An Interdisciplinary Problem-Based Engineering Technology Freshman Curriculum

J. C. Wood

Tri-County Technical College

Pendleton, SC 29670

Abstract: The sixteen colleges of the South Carolina Technical College System through an NSF-ATE grant have begun the development of an interdisciplinary problem-based engineering technology curriculum for associate degree programs. The first phase has been the development of an integrated freshman sequence of courses (ET Core). Using interdisciplinary teams (mathematics, science, technology, and communications), an integrated freshman curriculum framework has been developed. The ET Core is built on the six major physical systems (electrical, mechanical, thermal, fluid, optical, and material) common to the engineering technology programs in the South Carolina system and identifies the freshman level mathematics, science, and introductory technology performance objectives. Because technical communication is essential, a communication framework will also be part of the integrated ET Core. Industry has been involved in validation of the performance objectives and identification of problem-based exercises to allow the classroom activities to model the workplace by focusing on teamwork, communication, and problem solving as well as technical content. The curriculum design permits instruction to be delivered in three one semester integrated courses or in concurrently taught linked courses with coordinated presentation of material.

Introduction

United States' businesses and industries are changing their work environment to remain competitive in the world market. One of the major changes involves the technical workforce in shifting from the traditional manual industrial worker to an engineering technician, who both works with his/her hands and applies theoretical knowledge. This expanding role of the engineering technician requires changes in engineering technology programs. Engineering technology programs must identify the new characteristics and skills of the technician and create an educational environment to make it easier for graduates to make the transition from academia to the workplace. Educational programs should model the workplace environment, not just teach about it.

Traditional educational models consisting of isolated courses divided into isolated disciplines do not model the workplace. In order to improve the education of technicians, this isolation of the disciplines must be removed since industry does not operate in an isolated compartmentalized manner. Employers expect technicians to integrate the skills from many disciplines to solve problems. When employers (1,2,3) were asked to rank the necessary skills for entry-level technicians, they gave teamwork, communication, and computer skills top priority. Recently several four-year engineering programs have initiated freshmen curricula (4,5,6) that integrate multiple disciplinary content at the entry level. At the associate degree level, two development efforts are underway. (7,8) These initiatives provide guidelines for the development of the new curriculum.

Educational research also provides additional guidelines for a curriculum change. Gardner (9), in his concepts of multiple intelligence and Felder (10), in comments on students' learning styles, show that students require instructional strategies that differ from the traditional lecture format. Brown and Brown (11) have described how problem-based learning allows for the use of "real-world" problems that resemble an interdisciplinary work environment which incorporates the industrial methods (especially teamwork) and allows for new pedagogical techniques such as active learning and collaborative learning.

The South Carolina Technical College system of 16 technical colleges through an NSF grant (DUE 9602440) has undertaken to create a freshman year integrated curriculum for associate degree engineering technology that employs industrial problem-based activities in the classroom. To coordinate the statewide curriculum development, a nine member interdisciplinary, intercampus Curriculum Oversight Team (COT) was formed. Curriculum development has had five phases:

1. Create a cadre of interdisciplinary (mathematics, science, communication, and technology) reform-ready faculty. (12)
2. Use interdisciplinary faculty teams for each part of curriculum development.
3. Develop a first year integrated curriculum framework.
4. Validate framework performance objects with faculty and industry.
5. Identify industry problem-based activities related to the framework and create integrated learning activities for problem solving.

First Year Curriculum Framework

Development began with the COT reviewing the exiting engineering technology curricula and industry skill requirement to form the first year integrated content. They concluded that an integrated first year could be designed around six physical systems (electrical, mechanical, fluids, thermal, optical, and materials) with several themes (teamwork, communications, workplace technology, and workplace readiness) as threads through each system. The COT developed the framework format (Figure 1) for statewide faculty development teams as a guide.

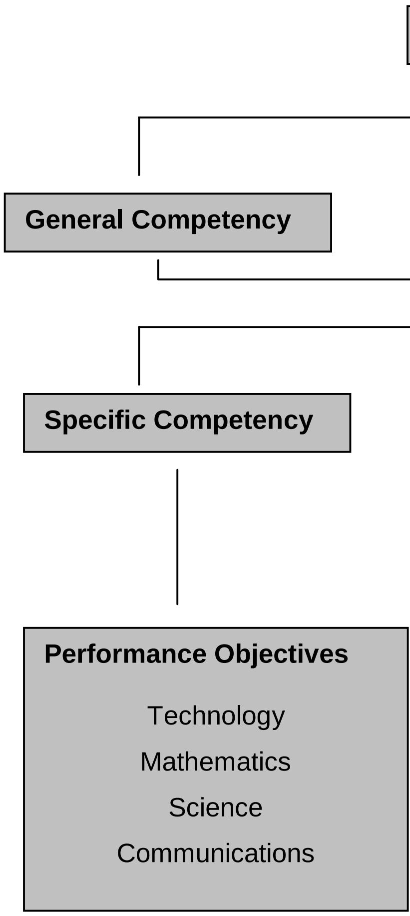

Figure 1

Where General Competencies give broad concepts, Specific Competencies give a content area, and Performance Objects give expected outcomes.

The process for development of the framework was for each team to brainstorm the first year competencies with each member contributing from their discipline. Through an affinity process, they identified general and specific competencies that were prerequisite for engineering technology courses. Mathematics, science, and technology performance objectives were then written to support a specific competency. In this model, integration is achieved at the performance objective level. Although the intent is to integrate communications into the core course, communication performance objectives do not flow as a natural progression in this process. For example, with Ohm's law there are identifiable mathematical and science competencies but no such communication competencies are identified. Therefore, it was necessary to develop a separate communication framework as a theme with the integration to be achieved during the problem-based activity level.

Figures 2 is an example of a portion of a mechanical framework

C.1 Understand rate in linear systems

C.1.3 Solve problems involving velocity.

- Demonstrate a conceptual understanding of velocity as a rate of change and distinguish between velocity & speed. (S)
- Determine velocity and speed by calculation of a ratio and using graphical analysis of empirical data. (M/S/ET)
- Write an equation of the linear function of displacement. (M)
- Solve linear equations of motion and algebraically manipulate formulas for unknown quantities. (M)

Figure 2

Framework Validation

Framework validation consisted of two activities. Faculty reviewed competencies and performance objectives to ensure correctness and to determine if any objectives were missing.

Second, industrial representatives will review competencies and performance objectives to evaluate and rate each in relation to entry-level technician skills. The rating system is:

1. not needed
2. useful but not necessary
3. necessary with general knowledge
4. necessary with application abilities
5. necessary used to problem solve

Problem-based Learning

In the problem-based learning approach, the problem is introduced first, and it provides the context for learning and indicates the skills to be learned. The student will be given a series of workshops (classes) in math, science, technology, or communications. Since the framework is not intended to be a course outline but to show the integrated relationships the course outline will be done at the problem-based activities level.

The criteria for the development of the problem-based activities by the ad hoc teams were that:

1. The problems relate to multiple objectives.
2. The problem is related in context to a industrial situation.
3. The problem has more than one answer.
4. The series of problems cover the topic area.
5. The problem must indicate the performance objectives covered.

All problem statements would have the following elements:

1. Statement of the problem context.
2. Statement of scenario.
3. Related competencies and objectives.
4. Prerequisite knowledge/skills
5. Resources
6. Guidance(teaching strategies/comments/technology used)
7. Content structure (math, science, communications, and engineering technology)
8. Assessment.

Curriculum Structure

The integrated core of mathematics, science, communications, and technology may be taught as a single integrated course of 9 credits and 13 contact hours or separate courses that are taken concurrently and taught in a block of time. For the later there would be linked courses with coordinated presentation of material.

The display below shows how the integrated course would fit into a semester schedule.

First Year			
Semester 1		Semester 2	
	Credits (contact hours)		Credits (contact hours)
Integrated Math 1	3(3)	Integrated Math 2	3(3)
Integrated Science 1	3(5)	Integrated Science 2	3(5)
Integrated Technology 1	1(3)	Integrated Technology 2	1(3)
Technical Communications 1	3(3)	Technical Communications 2	3(3)
General Ed	3(3)	General Ed	3(3)
Major Course	4(6)	Major Course	4(6)
Total	17(23)	Total	17(23)

Second Year			
Semester 3		Semester 4	
	Credits (contact hours)		Credits (contact hours)
Integrated Math 3	3(3)	Major Courses	14(22)
Integrated Science 3	3(5)		
Integrated Technology 3	1(3)		
		General Ed	3(3)
Major Courses	8(12)		
Total	15(23)	Total	17(25)

Conclusion

A new engineering technology curriculum model has been created for the freshman year and part of the sophomore year to model the workplace by integrating mathematics, science, technology and communications, by using teaming in the classroom for learning activities, and by exposing students to “real world” problems to place learning in context. The content was developed by interdisciplinary teams and validated by faculty and industry representatives. Pilot testing of the curriculum materials will begin in the fall of the year.

1. Russ Emerson, (January 1996), Torrington Plant Manager, Laurens, SC, SC ATE Chautauqua 1996.

2. Gary Blakeman , (March 1996), Becton Dickinson VACUTAINER Systems Division SC ATE Chautauqua 1996.
3. William Spalding, (April 1996), NISE East, SC ATE Chautauqua 1996.
4. Froyd, J. E., Roger, G., and Winkell, B. S., *An integrated First Year Curriculum in Science, Engineering and Mathematics – Innovation Research in the Classroom,* AlChe Conference, 1993.
5. Roedel, R, et.al. *An Integrated Project-based, Introductory Course in Calculus, Physics, English and Engineering,* FIE Conference 1995.
6. Barrow, D, et al., *An Integrated Freshman Engineering Curriculum, Why You Need It and How to Design It,* ASEE Annual Conference 1996.
7. Waintraub, J. L., *Mecomtronics Engineering Technology – Educating Technicians for 21st Century,* ASEE Annual Conference 1996.
8. Sehi, G., *NSF supported Engineering Technology Programs and Institutional Changes,* ASEE Annual Conference 1997.
9. Felder, Richard," Matter of Style " **ASEE Prism** December 1996.
10. Gardner, H., The Mind's New Science: A History of Cognitive Revolution, Basic Books, New York 1987.
11. .Brown, Buck F. Sr. and Brown B. (1997) Problem-Based Education (PROBE): Learning for a Lifetime of Change.
12. Wood, J. C. and Mack, L. G., *The Impact of Interdisciplinary Faculty Teams on Engineering Technology Curricula,* ASEE Annual Conference 1997.

James C. Wood has BS and MS degrees in physics from Clemson University and Ph. D. from the University of Virginia in physics. He has seven year of research experience in laboratories for American Cynamid and TRW. He has 25 year teaching experience in physics and engineering technology at Tri-County Technical College. He is current Division Chair and Co-PI for a statewide curriculum development grant for engineering technology.