

K-12 Programs Plug into Technology with Project Lead The Way Curriculum

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Abstract

Project Lead The Way (PLTW) is a national program that offers a pre-engineering curriculum for high schools and middle schools. The high school curriculum consists of five courses covering solid modeling with a CAD package, digital electronics, principles of engineering, computer integrated manufacturing, and implementation of a design project. Teachers learn the technical, project-based course material in an intensive, two-week summer training session at the PLTW Summer Training Center at Rochester Institute of Technology (RIT) or at one of the six National Training Affiliates. Nearly 300 high schools and middle schools across the country are affiliated with PLTW.

This report discusses the Project Lead The Way program nationally as well as its implementation in Indiana. This paper gives a brief description of the five courses in the high school curriculum and the gateway course in the middle school curriculum. These courses emphasize hands-on, project-oriented learning. This paper also tells how PLTW, the Indiana Department of Education, Purdue University, RIT, and affiliate schools in the state have come together to implement this program in Indiana.

Introduction

Project Lead The Way (PLTW) is a not-for-profit organization that partners with middle schools and high schools, organizations in the private sector, and institutes of higher education to provide students with a technology-based, project-oriented curriculum targeted to increase the quality and number of engineering and engineering technology professionals in this country. Conceptualized by Richard Blais in the early 1980's, this program, with the help of the Charitable Venture Foundation, started with 13 schools in 1997. Currently, 221 high schools and 57 middle schools in 27 states are affiliated with PLTW with a projection of 600 schools by the end of 2003. Approximately 80,000 students have been exposed to the PLTW program. In this program, teachers learn this technical, project-based curriculum in an intensive, two-week summer training session at a National Affiliate Training Center (NATC).

Recognized as an innovative approach in education [4], Project Lead The Way (PLTW) is distinguished for its comprehensive and intensive approach. That PLTW tries to cover all bases is illustrated by the following bullet list of program highlights taken directly from the PLTW web site at www.pltw.org:

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- Fully developed curriculum for high schools and middle schools
- Extensive training for teachers
- School counselor training conferences
- Affordability through an optional national bid
- Key partnerships with state education departments
- College level certification and college course credit
- Systematic evaluation
- Continuous improvement”[2]

This paper will concentrate on three important aspects of this program -- the curriculum, teacher training, and the involvement of state education departments and institutes of higher education. From the curriculum comes an emphasis on hands-on education. A significant amount of hardware and software is specified for use in each course. The true essence of engineering practice and engineering spirit can have a meaningful development with the presence of real-life tools-of-the-trade. The training of teachers to understand, use and teach the use of these tools is a major component of the program. The importance of this aspect of the program should not be underestimated. And the procurement of needed infrastructure is secured by attending to the partnership of state departments of education, industry, universities, and, of course, local school systems.

Project Lead The Way program

Project Lead The Way has developed a curriculum of five courses for high schools and one course for middle schools. The high school affiliate must agree to offer all five courses. These courses are for any interested student, but they are particularly targeted for the college-bound student in engineering and engineering technology. Each course is project-oriented. Computer development and simulation software are used throughout. Physical models, digital circuits and robotic models are used.

The five courses in the high school curriculum are:

- Introduction to Engineering Design
- Digital Electronics
- Principles of Engineering
- Computer Integrated Manufacturing
- Engineering Design and Development

A brief description of the content of these courses follows.

Introduction to Engineering Design (IED)

IED, the recommended introductory course, develops student problem solving skills. Visual thinking and measurement procedures are emphasized as the students learn 3-D modeling and solid rendering of objects using a state-of-the-art CAD (computer aided design) software package called Autodesk Inventor. One project is to design and render a computer model of a BRIO toy front-end loader that has moving parts such as wheels and a moving bucket with struts. Besides giving basic skills, the course emphasizes the

design development process for product applications and the need to analyze and evaluate results. At the time of this writing, Pentium III, 800 MMX Computers with networking to printers and plotters were required. The software is a major part of this course, but the use of calipers is significant.

Digital Electronics (DE)

DE is patterned after a first semester college-level digital electronics courses. Students learn the basics of digital logic and Boolean algebra. Circuits are constructed and tested on the basic breadboard with digital ICs and other electrical components. Voltmeters and oscilloscopes are used to test the circuits. The actual operation of digital counters and displays brings the world of electronics to life. The drawing and simulation package Circuit Maker 2000 is used extensively allowing the student to draw, test, and analyze basic and advanced digital circuits. A routing program generates printed circuit boards from the students' designs. This course includes programming the GAL22V10 PLD. Designing projects with the Basic Stamp and/or the PIC microcontroller is an option for schools with developed programs.

Principles of Engineering (POE)

POE is a survey course to provide the student with an understanding of the field of engineering and engineering technology with an eye to career possibilities. Students explore engineering systems and manufacturing processes. Students also grapple with questions of broader application such as the social and political consequences of technological change. In this course, the student sees many sides to the question of whether a career in engineering or engineering technology is a good choice for them. Equipment in this course includes the full kit of the Fischertechnik Principles of Engineering, numerous other Fischertechnik kits, calipers, dividers, rules, pitch gauges, and a structure stress analyzer.

Computer Integrated Manufacturing (CIM)

CIM integrates the use of the 3-D modeling package Inventor with problems of creating systems for process control. Actual prototypes of manufacturing systems, such as a marble sorter, are built from parts in a Fischertechnik kit. Actuators and sensors are designed into working systems. The interrelationship of the design, function, and materials used in a complex system is developed. And products are designed and milled. Oral and written communication of project development is emphasized. Equipment in this course includes a \$30K automated manufacturing package (CNC milling machine). The software in this course includes Mastercam and Esched Robotic Robocell.

Engineering Design and Development (EDD)

EDD is a capstone design course where students work in teams on a technically significant engineering problem. The source of the problem varies. The problem can originate from a national challenge or from a database of recognized problems. Ingenious students may suggest a project that is then approved by the teacher. The projects vary from a solar water heater to a remote control hovering craft. Students must maintain a technical journal of their work throughout the class. Final reports, presentations, and demonstrations are given to an outside review panel.

Middle school course content

The middle school course, called *Gateway to Technology*, is an integrated math, science and technology program. It is a 40-week class divided into the four 10-week units: *Design and Modeling*, *The Magic of Electrons*, *The Science of Technology*, and *Automation and Robotics*. Math and science teachers are encouraged to help students learn and use knowledge gained in their math and science classes to solve the problems presented in the course. This course introduces students to the excitement of technology and is highly project oriented. Autodesk Inventor is used in the design and modeling unit where sketching, measuring, computer modeling and geometric visualization modes of activity are used. In the robotics unit, the Fischertechnik Focus Kit provides a vehicle for instruction. Concepts are developed that tie the physical activity with the lessons learned from scientific understanding.

To give a feeling for how the courses can be integrated into an existing high school program with college-prep intent, a suggested sample schedule from a PLTW booklet [1] is shown in Table I.

Grade 9	Grade 10	Grade 11	Grade 12
English	English	English	English
Social Studies	Social Studies	Social Studies	Social Studies
Mathematics	Mathematics	Mathematics	Mathematics
Science	Science	Science	Science
Introduction to Engineering Design	Digital Electronics	Principles of Engineering	Engineering Design and Development
Foreign Language	Foreign Language	Computer Integrated Manufacturing	Phys. Ed. /SH
Phys. Ed. /SH	Phys. Ed. /SH	Phys. Ed. /SH	Music/Art/Business
Music/Art/Business	Music/Art/Business	Music/Art/Business	

Table 1: Sample PLTW high school program

Equipment and the high school course contents

A breakdown of the estimated equipment costs to set up the labs for each course is found at the PLTW web site. The following summary combines the categories of computers, equipment, supplies, furniture, software, and consumables. To set up a laboratory for 26 students in the Gateway course it is estimated that \$54,147 is required. An estimate of \$95,508 is estimated to set up one high school laboratory with 20 student stations for all five courses. Estimates for the first two courses only are much less and the amount can be reduced by the prior existence of equipment, furniture, etc. The presence of significant equipment certainly changes the emphasis of a course from learning about the

technology to actually learning how to solve problems by engagement will the physical reality of things.

PLTW course material and teacher training

Curriculum development is of little consequence without training and support for the teachers that will be delivering the material in the classroom. The success of the PLTW program is largely due the summer core training and ongoing training of the teachers involved in the program. These teachers usually come from backgrounds in mathematics, science, and vocational education. With training, a teacher with an art background might well accommodate to the hands-on presentation of the material. However, extensive training in the technology of each course is required.

Prospective teachers of each course must attend a two-week, 75-hour training session in the summer at an approved PLTW national training site. Rochester Institute of Technology is the original home site for the overall summer training of teachers. Due to the rapid growth of this program, six other universities have become National Training Affiliates with RIT. These six institutions are Ferris State University, New Hampshire Technical Institute, Purdue University, University of Houston, University of New Haven and University of Southern Florida.

All teachers must attend a two-week summer training session at a National Training Center for each course they teach. This session is the core of the training. Each class of approximately 21 student teachers is instructed by at least two master teachers or by an affiliate professor and a master teacher. A steering committee of affiliate professors and master teachers directs the development of teacher training. Potential master teachers are selected from the group of teachers who have completed training and are using the material at their home sites. These master teachers, along with affiliate professors, receive two and a half days of training twice a year at RIT where they learn about updates to hardware, software and curriculum changes.

Beyond the summer training, teachers receive a detailed set of course material on CD ROMs. On-going training is provided during the school year in the form of participation in instructional sessions provided by PLTW training personnel. In Indiana, Purdue has set up a listserv to establish and maintain communication between all parties involved in making PLTW in the state a success. Affiliate professors at Purdue University are involved in providing support as they learn of teachers' needs. In addition, the support of school and state legislators and administrators insure that equipment and laboratory space are allocated so that the program becomes a reality.

Student Tracking

PLTW commissioned Hezel Associates of Syracuse, NY to make a study of high school graduates from the program. A PowerPoint presentation of this study can be found on the web at www.pltw.org. This study was based on approximately 24 graduates of June 1999 and 17 graduates of June 2000. Of these groups, 39 of 40 respondents would recommend

PLTW to a friend and 39 of 40 respondents would participate in the PLTW experience again. In face-to-face interviews 20 of 29 students credited PLTW for their choice to enroll in engineering or technology. The majority of students thought that PLTW had a positive effect on college performance. In a sample of 3,019 students, the overall satisfaction with the PLTW experience broke down as follows: extremely 30%, very 37%, somewhat 21%, not at all 7%, and not sure 5%. To be sure, the longitudinal tracking of students to this point is small. However, the data show a very positive outlook on the program by graduates and current students.

Appendix - PLTW in Indiana

The author has long felt that the tools and toys of technology should and could be used to enhance education at the high school level. He has presented workshops to teachers to transfer an understanding of technology. But, however excited he was and however interested the teachers were, there were roadblocks to the actual transfer to students. PLTW removes many of those roadblocks. Below is a brief story of how Purdue University is engaging the State of Indiana with Project Lead The Way.

In December 1999 at a meeting at Purdue University, School of Technology at Kokomo, Richard Blais, Executive Director and founder of PLTW, presented the story of this dynamic pre-engineering, pre-engineering technology program to forty Indiana people from education and industry. It was evident that the establishment of PLTW in Indiana would be a large task. In the spring of 2000, Dr. Michael O'Hair of Purdue University solicited the help of the Indiana Department of Education. The essence of this collaboration is set forth in the following points from an agreement titled Project Lead The Way Indiana Collaboration dated February 8, 2001.

In Indiana, Purdue University would be responsible for the following:

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- Provide the Summer Institute teacher assessment on-line through the PLTW web site.
- Provide advice for teachers needing readiness training prior to Summer Institute training.
- Provide teacher training through an Indiana PLTW Summer Institute. ...
- Coordinate with PLTW for the ongoing teacher training.
- Develop a plan to certify school programs as exemplary. ...
- Assist schools in forming and operating partnership teams.
- Participate as a member of the PLTW Committee of Affiliate Directors.
- Establish and maintain a University Affiliate Agreement with Rochester Institute of Technology (RIT)”

Indiana Department of Education responsibilities are as follows:

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- Promote PLTW to all schools in the State of Indiana.
- Assist schools in completing applications to become schools in the PLTW program.

- Communicate PLTW information and contracts.
- Provide the PLTW school counselor training conference.
- Facilitate informational meetings of school superintendents, principals, and teachers of schools in the PLTW program.
- Assist school corporations in finding state and federal funding to offset costs associated with the implementation of PLTW.
- Participate as a member of the PLTW National Coordinator and Facilitator Team.
- Assess PLTW effectiveness in Indiana.”

The involvement of the Indiana Department of Education (IDE) has been instrumental in procuring funds from various sources including the Indiana Department of Commerce to make a bold commitment to this program. IDE is an effective interface for high schools and middle schools in the state. IDE personnel understand national curriculum issues and standards requirements. Currently, Indiana is second to New York in the number of schools affiliated with PLTW. Thirty-five schools in Indiana will implement a PLTW course by the end of 2002. The initial success experienced in Indiana helped develop a new model of partnership in PLTW whereby state sponsors of the PLTW program are called State Leaders. Patricia Shutt, Indiana PLTW Director and David Wilkinson of the Department of Education are the State Leaders in Indiana. State Leaders have been found to represent the interests in 28 states.

Following up its commitment, Dr. Michael O’Hair, Purdue Training Affiliate Director, has procured startup funds for summer training and initial year-round support. A web-based list server is in place to service PLTW in Indiana. The PLTW Summer Institute at Purdue University will be held from July 21, 2002 to August 2, 2002 at the School of Technology at Kokomo. Professor Calvin Kunkle is the coordinator and Affiliate Professor for the Introduction to Engineering Design course. The author is the coordinator and Affiliate Professor for the Digital Electronics course. Purdue University, with its statewide system of technology programs, is in a good position to offer the teacher training in the summer and to provide the support necessary to maintain quality technical courses in the participating schools. Throughout this mission, Purdue University School of Technology will be an affiliate of PLTW and the PLTW National Training Institute at RIT.

Conclusion

Enrollments in engineering and engineering technology have been going down for over a decade. Yet employment opportunities abound. Project Lead The Way offers an excellent program for developing young people’s knowledge of the engineering and technology areas. This program provides the type of hands-on education that will hold the young student’s interest and that will provide the concrete experience in technical areas that the student will remember. Across the country, almost 300 middle schools and high schools have affiliated with PLTW. And the number is growing. Schools in Canada have recently shown interest in involvement. We in Indiana share a sense of optimism that this is a program that will significantly impact current K-12 students to find education paths to careers in engineering and technology.

Bibliography

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Biography

Gerard N. Foster was a 2001 faculty member at the summer session at the PLTW National Training Institute at Rochester Institute of Technology in Rochester, NY. He is the Digital Electronics Course Coordinator of the 2002 PLTW summer session at Purdue University. Professor Foster is an Associate Professor of EET and supervises the digital electronics, and microcontroller and DSP course sequences at the Purdue University, School of Technology at Kokomo.