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At Issue: Technology Education Benefits from the Inclusion of Pre-Engineering Education

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Technology education is being taught today in almost every high school and middle school in America. Over 1000 technology education departments are now including pre-engineering education in their programs (Blais, 2004). The time has come for our profession to agree that including pre-engineering education in technology education programs will benefit everyone. Technology education can benefit from the inclusion of pre-engineering education by increasing students' technological literacy, promoting increased academic rigor and relevance, and eliminating the view that technology education is unessential in school curriculums.

Focus of Technology Education and Pre-Engineering Education

The basic tenets of technology education are universally accepted. According to the International Technology Education Association (2000), technology education is defined as problem-based learning utilizing math, science and technology principles. The study of technology involves

- Designing, developing, and utilizing technological systems
- Utilizing open-ended, problem-based design activities
- Incorporating cognitive, manipulative, and affective learning strategies

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- Applying technological knowledge and processes to real world experiences using up-to-date resources
- Working individually as well as in teams to solve problems.

These basic tenets are accepted as what and how we teach in technology education. But what are the basic tenets of pre-engineering education? According to Lewis (2004) pre-engineering education involves coursework in subjects that draw content from the work of engineers and promises engineering careers as likely futures of the students who pursue these courses. Many high schools offer students a course sequence option that sets the stage for possible enrollment after graduation in engineering programs in two and four-year colleges.

Project Lead The Way (PLTW) is a not-for-profit organization that works with public schools, the private sector, and higher education to increase the quantity and quality of engineers and engineering technologists by providing high school students with engaging pre-engineering education (Southern Regional Education Board, 2001). According to PLTW, students who complete PLTW's pre-engineering program

- Understand technology as a problem-solving tool
- Understand scientific process, engineering problem solving and the application of technology
- Understand how technological systems work with other systems
- Use mathematics knowledge and skills in solving problems
- Communicate effectively through reading, writing, listening and speaking
- Work effectively with others (Southern Regional Education Board, 2001, p. 7).

In essence technology education and pre-engineering education both have the similar goals. However, each has a slightly different focus. Pre-engineering education focuses on preparing students for careers in engineering and engineering technology, while technology education provides students with general technological literacy applicable to every career field.

Benefits of inclusion of Pre-Engineering Education

Many benefits result from the inclusion of pre-engineering education in technology education programs. The first benefit is that it provides an antidote to the widely held view that technology education is unessential in many high school curriculums. Technology education programs are vulnerable beyond the middle grades, where courses become elective, and where states may exclude the subject altogether from high school graduation requirements (Lewis, 2004). The current technology education curriculum has difficulty succinctly informing parents, students, and administrators of the goals of its program in grades 9-12. The general public often refers to the field as "shop class". Or technology education is misunderstood as computer technology or information technology. However almost everyone understands the word "engineering" and recognizes what engineers do. It is much easier to sell the public and the school administration on the importance of a program if everyone understands what it teaches. Pre-engineering provides a way to give technology education legitimacy and life in these grades by providing ways to discuss with any teacher, administrator, student, or parent why and what the program teaches.

The second benefit resulting from the inclusion of pre-engineering in technology education is in the area of technological literacy. If, as expressed in the "Standards for Technological Literacy" (ITEA 2000) and "Technically Speaking" (Pearson and Young, 2002), the goal of technological literacy is to prepare students with technological literacy applicable to every career field, then preparing students for an engineering or engineering technology degree certainly fulfills the goals of technological literacy. Technological literacy is then a common theme which melds pre-engineering and technology education together in a meaningful relationship (Pearson, 2004).

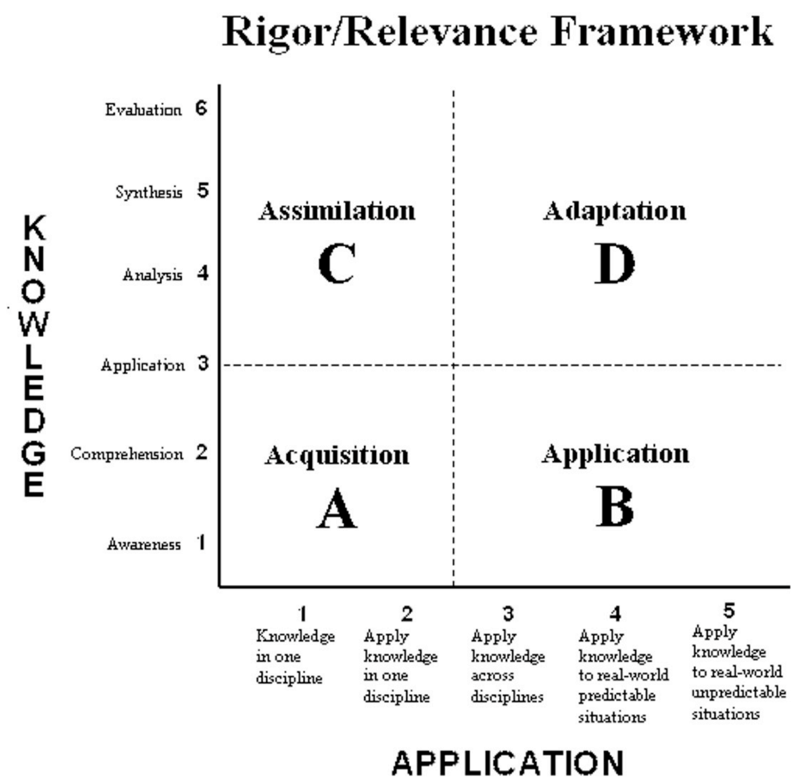
Through Project Lead The Way, many high schools are now doing just that by offering programs that prepare students to be technologically literate before they enter college. In these high schools, any student who is enrolled in a college preparatory math course is eligible to enroll in the PLTW pre-engineering program of study. Students who have an interest in science and math are encouraged to consider the PLTW program as a means of career exploration. Those who then find the engineering program to be of interest can complete five or more courses in the PLTW sequence and become fully prepared for a two or four-year college program with a level of technological literacy which will smooth their entrance into any engineering program (Southern Regional Education Board, 2001).

A third benefit of the inclusion of pre-engineering education in technology education is the increased academic rigor and relevance it brings. Teachers are hearing more and more about the need to increase academic rigor and relevance in their classrooms. With the passage of the No Child Left Behind Act of 2001, the focus in education is on students' academic records. Pre-engineering allows technology education departments the opportunity to teach courses that require academic rigor and relevance while still maintaining a focus on project-based learning.

Figure 1 shows the "Rigor and Relevance Framework" from the International Center for Leadership in Education (2005). According to Blais (2004), executive director for PLTW, the framework assesses whether or not a specific problem is academically relevant or rigorous. The framework employs two scales. The vertical axis measures the knowledge level required to solve the problem and, using a scale based on Bloom's Taxonomy (Bloom and Krathwohl, 1964), ranges from level 1 (awareness) to level 6 (evaluation). The horizontal axis measures the degree to which a student applies the knowledge in finding the problem's solution. This scale ranges from level 1, which requires no application of the knowledge, to level 5, in which the knowledge is applied to real world, unpredictable situations. The rigor and relevance of a teacher-posed problem may be assessed by charting the intersection of the two axes and determining in which of the four areas of the framework the problem falls: acquisition, (A); application, (B); assimilation, (C); or adaptation, (D).

Blais illustrates the use of the "Rigor and Relevance Framework" by comparing two examples—one from a hypothetical technology education class and the other from a typical pre-engineering class. The technology education teacher might ask, "Design a beverage container that can be used by students while they are studying. Use good design criteria of function and aesthetic value" (p. 10). This problem is non-rigorous

Figure 1
Rigor and Relevance Framework



and non-relevant. In solving this problem, the student is only at level 2 (knowledge comprehension) of Bloom's Taxonomy on the vertical scale of the framework and on level 2 (applying knowledge in one discipline) of the horizontal, application, scale. The charted intersection of these values falls in the area of acquisition (A) in which students gather and store bits of knowledge and information. In the acquisition area, students are primarily expected to remember or understand what they have learned.

However if we look again at the framework with a different problem from a pre-engineering curriculum, we see something completely different (Blais, 2004). The pre-engineering teacher might pose this problem:

> "Design a beverage container that will hold 12 fluid ounces:
> - Sketch the top view and a front cross-sectional view of the container.
> - Show the correct dimensions on the sketch needed to acquire 12 fluid ounces (show all your math calculations)
> - Use the computer design tool to apply good design criteria of function and aesthetic value to communicate the solution to this problem" (p.12).

Unlike the first example, this problem is both rigorous and relevant. The student must synthesize knowledge (level 5 on Bloom's Taxonomy) on the vertical scale and apply the knowledge to real-world predictable situations (level 4) on the horizontal scale. Charting the intersection of these values places the problem in the adaptation area (D) of the framework. To solve this problem, the student must think in complex ways and apply knowledge and skills extensively. By confronting students with perplexing unknowns, the teacher requires the students to use what they have learned to create solutions and take action that further develops their comprehension of the concepts.

Current technology education classes for the most part are not offering this kind of rigor and relevance. According to Wicklien (1997),

> Current modes of delivering technology education curriculum activate certain aspects of learning theory but often come up short from delivering the total package. The modular curriculum which is so pervasive within the field today begins to address collaborative, "authentic" real world learning opportunities; however, it tends to be restrictive (limited in scope, collaboration, and sequence), disconnected (limited in transfer potential and unrealistic), and lacking a reality based learning context (hypothetically abstract) (p. 73-74).

However, in current pre-engineering classrooms, high academic rigor and relevance is prevalent. The problems students face in pre-engineering are real world; they are sequenced, and connected to math and science. The previous pre-engineering problem illustrates the kind of real world application that technology education is lacking.

Conclusion

Eliminating the view that technology education is unessential in school curriculums, increasing students' technological literacy, and promoting increased academic rigor and relevance are three of the major benefits of the inclusion of pre-engineering education in technology education. For those who doubt that pre-engineering belongs in technology education, look no further than the foreword to the Standards for Technological Literacy (ITEA, 2000). William A. Wulf, who is president of the National Academy of Engineering, wrote the foreword. This stands as evidence that pre-engineering has become a part of technology education. To ensure that technology education remains a viable option for students in the future, its inclusion must continue.

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