Abstract - Project Lead the Way® (PLTW) is a U.S. high school initiative which, combined with college preparatory science and mathematics courses, introduces students to engineering and engineering technology. It is a four year program aimed at attracting more students into technical studies, thereby increasing the pool of engineers and technologists. PLTW courses allow students to discover whether a technical career is what they wish to pursue in post-secondary study. Because the rigorous curriculum uses modern technological tools and software, students who participate in the program are better prepared for technical study. Thus attrition rates in engineering and engineering technology programs are reduced. The courses offered include Introduction to Engineering Design, Principles of Engineering, Computer Integrated Manufacturing, Digital Electronics, Civil Engineering and Architecture, Aerospace Engineering, Biotechnical Engineering and Engineering Design and Development (capstone project course). In order to recruit more females and underrepresented minorities, PLTW also offers the Gateway to Technology (GTT) course offered to all middle school students (grades 6-8).

Index Terms – K-12 programs, Science, Technology, Engineering and Mathematics (STEM), Pre-engineering.

INTRODUCTION

Project Lead the Way® (PLTW) is a non-profit organization that promotes pre-engineering courses in middle and high schools. With the growing shortage of engineers and technologists completing degrees from colleges and universities, the mission of PLTW is to promote engineering and engineering technology as a major for high school graduates and to create a more diverse group of graduates in these areas. The PLTW curriculum was first introduced in twelve New York State high schools in the 1997-98 academic year. The following year the middle school curricula were field tested at three middle schools. Currently, approximately 1700 schools across the U.S. are offering PLTW courses [1].

THE HIGH SCHOOL PROGRAM

The high school curricula contains eight courses. These are grouped into foundation courses, specialization courses and the capstone course listed below. While not required, it is suggested that students take the three foundation courses, at least one specialization course, and complete the sequence with the capstone course.

Foundation Courses:
- **Principles of Engineering (POE)** helps students understand the fields of engineering and engineering technology. By exploring various technology systems and manufacturing processes students learn how engineers and technologists use mathematics, science and technology in the problem solving process to benefit society. The course also discusses the implications of technological change.
- **Introduction to Engineering Design (IED)** teaches problem-solving skills using a design development process. Models of three-dimensional product solutions are created, analyzed and communicated using solid modeling computer design software.
- **Digital Electronics (DE)** investigates the application of electronic devices in logic circuits. Following industry methodology, students perform computer simulation software to design and test digital circuits prior to the actual construction of circuits and devices.

Specialization Courses:
- **Computer Integrated Manufacturing (CIM)** applies principles of robotics and automation. Building upon solid modeling skills developed in IED, students use CNC equipment to produce actual models of their three-dimensional designs. Fundamental concepts of robotics used in automated manufacturing and design analysis are included.
- **Civil Engineering and Architecture (CEA)** provides an overview of the fields of Civil Engineering and Architecture, while emphasizing the interrelationship and dependence of both fields upon each other. Students use modern software to solve real world problems and communicate solutions to hands-on projects and activities. This course covers topics such as project and site planning, building design, project documentation and project presentation.
- **Aerospace Engineering (ASE)** is a new curriculum developed with funding from NASA. For the 2005-06 academic year, ASE is being field tested at high schools across the U.S. The course introduces students to the
world of aeronautics, flight, and engineering. Exercises include creating airfoils and testing them in a wind tunnel.

- **Biotechnical Engineering (BTE)** is another new curriculum under field test for 2005-06. BTE applies and expands upon secondary level knowledge and skills developed in biology, physics, technology, and mathematics. It includes experiences from the diverse fields of bio-technology, bio-engineering, bio-medical engineering, and bio-molecular engineering.

**Capstone Course:**

- **Engineering Design and Development (EDD)** is a course where students work in teams to research, design and construct a solution to an open-ended problem. Students apply principles developed in the foundation and specialization courses and are guided by a community mentor. They must present progress reports, submit a final written report and defend their final solutions to a panel of outside reviewers.

There is a misconception that PLTW curricula are vocational in nature. While the curricula is activity based, it requires that students enroll in college preparatory mathematics. It is recommended that students also enroll in college preparatory biology, chemistry and physics. The program is designed around national standards in mathematics, science and technology and focuses on preparing students for two- and four-year post-secondary studies. For this reason, many community colleges and universities are offering college credit to students completing one or more PLTW courses [1].

**THE MIDDLE SCHOOL PROGRAM**

The PLTW middle school program (grades 6-8), called Gateway to Technology (GTT), uses activity based lessons while incorporating national standards in mathematics, science and technology. Unlike the high school program where students may select PLTW courses, GTT is designed to be offered to all students. There are five, 10-week, instructional units which introduce many of the fundamentals covered in the PLTW high school curricula. High school students in PLTW often cite their involvement in GTT as their motivation for enrolling. The units are:

- **Design and Modeling** uses solid modeling to introduce students to the design process. Utilizing this design approach, students see how solid modeling has influenced their lives. Students also learn sketching techniques and use of descriptive geometry as a component of design, measurement, and computer modeling. Using design briefs or abstracts, students create models and documentation to solve problems.

- **Magic of Electrons** allows students to explore the science of electricity, the movement of charge, circuit design, and sensing devices through hands-on exercises. Students acquire knowledge and skills in basic circuit design and explore the impact of electricity on our lives.

- **Science of Technology** traces how science has affected technology throughout history. Students learn about the mechanics of motion, the conversion of energy, and the use of science to improve communication.

- **Automation and Robotics** has students trace the history and development of automation and robotics. They learn about structures, energy transfer, machine automation, and computer control systems. Students acquire knowledge and skills in engineering problem solving and explore the requirements for careers in engineering and technology.

- **Flight and Space** introduces the students to aeronautics, space, and the use of design. They learn about Newton’s Laws of Motion, forces, rockets, propulsion, and how things fly. Students acquire and apply knowledge and skills in engineering problem solving and explore the many aspects of aerospace engineering.

The GTT program provides schools with an opportunity to implement the units in a variety of ways. Schools are encouraged to offer the first unit in grade 6, but they may decide to spread the units through grades 6 through 8. For maximum benefit the GTT curriculum should be combined with a challenging academic curriculum which includes:

- Completion of Algebra I and use of algebra concepts to reason and solve problems;
- Use of laboratory and technology experiences to learn scientific concepts in physical, life and earth/space sciences;
- Reading instruction through grade eight;
- Use of oral and written communication skills to find, organize and report information; and
- Study of global and societal issues through the study of milestones of the past, present and future [1]

**CURRICULA AND IMPLEMENTATION**

The curricula are designed with input from teachers, professors, and industry and are modeled toward achieving ABET program outcomes (a-k) as well as national standards of English, science, mathematics and technology. Lessons are built upon the activity, project, problem based (AP3) approach. Each course curriculum is supplied on a CD that has resources for the teacher to utilize including the standards, implementation suggestions and lessons. The lessons include performance objectives, assessment tools, key terms, daily activities and other resources. In order to maintain currency, the curricula are revised on a rotating basis. These revisions are coordinated by PLTW staff which include a curriculum specialist and former PLTW classroom teachers and teachers who have experience delivering the course in the classroom [2].

Schools choosing to participate in PLTW must sign an agreement saying they will implement the curriculum as intended, support the program with the necessary equipment, and participate in a certification visit (like an accreditation visit) within two years. The school must also form a partnership team with local industry to advise them on
activities and projects that would be appropriate for implementation in the classroom. These partnerships help bring relevant industry expertise to the classroom. Teachers slated to teach a PLTW course must first complete a two-week intensive summer training institute (STI) for that course. STI sessions are delivered by the PLTW Affiliate University partners and in 2006 will be offered at 24 locations around the U.S. with a capacity for over 2000 teachers to be trained [3]. The authors’ institution, Purdue University, serves as the Affiliate University for the state of Indiana and anticipates over 150 teacher to be trained at their STI in 2006.

The STI class model typically teams a university professor with an experienced PLTW high school teacher (known as a master teacher). This synergy allows the participants to gain knowledge on theory from the professor and to gain experience in implementing this curricula to the middle and high school students from the master teacher. These professors and master teachers later serve as resources for the STI participants when they teach the course in the fall. At the beginning of 2006, there were over 2800 teachers trained to teach the curricula. Some teachers have been trained in more than one course, so this group represents training to teach nearly 4300 PLTW courses [3].

RESULTS AND RECOGNITION

The program is growing at a phenomenal pace. As of Spring 2006, approximately 1700 schools from 46 states and the District of Columbia have schools that have adopted PLTW. Additionally, through an industry relationship with Rolls Royce, there is one school in Derby, England that has implemented the program. As the program matures, data are being collected which point to the program’s success.

A report by the National Academy of Science, the National Academy of Engineering and the Institute of Medicine, Rising Above the Gathering Storm, recommends strengthening the skills of 250,000 teachers through training and education programs. In the Executive Summary of the report it cites PLTW as a model for K-12 curricula based upon world-class standards [4]. The Southern Regional Education Board (SREB) published a brief touting PLTW as “a Pre-engineering curriculum that works.” Their key findings are that PLTW students achieve higher scores in mathematics, science and reading, complete more high level mathematics and science courses, and enrolled in more courses involving real-world problems, technology and teamwork [5].

Research data from TrueOutcomes, Inc. found that 80% of the seniors in PLTW courses planned on some post-secondary education (versus 60% nationally), and 54% planned to enroll in engineering or technology (versus 10% nationally). Other findings showed that participation by minorities met or exceeded the proportion of baccalaureate graduates by race in engineering. Furthermore, participation by Hispanics and African-Americans is about double that of the current enrollment of those groups in post-secondary engineering. Female participation in PLTW courses is 15% which is comparable to that of females in the fields of electrical engineering (15%), mechanical engineering (13.7%), computer engineering (12.1%), and engineering technology (11.7%); however, this is well below those engineering disciplines which involve life sciences such as environmental (41%), agricultural (37%) and biomedical (46%). TrueOutcomes has begun a longitudinal study of PLTW participants and will be looking at their success in engineering and engineering technology programs [3].

SUMMARY

In eight years PLTW has grown from twelve schools in New York State to about 1700 schools in 46 states. The number of high school students who have participated in a PLTW course reached 175,000 in 2006. The curricula are well designed and focus on national standards as well as ABET program outcomes. Resources for teachers implementing the curriculum are included as well as support by the affiliate university professors and through industry partnerships. The quality of instruction is maintained through certification of university professors and through industry partnerships. The quantity of instruction is maintained through certification of university professors and through industry partnerships. The quality of instruction is maintained through certification of university professors and through industry partnerships. The quality of instruction is maintained through certification of university professors and through industry partnerships.

ACKNOWLEDGMENT

The authors wish to acknowledge the Indiana Department of Education who supporting the growth of PLTW through funding of STI for Indiana teachers and providing a grant used to design the Biotechnical Engineering Curriculum.

REFERENCES


