

Session 2550

Pre-Engineering in High School – An Oxymoron?

Dr. Warren R. Hill
Weber State University

Introduction

No, pre-engineering in high school is not an oxymoron. Pre-engineering can be taught in the high schools and already is being done so successfully through a nationwide program called Project Lead the Way (PLTW). PLTW is a non-profit organization that was founded specifically to attract more high school students into Engineering and Engineering Technology programs and have them succeed once they reach college.

This paper will discuss the basic operation of the program, some of the things that make the program successful, the history of PLTW, and how colleges and universities can get involved with the program. The pre-engineering courses that make up the pre-engineering curriculum in the high schools are project based and as a result, the students get to immediately apply what they are learning. The courses that make up the program will be presented and additionally, some of the reasons a high school would want to get involved in the program will be discussed.

What is Project Lead the Way?

Project Lead the Way (PLTW) is a high school pre-engineering program that has as its main focus getting high school students to enroll in engineering and engineering technology programs in college and to succeed in those programs. To accomplish this goal, PLTW, which is not-for-profit corporation, has created a series of five yearlong high school courses. These courses introduce students to engineering as a career and provide them with the critical thinking and analytical skills they will need to succeed as engineers. These courses also bring into them the necessary math, science, and language arts skills and teach these skills in the context of the pre-engineering classes. Thus, students can see the application of these subjects, many of which are not normally taught in context, such that they can understand their value and use.

These five courses are Introduction to Engineering Design (IED), Digital Electronics (DE), Principles of Engineering (POE), Computer Integrated Manufacturing (CIM) or Civil and Architectural Engineering (CAE), and Engineering Design and Development (EDD). IED is a three-dimensional modeling course that teaches students 3D modeling using Autodesk Inventor. The DE course is a basic digital electronics course that teaches students the basics of Boolean algebra, combinatorial logic, Karnaugh mapping, and sequential logic. The POE course covers career exploration, what engineers do and how they do it, as well as some of the basics of materials including materials testing. The CIM course covers the basics of machining and robotics while the CAE course introduces students to civil and architectural engineering. The EDD course is a senior capstone where the students, working in teams, must design something,

build it, and test it. As part of this course they must also do a patent search as well as give both oral and written presentations.

Besides the material that is specific to these five courses, every high school student that graduates from a PLTW program is also expected to meet a clear set of educational goals. These are:

- Understand how technology is used as a tool for problem solving
- Have a broad understanding of the methodology of the scientific process
- Be well prepared for a rigorous college engineering or engineering technology curriculum
- Understand, apply, analyze, and design technological systems
- Select an appropriate technological system for a given task
- Demonstrate an understanding of the principles of mathematics and their application to problem solving
- Demonstrate effective communication of information in a variety of contexts
- Demonstrate the skills necessary to work in teams

Even if a PLTW student decides that engineering or engineering technology is not an appropriate career choice for them, this is not a negative. It is much better for a student to make this choice in high school rather than after they get to college. In the meantime, they will have still obtained a set of skills including problem solving and critical thinking that will serve them well regardless of what discipline they eventually choose to go into.

In addition to the high school courses described above, PLTW has also developed a year long (40 weeks) pre-engineering program for middle schools or junior high schools called Gateway to Technology (GTT) that incorporates many of the above subjects but at slightly less depth. This program, which is also project-based, consists of four 10-week modules: Design and Modeling (where students get introduced to Autodesk Inventor), The Magic of Electronics, The Science of Technology, and Automation and Robotics. For additional information regarding any aspect of Project Lead the Way, visit their website at <http://www.pltw.org>.

Why Project Lead the Way?

There is a growing need for engineers and technologists in this country at a time when the number of graduates with engineering and technology degrees has remained essentially constant, or has been declining, over the past fifteen years. The graphs in Figures 1 and 2 show what has been happening to the number of engineering and engineering technology graduates over this time period. These declines have been occurring during a time when the number of students attending college is at an all time high. Thus, it is apparent that the number of students going into and graduating in engineering and engineering technology is a decreasing fraction of the college bound population.

But it is also not just a matter of getting students to go into engineering as a career, it is also a matter of having them graduate once they get there. The dropout rate is very high in engineering programs for a number of reasons. Two of these reasons are first, students are not aware of what

engineering is all about and therefore after enrolling decide it is not for them and second, they are not prepared for the rigor of most engineering programs. PLTW attempts to address both of these issues by educating high school students about engineering as a career and then have them take a

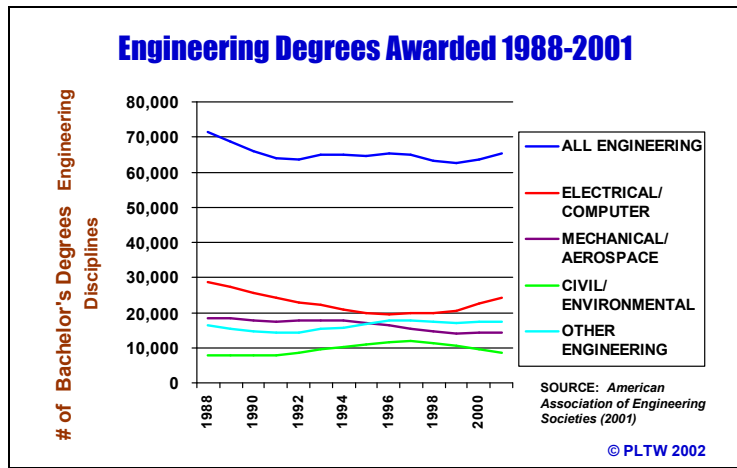


Figure 1. Engineering Graduation Rates, 1988-2002¹

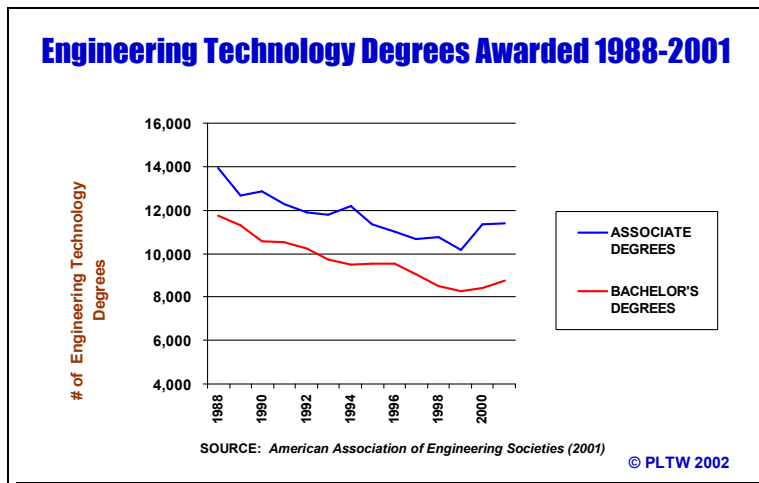


Figure 2. Engineering Technology Graduation Rates, 1988-2002¹

series of academically rigorous courses. There is already evidence that PLTW students do better in their introductory engineering courses in college than do non-PLTW students.²

Who Started Project Lead the Way?

Project Lead the Way was started in the 1980's by Richard Blais who is now the Executive Director of PLTW. At the time he was the chairman of a Technology Department in a school district in upstate New York. While the program was very successful, the people involved realized that to have a broader impact, they would need to take the program beyond their local

district. They then sought and received funding from the Charitable Venture Foundation which was started by an industrialist from Buffalo, NY, who was having a very difficult time hiring manufacturing engineers. The funding provided by this foundation was the genesis of PLTW. The first PLTW courses were offered in high schools in 1997. Since that time it has grown such that the program is now offered in over 725 schools in 38 different states.

Why Would a High School Choose to do the PLTW Program?

There are several reasons this program has become so popular. One is that the curriculum is already developed and is continuously being revised by professional curriculum personnel on the staff of PLTW. Thus, there is no need for teachers to develop their own curriculum. For a high school or middle school teacher to be allowed to teach any of the PLTW courses they must have received two weeks of training specific to that course. This training is done at what are called affiliate universities and each of the training courses are team taught by a master teacher and a university faculty. The master teacher is a high school faculty member who has taught that course at least once in their high school and the university faculty are people who have already gone through the two weeks of training themselves.

A second reason is that the curriculum is continuously being upgraded and upgrade training is offered to the teachers at least twice a year. Thus, the teachers are always receiving the latest in available curriculum. Additionally, the PLTW staff and the university affiliate faculty are available throughout the school year to answer questions teachers may have. In addition to the teacher training, PLTW also offer counselor training such that the counselors are aware of what PLTW offers to their students. This training is now starting to be made available at the affiliate universities.

Another very important part of PLTW is that all aspects of the program are systematically evaluated on a regular basis. This evaluation is done by an independent outside firm, Hezel and Associates, and is starting to provide excellent data on the effectiveness of the program.

As for the equipment each school needs to teach the PLTW courses, PLTW has worked with the equipment vendors to get the best possible prices. Since the equipment is standard across the curriculum, with over 600 schools involved the prices are much better than an individual school or district could achieve on their own.

Finally, there is the prestige of having a pre-engineering program in your high school. Such a program provides a focus for students who are currently college bound but also provides an option for students who are not sure either about going to college or about going into engineering or technology.

How Can my College or University Get Involved with the PLTW Program?

If there is not an affiliate university in your state, your school should consider becoming one. In order to become an affiliate, you need to develop an agreement with your state's office of education or the entity that oversees K-12 education. The current affiliate universities are as follows:

Project Lead the Way National Affiliates

- Duke University
- Ferris State University
- New Hampshire Technical Institute
- New Jersey Institute of Technology
- Penn State
- Purdue University
- Rochester Institute of Technology
- San Diego State University
- South Seattle Community College
- University of Colorado
- University of Houston
- University of Maryland, Baltimore County
- University of New Haven
- University of South Carolina
- University of South Florida
- Weber State University

If there is already an affiliate in your state (there is currently only one per state), please feel free to contact the PLTW Director for that institution to see how you might be able to work with them. You could also work directly with the PLTW schools in your state to provide workshops or guest lectures at their schools. If a local high school does not have a PLTW program, you should consider working with them to establish one.

Conclusions Regarding the PLTW Program

Many colleges and universities offer a variety of different programs and use a number of methods to recruit students into their engineering and technology programs. These include summer camps, both resident and non-resident, campus visits, weekend workshops and others; however, none of these have the ability to provide an integrated engineering experience at the high school level that is both systemic and systematic. In this author's opinion, this program is one of the few that will be able to sustain a long-term impact on engineering and technology enrollments. To summarize, it offers curriculum, teacher training, upgrade training, and counselor training. It is also a partnership with the local universities in each state. For all of these reasons, it should be the program of choice for high schools and middle schools wanting to do pre-engineering.

Bibliography

1. PLTW website, www.pltw.org
2. Private conversation with William Leonard, MET faculty member at Rochester Institute of Technology

DR. WARREN R. HILL

Dr. Warren R. Hill is currently professor of Electronics Engineering Technology and dean of the College of Applied Science and Technology at Weber State University, a position he has held since July, 1990. Prior to that, he was department chair for Engineering Technology at the University of Southern Colorado for 3 ½ years, as well as teaching electronics engineering technology there for nine years. He holds a BSEE and MSEE from the University of Nebraska and Wayne State University, respectively, and Doctor of Engineering degree from the University of Detroit.