



Strengthening Wisconsin's Science and Engineering Workforce: Educational Challenges and Prospects

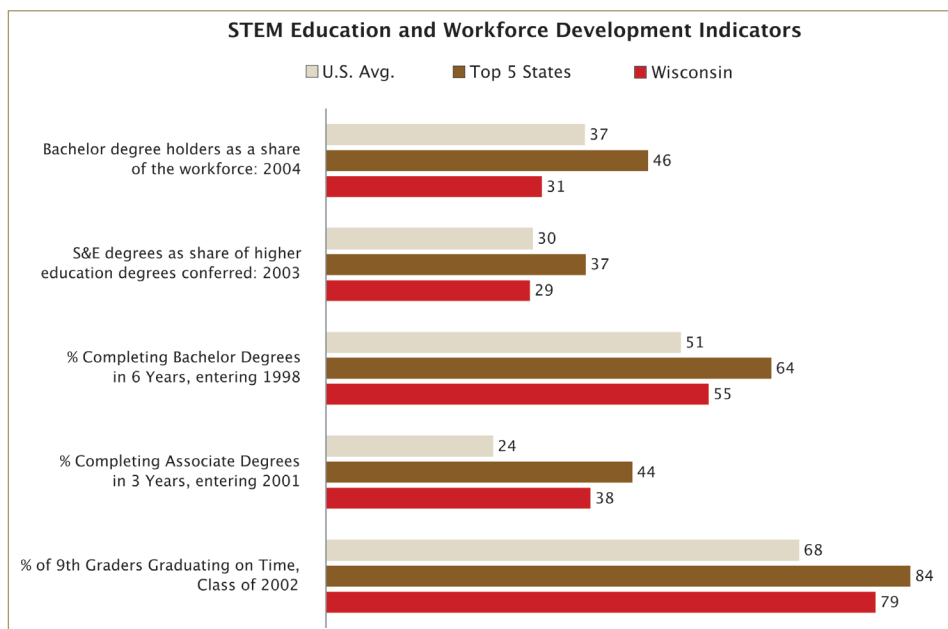
The Challenge: Building the STEM Postsecondary Education Pipeline

In Wisconsin, job openings requiring expertise in science, technology, engineering and mathematics (STEM) will increase by 18.3% through 2014, compared to 11.5% for all occupations. Of these 13,800 annual STEM openings, 71% will require a postsecondary degree (associate or bachelor) or certificate. While Wisconsin's science and engineering workplaces are currently creating 10,500 openings each year requiring a college degree or credential, less than 7,000 degrees are awarded annually in the STEM fields by Wisconsin's universities and technical colleges.

On several indicators of educational attainment and workforce development, Wisconsin ranks substantially below the performance level of several states and other nations.

Percent of bachelor's degrees completed in science and engineering:

Japan: 66%
 China: 59%
 U.S.: 32%
 University of Wisconsin System: 21%



To sustain the state's economic productivity and tax base, the Governor, the Wisconsin Technology Council and several other organizations, have called for new initiatives to expand and align STEM education and workforce development investments. As these indicators suggest, particular attention must be given to ensuring that Wisconsin students are prepared to enter and succeed in STEM related postsecondary education programs.

Prospects for Improving STEM Education

With support from the Kern Family Foundation, the Greater Milwaukee Foundation, and the Wisconsin Department of Public Instruction approximately 100 middle and high schools in Wisconsin are currently implementing Project Lead the Way (PLTW)¹—a pre-engineering and technology education curriculum. Researchers collected evaluative information during the 2005-06 school year in four Wisconsin high schools and two Wisconsin middle schools with diverse student populations. These schools were in the first or second year of implementing PLTW courses or middle school modules. The project sought to design and field-test assessment tools and processes for improving technology and pre-engineering instructional practices by examining student outcomes, and to compile some early evidence on the implementation of PLTW programs.

- *(PLTW) is a better learning experience because you are self-motivated*

Near the end of the 2006 spring semester, a sample of PLTW students and educators from each school participated in researcher-led focus groups. In addition, about 150 students from the four high schools completed a nationally-marketed student engagement survey (the High School Survey of Student Engagement-HSSSE) designed to compile students' assessment of their high school learning experiences. Of the 150 students surveyed in the four schools, approximately 100 had completed one or two PLTW courses, while 50 students who had not completed a PLTW course served as a comparison group. The 82,000 high school students from 28 states who completed the HSSSE in 2006 were also a comparison group.

The following findings² emerged from the HSSSE survey and focus group data:

1. In rating their *feelings about the high school they attend*, PLTW students are 9-13% more likely than non-PLTW students attending the same high schools to say:
 - They have opportunities to be creative in classroom assignments and projects (91% vs. 81%; national sample-71%)
 - They are engaged in school (82% vs. 72%, ns-72%)
 - The school makes them feel confident in who they are (76% vs. 63%, ns-58%)

In focus group settings, student comments included:

- *I had some interest in engineering, but wanted to get some background.*
- *Some students are scared off because it is 'engineering'.*
- *After PLTW, you can see 'why' the ideas from Physics are important.*

- *This is as challenging as an AP math or science course*

These findings suggest that the PLTW project-based learning experiences are potentially associated with promoting: students' self-confidence and creativity, their career exploration goals, and their overall engagement with the school.

2. In describing how often during this school year (2005-06) they *spent time engaged in various learning experiences*, PLTW students are 8-18% more likely to say that "sometimes or often" they were:
 - Working on a paper or project that required research outside of assigned texts (90% vs. 72%; national sample (ns)-77%)
 - Working with other students on projects/ assignments during or outside of class (73% vs. 65%; ns-70%)
 - Connecting ideas or concepts from one class (or subject area) to another in doing assignments or participating in class discussions (75% vs. 63%; ns-68%)

Student comments and insights expressed in the focus groups included:

- *I used math and some physics in the IED class.*
- *This is the only elective where you apply core subjects.*
- *The Digital Electronics course encouraged me to take senior level math.*
- *I took a lot of math and science, and I was looking for a class in which I could apply that.*

PLTW's emphasis on project-based or problem-focused teaching methods is reflected when students indicate they often have to go beyond the assigned text material and spend time with other students studying outside of class. With 75% of PLTW students saying they sometimes or often connect ideas across the curriculum, it appears that the PLTW alignment with math, science, and English standards reinforces student learning. Math and science concepts were applied in PLTW courses, and conversely PLTW applications were also found in math and science curricula.

3. When asked to what extent their high school encourages students to engage in active learning and futuristic thinking, PLTW students were 10-20% more likely than non-PLTW students to say the school encourages them to:

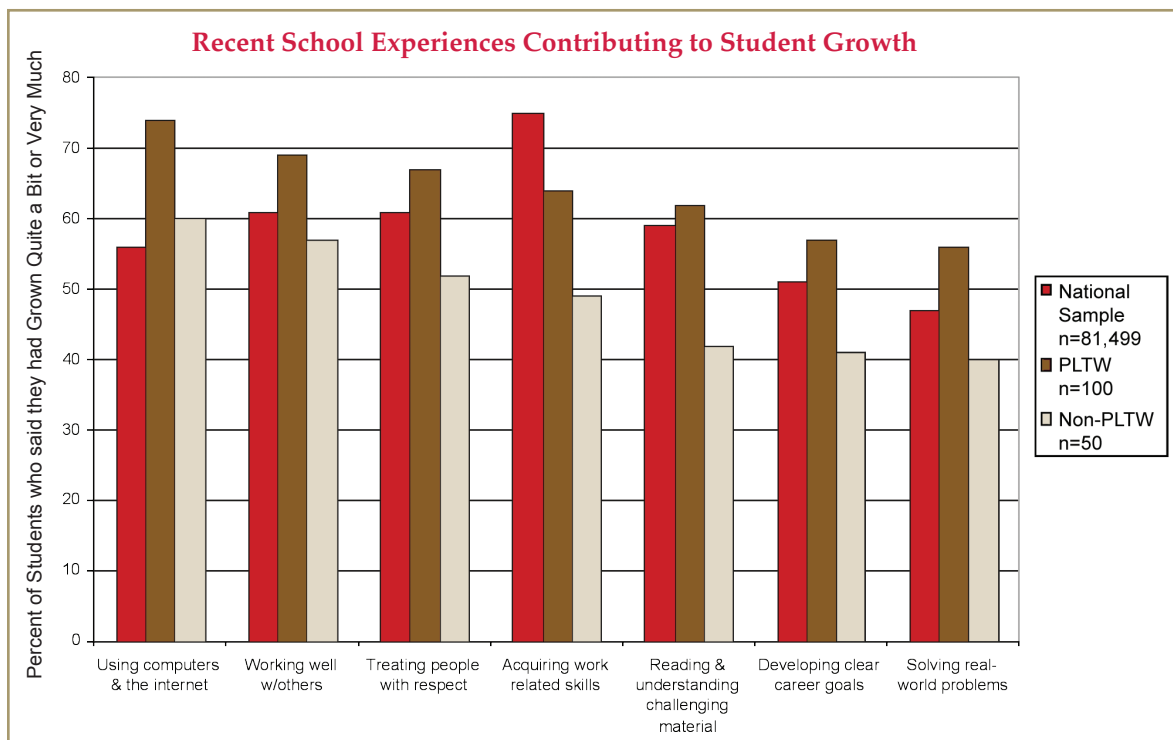
- Use computers (72% vs. 52%; national sample (ns)-50%)
- Explore new ideas (63% vs. 51%; ns-49%)
- Continue schooling beyond high school (college, career training, etc.) (88% vs. 78%; ns-78%)

In discussing PLTW courses, students offered some key observations about the applied and futuristic learning experiences they encountered:

- PLTW gives us a taste of what we are getting into.
- This is practical for any profession.
- The learning that comes when it doesn't work is just as valuable as the learning when it does work.

For some students, the availability of college transfer credits for the PLTW courses encouraged enrollment in PLTW classes. Further, students exposed to this pre-engineering and technology education curriculum develop a better understanding of available career options and the talents and interests required. Technology tools used in PLTW classes, such as the Inventor software, appear to give students more time with computers and more opportunities to develop generalize-able skills and knowledge. Finally, the problem-focused learning experiences have general intrinsic value for some students.

4. The differences in how PLTW and non-PLTW students see their recent school experience as contributing to their growth are profound. Compared to non-PLTW students, those completing PLTW courses are 12-20% more likely to say they had grown quite a bit or very much in the seven interpersonal, developmental, and technical skill areas listed in the figure:



• You think so differently because you cannot just look up the answers. You have to come up with the solution. It is more critical thinking.

Comments from the student focus groups illustrate how PLTW learning promotes growth in particular areas:

- *Even though I'm not pursuing an engineering profession, the problem-solving skills learned are important no matter your field.*
- *PLTW has helped me choose a career and college major.*
- *PLTW teaches you how to work with people.*

Exposure to courses in engineering principles and digital electronics appears to help students clarify their goals and gain skills for pursuing careers and to solve workplace problems. Involvement with the curriculum gives students skills in working with others, treating others with respect, and developing personal values. Equally important, PLTW students are 20% more likely to indicate they had experienced substantial growth in reading and comprehending challenging material.

Use of the 2006 High School Survey of Student Engagement provided the opportunity to compare the responses of Wisconsin's PLTW and non-PLTW students from four high schools to a large national sample of high school students (n=81,499). Compared to the 2006 national benchmarks, both PLTW and non-PLTW students were 5-10% more likely to indicate: (a) they had opportunities to be creative in classroom assignments and projects, (b) the school helped them feel confident in who they are, and (c) they had grown substantially in using computers and the internet. For Wisconsin's PLTW students, they were 5-10% more likely than their national peers to say they:

- Were encouraged to continue schooling beyond high school (88% vs. 78%)
- Were engaged in school (82% vs. 71%)
- Working on a paper or project that required research outside of assigned texts (90% vs. 77%)
- Connecting ideas or concepts from one class (or subject area) to another in doing assignments or participating in class discussions (75% vs. 67%)

Compared to a national sample of high school students, the four Wisconsin high schools in this study had teaching and learning practices in place that enabled students to feel creative in their classroom learning, build their self-confidence, and expand their knowledge of computers and the internet. The value-added factors for PLTW students placed them well above the school engagement ratings of their peers nationally in several areas crucial to improving the STEM education pipeline. Notably, Wisconsin's PLTW students were: 22% more likely to be using computers, 10% more likely to indicate they were working on projects requiring research beyond assigned text material, 9% more likely to indicate they were solving real world problems, and 6% more likely to have clear career goals.

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¹PLTW is a high school pre-engineering and technology education program that includes foundation and specialization courses, as well as a capstone course, designed to prepare students for postsecondary engineering studies. A fully implemented program would provide students with 3-5 PLTW courses, along with 4 years of college preparatory science and mathematics courses. In addition, Gateway to Technology (GTT) is a series of four modules implemented in middle schools. More information about PLTW is available at: www.pltw.org

²These early findings and observations should be interpreted with caution. Due to local circumstances, it was not possible to randomly select students for participation in the focus groups. In this analysis of the survey data, the samples of PLTW and non-PLTW students were not matched by gender, income level, grade level, academic ability, or other similar factors, which may contribute to their ratings of school engagement factors.

Data Sources:

From cradle to career: Connecting American education from birth through adulthood. Quality Counts 2007. *Education Week*, (January 4, 2007). Volume 26, No. 17. See: www.edweek.org

National Center for Public Policy and Higher Education (2004, April). The education pipeline: Big investment, big returns. *Policy Alert*. Available at: www.highereducation.org

National Science Foundation. *Science and Engineering Indicators 2006*. See: <http://www.nsf.gov/statistics/seind06/> Office of Economic Advisors. (September 23, 2006). *Science, Technology, Engineering and Mathematics Occupations: Outlook and Impact* Madison: Wisconsin Department of Workforce Development retrieved November 15, 2006 from: http://dwd.wisconsin.gov/oea/online_ppt.htm

Office of Policy Analysis and Research (August, 2006). *Bachelor Degrees Conferred by UW System Institutions, 2000-2005*. Madison: University of Wisconsin System.