PROBLEM BASED LEARNING IN TECHNICAL EDUCATION

Edward Webster

Current Situation:

Technical concepts have been taught at the community college level for many years using traditional classroom lectures reinforced with student laboratory exercises. Although problem based learning (PBL) has been used recently with some success in these programs, educators are often still confused about this learning strategy. This paper will attempt to answer three questions:

- What is problem-based learning?
- What isn't problem based learning?
- How can problem based learning be successfully implemented?

Definitions:

1. Problem based learning is a curriculum development and delivery system that recognizes the need to develop problem solving skills as well as the necessity of helping students to acquire necessary knowledge and skills (Stepien & Gallagher 1993).

2. Problem based learning is an educational strategy that involves the presentation of significant, complex, and "real-world" problems to students, that are structured in such a way that there is not one specific correct answer or predetermined outcome. In this approach, students work in small groups to negotiate a common understanding of the problem identify areas that need to be researched, form hypotheses, and fully develop a solution that they can present to others (Merrill 2001).

3. Problem based learning is a learning approach defined as student-centered, and includes the teacher in the role of facilitator or coach. Students engaged in project based or problem based learning generally work in cooperative groups for extended periods of time, and are encouraged to seek out multiple sources of information; these approaches often include an emphasis on authentic, performance-based assessment (Esch 1998).

4. In problem based learning, students collaborate to study the issues of a problem as they strive to create viable solutions. Unlike traditional instruction, which is often conducted in lecture format, teaching in problem based learning normally occurs within small discussion groups of students facilitated by a faculty tutor (Aspy, D.N., Aspy, C. B., & Quimby, 1993).

5. The instructor's role becomes one of subject matter expert, resource guide, and task group consultant. This arrangement promotes group processing of information rather than an imparting of information by faculty (Vernon & Blake 1993).

Related Items:

Self-directed learning may be defined as self-direction in a group experience (Tough 1971), learner directed education (Knowles 1975), or the process where adults take control of their own learning (Brookfield 1995).

Operational Definition:

For purposes of this concept paper, problem based learning will be defined as an educational strategy that involves the presentation of significant, complex, and "real-world" problems to students, that are structured in such a way that there is not one specific correct answer or predetermined outcome (Merrill 2001).

Application:
What is problem based learning?
The current iteration of problem based learning movement appeared in medical schools in the 1950's. Unlike traditional instruction that presents students with problems after they receive basic instruction, PBL begins with a problem. The necessary facts and skills are then learned in a relevant context as part of solving the problem. This instructional strategy is now employed in K-12 classrooms, higher education and business.

PBL requires students to solve real-life, often vague, open-ended problems that may well have several correct answers. The challenges must be crafted to be realistic and similar to the types of problems that will be required of the student eventually in the workplace. The students' pre-existing knowledge and instincts are emphasized, "start with what you know". The need for each students active participation in planning, organizing, and evaluating the problem solutions is stressed in the context of group success. The roles each of the students play in the brainstorming, research and solution process of the problem must be as close as possible to a real life situation.

Typical problem solving taught in schools often focuses on well-defined problems that lead the student to one correct answer. The procedures needed to solve the problem become the focus of the instructor in the classroom. Students that are successful in this method of problem solving are often not prepared for the much more vague, unstructured and difficult problems in the real world. The student's ability to think critically is not increased as a result of solving the sterile, controlled, one-answer problems of the classroom. The repeatable classroom problem solving methodology is not easily transferred to the messy problems in the workplace.

Inter-disciplinary concerns are typically not addressed in the technical classroom but are a very real concern in real life. The importance and implications of politics, personnel & material cost, and ergonomics are rarely stressed in the classroom problem solving process. The correct, single answer is the quest, not a variety of solutions that address the many different contexts of the problem. Solving problems is so much more than just memorizing facts, rules and problem solving steps. It is the development of cognitive strategies that help the student analyze the complexity of technical chaos and produce effective solutions.

For the student to be successful in their technical career, they need practice solving vague and confusing problems that will undoubtedly be encountered after their student days. This acquired skill is the goal of problem based learning.

What isn't problem based learning?
There are three aspects of problem based learning that are quite similar to self-directed learning; these similarities often create confusion for both educators and students:

1. The learning processes are both student centered
2. Students have active roles in both educational processes

3. Students work in groups in both types of learning

Self-directed learning is typically associated with adults taking responsibility for their own learning, often without formal instruction or instructors (Knowles 1975). Problem based learning requires a skilled facilitator to frame problems relevantly, provide resources and tutor the problem solving process.

Both self-directed and problem based learning are student centered, meaning that student is a part of the education process and takes an active role in what is learned and how it is learned. However, problem based learning relies on the synergy of organized group activity to interactively brainstorm, discuss and strategize solutions while the adult learner may well be on a solitary, self-determined pursuit of knowledge.

It is critical that both the similarities and the differences between self-directed and problem based learning be clearly understood by the educator. Successful problem based learning programs require thoughtful preparation and close supervision. To simply say that a program of instruction uses problem based learning without embracing and practicing each of the tenets successfully results in confusion and frustration for the student.

Problem based learning can be an effective tool to teach cognitive problem solving skills, foster creativity and encourage team leadership. But too often this effective learning strategy is unfairly criticized because of practitioners who fail to do all that is needed to make a problem based learning program successful.

How can problem based learning be successfully implemented?
A problem based learning program is a student-centered, faculty-facilitated instructional strategy that goes well beyond just course content by presenting the problem first and facilitating the quest for knowledge. As an example, PBL could be used successfully in electronics instruction at the community college level. However, the electronics instructor must first have a working knowledge of the roles and procedures as well as the underlying learning theories of PBL.

Traditionally, an electronics concept is first introduced to the student in required readings of their text; the concept is then discussed in depth in a classroom lecture. The student completes textbook problems and laboratory experiments that require a working knowledge of the concept; these problems and experiments invariably have one correct answer. The instructor assesses the degree of learning that has taken place and a letter or number grade is issued accordingly. Competition is inevitable among students, and the grading process can often encourage rivalry.

In a PBL environment the problem drives the learning; a difficult problem is presented to the students. Success requires a collaborative team effort that will ultimately develop a number of possible solutions. Student solutions are presented in class; their research in the concepts and theories underlying the assigned problem are discussed. There is no one correct answer and the rationale for each solution is discussed and defended by each collaborative team. Creative, resourceful and thorough problem solving techniques are the assessment criteria, not the arrival at one universal correct answer.

Typically, most students are unfamiliar with the problem based learning strategy and time must be taken in the first few weeks of the course to thoroughly explain how the course will be structured and illustrate the roles each class member will play. The instructor / facilitator plays a key role in creating a safe learning environment for each student. The PBL environment will develop cognition and processing in student but often the instructor must proceed slowly and patiently at first with this new and different approach to learning.

The PBL instructor must strive for student understanding and cognition while downplaying the recitation of memorized facts and figures. While posing and framing a problem to students, the instructor must take care not to state opinions that may bias the problem solving process. Questions can be posed that will help the students think creatively, "what aspects of this electronic circuit don't you know?" or "where would you look for that formula?" or "what is the next step in the process?" At first, the non-traditional role of a PBL facilitator may not be easy or intuitive for the instructor. Working effectively with groups and knowing how to guide without hiding the answer is a challenge, but with training and practice the group process will soon seem as natural as the traditional lecture.

Developing problems for group work is the biggest challenge an instructor in an electronics course will face at the outset. Creating open-ended questions that reinforce known concepts, while requiring the investigation of new concepts is difficult at first. Working backward from an exam type question is a technique often utilized, clearly identifying the desired learning objectives and including them is a class problem.

Here is an example of an open ended question that illustrates the electronics concepts of Ohm's law, series and parallel circuits and wire gauge while requiring consideration of manufacturing costs and the user friendliness:

You just inherited a failing Christmas tree light manufacturing plant. To keep the plant in business you need to quickly determine the three most cost effective, user friendly configurations of Christmas tree light set that your plant should be making. Investigate and document your three solutions addressing the following concerns:

1. *Wire size*
2. *Wattage of bulb*
3. *Bulb burnout*

Each solution will represent a trade-off in cost versus functionality, or cost versus convenience, etc. Successful completion of the exercise will require knowledge and application of several electronic concepts as well as the critical thinking skills necessary to explore all the parameters of the problem and negotiate solutions in a group setting.

The first step in establishing a PBL classroom is to divide the students into groups, typically five or less. The groups' membership generally remains the same throughout the term, although the facilitator may exchange members as needed to create as productive groups as possible.

Each group is presented with the identical problem by the facilitator. Students are encouraged by the facilitator to first identify what is known, what information is needed, and what strategies or next steps should the group take. Tasks are then delegated amongst the students; some research

different issues, some gather resources. When a gap is obvious in the necessary information, these "learning issues" are divided among group members for further research. This research requires investigation of a variety of facilitator provided resources and is often where most students acquire the most knowledge. The student takes ownership of the newly found information and rightly feels it is a needed and valued part of the group's success. The gathered resources are examined and discussed by the group, and further investigative work is delegated as needed.

When the group feels adequate research has been completed the solution process begins. Hypotheses, recommendations and solutions are brainstormed, discussed and prioritized for presentation to the entire class. The facilitator often will participate in final discussions, asking questions that help students keep their solutions framed in context.

After solutions have been presented to the class, the groups often reconvene for student self-assessments and critiques of one another's performance. Students are asked to comment on their own performance and productivity as well as the each group member's efforts. These critique sessions are usually awkward and strained at first. But the facilitator works to assure that a safe learning environment is maintained and that the sessions have value for the individual and the group.

Conclusion:
Problem based learning in technical education has many advantages for the student over the traditional lecture-laboratory-test model:

- Greater recall of knowledge and technical detail
- Better understanding of interdisciplinary concerns
- Better integration of knowledge
- Better research skills
- Better group communication
- Better problem solving skills
- Increased motivation and interest
- Increased student-student and student-instructor interaction

In problem based learning each student must be able to explain and often defend the results of his or her research and study to members of the group, the facilitator and the class. The requirement to explain knowledge gained in research to others is the key to firmly establishing true knowledge in the mind of the student. This process does not happen in traditional education where the students mainly recite knowledge presented by the teacher.

To realize the tremendous potential of problem based learning, the facilitator must fully understand and embrace the entire PBL process and successfully translate the theories to the classroom. Students in technical education in community college will benefit greatly from a problem based learning strategy where they will be more involved, retain more knowledge and transition from school to career much easier.

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