

# Integrating Learning Technologies and Problem-based Learning

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## Abstract

Problem-based learning (PBL) and learning technology represent two of the most important trends in teaching and learning that have emerged over the past two decades. PBL developed in response to the need for education that increases the retention of learning, fosters transfer of learning, and develops attitudes and skills for life-long learning. In contrast, learning technology emerged somewhat more as a “solution in search of a problem.” Proponents of technology were convinced that the capabilities of technology had great potential for education.

The goal of this paper is to examine the relationship between emerging technologies (e.g., software, hardware, multi-media) and PBL. The paper explores the range of possible roles that these technologies can play in the enhancement of PBL. This paper begins with the assumption that in order for technologies to assist in learning, they must be used within a pedagogical framework. PBL represents one such framework.

This paper will:

- Briefly discuss what is problem-based learning;
- Present a framework for thinking about the use of learning technologies in problem-based learning;
- Provide examples through the description of several technology-enhanced PBL projects used at the College of Management, Mahidol University (CMMU).

Keywords: Problem-based learning, learning technology, simulation, higher education, instructional technology

## What is Problem-based Learning?

Before discussing the uses of technology, it is necessary to define what we mean by problem-based learning. In our experience with training faculty in PBL, we have found that an important first step is to clarify misunderstandings about PBL. In particular we need to clarify how the goals and processes of PBL differ from the case method commonly used in university education.

The method that came to be known as problem-based learning emerged gradually over a 10-year period with numerous variants. However, at its heart, PBL has six defining characteristics:

1. The starting point for learning is a problem.
2. The problem is one that students are apt to face in the future workplace.
3. Subject matter is organized around problems rather than the disciplines.
4. Students assume a major responsibility for their own instruction and learning.
5. Most learning occurs within the context of small groups rather than lectures.
6. The solution to the focal problem has an implementation focus that goes beyond problem diagnosis and analysis. (Bridges & Hallinger, 1993, 1995)

As Barrows and Tamblyn (1980) note, in problem-based learning “the learning results from the process of working towards the understanding or resolution of a problem. The problem is encountered first in the learning process, rather than facts, models, conceptual frameworks, or other information. The problem serves as a stimulus and focus for problem-solving and learning.”

Thus, the role of the focal problem in PBL is quite different from the typical use of *problems* in cases. In PBL, focal problems are *not* presented to students for the purpose of giving them practice in applying previously learned information; rather they are used as the stimulus for *new* learning. This is an important characteristic that distinguishes problem-based learning from other problem-oriented approaches such as the case method (Bransford et al., 1986; Bridges & Hallinger, 1995; Christensen, 1987).

In contrast to the case method, in problem-based learning the learning objectives and activities are based on the knowledge and skills needed to address problems encountered in the field, rather than on discrete competencies or disciplinary domains (Barrows & Tamblyn, 1980; Boud & Feletti, 199). Knowledge derived from disciplinary domains remains important, but it is organized quite differently.

Another critical distinction between PBL and the case method lies in the explicit use of *cooperative group learning* in PBL (Bridges & Hallinger, 1995; Schmidt & Norman, 1988). The essence of managerial work is being able to accomplish results through people (Bridges, 1977). In PBL the learning experience is structured so as to emphasize *implementation* as well as analysis and reflection (Bridges & Hallinger, 1992, 1995). The most common forms of the case method ask participants to analyze and describe what they would do if they faced a particular problematic situation. In problem-

based learning students are asked to develop a plan for responding to the situation and, to the extent possible, execute the plan through different forms of role-play. Thus, learners confront as directly as possible the implementation of their solutions as well as some of the potential consequences of their actions.

### **A Framework for Thinking about the Uses of Technology in PBL**

In this section I will present a framework constructed around the components of a PBL project as well as the instructional process of problem-based learning. The framework includes four categories:

- ///The Problem,
- ///The Learning Process,
- ///Tools for Product Development and Problem-solving,
- ///Product Representation.

[See Table 1]

### **Using Multi-media Technologies to Convey the Problematic Situation**

Research on the development of expertise across numerous professional domains finds that a key difference between novices and experts lies in their ability to find and identify patterns in a given problematic situation (Bransford et al., 1986; Leithwood & Stager, 1986). PBL seeks to build on this finding by presenting students with multiple problematic situations for analysis and solution. PBL seeks the simultaneous development of students' problem-solving skills and domain-specific knowledge. It is through the application of domain specific knowledge to the solution of problems similar to those that would be encountered in the students' future profession that PBL seeks to accelerate the learning of novices.

Problem	Process	Tools	Product
<ul style="list-style-type: none"> <li>• Technology is used to present the problem</li> <li>• Use video to give information on the problem</li> <li>• Embed info in video and text description</li> <li>• Provide a query-based system of info-giving and retrieval about the problem</li> <li>• Examples:               <ul style="list-style-type: none"> <li>– <i>Problem of Senki Denki</i> Project</li> <li>– <i>Jasper Woodbury</i> Series</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Technology is used to simulate the process related to the problem</li> <li>• Provides access to a data-base of knowledge used for problem-solving</li> <li>• Technology is used as a “shell” that enables access to the problem as well as other resources</li> <li>• Examples:               <ul style="list-style-type: none"> <li>– <i>Making Change Happen!</i> Project</li> <li>– <i>Strategies for Success</i> Project</li> <li>– <i>Improving Student Success</i> Project</li> <li>– Human organ function</li> <li>– Spread of a disease in a community</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Tech is a tool for generating or analyzing info to make a decision and solving the problem               <ul style="list-style-type: none"> <li>– Statistics program</li> <li>– Excel</li> </ul> </li> <li>• Tech is a tool for creating the product               <ul style="list-style-type: none"> <li>– Word processor</li> <li>– Web design program</li> <li>– Database program</li> <li>– CAD</li> </ul> </li> <li>• Examples:               <ul style="list-style-type: none"> <li>– <i>D2I</i> Project</li> <li>– <i>Projects and People</i></li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Tech is used as a means of conveying the product</li> <li>• Examples:               <ul style="list-style-type: none"> <li>– Website</li> <li>– Presentation</li> <li>– CAD</li> </ul> </li> <li>• Examples:               <ul style="list-style-type: none"> <li>– <i>Retail to e-tail</i> Project</li> </ul> </li> </ul>

**Table 1: Taxonomy of Technology Uses in PBL**

### ***How Technology is used in Problem Presentation***

The most common and powerful way is through the actual presentation of the problem through multi-media audio and video. Video has specific advantages over written or verbally conveyed cases. When the problem scenario is conveyed through written format, many of the contextual cues that are necessary to understanding the problem have already been filtered or processed by the case writer. Although a skillful case writer will embed the important problem-related data in the narrative description and quantitative tables, the reader

the context from afar.

Video representation of a case scenario reduces the gap significantly. While a video-based representation of a problem also contains *processed information*, the viewer is presented with a more immediate and much richer representation of the problematic situation. Given a video scenario, the viewer must find and identify a broader range of cues and use more modalities in processing the available information than in a written case.

Proponents of using technology in PBL take this a significant step further. The video scenario is also designed so as to embed all

relevant data about the problem in the “story.” Again, the idea is to develop the capacity of the learners to “recognize” the cues and search for the necessary information without being told what is relevant. Information can consist of hard data, relationships, explicit and implicit goals, emotions that are demonstrated or underlying processes that are at work.

An example of using technology to present the problem scenario is a PBL project developed at the College of Management, Mahidol University, entitled *Cross-cultural Conflict at Senki Denki (Thailand)*. In this project students are introduced to a management problem that has evolved at a Japanese Company operating in Thailand. The scenario involves cross-cultural conflict, a problem with widespread salience in multi-national companies operating in Thailand.

The senior management at Senki Denki Co. (Thailand) has decided to install a new “just-in-time” (JIT) system of production into the Thailand factory. Conflict has developed gradually between the Thai middle manager placed in charge of the new installation and his Japanese Managing Director. The installation of the JIT system is proceeding more slowly than anticipated by the head office, which is creating pressure on the Japanese MD in Thailand.

The complexity of the problem unfolds gradually as the learners come to see the different points of view. These are portrayed through a series of scenes in which the Thai and Japanese managers and staff interact around a variety of implementation issues. The video scenario embeds the data needed for analyzing the sources of cross-cultural conflict in a chronological storyline that evolves over a period of a year.

As suggested earlier the learners must observe and interpret key incidents. These incidents include not only speech, but also body language (e.g., the cultural meaning of conveying certain types of information in

front of subordinates), facial expressions (e.g., types of Thai smiles), and tones of voice (e.g., the cultural meaning of behaviors such as raising one’s voice).

### **Using Technologies in the Learning Process**

Here technologies are used to simulate the “work process” in which the learner engages while solving problems in their profession. The most common way of accomplishing this is through problem-based simulations. Examples of problem-based simulations have spread through numerous fields of professional education including medicine (Qayumi, & Qayumi, 1999; Rendas, Rosado Pinto, & Gamboa, 1999), management (Glass-Husain, 2001; Hallinger, Crandall, Ng Foo Seong, 2000; Hallinger & Kantamara, 2001; Hallinger & McCary, 1990), health (Westera & Niesink, 2001), and international studies (see [www.forio.com](http://www.forio.com)).

Simulations, by nature, tend to be well suited for problem-based learning. Whether or not they are problem-based depends upon how the learning process is structured for learning. For example, when we use simulations in a PBL mode, we continue to place students in learning teams of two to four students. We do this even when the computer facilities are sufficient for students to learn individually. This enables us to take advantage of the cooperative learning aspect of PBL, a feature that often is not explicitly incorporated into simulations (Hallinger et al., 2000). Other features that comprise a PBL project (see Bridges & Hallinger, 1995) are similarly organized to support the learning process.

The learning process of a computer-based simulation uses the computer’s ability to model and execute complex relationships and decision rules. The designer of a problem-based, computer simulation can create a scenario, identify theories and best practices salient to the problem, and build

those into a highly sophisticated problem-solving process. The computer allows a more sophisticated modeling of “reality” (including random events) than an instructor could typically bring into a classroom simulation using only live or text resources. This is especially the case when you wish to give many students the chance to solve the problem, a limitation of live role-plays.

For example, in the *Making Change Happen!* simulation, learners are given the charge of implementing new information technology into an organization. The problem is conveyed via text on the computer screen or in a video clip.

The learners are given sufficient additional information about the people and the situation to proceed with development of a strategy for implementing this change in the company. They implement their strategy through a series of decisions, each of which generates a response from the computer. The team *experiences* the responses of people in the company to their implementation strategy over a three-year period. The computer not only models change in the staff attitudes and behavior, but also changes in the company’s productivity that accompany implementation of the new IT.

I would emphasize that in cases where PBL is incorporated into a simulation, there is always a knowledge base of theory and best practices underlying the decision process. In the case of this PBL simulation, the knowledge base derives from theories and research in the fields of organizational change, psychological change, and knowledge dissemination. However, in PBL the theory is not taught in advance of the learning. Students *construct* their understanding of relevant theory through the process of solving the simulated problem.

This approach to leveraging the capabilities of PBL through the use of learning technologies holds great promise. Although computer simulations lack the live interaction that is a part of real problem

contexts, they allow a closer approximation of important aspects than is typically possible. In particular, problem-based simulations provide a useful means of getting students to demonstrate the thinking processes that underlie effective professional practice. Again, we come back to the notion that expertise develops in a process of finding key patterns in problematic situations as well as in the solution of problems.

### **Using Technology as Tools for Solving Problems in PBL**

A third way in which technology can be incorporated into PBL is as a tool for problem-solving. Wholly apart from the use of technologies for problem representative or simulation, information technologies, both hardware and software, have an important role in the solution of a wide range of problems across the professions.

It should be emphasized, however, that the PBL project is not designed to teach the software package. Rather we design the PBL project around a problem and look at different ways in which learners might address the problem. Then we may decide to select a relevant software package. Again, students are learning to use the software in the context of a problem relevant to their current or future professional role.

For example, at the College of Management, we have designed a project entitled *Data to Intelligence* (D2I). In this project, students use selected features of Microsoft Excel (i.e., pivot table) to learn how to analyze, interpret and display data in order to solve one of a number of management problems presented to them. The software is used as a tool for enhancing the decision-making of the learners. Other problems would require other applications of a similar nature.

In this project, the technology is used as a tool for problem-solving. One of the project’s learning objectives is “learning how to use Excel for making sense of corporate

data.” Although this objective is important, it is secondary to the broader goal of learning how to turn data into intelligence.

### **The Use of Technologies in the *Product* of the PBL Process**

The last of the categories involves the use of technologies for the representation of the product itself. We have found that after the problem, the product is the most important component of the PBL process. Learners are more highly motivated when they see that their solution to the problem will be conveyed in the form of a workplace-type product. Moreover, the fact that they begin to think in terms of the product relatively early in the project again places the knowledge in an “active perspective” (Prawat, 1989). This also means that the learner must measure their solution against more realistic criteria than might otherwise be the case.

Whereas the prior category cast technology as a tool for *creating the product*, here technology is a key tool in *representing the product*. Although, in a sense, this is a less significant application of technology to PBL, it is worth mentioning.

At the College of Management we have designed a PBL project entitled *retail to e-tail* in which the students are presented with a video case problem of a small to medium size company that is struggling with how to utilize the Internet to increase sales, decrease costs and increase profitability. The students take the role of the Marketing Consultants specializing in E-Commerce solutions. They are asked to produce an E-Marketing Strategy including a prototype website for the client.

Finally, two of the products are represented via technology. One product is the team’s website, which is uploaded and posted on-line. The second is a PowerPoint presentation. Both of these products are actually presented via technology. We could envision similar types of products in other

fields such as architecture and medicine where technologies are used to represent the results of a problem solution.

### **Conclusion**

This paper has presented a theoretical rationale for the incorporation of information technologies into problem-based learning. Earlier I referred to research on the outcomes of PBL that incorporates technologies. While there is less solid empirical evidence than we might like on the effects of this partnership, users of these technologies quickly become aware of their ability to model processes in ways heretofore unavailable.

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