2006-1115: RESEARCH OF PROJECT LEAD THE WAY (PLTW) CURRICULA, PEDAGOGY, AND PROFESSIONAL DEVELOPMENT: ACTIVITIES REGARDING INCREASING ENGINEERING AND TECHNOLOGICAL LITERACY OF K-12 STUDENTS IN THE PLTW NETWORK

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Research of Project Lead The Way® (PLTW) Curricula, Pedagogy, and Professional Development

Abstract

Pre-college students must be educated to make informed decisions in our technology-based world. Project Lead The Way® (PLTW), a pre-engineering curriculum, focuses on producing secondary graduates with an enhanced level of technological literacy and competency. The research activities regarding increasing engineering and technological literacy of K-12 students in the PLTW network will provide a perspective of how well pre-college students are learning about technology and engineering, and becoming technologically literate. This paper will discuss the recent research gathered by three independent sources. First, a research brief[1] by the Southern Regional Education Board (SREB) High Schools That Work (HSTW) shows the achievement of PLTW students compared to the achievement of other students in the HSTW network. Second, TrueOutcomes[2] research will provide data on the curricula integration and outreach for greater diversity and access of the PLTW program. Last, the ongoing research of John Hansen[3] and colleagues from the University of Texas at Tyler will provide data on the PLTW Professional Development model.

Background

Project Lead The Way® (PLTW) is a 501(c) (3) not-for-profit national organization, established in 1997 to help schools give students the knowledge they need to excel in high-tech fields, such as engineering and engineering technology. PLTW is committed to preparing an increasing and more diverse group of students to successfully pursue these fields at the post-secondary level. To accomplish this goal, PLTW has created two programs. The first is Gateway To Technology, a five-unit middle school program designed to help students explore mathematics, science, and technology. It is taught in conjunction with rigorous, academic, middle school courses and adheres to the national standards in mathematics, science, technology, and English. The second is Pathway To Engineering, an eight-course high school program that centers on developing better problem-solving skills by immersing students in real-world engineering problems. Each of the eight challenging courses taken in conjunction with college-preparatory level academics is designed to prepare students for postsecondary studies in engineering and engineering technology and other high tech, high wage careers. The courses are in alignment with the national standards for mathematics, science, technology and English and use activities, projects, and problem-based learning with hands-on experiences to teach students the key knowledge and skills of engineering and technology-based careers.

For the past eight years, the PLTW network has grown to encompass 1,300 schools in 45 states, including the District of Columbia. Over 175,000 students are currently enrolled in PLTW courses. Currently, 21 affiliate colleges and universities across the U.S. work with PLTW to train middle and high school teachers in the challenging curriculum. Several of these universities offer transcripted credit to PLTW students who maintain an 85% or better cumulative average and pass the end-of-course exam with a minimum 70% score. Teachers are offered continuous, just-in-time professional development through the PLTW Virtual Academy. The Virtual Academy is

an interactive, non-linear, on-line resource of streaming video lessons where PLTW teachers have continuous access to PLTW professional development lessons.

SREB Research Brief: Project Lead The Way: A Pre-engineering Curriculum That Works

The Southern Regional Education Board (SREB) is the nation's first interstate compact for education, founded in 1948 by visionary Southern leaders who recognized the impact of education on the economic life of the region. That leadership continues today with 16 member states. The Southern Regional Education Board has set specific *Challenge to Lead* goals for every level of education — from early childhood to doctoral degrees. High Schools That Work (HSTW*)* is the largest and oldest of the SREB school-improvement initiatives for high school and middle school leaders and teachers. For more than a decade and a half, HSTW has been an initiative of the SREB-State Vocational Education Consortium with over 1,100 high schools working to improve students' academic and technical achievement. This effort is based on a number of unique features, such as requiring students to take the right academic courses; customizing improvement plans to the unique needs of each school; having students complete quality vocational and technical courses; building programs on existing school strengths; having teachers engage students in difficult assignments in all courses; having students receive extra help in meeting higher standards; having schools offer a supportive guidance system; and having schools provide time and an organizational structure to allow teachers to work together. High Schools That Work is about raising achievement by changing what is taught, how it is taught, and what is expected of students, educators, administrators, families, and the community.

The HSTW and PLTW partnership began in September of 1999 in order to create a high school pre-engineering pathway. The design and rigor of the PLTW program provide students with quality learning experiences across both academic and career and technical courses. Project Lead The Way® complements the major goals of the HSTW design by providing the essential content of traditional college-preparatory academic studies with challenging career and technical studies, thus increasing the percentages of students completing a quality core curriculum and scoring at or above the proficient level in reading, mathematics, and science. The purpose of the research by the SREB is to determine whether the PLTW program results in students with high quality learning experience – and higher achievement – when compared to other students in the HSTW network.

In the analysis of the PLTW students, the following questions were posed:

- Do PLTW students in the HSTW network have significantly higher achievement in reading, mathematics, and science on a National Assessment of Educational Progress (NAEP)-referenced assessment than other students in the network?
- Are PLTW students more likely to take higher-level mathematics and science courses than other students?
- How do PLTW students who complete four years of college-preparatory mathematics and science perform in school compared to PLTW students who do not complete four years of college preparatory mathematics and science?
- Do PLTW students experience more engaging instructional strategies in mathematics and science classes and across the curriculum?

- Do PLTW students have a richer set of learning experiences in their career/technical courses?
- Are PLTW students more likely than other career/technical students to plan on attending a four-year college or university?

This paper focuses on two questions of the six questions:

- Do PLTW students in the HSTW network have significantly higher achievement in reading, mathematics, and science on a National Assessment of Educational Progress (NAEP)-referenced assessment than other students in the network?
- How do PLTW students who complete four years of college-preparatory mathematics and science perform in school compared to PLTW students who do not complete four years of college preparatory mathematics and science?

For further review and analysis of the remaining questions, *Project Lead the Way: A Pre-Engineering Curriculum That Works*: *A New Design for High School Career/Technical Studies* full research report is available on the SREB website: http://www.sreb.org/programs/hstw/publications/briefs/ProjectLeadTheWay.asp

To answer the questions listed above, the SREB used the results of the 2004 HSTW Assessment and Student Survey to analyze the impact of the PLTW program. The 274 students who participated in the 2004 HSTW Assessment completed at least two PLTW courses. Preliminary analyses revealed that this group of students had significantly different demographics than other career/technical students (Career and Technical Education (CTE) students) in the HSTW network. In order to make valid comparisons between career/technical students and PLTW students, a random sample of career/technical students matching the demographic composition of the PLTW group was drawn so that differences between the two groups would be more attributable to students' school and classroom experiences, rather than their backgrounds. For those analyses, two different comparison groups were used: (1) career/technical students from high-tech fields, and a sample of (2) all career/technical students.

For both comparison groups – high tech fields and all career/technical students – two stratified random samples of 274 students were drawn to match the demographics of the 274 PLTW students (Table 1).

Table 1

Student Demographics for All PLTW Students and CTE Comparison Groups

Group	Male	Female	White	African-American	Other Ethnicities	Students Whose Parent Attended College	Students Whose Parent Did Not Attend College
All PLTW Students	76%	24%	64%	24%	12%	69%	31%

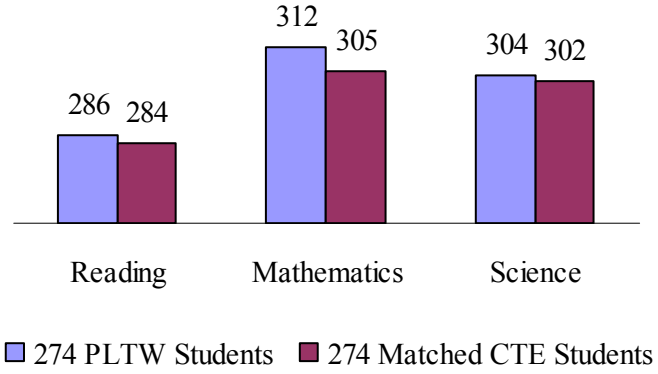
CTE Comparison Groups	76%	24%	64%	24%	12%	69%	31%

Source: Special Analyses of 2004 HSTW Assessment Data from SREB Research Brief[1], pg. 4

Do PLTW students in the HSTW network have significantly higher achievement in reading, mathematics, and science on a National Assessment of Educational Progress (NAEP)-referenced assessment than other students in the network?

The PLTW program requires teachers to participate in two weeks of training for each course they plan to teach to help them learn how to engage students in the mathematics and science needed in pre-engineering courses. Teachers also learn how to utilize a course guide. Because of the preparation of the teachers and the rigorous curriculum, it would be expected that PLTW students would score well. In the study, PLTW students scored slightly higher in reading and science and significantly higher in mathematics than the high-tech career/technical fields' student group (Figure 1). The difference in the mean scores for mathematics between the two groups is significant at $p \leq 0.05$ on the t test.

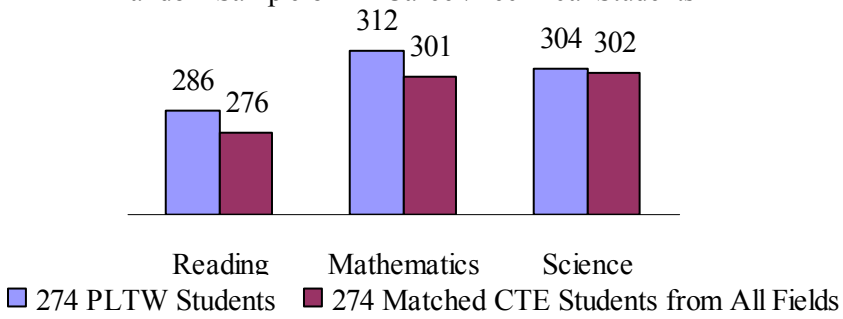
Figure 1
Comparison of Pre-engineering Students' Mean Scores to a Random Sample of Career/Technical Students from Similar Fields



Source: Special analyses of 2004 HSTW Assessment data SREB Research Brief[1], Pg. 4

When comparing the PLTW students to a random sample of all career/technical students (Figure 2), there were much greater differences in achievement. PLTW students outscored a random sample of career/technical students by 10 points in reading, 11 points in mathematics and 10 points in science. The differences in reading, mathematics, and science achievement are significant. The differences in the reading and mathematics mean scores between the two groups are significant at $p \leq 0.001$, and the difference in the science mean score is significant at $p \leq 0.05$ based on the t test. This may suggest that many high school career/technical students are achieving far below their potential because they are not completing a challenging curriculum and are not experiencing classes with an intensive emphasis on research-based problems.

Figure 2
Comparison of Pre-engineering Students' Mean Scores to a Random Sample of All Career/Technical Students

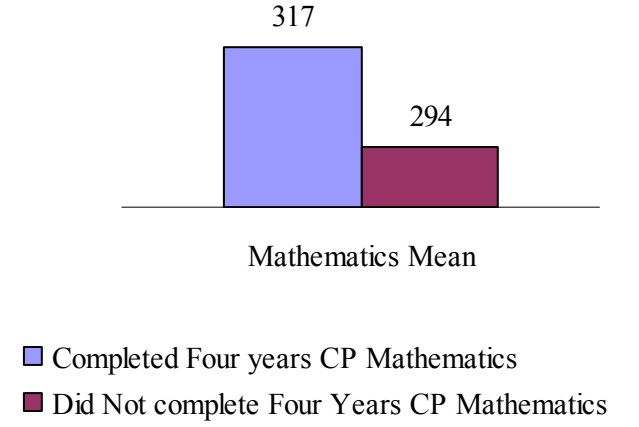


Source: Special analyses of 2004 HSTW Assessment data from SREB Research Brief[l], Pg. 5

How do PLTW students who complete four years of college-preparatory mathematics and science perform [in regards to mathematics and science assessment on the HSTW assessment], compared to PLTW students who do not complete four years of college preparatory mathematics and science?

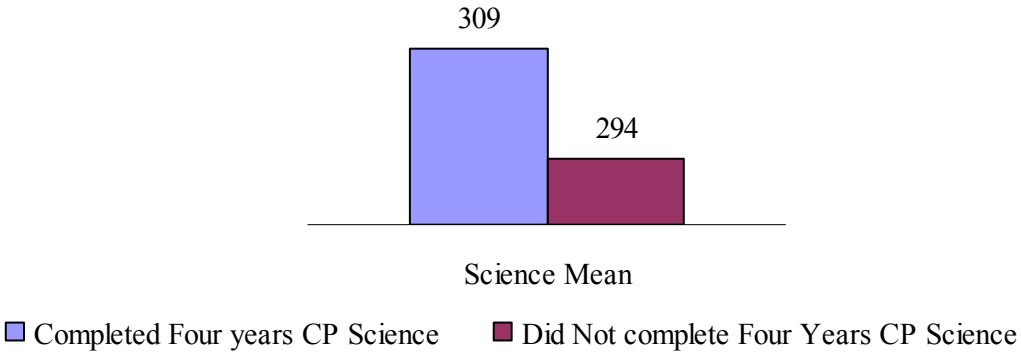
Seventy-nine percent of PLTW students completed four years of college-preparatory mathematics, and 63 percent completed four years of college-preparatory science (Figures 3 and 4). When PLTW students who completed higher-level mathematics and science courses are compared to PLTW students who did not, significant differences in achievement were evident. Those completing the mathematics curriculum had a mean score 23 points higher on the 2004 HSTW Assessment than other PLTW students, and those completing the science curriculum had a mean score 15 points higher.

Figure 3
PLTW Students' Mean Mathematics Scores by College-preparatory Mathematics Courses Completed



Note: the difference in the mean scores for mathematics between the two groups is significant at $p \leq 0.001$ Based on the *t* test.
Source: Special analyses of 2004 HSTW Assessment data from SREB Research Brief[1], Pg. 6 - 7

Figure 4
PLTW Students' Mean Science Scores by
College-preparatory Science Courses Completed



Note: the difference in the mean scores for science between the two groups is significant at $p \leq 0.05$ Based on the *t* test.
Source: Special analyses of 2004 HSTW Assessment data from SREB Research Brief[1], Pg. 6 - 7

Project Lead The Way® students who completed the recommended number of mathematics and science courses had mean scores at the proficient and advanced levels on the mathematics and science subtests of the 2004 HSTW Assessment (Table 2). However, it must be noted that it is unacceptable that students can complete four years of college-preparatory level mathematics and science courses and still performed below the basic level, 18 percent and 30 percent, respectively.

Table 2

Percentages of PLTW Students Scoring at Each Proficiency Level on the HSTW Assessment by Completion of Mathematics and Science Curriculum

	Below Basic	Basic	Proficient and Above
Completed Four Years CP Mathematics	18%	41%	41%
Did Not Complete Four Years CP Mathematics	42%	48%	10%
Completed Four Years CP Science	30%	29%	42%
Did Not complete Four Years CP Science	43%	22%	35%

Note: The differences in the percentages for level of performance in mathematics between groups are significant at $p \leq 0.001$ based on the chi-square test.
Source: Special Analyses of 2004 HSTW Assessment Data from SREB Research Brief[1], Pg. 8

These results suggest that a way to increase the achievement scores of PLTW students is to ensure that *all* PLTW students take four years of college-preparatory mathematics and science and to improve the quality of mathematics and science instruction.

Below is a bulleted summary of key findings of the SREB research. This paper only focused on a few of the items noted below. The full report may be accessed on the SREB website.

- When PLTW students are compared to similar students from comparable career/technical fields, PLTW students have significantly higher achievement in mathematics on a NAEP-referenced assessment.
- When PLTW students are compared to similar students across all career/technical fields, PLTW students have significantly higher achievement in reading, mathematics, and science on a NAEP-reference assessment.
- When PLTW students are compared to similar students in comparable fields of study and to similar students drawn from all career/technical fields, PLTW students complete significantly more high-level mathematics and science courses.
- Significantly more PLTW students were enrolled in classes that engage them in reading and writing across the curriculum; and in using real-world problems, technology and group work to advance mathematics and science achievement.
- Significantly more PLTW students experience career/technical classes that required students to use academic knowledge and skills to complete project assignments.

TrueOutcomes Assessment System for Project Lead The Way: Report of the first year

TrueOutcomes Assessment System's mission is to provide processes, software, and support services to create effective outcomes assessment and continuous improvement programs for higher education. TrueOutcomes follows the best practices of assessment as described by accrediting agencies, such as the Accreditation Board for Engineering and Technology (ABET, Inc.) and the American Association for Higher Education. TrueOutcomes offers a holistic curriculum-based view of assessment through an integrated set of instruments. The TrueOutcomes methodology is intended to enhance, not replace, the existing processes.

TrueOutcomes became the evaluators of the PLTW program in 2004. The annual report describes the activities and results of the first year of a five-year assessment plan devoted to measuring the Strategic Objectives set forth by PLTW. The report examines two fundamental questions:

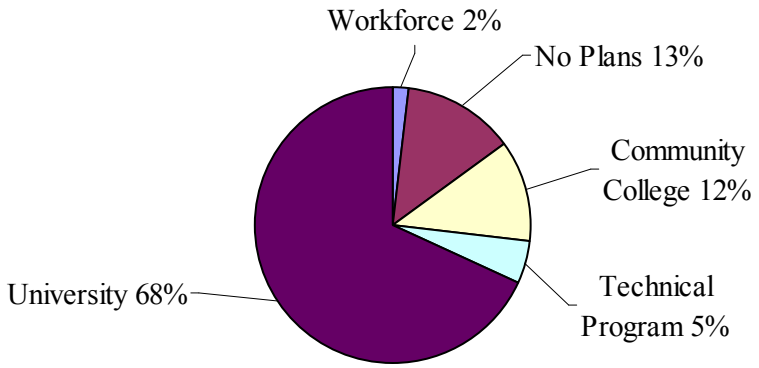
1. Does the data collection process work? In other words, does the system of on-line forms combined with telephone, email, and paper mail instructions and reminders result in a high level of compliance with requests for data among administrators, teachers, and students?
2. Does the data that we collect provide credible measures of the strategic objectives? In other words, if data collection is successful, will the data allow us to calculate numbers that clearly and convincingly show how well PLTW has met the strategic objectives?

The primary function of the TrueOutcomes assessment system is to track PLTW students through high school and college and into their entry-level jobs to determine whether participation in PLTW increases the number of young professionals entering engineering and technology careers. Project Lead The Way® in 2001 established four strategic objectives to ensure that the largest population of students is recruited and that rates of continuation and completion are high:

1. By 2005, at least 90% of PLTW graduates will successfully complete their first year of postsecondary study.
2. By 2005, at least 75% of PLTW graduates will graduate from two or four year engineering and engineering technology programs.
3. By 2005, the enrollment of females in PLTW will be 10 percentage points higher than the current national average in engineering and engineering technology programs.
4. By 2005, the racial and ethnic minority student population in schools with PLTW courses will be collectively proportionate to the overall state population.

Over 450 high school seniors submitted their plans for post secondary education to the assessment system in 2004-2005, thus providing an early indicator for the first two strategic objectives. Approximately 80% of PLTW graduates plan to attend college or community college next year, well above the national average of 65% for immediate college attendance, but not high enough to meet the PLTW objective of 90% of PLTW graduates successfully completing their first year of further study (Figure 5).

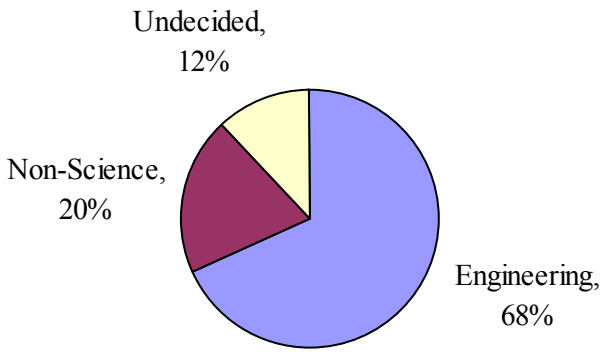
Figure 5
PLTW Graduates' Post-Secondary Education Plans



Source: TrueOutcomes: Report on the First Year of Implementation[2]

From the responses, approximately 68% of college-bound PLTW graduates intend to enroll in engineering or engineering technology programs. This is almost seven times the national average of 10%, but not high enough to meet the PLTW objective of 75% PLTW graduates will successfully complete a 2- or 4-year program in engineering or engineering technology (Figure 6).

Figure 6
PLTW Graduates' Post-Secondary Education Plans
(Does not include non-college bound graduates)

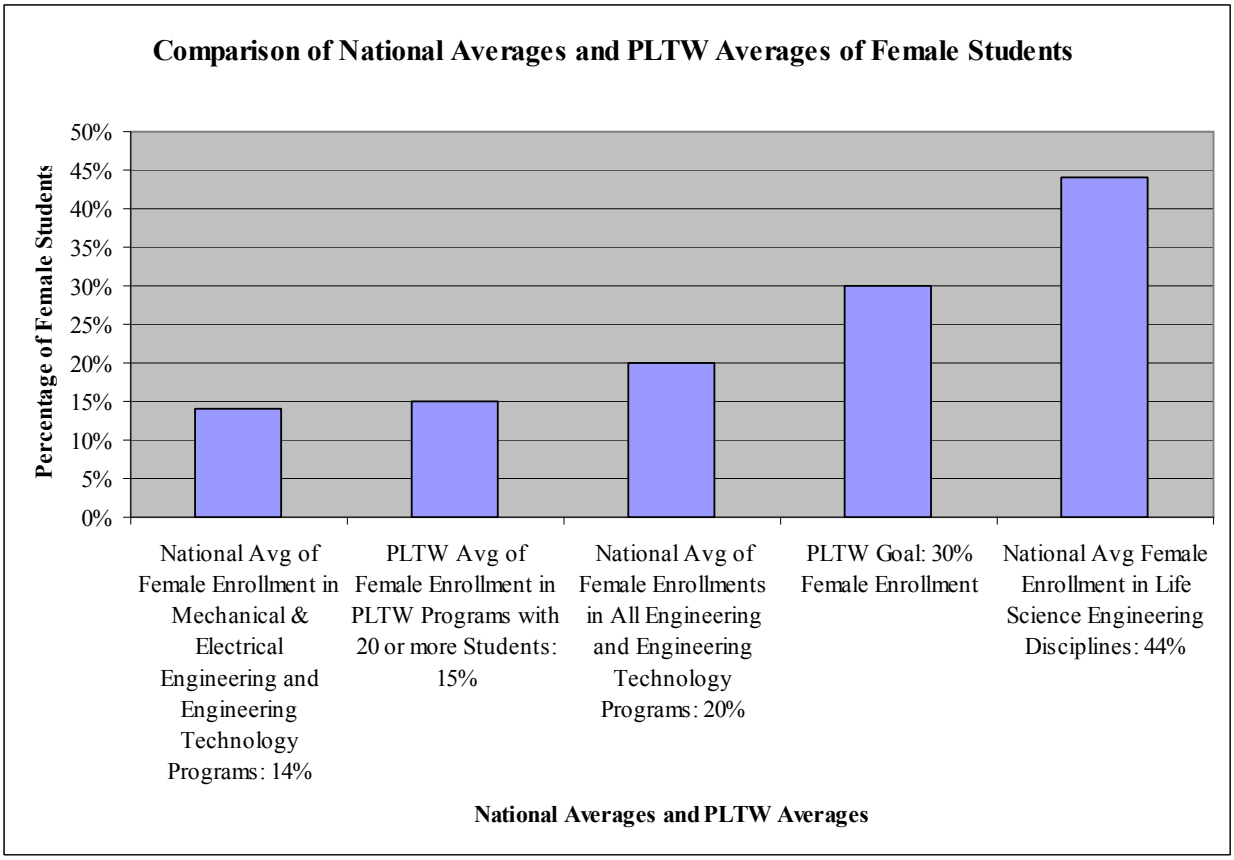


Source: TrueOutcomes Report on the First Year of Implementation[2]

The early indicators show that rates of continuation from high school to college and from PLTW to engineering and engineering technology programs are much higher than national averages, but not high enough to meet the PLTW strategic objectives. The early indicators for continuation and completion will be replaced by direct measures in three to six years when high school completers who are in the TrueOutcomes database have had an opportunity to complete their first year of study or complete a degree.

Over 3,000 students at 52 schools completed the on-line registration process, thus providing a direct measure of the gender and ethnicity of PLTW students. About 15% of high school students in PLTW courses are female, which is about the same as the percentage of female students in electrical and mechanical engineering and engineering technology programs nation wide (14%). The percentage of females in all engineering and engineering technology programs is 20%, so the PLTW objective of enrolling females at a rate 10% higher than the national average is not being met (Figure 7). Only five out of 39 schools had 30% or greater female enrollment. TrueOutcomes noticed that the percentage of females in life science-based engineering programs, such a bioengineering or environmental engineering is quite high, which is greater than 40%, so the new PLTW bioengineering curriculum may generate significant gains in female enrollment. The proposed partnership to develop institutional change strategies aimed at increasing female enrollment in science, technology, engineering, and mathematics courses may also boost female enrollment.

Figure 7:



Source: TrueOutcomes: Report on the First Year of Implementation[2]

The objective of achieving proportional representation of races and ethnicities in PLTW schools relative to the statewide population is largely being met. Several states show an over representation of minority students at PLTW schools and a slightly smaller number of states show an under representation; overall, it is clear that schools offering PLTW are representative of the public school population. This means that a broadly representative population of students has the opportunity to enroll in PLTW courses, but it doesn't mean that they all take advantage of that opportunity. A deeper look at the enrollment of minorities in the PTLW classes shows that Hispanics enroll in PLTW at a rate that is proportional to their population, but African-Americans are significantly underrepresented and whites are significantly over represented. This is true even in schools with significant (20% to 70%) populations of African-Americans, which is clearly a concern since these schools have the potential to educate significant numbers of future African-American engineers. Comparing minority enrollments in PLTW to engineering programs shows that PLTW is doing much better than engineering programs at attracting minorities. The representation of African-Americans and Hispanics in PLTW is approximately double their representation in engineering programs. Thus, PLTW has made progress in its efforts to achieve proportional representation of races and ethnicities even though it hasn't yet reached the final PLTW goal of proportional representation.

The data collection process has been in use now for one year and appears to be fundamentally sound. The ability to measure the demographics of thousands of students in PLTW courses is one of the greatest advantages of the TrueOutcomes on-line registration. Incremental improvements

in the process and software will be made, but no major changes are anticipated by TrueOutcomes. The focus of the coming year will be on increasing awareness and participation in the TrueOutcomes assessment of PLTW students and schools in order to improve upon data collection and analyses.

PLTW Professional Development

A critical component for initiating change in the classroom is the preparation and continued development of the participating teachers. The PLTW curriculum requires teachers to utilize cutting-edge technology and software for which they have not previously received training. PLTW developed a required training program for teachers before they are authorized or qualified to teach a PLTW course. Teachers are required to attend, participate, and pass a two-week 80 contact hour summer training session that is offered at various affiliate universities around the country. The Summer Training Institute (STI) is an intensive training program that instructs teachers on course content, software, and effective teaching strategies. It is during the STI that teachers receive direct instruction on the course they will be teaching. The training is conducted by approved and trained "Master Teachers" and "Affiliate University Professors" with at least two trainers in the classroom.

The purpose of this phase of the research was to determine if the PLTW training model is perceived by the participating teachers, as sufficient for preparing them to teach their new course. In addition, the investigators sought to determine if the teachers continued their professional development through other activities. The investigators posed three research questions regarding the PLTW professional development model:

1. How satisfied were PLTW teachers with the training they received at the PLTW Summer Training Institute?
2. Did teachers believe that the PLTW Summer Training Institute prepared them to teach their new course?
3. Did PLTW teachers pursue other professional development activities?

A forty-six question survey was developed and delivered on-line. All of the registered PLTW teachers, approximately 1,862 middle and high school, were invited to participate in the survey. The survey contained five sections: (1) Background Information, (2) PLTW Curriculum, (3) PLTW Support, Training, and Professional Development, (4) Current Teaching Practices, and (5) PLTW and Student Learning. This paper reports on a portion of Section Three: PLTW Support, Training, and Professional Development. The survey was pilot tested with three PLTW teachers. Modifications were made to the survey based on the teachers' feedback.

The teachers were first notified via email about the nature of the study and asked to participate by completing the on-line survey within the next two-weeks after receiving notification. One week after the first survey deadline, a follow-up postcard was mailed to each participant reminding them of the importance of their participation in the research. An additional twelve days were provided for completion of the survey. At the end of this time period, an additional email was distributed allowing an additional week for completing the survey. At the end of this time period, the survey was closed. Of the 1,862 potential respondents, 722 valid responses were

received, representing a response rate of 39 percent. There were no statistically significant differences between the respondents submitting their surveys on the first, second, or third notification.

Demographic characteristics are displayed in Table 3. Almost forty-five percent of the respondents were 46 years of age or older. Eighty-four percent were male and 92 percent were white. Fifty-eight percent of the respondents had a graduate degree. Seventy-nine percent of the respondents taught high school courses, sixteen percent taught middle school courses, and the remaining five percent of the respondents taught both middle and high school courses.

Table 3:
Age, gender, race, and degree attainment

		35 Years and Younger		36 – 45 Years		46 Years and Older	
		Female	Male	Female	Male	Female	Male
Undergraduate	White	18	84	19	61	13	81
Degree	African-American	2	1	1	4	2	3
	Hispanic	0	1	3	3	2	1
	Other	0	0	1	3	0	2
Graduate	White	14	65	18	78	12	191
Degree	African-American	3	2	1	4	6	1
	Hispanic	0	2	1	2	0	2
	Other	0	1	0	3	0	2

Source: Hansen, J., & Gallagher, M. A. (2005). PLTW: The Teachers Perspective[3]

Figure 8 provides the frequency distribution for the research questions "How satisfied were you with the PLTW Summer Teaching Institute?" and "Did the PLTW Summer Teaching Institute prepare you to teach your new course?" There were a significant number of positive responses for the first two research questions (91.6 percent and 87.8 percent, respectively). The third research question, concerning additional professional development activities (Table 4), revealed that 59.9 percent of the respondents participated in additional PLTW professional development activities. Overall, 68.6 percent of the respondents participate in some form of professional development.

Figure 8:
Research Question Frequency Responses

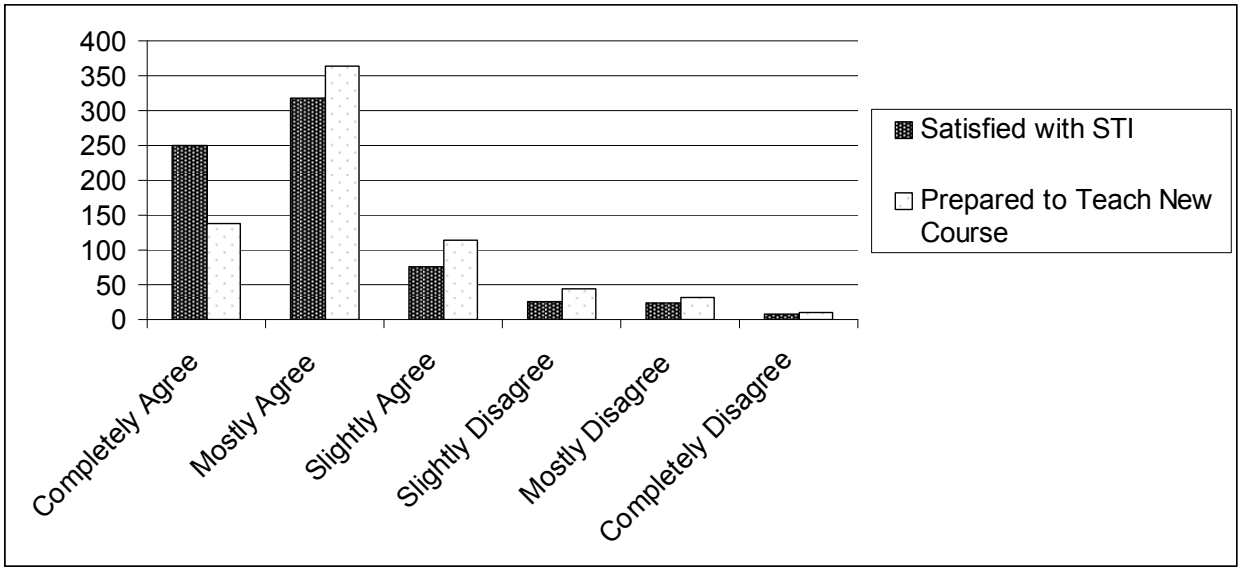


Table 4:
Participation in Professional Development Opportunities

Response	Frequency	Cumulative Percentage
PLTW Sponsored Only	419	59.9
PLTW and Others	24	63.3
Non-PLTW Opportunities	37	68.6
None	220	100
Total	700	

Source: Hansen, J., & Gallagher, M. A. (2005). PLTW: The Teachers Perspective[3]

Contingency tables were developed utilizing the "Crosstabulation" function of SPSS version 13.0 to test for variable dependency. Pearson Chi-Square analyses were utilized to test for potential significant relationships ($\alpha < 0.05$) .

The Chi-Square *analysis of associations* revealed several statistically significant relationships (Table 5) between respondent-reported demographic information and their (1) participation in subsequent PLTW sponsored professional development activities, (2) satisfaction with the PLTW Summer Training Institute, and (3) belief that they were prepared to teach their new PLTW course

Table 5:
χ^2 Significant Relationships

Demographic X Response	χ^2	df	*p*
PLTW Sponsored professional development			
Age**	19.772	6	0.003
Gender**	21.096	3	0.000

Years teaching PLTW**	143.559	6	0.000
How recruited**	19.172	3	0.000
Years of District Implementation**	42.958	6	0.000
Satisfied with PLTW STI			
Years teaching PLTW**	32.03	10	0.000
STI Prepared me to teach my course			
Level of degree*	11.949	5	0.035
Years teaching PLTW**	32.258	10	0.000

*$p < 0.05$; **$p < 0.01$

Source: Hansen, J., & Gallagher, M. A. (2005). PLTW: The Teachers Perspective[3]

In particular, the years of PLTW experience were significantly related to their (1) satisfaction with the PLTW Summer Training Institute, (2) belief that they were prepared to teach their new PLTW course, and (3) involvement in PLTW sponsored professional development activities.

Those with one or fewer years of PLTW teaching experience tended not to participate in additional PLTW-sponsored professional development activities ($\chi^2 = 143.559$, df = 6, p = 0.000).

In relationship to the respondents' level of college degree (undergraduate or graduate), respondents with graduate degrees tended to believe they were more prepared to teach their new PLTW course after attending the PLTW Summer Training Institute than those who had an undergraduate degree ($\chi^2 = 11.949$, df = 5, p = 0.035).

Participation in additional PLTW-sponsored professional development activities tended to be supported by those who were 36 years old and older ($\chi^2 = 19.772$, df = 6, p = 0.003), were female ($\chi^2 = 21.096$, df = 3, p = 0.000), had been in the PLTW program since 2003 ($\chi^2 = 42.958$, df = 6, p = 0.000), or had volunteered to participate in the PLTW program ($\chi^2 = 19.172$, df = 3, p = 0.000).

It is clear from the self-reported demographic information that the majority of PLTW teachers are male and white, with a significant number being 46 years and over and possessing a graduate degree. One of the goals of PLTW is to increase the diversity of the students pursuing science, technology, engineering, and mathematics degrees, and careers. From a mentoring perspective it may be important for school districts, state departments of education, and PLTW to develop a strategic plan to recruit and train a more diverse pool of PLTW teachers.

Figure 8 reveals that the majority of teachers had positive responses about their satisfaction with the Summer Training Institute and the degree to which it prepared them to teach their new course. The large number of positive responses suggests that the PLTW professional development is well received by the participants and provides an appropriate level of training for

the majority of teachers. The only statistically significant relationship between the demographic variables and the teachers' satisfaction with the STI is related to the number of years teaching PLTW courses. Teachers with more than three years of PLTW teaching experience tended to be more satisfied with the PLTW Summer Training Institute than those with three or fewer years of PLTW teaching experience ($\chi^2 = 32.030$, df = 10, p = 0.000). An analysis of the crosstabulation table suggests that as the number of years of teaching PLTW courses increases, the satisfaction of the teachers with the STI training increases. This can probably be attributed to the apparently overwhelming amount of material new teachers believe they need to know before entering the pre-engineering classroom. Most of the PLTW teachers have not gone through an engineering education program, nor have they been prepared to teach engineering concepts. One can surmise that as the teachers become more comfortable with the course curriculum, the teaching strategies, activities, organization, and delivery of instruction can be modified to meet the needs of the students and the instructors, it would increase teacher satisfaction with the training.

An analysis of the second research question findings, "Did teachers believe that the PLTW Summer Training Institute prepared them to teach their new course?" indicates that 71.4 percent of the responding teachers mostly or completely agreed that the training prepared them to teach their new course. Those with one or fewer years of PLTW teaching experience tended to believe they were less prepared to teach their new PLTW course ($\chi^2 = 32.258$, df = 10, p = 0.000). A significant shift occurs between the first and second years of PLTW teaching, with respondents being more positive about their preparation after the first year. This would suggest that the PLTW trainers might reconsider the needs of the first year PLTW teacher as they relate to teachers' level of confidence with the new materials and technologies. This suggestion is supported by the significant difference between those who had either an undergraduate degree or a graduate degree. Those with a graduate degree tended to believe the STI prepared them for teaching their course while those with an undergraduate degree did not believe they were sufficiently prepared. It may be that some consideration should be given to the differences in the teaching preparation of the teachers during the summer training. In other words, the pace, strategies, and activities might be redesigned to take into account the needs of teachers with fewer years of preparation. Since there were no significant differences on this question based on the number of years of overall teaching experience, it can be posited that graduate education prepares teachers for a better appreciation of their professional development experiences.

Participation in professional development activities was the research question that evidenced the most significant differences among the demographic variables. Older teachers, 36 years and above tended to participate more in professional development activities. Younger teachers (35 years and younger) tended not to be involved in any professional development activities more than the older teachers. A higher percentage of female teachers than males participated in PLTW-sponsored activities. Males were more prone to not be involved in any professional development activities. Teachers with one year or less were significantly less likely to be involved with professional development activities regardless of the sponsor. Those with more than three years teaching experience focused their professional development activities around the PLTW-sponsored activities. Teachers who taught in school districts that had implemented the PLTW program prior to 2003 were more likely to participate in professional development activities. Finally, teachers who volunteered for teaching PLTW courses were more likely to

participate in additional professional development activities than those who had been required to participate in the program.

As PLTW seeks to improve its professional development system beyond the Summer Training Institute, it may be appropriate to consider the characteristics of the participating teacher population as well the development of the content knowledge and skills. Issues of age, gender, experience, and volunteerism appear to play a significant role in the participation of teachers in additional professional development. This is particularly important as PLTW incorporates on-line instruction in its professional development program. Distance education research continues to indicate that only teachers with certain characteristics like or benefit from on-line education. This study did not seek to determine what the preferred professional development characteristics were for the respondents.

Summary

The three research studies provide a foundation that covers a broad spectrum of attributes and areas to watch as the PLTW pre-engineering program continues to evolve. As more schools join the PLTW network, more opportunities for data collection are realized. Likewise, as more students, parents, and communities begin to encourage students to consider engineering and engineering technology fields, it will be important for PLTW to address some of the key points uncovered through these research projects. The need for follow-up and further study is always paramount and well documented. The fact that TrueOutcomes is prepared to complete a five-year study is good. It is anticipated that the SREB and that other researchers, such as John Hansen, will continue to study and provide information that will aid PLTW in improving the overall pre-engineering program. It is important for PLTW to consider the key findings discussed in this paper as it seeks to continuously improve its programs. Currently, the curriculum development and revision process is employing strategies to develop high-quality instructional and curriculum guides that define course objectives, outline the content to be covered, and provide challenging, authentic activities, projects, and problems that require students to apply academic and technical knowledge. PLTW is working to improve gender equity aspects in all areas of the pre-engineering program. The PLTW Summer Training Institutes (STIs) are being enhanced and modified to encourage teachers to improve their professional development as well as prepare them to teach their PLTW courses. Additional efforts are underway and future studies will aid in determining what aspects still need to be addressed.

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