Using Problem-based Learning to Modify Curriculum to Meet Industry Needs

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Abstract
The problem-based learning (PBL) process is an effective teaching and learning approach that allows instructors to meet educational and industry-specific objectives. Also, PBL is an effective means of incorporating workplace skills such as teaming, problem solving, and technical communications into technical courses. To modify curriculum to meet a specific industry's needs, a model using the PBL-approach will be presented. In this model, an interdisciplinary development team, consisting of technical and general education instructors familiar with interdisciplinary and problem-based instruction, is formed. Through interviews with plant employees and visits to the plant floor, the team evaluates the scope and sequence of an existing course and identifies potential PBL modules to fit both the educational requirements of the course and workplace activities. Workplace scenarios are written, reviewed with industry personnel, and modified, if necessary, to reflect actual workplace situations. When the material is presented, students are presented a problem that relates to their workplace and emphasizes the skills desired by the employer. Throughout the development process, the instructional integrity of the course is maintained. This paper will show how one college has used the PBL approach to effectively balance the broad educational goals of a curriculum course and the more focused requirements of industry.

Introduction

To gain a competitive edge in the world market, manufacturing companies must continue to find new ways of designing and producing high-quality products on time and at minimal cost. A well-trained workforce that contributes to the profitability of the company is vital to maintaining this competitive edge. In the past, companies have relied on engineering professionals to provide wide-ranging expertise; technicians were expected to be competent in a more narrowly focused discipline or workplace skill. In today's new manufacturing environment, the role of the engineering technology technician is expanding to include competencies such as teaming, problem solving, effective communications, planning and prioritizing, time management, and good work ethics.[1] It has been reported that the problem-based learning (PBL) approach will accomplish the goals of preparing graduates for this new workplace.[2, 3]

The South Carolina Advanced Technological Education (SC ATE) Center of Excellence has addressed the demand for such a technician by restructuring the entry-level general education courses for engineering technology curricula to incorporate the best models from educational research. The SC ATE problem-based learning (PBL) model[4] is an interdisciplinary, problem-based series of courses that integrate mathematics, physics, communications, and engineering technology instruction around industry-related problems. Curriculum materials developed include an interdisciplinary scope and sequence, workplace scenarios, integrated competencies, and collaborative learning activities. The SC ATE model includes a one-semester (mathematics, communications, and technology) pre-engineering technology curriculum component (called "Technology Gateway") for under-prepared entering students and a three-semester series of core courses ("Engineering Technology Core" or "ET Core") integrating mathematics, physics, communications, and engineering technology content.[5] In the ET Core, 16 workplace scenarios that relate to the six major physics/technical areas (electrical, mechanical, materials, thermal, fluids, and optics) were developed to provide students foundational technical skills that they will need in their engineering technology majors. The problem-based learning (PBL) process has proved to be an effective teaching and learning approach that has dramatically increased student retention. [6, 7]

When a need to improve employee skills has been identified, industries traditionally have turned to short-term, narrowly focused continuing education courses to meet training needs. As external pressures push companies to higher productivity, companies are looking to upgrade existing skills for operators and maintenance employees in an effort to create cross-trained, multi-functional technical employees. Because they are attempting to keep the workforce lean, companies cannot release employees for full-time educational activities, but must fit education around work schedules. Also, companies want instruction to give immediate “value added” for present job duties. For these reasons, companies have avoided traditional academic courses, such as mathematics, sciences, and communications. The PBL approach developed by SC ATE counters this resistance by using workplace-based problem scenarios that can be designed to meet industry-specific and academic objectives. Through the integrated content presented in a problem-based learning format, the SC ATE approach supplements and strengthens industry-specific content with appropriate mathematics and communications content.

Tri-County Technical College in Pendleton, SC, has successfully adapted the SC ATE-developed PBL materials to create a customized certificate program to fit an industry-specific situation. A local textile manufacturer requested the college's help to cross-train maintenance technicians as electrical/electronic technicians. Existing SC ATE curriculum modules and the SC ATE approach to instruction provided a flexible foundation for quickly and effectively responding to a workplace need.

Development of Customized Certificate Program

The development of a certificate program to meet the retraining needs of a local textile manufacturer began with the formation of an interdisciplinary faculty team. The team was comprised of physics, mathematics, mechanical engineering technology, textile technology, and electronic engineering technology faculty. The team's mission was to assess the abilities of the current technical employees, identify the required competencies for the electronic technicians, and, through modification and adaptation of the SC ATE modules, develop a Control Equipment certificate program for plant-specific instruction. In keeping with the SC ATE model, the team visited the textile company to conduct workplace research through interviews and observations of operations of the technicians.[8] Also, the academic level of prospective students' was assessed using a standard college placement test.

After initial selections of possible PBL modules, it was necessary to make several company visits to verify the applicability and relevance of the modules by conferring with supervisory personnel. The faculty team then determined the modifications needed to make the modules suitable for the customized certificate program. These industry visits allowed the faculty to fully understand the applications of the basic mathematics and physical concepts to the operations of the equipment in the plant. The company also provided drawings and schematics of several pieces of the equipment so these could be incorporated into the module modifications.

Program Implementation

An employee profile showed that most had been with the company 10 or more years with little or no formal education since joining the company. All targeted employees were in the maintenance area and had reached the top of their job classification with little possibility of promotion without obtaining additional skills. Their mathematical abilities were limited to basic numerical operations with poor algebra skills. On-the-job mathematical requirements had been confined to basic numerical operations. Computer skills had been acquired through the use of home computer systems. Troubleshooting and problem solving were confined to familiar situations; these employees did not apply physics/technical concepts to problem solving or troubleshooting situations. The learning styles inventory[9] showed targeted employees to be active and visual learners. All of these characteristics indicated that these potential students would benefit from the SC ATE PBL approach, which emphasizes active team learning.

The teaching team suggested that instruction begin with mathematics/physics courses. The mathematics level would need to be equivalent to the Technology Gateway mathematics, but with PBL modules that would reflect plant operations and would develop the prerequisite skills necessary for entry into electronics courses. The list below shows the sequence of courses to be taught.

BEGINNING ALGEBRA
CONCEPTUAL PHYSICS I &II
DC/AC CIRCUITS
CONTROL CIRCUITS
INDUSTRIAL INSTRUMENTATION
PROCESS CONTROL INSTRUMENTATION

Instruction was limited to eight hours per week because the company was willing to allow the employees four hours of company time if they would contribute four hours of their own time. To fit company shift times and holidays, classes were scheduled outside of the traditional semester and day class-time hours. Classes were held two hours a day, four days a week around shift-change time (7 to 9 a.m.). The length of this certificate program would be 66 weeks.

The algebra and conceptual physics courses were developed using the scope and sequence from the Gateway courses as a framework. From the workplace, it was found that very few changes

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were needed in the mathematics sequence. Many of the communications competencies were kept, and the physics topics were modified to reflect the preparation needed for DC circuits.

For the math/physic courses, the team selected the following modules to be adapted.

Module	Source	Content
Linear Measure	New	Case study to develop teaming, to introduce the PBL process, and evaluate types of measuring devices and systems.
Simple Machines	Gateway	Scenario modified to reflect movement of textile-related materials.
Displacement/ Velocity	ET Core – Mechanical	Scenario modified to investigate the movement of cloth through a machine to wash and dry it. Math level changed to simple formula manipulation. Vectors not included.
Rotation	ET Core – Mechanical	Scenario written to investigate the motors, gears, and rollers in the wash/dry machine.
Forces	ET Core – Mechanical	Scenario modified to investigate the motion on an inclined plane as linear motion. Vectors not used.
Temperature	Gateway	Used as written.
Resistance	ET Core – Electrical	Used as written.
Current	ET Core – Electrical	Scenario modified to reflect parallel circuits in the plant.

Once the modules were identified, the scope and sequence was modified to reflect the level needed by the students. Below is shown the scope and sequence chart for the mathematics and physics.

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Engineering Technology Integrated Curriculum

Industrial Math/Physics

Mathematics Scope and Sequence Chart

Module / Topics	Measurements	Simple Machines	Displacement Velocity	Rotation	Force	Thermal	Electrical
	1st Term					2nd Term	
Basic Numerical Operations	√						
Fractions	√						
Decimals	√						
Percentage	√						
Ratio and Proportions	√						
Averages and Means	√						
Linear Measurements	√						
Significant Figures	√						
Scientific Notation		√					
Engineering Notation		√					
Exponents		√					
Calculators		√					
Formulas			√				
Symbols and Units			√				
Conversion of Units			√				
Algebraic Manipulations				√			
Direct and Inverse				√			
Order of Operations				√			
Formula Manipulation				√			
Angles					√		
Right Triangles					√		
Vectors					√		
Geometric Calculations					√		
Standard Deviations						√	
Exponentials and Logarithims						√	
Basic Trigonometry							√

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Industrial Math/Physics

Physics
Scope and Sequence Chart

Module	1st Term					2nd Term	
Topics	Measurements	Simple Machines	Displacement Velocity	Rotation	Force	Thermal	Electrical
Measurements	√						
Linear	√						
Mass / Weight	√						
Time	√						
Volume	√						
Electrical	√						
Averages	√						
Errors in Measurements	√						
Lever		√					
Pulley		√					
Gears		√					
Inclined Plane		√					
Basic Mechanical Quantities			√				
Rates			√				
Force			√		√		
Friction			√		√		
Energy / Work							
Rotational Measurements				√			
Temperature / Heat						√	
Pressure Density						√	
Fluids						√	
Voltage							√
Current							√
Resistance							√

Lessons Learned

- The Technology Gateway scope and sequence provided a framework for the development of the first course and reduced the development time.
- With the SC ATE modules as a framework, identifying and adapting existing scenarios to fit an industry's environment was not as time consuming as creating materials from scratch.
- Modifying an existing module to fit company situations focused on scenario changes.
- Modifying the mathematics level to meet students' needs did not require major changes in scenarios, but did require changes in the products that the students produced.
- Many of the communications competencies in the modules were kept and helped the technical faculty to emphasis relevant communications skills.

Conclusions

The use of the SC ATE problem-based learning approach, which uses a workplace scenario to teach interdisciplinary concepts, proved to be an effective means of satisfying both industry's need for plant-specific instruction and academic requirements for content coverage. Students have responded well to the approach and have been successful in returning to the classroom. The PBL approach, with the emphasis on collaborative learning, has helped them to make a successful transition from traditional continuing education courses to academic course work.

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