Project Lead The Way®
A Pre-engineering Secondary School Curriculum

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Abstract

Project Lead The Way® (PLTW) is a nonprofit corporation that developed a national program forming partnerships among public schools, higher education institutions and the private sector to increase the quantity and quality of engineers and engineering technologists graduating from our educational system. The Rochester Institute of Technology has joined in a partnership with PLTW by establishing the National Technology Training Center to work on the professional development of new and existing teachers in schools that have adopted the PLTW curriculum.

PLTW has developed a four year sequence of high school courses which, when combined with traditional mathematics and science courses, introduces students to the scope, rigor and discipline of engineering and engineering technology prior to entering college. The courses are Introduction to Engineering Design, Digital Electronics, Computer Integrated Manufacturing, Principles of Engineering, and Engineering Design and Development. A Middle School course (Grades 6-8), called Gateway to Technology, was developed on RIT's campus in July 1998, and is currently operating in schools in New York State. Introduction at this level will attract more students to engineering and engineering technology, and will allow students, while still in high school, to determine if engineering is the career they desire. The PLTW graduate will be better prepared for college programs and more likely to be successful, thus reducing the attrition rate in these college programs, which currently exceeds 50% nationally.

A comprehensive organizational structure has been created by PLTW to ensure continued participation and success. Key elements promote support at every level of the program. PLTW provides local, state and national organization for leadership and support, a model curriculum, teacher training and development, and a network of consultants throughout the country. The participating school districts implement the 5 course sequence based on a plan developed in partnership with colleges and universities, operate a Partnership Team with members drawn from higher education and the private sector, and serve as a model for other school districts. Colleges and universities provide strategic regional leadership, involve industry, and assist school districts to establish partnership teams. Private Sector members provide advisors, supporters, mentors and financial support, and assist the colleges and school districts achieve the goals of the program. School Partnership Teams advise and support the school districts in their operational plans.

Currently operating in 26 states from New York to California, PLTW also partners with the High Schools That Work initiative of the Southern Regional Educational Board (SREB) with schools in 23 states. For more detailed information, please check the PLTW web site: http://www.pltw.org

The Problem

There is a critical shortage of engineers entering the field at a time when technology is reinventing itself every few years. The accelerating pace of technological change in such fields as computer technology and communications has increased the demand for skilled workers in a field already suffering from declining interest. The September 1997 issue of ASEE Prism cites a 1 % decline in first year full-time engineering students with a similar, but larger decline in engineering technology. Writing in Business Week (July 21, 1997), Stephen Baker reports that there are 190,000 jobs currently open in the United States, just in the area of software products and services. Ellis (1998, p.2) reports that the number of engineering jobs available is projected to grow more than twice as fast as the labor force as a whole. Yet there has been a drop in the number of trained engineers of over 6000 in the last 10 years. An even larger drop of 9000 has

been recorded in the number of students receiving B.S. degrees in electrical and computer engineering in the same time period (Engineers 4:1, p. 10)

The prospects for the future are not optimistic, either, with a large number of baby boomers approaching their 60's in the next decade (Cohen, p. 104). At the same time, the next generation of workers entering the labor force is smaller than those retiring. As they retire, where will we find skilled workers to take their place?

In addition, the SME Education Foundation has found that among graduating engineers and technologists there are significant competency gaps in areas that will adversely affect the future of the manufacturing enterprise. ("Manufacturing Education Plan: Phase I Report", SME).

These statistics identify a major challenge for the United States. The country cannot remain economically competitive with demand for people trained in engineering and engineering technology growing rapidly while the pool of students entering and graduating from programs in these areas is declining.

A Solution- Introduce Pre-engineering Education in High School Technology Programs

One way to address the challenge is to provide engineering-type educational experiences for students in secondary schools. A promising instructional model has been developed by **Project Lead The Way®** in upstate New York. This nonprofit organization developed a five-course curriculum that helps students explore engineering-related careers and develop engineering concepts that help them as the enter two and four year college engineering and engineering technology degree programs. PLTW takes direct aim at changing the focus of technology education at the high school level.

The mission of PLTW is to forge a dynamic and on-going partnership among school districts, colleges and universities and industry that will establish and support a pre-engineering education career cluster program in America's high schools. It will excite students about engineering

careers and strengthen the link between traditional academic programs with hands-on learning experiences.

PLTW has established a set of goals for its program, as follows:

- Increase the number of young people who pursue engineering and engineering technology programs requiring a four or two-year college degree.
- Provide clear standards and expectations for student success in the program.
- Provide leadership and support that will produce continuous improvement and innovation in the program.
- Provide equitable and inclusive opportunities for all academically qualified students.
- Reduce the future attrition rates within four and two-year engineering and engineering technology programs.
- Contribute to the continuance of America's national prosperity.

The courses in this program are as follows:

Introduction to Engineering Design: A course that teaches problem solving skills using a design development process for products and represents how models of products can be produced, analyzed, and evaluated using a Computer Aided Design system.

Digital Electronics: A course in applied logic that encompasses the application of electronic circuits and devices using computer simulation software to test and analyze digital circuitry.

Computer Integrated Manufacturing: A course that applies principles of rapid prototyping, robotics and automation. The course builds on the computer solid modeling skills developed in Introduction to Engineering Design. Students use computer controlled rapid prototyping and CNC equipment to solve problems by constructing actual models of their three-dimensional designs. Fundamental concepts of robotics used in automated manufacturing, and design analysis will be included.

Principles of Engineering: A course that helps students understand the field of engineering and engineering technology and its career possibilities. Students develop engineering problem solving skills and explore engineering systems and manufacturing processes and learn how engineers address concerns about social and political consequences of technological change.

Engineering Design and Development: A course in which students work in teams to design and construct the solution to an engineering problem by applying the principles developed in the four preceding courses.

The graduation expectations of a secondary school student participating in the PLTW program include the capabilities of:

- Understanding the use of technology in problem solving
- Possessing knowledge of engineering and scientific methodologies.
- Being prepared for the rigors of science, engineering and technology education at the university level.
- Understanding the systems approach in engineering design and analysis.
- Developing skills in problem solving and problem analysis.
- Being skilled in the use of mathematics
- Being an effective communicator
- Demonstrating the skills necessary to work in teams effectively

Students in the PLTW program have the option to earn college credit through a certification program by RIT that enables students to take a college credit exam and get transcripted credit. In addition, articulation agreements between secondary schools and area colleges offer seamless links between the two levels of education.

A Need for Teacher Development

The pre-engineering curriculum developed by PLTW provides a new avenue for students to explore the world of engineering. However, it also provides a unique challenge for schools that adopt the program – teacher training and retraining. When a school district becomes a PLTW school, technology education teachers, as well as science and mathematics teachers, are selected to present the program. Generally, these teachers possess strong traditional content and pedagogical skills. They are capable of organizing, managing, and evaluating normal classroom activities and have a fundamental knowledge of technology content related to materials and processes. However, most of these teachers require a rigorous, technology-based, in-service education program that addresses the unique content and pedagogy of the PLTW curriculum. Specifically, if they are to teach their students about engineering, they need content training in engineering problems and problem solving, ideation processes, digital electronics, engineering

materials, computer based design, computer aided manufacturing, and personal computing. The pedagogical areas for additional training include the philosophy and use of the Hunter and Bloom models; organizing, managing, and evaluating group instruction; managing independent study projects; using electronic means to gather and communicate information; and using portfolios as assessment tools.

A previous approach to training required one teacher from the district to participate in a special, semester long, training program at a local college, concentrating on the core technology curriculum that would apply to the PLTW program. Some specific course work was available in such courses as digital electronics and engineering materials. While generally effective and enjoyable, this approach to training had several serious drawbacks. It was difficult to find a replacement teacher for the teacher being trained. It was also difficult to find college courses that aligned themselves to the PLTW curriculum. Further, when the teachers returned to their district they did not have time to help other teachers learn the program and often had to relearn material for courses they were not scheduled to teach for another year or two.

A New Teacher Training Model That Works

Based on responses from school districts and their teachers, PLTW has refined its training plan to focus on the specific training needs of the teachers coupled with intensive core training in the PLTW curriculum. The curriculum that the teachers use utilizes cutting edge technology. Before endeavoring to master this material, it is critical that the teachers are ready for this training. The new model employs an assessment of each teacher's basic preparation, followed by individually prescribed instruction (pre-core training). The most intensive aspect of the plan provides an extended period of training during the summer in each of the PLTW courses, conducted at a training center, housed at RIT. Each course is instructed by a college professor, and a high school teacher experienced in the curriculum, working as a team. When school begins in the fall, the period of training shifts to ongoing teacher development through seminars conducted by other experienced teachers in the program. The following is a schematic representation of the teacher training model.

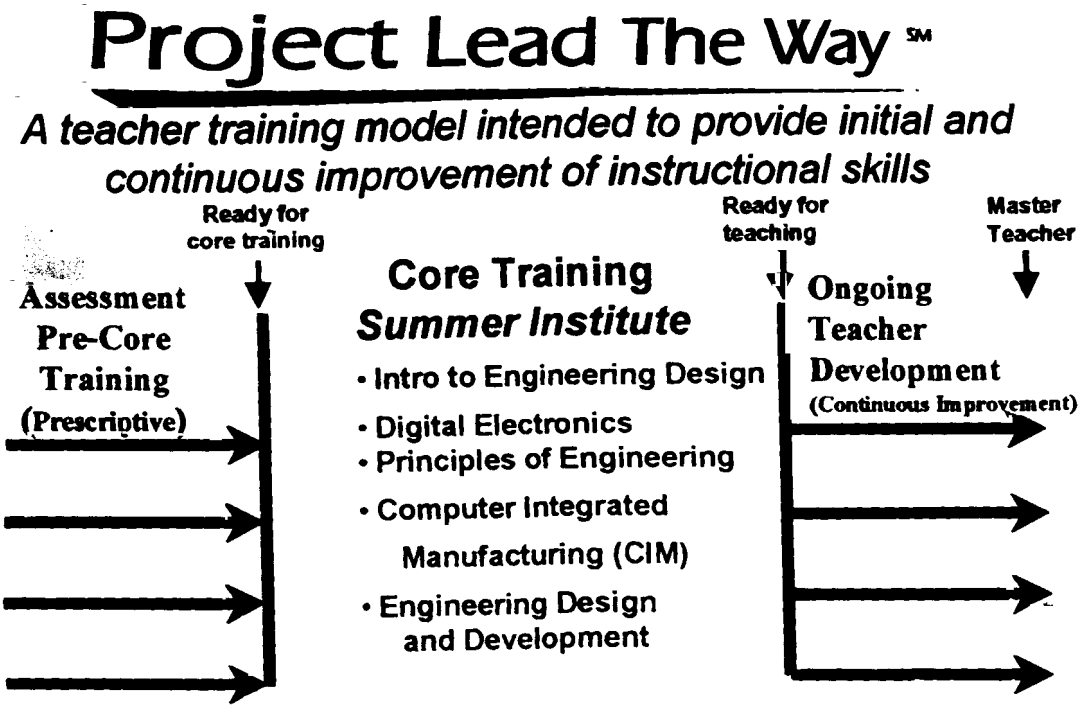

Fig. 1.1

The new training model, piloted at RIT in the summer of 1998, proved to be highly successful from all standpoints. The seventy-one teachers in attendance rated the different aspects of their experience 4.3, overall, on a scale of 1 (low) – 5 (high). Evaluations of the instructors in the program, their interest, knowledge, preparation and teaching strategies warranted a 4.6 rating, and the participants' rating of the training sessions and their confidence in teaching the courses themselves, averaged 4.5.

In July 2000, RIT hosted the third National Summer Training Institute. Over **249** Technology teachers from **26** states participated in the training sessions. They attended classes that prepared them to teach Introduction to Engineering Design, Digital Electronics, Computer Integrated manufacturing, Principles of Engineering and Engineering Design and Development. In addition, participants toured local companies, and departments on RIT's campus to round out their professional development in technology information. 75 of these teachers earned graduate credit for their work.

When asked what they saw as the benefits of the summer institute, teachers listed the following: Interaction and sharing of information with colleagues; content of the courses; ideal learning conditions with no distractions; committed and professional instructors and the informative nature of the program.

National Technology Training Center at RIT

The success of the pilot project at RIT is encouraging. The model used (fig. 1.1) has been tested and proven to be an innovative and effective method of preparing teachers to provide high school students with a quality pre-engineering program.. Implementing and maintaining such a program using the latest equipment and software requires a permanent National Technology Training Center that has been established at RIT. In addition a program of developing similar centers at affiliate universities around the country has begun to better serve schools in their home state.

Such centers serve teachers, college professors, and high school students as a place for ongoing, year-round, classes, projects and a laboratory setting for the development and revision of curriculum and teaching strategies. Bringing teachers, professors and high school students together in a place devoted to the encouragement of engineering studies will ensure interaction among these groups and lead to increased understanding of the educational needs of students and a subsequent improvement in instruction at both the high school and college level. At the same time, it will enhance efforts at attracting students to this field of study and ultimately contribute to the reduction of the college engineering attrition rate and increase the entry of graduate engineers into the field.

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Biography

Professor Guy Johnson is the Director of the National Technology Training Center at the Rochester Institute of Technology in Rochester, NY. The Summer Training Institute is held at RIT for all educators who will be teaching Gateway to Technology (Middle School Program) or any of the five Pre-Engineering High School courses. He also oversees the RIT High School Certification and the Exemplary Student Recognition programs. Prior to this assignment he was the Department Chair for the Manufacturing and Mechanical Engineering Technology Department at RIT. He received his B.S. degree in Chemistry from the Pennsylvania State University in 1969 and M.S. degree in Systems and Information Science from Syracuse University in 1972. He has served as a faculty member at RIT since 1974 and taught in graduate and undergraduate programs in Computer Science, Information Technology and Engineering Technology.