for which they received a grade in their science classes **at least monthly**.
- They completed short writing assignments of one to three pages for which they received a grade in their social studies classes **at least monthly**.
- They read and interpreted technical books and manuals **at least monthly** to complete assignments in their career/technical areas (CTE students only).

Source: 2006 *HSTW* Assessment

Literacy across the curriculum focuses on students' experiences with reading and writing for learning in all courses. Students are challenged to write long and short papers and complete these assignments on computers in all of their courses as a means of increasing their comprehension, analysis and synthesis of subject matter. Literacy across the curriculum improves students' reading achievement, advances their academic and technical achievement, and encourages them to become independent and lifelong learners.

PLTW students were more likely to experience an intensive emphasis on literacy across the curriculum in their academic and CT classrooms — experiencing at least seven of the 10 indicators — than other CT students. (See Figure 7.) **Specifically, PLTW students were asked more often than other CT students to write in-depth papers and short one- to three-page papers for a grade, complete assignments on a computer, and interpret technical books and projects in engineering courses.** (See Table 3.)

Figure 7
Percentages of Students Experiencing an Intensive Emphasis on Literacy Across the Curriculum



Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .01$ on the chi-square test. Students experiencing an intensive emphasis on literacy across the curriculum reported experiencing at least seven of the 10 indicators.

Table 3
Select Indicators for Literacy Across the Curriculum

Select Indicators	PLTW Students	CT Students from Similar Fields	CT Students from All Fields
Students used word processing software to complete an assignment or project **often**.	66%	52%	44%
Students were asked to write in-depth explanations about a class project or activity **sometimes** or **often**.	71	63	61
Students completed short writing assignments of one to three pages for which they received a grade in their English classes **at least monthly**.	85	76	68
Career/technical students read and interpreted technical books and manuals **at least monthly** to complete assignments in their career/technical area.	65	50	45

Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .05$ on the chi-square test.

HSTW has found that students who have intensive and quality mathematics learning experiences are more likely to:

- take four years of mathematics courses, including one during their senior year;
- use mathematics to solve real-world problems;
- work in collaborative teams with other students;
- make use of technology to advance their mathematics achievement; and
- use mathematics to complete assignments in career/technical classes.

HSTW Indicators for Emphasis on Numeracy Across the Curriculum

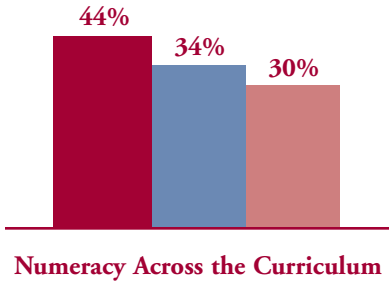
Students reported that:

- They took a mathematics class during their senior year.
- They took at least four full-year courses in mathematics in grades nine through 12.
- Their mathematics teachers **sometimes** or **often** show them how mathematics concepts are used to solve problems in real-life situations.
- They used a graphing calculator to complete mathematics assignments **at least monthly**.
- They completed a mathematics project **at least monthly** that used mathematics in ways that most people would use mathematics in a work setting.
- They orally defended a process they used to solve a mathematics problem **at least monthly**.
- They worked with one or more students in their class **at least monthly** on a challenging mathematics assignment and received a group and individual grade.
- They worked in groups to brainstorm how to solve a mathematics problem **at least monthly**.
- They solved mathematics problems with more than one possible answer **at least monthly**.
- They solved mathematics problems other than those found in the textbook **at least monthly**.
- They used mathematics to complete challenging assignments in their career/technical areas **at least monthly** (CTE students only).

Source: 2006 *HSTW* Assessment

PLTW students are more likely to have experienced an intensive emphasis on numeracy in their mathematics classes when compared with other *HSTW* career/technical students. (See Figure 8.) Eighty-one percent of PLTW students were required to use mathematics to complete a challenging assignment at least monthly, compared with 45 percent of students from similar fields, and more PLTW students applied mathematics to solve problems in real-life situations and work settings. Also, PLTW teachers are engaging more of their students in challenging assignments. (See Table 4.) The combination of the blended PLTW curriculum materials, special training for PLTW teachers and more engaging mathematics instruction results in a learning experience that better connects mathematics assignments to other classes and to real-world problems.

Figure 8
Percentages of Students Experiencing an Intensive Emphasis on Numeracy Across the Curriculum



Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .01$ on the chi-square test. Students experiencing an intensive emphasis on numeracy across the curriculum reported experiencing at least eight of the 11 indicators.

Table 4
Select Indicators for Numeracy Across the Curriculum

Select Indicators	PLTW Students	CT Students from Similar Fields	CT Students from All Fields
Students' mathematics teachers **sometimes** or **often** showed them how mathematics concepts are used to solve problems in real-life situations.	80%	71%	71%
Students used a graphing calculator to complete mathematics assignments **at least monthly**.	83	75	69
Students completed a mathematics project **at least monthly** that used mathematics in ways that most people would use mathematics in a work setting.	43	32	35
Career/technical students used mathematics to complete challenging assignments in their career/technical areas **at least monthly**.	81	45	43

Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .05$ on the chi-square test.

HSTW thinks a rigorous and engaging science curriculum is most effective when instruction is based on three principles:

- Students design and conduct projects and activities.
- Students work in teams to complete challenging projects and activities.
- Students design studies around authentic real-world problems.

HSTW Indicators for Emphasis on Challenging and Engaging Science Curriculum and Instruction

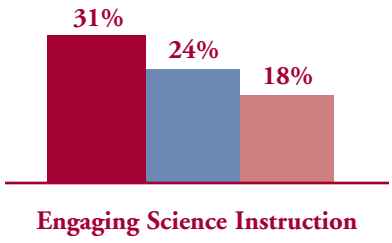
Students reported that:

- They completed any three of the following science courses: college-preparatory physical science, college-preparatory biology/Biology 2, anatomy, college-preparatory chemistry, physics or an Advanced Placement science.
- Their science teachers showed them how scientific concepts are used to solve problems in real-life situations **often**.
- They took a science class during their senior year.
- They used science equipment to do science activities in a laboratory with tables and sinks **at least weekly**.
- They read an assigned book (other than a textbook) or article dealing with science **at least monthly**.
- They used science equipment to do science activities in a classroom **at least monthly**.
- They worked with one or more students in their class on a challenging science assignment **at least monthly**.
- They prepared a written report of lab results for laboratory investigations in science **at least monthly**.

Source: 2006 *HSTW* Assessment

PLTW students were significantly more likely to experience an intensive emphasis on engaging and challenging science curriculum and instruction when compared with *HSTW* career/technical students. (See Figure 9.) Students can advance their science achievement if they are enrolled in rigorous science courses. PLTW students were more likely to be encouraged to enroll in college-preparatory science courses and take a science course during their senior year than *HSTW* career/technical students from similar and all fields. In addition, more PLTW students completed science assignments based on their own work experiences and had to design and write a report based on their laboratory investigations. (See Table 5.) Such assignments engage students in learning and motivate them to improve their achievement in science.

Figure 9
Percentages of Students Experiencing an Intensive Emphasis on Challenging and Engaging Science Curriculum and Instruction



Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .01$ on the chi-square test. Students experiencing challenging and engaging science curriculum reported experiencing at least six of the eight indicators.

Table 5
Experiences in Science and Career/Technical Classrooms

Select Indicators and Experiences	PLTW Students	CT Students from Similar Fields	CT Students from All Fields
Students completed any three of the following science courses: CP physical science, CP biology/Biology 2, anatomy, CP chemistry, physics or an AP science.	56%	30%	24%
Students stated they took a science course during their senior year.	69	60	54
Students were encouraged by counselors or teachers to take more challenging science courses **sometimes** or **often**.	46	31	40
Students completed a science assignment based on their own work experience or a career/technical class **at least once a semester**.	52	39	44
For laboratory investigations in science, students were required to design an experiment about a topic they chose **at least monthly**.	45	33	36
For laboratory investigations in science, students were required to prepare a written report of the lab results **at least monthly**.	63	57	51

Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .05$ on the chi-square test.

Do PLTW students have a richer set of learning experiences in their career/technical courses?

The PLTW sequence of engineering courses encourages students to use their mathematics and science knowledge and skills to complete problem-based project assignments. **PLTW students were more likely than other *HSTW* career/technical students to experience such courses that required them to use academic knowledge to complete authentic assignments.** (See Table 6.) Eighty-one percent of PLTW students used mathematics to complete challenging assignments at least monthly, compared with 45 percent of CT students from similar CT fields and 43 percent from all CT fields. Also, PLTW students were more likely to apply knowledge from their science courses in their CT courses, and more likely to keep portfolios with examples of how they used mathematics and science in their CT courses.

Table 6
Experiences from Career/Technical Classrooms

Select Indicators	PLTW Students	CT Students from Similar Fields	CT Students from All Fields
Students said they had a challenging assignment in their CT classrooms **at least monthly**.	69%	56%	48%
Students used mathematics to complete challenging assignments in their CT areas **at least monthly**.	81	45	43
In their career/technical classes, students **sometimes** or **often** studied subjects related to what they had studied in their science classes.	30	15	17
Students' portfolios contained examples from their CT classes on how they used mathematics.	66	40	41
Students' portfolios contained examples of how they used science in their CT classes.	60	35	34

Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .01$ on the chi-square test.

Do more PLTW students perceive the importance of their high school education and plan to pursue postsecondary education than other career/technical students?

Both *HSTW* and PLTW seek to assist students to see high school as a means to an end goal and to instill in students the importance of high school in preparing them for the future. Students who can see a meaningful goal at the end of high school are more motivated to complete assignments and work harder to achieve at a significantly higher level.

HSTW Indicators for Emphasis on Perceived Importance of High School Studies

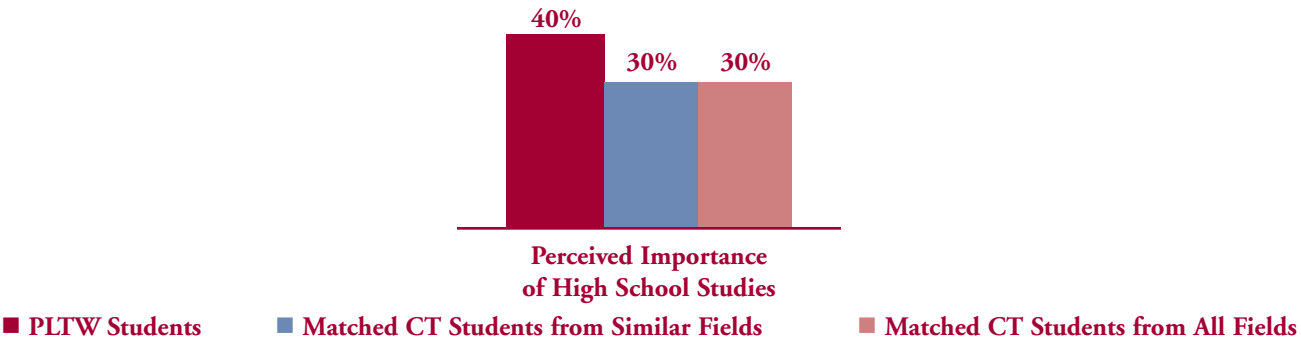
Students reported that:

- Their courses were **sometimes** or **often** exciting and challenging.
- They **often** tried to do their best work in school.
- They **seldom** or **never** failed to complete or turn in their assignments.
- Most of their teachers **often** encouraged students to do well in school.
- Teachers **often** showed they care about them by not letting them get by without doing the work.
- It is **very important** to study hard to get good grades.
- It is **very important** to participate actively in class.
- It is **very important** to attend all of their classes.
- It is **very important** to take a lot of college-preparatory classes.

Source: 2006 *HSTW* Assessment

Forty percent of PLTW students perceived high school to be very important to their future, compared with 30 percent of other career/technical students. (See Figure 10.) PLTW students were more likely to be challenged in their courses and perceive it to be very important that they attend their classes and take college-preparatory courses. (See Table 7.)

Figure 10
Percentages of Students Experiencing an Intensive Emphasis on Perceived Importance of High School Studies



Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .05$ on the chi-square test. Students experiencing an intensive emphasis perceived importance of high school studies reported experiencing at least seven of the nine indicators.

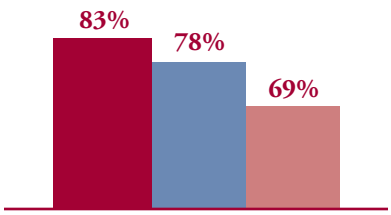
Table 7
Perceived Importance of High School Studies

Select Indicators	PLTW students	CT students from similar fields	CT students from all fields
Students said their courses are **sometimes** or **often** exciting and challenging.	84%	75%	71%
Students said it is **very important** that they participate actively in class.	65	63	54
Students said it is **very important** that they attend all of their classes.	85	78	77
Students said it is **very important** that they take a lot of college-preparatory classes.	60	51	46

Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .05$ on the chi-square test.

Eighty-three percent of PLTW students said they planned to attend a two- or four-year college or university after they graduated, compared with 78 percent of CT students from similar fields and 69 percent of CT students from all fields. (See Figure 11.)

Figure 11
Percentages of Students Planning Postsecondary Study



■ PLTW Students ■ Matched CT Students from Similar Fields ■ Matched CT Students from All Fields

Source: 2006 *HSTW* Assessment
Note: Differences in the percentages between groups are significant at $p < .01$ on the chi-square test.

Mathematics achievement appears to be a strong predictor of students' interest in pursuing postsecondary studies. Students who achieve at the Proficient level or higher in mathematics are more likely to enter a two- or four-year college after high school. Ninety-three percent of PLTW students performing at the Proficient level or higher in mathematics planned to pursue postsecondary studies, compared with only 77 percent of students who achieved mathematics scores at the Basic level and 65 percent of students who achieved at the Below Basic level.

Implications for Linking Career/Technical Studies to Broader High School Reform

What lessons can state and district policy-makers and CT leaders learn from the PLTW engineering curriculum? The results of this analysis of PLTW students suggest the importance of embedding academic content into redesigned CT courses and the need to set policies and create incentives that make redesigned CT studies a priority. Consider the following actions to improve CT programs:

- Invest in developing and adapting high-quality curriculum and instructional materials that engage students in applying academic and technical knowledge to challenging, authentic projects.
- Provide challenging, hands-on, authentic projects in CT courses as early as grade nine — or perhaps earlier — in conjunction with students' academic courses to help them understand how academic and technical knowledge work together.
- Provide training to prepare CT teachers to: a) plan and engage students in authentic project- and problem-based assignments; b) develop lessons for teaching academic content embedded in authentic projects; and c) assess students' academic and technical achievement learned through CT curriculum and instruction.
- Create relevant end-of-course exams to determine whether students have met expected academic and technical achievement standards.
- Assist students to outline a program of college-preparatory mathematics and science courses with a sequence of redesigned career/technical courses.
- Train counselors on: a) changing workplace requirements; b) the need for more students to complete challenging academic and CT programs of study; and c) benefits of quality CT studies to ensure high school completion and preparation for both work and further study.

- Align high school CT courses in grades 11 and 12 to postsecondary and workplace standards through the involvement of faculty and administrative leaders, such as a district superintendent or a dean from a university or two-year college.
- Modernize CT laboratories and acquire the necessary equipment and instructional supplies required to blend academic and technical content.

Implications for Improving the PLTW Engineering Program

National, state and local PLTW leaders can improve the achievement of their students by considering the following actions:

- Continue to stress to PLTW teachers, counselors and school leaders that PLTW students must complete four years of mathematics — Algebra I, geometry, Algebra II and higher — and at least three years of college-preparatory science courses.
- Train PLTW teachers to plan lessons using proven instructional strategies that frequently engage students in reading, interpreting and analyzing technical materials and writing technical reports.
- Provide special workshops where PLTW teachers collaborate with mathematics and science educators to plan lessons for instructing mathematics and science concepts embedded in career/technical assigned projects and problems.
- Provide materials, workshops and online support to improve the rigor and quality of mathematics and science instruction within the high schools participating in PLTW.
- Provide tips to school leaders on what they can do to create and support the conditions for a quality PLTW program at their school.
- Provide support to districts and schools interested in the PLTW program by locating grants from federal, state or local governments or other sources to provide the equipment necessary for authentic, hands-on projects.

Appendix
Methodology

To create the list of PLTW students, *HSTW* chose those students in the 2006 *HSTW* Assessment pool who stated they completed at least three courses in the PLTW program within a high school at the PLTW program. The list of PLTW students was then verified with the respective high school to determine whether or not these students had completed three or more PLTW courses. *HSTW* was able to confirm that 292 students on the list were PLTW students.

Preliminary analysis revealed that the PLTW students had a significantly different demographic composition than other career/technical students in the 2006 *HSTW* Assessment. For *HSTW* to make comparisons between the PLTW students and other CT students, a random sample of CT students had to be drawn that demographically matched PLTW students. Two groups of randomly drawn CT students were selected to compare with PLTW students: career/technical students from similar CT fields and career/technical students from all CT fields. Career/technical students with similar CT fields are those whose CT major is in Information Technology, A/V Technology and Communications, Electricity and Electronics, Drafting and Design, or Technology and Engineering.

The first step in establishing the two sample groups was to collect a list of all *HSTW* career/technical students who did not attend a PLTW high school to prevent any spillover benefits from having a PLTW program at the school. Any CT students who stated they completed at least one PLTW credit and did not attend a PLTW high school were also removed from the sample, since such students were not verifiable by their current high school.

Next, this group of CT students was randomly split into two pools of students to prevent any student from being drawn in both samples. Thus, when the two comparison groups were drawn, there was no chance that a student could appear in both comparison groups and be overrepresented.

A stratified random sample of students was drawn from one of the two pools of students to match the demographic composition of the PLTW students. This technique was used to separate students in the CT comparison group into categories based on their gender, ethnicity and parent education level. For each CT comparison group, a random sample of students was chosen from each demographic category to exactly match the number of students in each category in the PLTW student group. Career/technical students from similar fields were drawn from the first pool of students and CT students from all fields were drawn from the second pool of students.

By matching PLTW students' demographic composition to other CT students, differences between the groups of students could be attributed to students' school and classroom experiences, rather than their backgrounds.

Recent *HSTW* Research Briefs and Research Reports

We Know What Works in the Middle Grades: Smart District Leadership Can Make It Happen

SREB compared schools in the *MMGW* initiative that have more fully implemented the *MMGW* research-based design with others that have been defined as low-implementation schools. The report shows clear differences in the achievement levels of these two groups of schools — and that sustainable middle grades reform is far more likely to occur when leaders are all committed to the same improvement goals and means of achieving them. By Gene Bottoms, Sondra Cooney and Allison Timberlake (07V10); 80 pages; 2007; $7.50; $5 each for 10 or more

Comprehensive School Reform: Making a Difference in Improving High Schools

States and school districts are discovering that a small investment can yield positive returns for schools that deeply implement the *HSTW* Goals and Key Practices. Through *HSTW* Technical Assistance Visits, school-based staff development, workshops and NAEP-based assessments, teams from low-performing schools learned how to make needed changes in improving student performance — and made more progress in raising student achievement than similar schools that failed to receive such assistance. By Gene Bottoms, Lingling Han and Alice Presson (07V09); 80 pages; 2007; $7.50; $5 each for 10 or more

Good Principals Aren't Born — They're Mentored: Are We Investing Enough to Get the School Leaders We Need?

This report describes the present condition of mentoring for aspiring school leaders and lays out a course of action for policy-makers and the leaders of universities and school districts to ensure that every beginning principal comes to the job fully prepared to make a difference in teaching and learning. By Cheryl Gray, Betty Fry, Gene Bottoms and Kathy O'Neill (07V05); 96 pages; 2007; $7.50; $5 each for 10 or more

Urban Students Achieve When High Schools Implement Proven Practices

A great challenge today is improving urban education and getting urban students ready for postsecondary education and careers. This research brief shows how, through comparisons of the 2002 and 2004 *HSTW* Assessments, deep implementation of the *HSTW* design in urban districts has raised student achievement levels. (06V61); 2006; $2; $1 each for 10 or more

High Schools That Work Follow-up Study of 2004 High School Graduates: Transitioning to College and Careers from a *High Schools That Work* High School

This brief summarizes the results of the *High Schools That Work* follow-up survey of 2004 graduates from its network schools. It provides insights into how well-prepared these graduates felt they were and what they thought their high schools should have done differently. (06V54); 2006; $2; $1 each for 10 or more

Students Can't Wait: High Schools Must Turn Knowledge into Action

A high school reform effort that fails to accelerate all students' achievement cannot be called successful. The 2002 and 2004 *High Schools That Work* Assessments show that some *HSTW* schools posted significant improvement in achievement across every student group, while others did not. This report looks at the factors that separate the improved schools from the non-improved schools. (06V19); 2006; $7.50

Schools Can't Wait: Accelerating the Redesign of University Principal Preparation Programs

Better-prepared school leaders are essential for implementing school reform and maintaining continuous school improvement. This report highlights the redesign process for principal preparation programs and recommends a course of action for states to follow in planning and implementing successful program reform. (06V04); 2006; $8; $5 each for 5 or more

Improving Reading Achievement in Middle Grades Rural Schools

This research brief addresses low reading achievement among rural middle grades students, particularly in the Southern states. It offers strategies for addressing the problem, provides data that will help teachers and administrators assess the reading achievement of students, and provides a foundation for raising the literacy expectations of all students in all subject areas. By Renee Murray and Gene Bottoms (05V69); 8 pages; 2005; $1

Rigor, Relevance and Relationships Improve Achievement in Rural Schools: High School Reform Works When Schools Do the Right Things

This report compares student achievement at 12 high-achieving rural high schools in the Southern region with 12 low-achieving schools with similar demographics. The primary finding: The high-achieving schools had higher-level implementation of the *HSTW* school improvement design than the low-achieving schools. By Gene Bottoms, Alice Presson and Lingling Han (05V18); 80 pages; 2005; $7.50; $5 each for 5 or more

Raising Achievement and Improving Graduation Rates: How Nine *High Schools That Work* Sites Are Doing It

This research brief describes how nine high schools in the *HSTW* network are succeeding in achieving raising achievement and improving graduation rates. Their success is built upon four key actions: providing an opportunity for students to learn a rigorous and relevant curriculum; helping students set challenging goals and providing support for achieving them; using instructional strategies that actively engage students in learning challenging content; and involving teachers in continuous school improvement. By Gene Bottoms and Karen Anthony (05V14); 12 pages; 2005; $2; $1 each for 10 or more

High Schools That Work Follow-up Study of 2002 High School Graduates: Implications for Improving Transitions from High School to College and Careers

This brief summarizes the results of the *High Schools That Work* follow-up survey of 2002's graduates from its network schools. The survey gathers information about graduates' pursuit of postsecondary studies and careers during the 18 months after high school. This brief provides insights into how well-prepared these graduates felt they were and what they thought their high schools should have done differently. By Gene Bottoms and Marna Young (05V10); 20 pages; 2005; $2; $1 each for 10 or more

Project Lead the Way: A Pre-engineering Curriculum That Works A New Design for High School Career/Technical Studies

This research brief examines the effectiveness of Project Lead the Way® (PLTW) at *HSTW* sites. When comparing the reading, mathematics and science achievement scores with career/technical students in similar fields, PLTW students have significantly higher achievement; when compared with all career/technical students, PLTW students score significantly higher. By Gene Bottoms and Karen Anthony (05V08); 16 pages; 2005; This publication is available only online.

Well-qualified Teachers and High Quality Teaching: Are They the Same?

Using data from SREB's Middle Grades Assessment, four factors that measure teacher quality were found to be significantly and positively related to student achievement in the middle grades. This brief describes those factors as they relate to teacher quality and the quality of instruction. (05V06); 8 pages; 2005; $2; $1 each for 10 or more

Linking Career/Technical Studies to Broader High School Reform: What can school districts, states and the nation do to get more high schools to implement comprehensive high school reform?

This brief contrasted the 2002 *HSTW* Assessment results in reading, mathematics and science for students at the top 50 *HSTW* high-implementation schools with those at 50 low-implementation schools. See how linking *HSTW* Key Practices with a strong career/technical program can give career-oriented students the academic core preparation they need for postsecondary education and good careers. By Gene Bottoms, Alice Presson and Lingling Han (04V09); 8 pages; 2004; $2; $1 each for 10 or more

High School Reform Works — When Implemented: A Comparative Study of High- and Low-implementation Schools

No school improvement design can be judged as succeeding or failing unless there is evidence that it has been implemented. This research report compares the results from the 2002 *HSTW* Assessment of the top 50 high schools that have more deeply implemented the *HSTW* improvement design to the 50 schools that have done less. The proven research-based practices identified in this report can help high school leaders create schools that improve all students' achievement and increase the percentages who enter ninth grade and graduate four years later. By Gene Bottoms, Alice Presson and Lingling Han (04V06); 112 pages; 2004; $7.50; $5 each for 10 or more

Raise Academic Standards and Get More Students to Complete High School: How 13 Georgia Schools Did It

How can education leaders raise expectations and standards without causing more students to drop out of high school? This publication shares the insights of school leaders from the 13 Georgia high schools that showed the most improvement in first-time passing rates on the Georgia High School Graduation Test (GHSGT) between 1997 and 2002 and in high school completion rates between 1999 and 2002. By Gene Bottoms and Karen Anthony (04V01); 8 pages; 2004; $2; $1 each for 10 or more