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Using Technology to Promote Success in PBL Courses

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Problem-based learning (PBL) is an instructional method that challenges students to "learn to learn," working cooperatively in groups to seek solutions to problems (Duch, Groh, & Allen, 2001). These problems are used to engage students' curiosity and initiate learning the subject matter. At its most fundamental level, PBL is characterized by the use of "real world" problems as a context for students to learn critical thinking and problem solving skills, and thereby acquire knowledge of the essential concepts of the course. Using PBL, students acquire life-long learning skills that include the ability to find and use appropriate learning resources.

The appeal of problem-based learning has several elements. Carefully constructed, open-ended problems help develop critical thinking skills. Through such problems, students encounter concepts in contextually rich situations that impart meaning to those ideas and enhance their retention (see **Exhibit 1** for an overview of the PBL learning cycle). In encouraging students to assess their own knowledge, to recognize deficiencies, and to remedy those shortcomings through their own investigations, PBL provides them with an explicit model for lifelong learning (Boud, 1997). Through PBL, students learn how to learn by asking the right questions.

The group format of PBL teaches students the power of working cooperatively, which in turn builds valuable communication and interpersonal skills and fosters a sense of community in which diversity enhances the learning experience for all. PBL also addresses the real concerns of industry and graduate schools—namely, that graduates will be prepared with problem-solving skills, that they will be able to communicate effectively across disciplines, and that they will be trained to work with others to solve problems (NSF, 1997).

PBL originated in medical education and has progressed steadily as a mode of learning through all levels of education. Some universities have adopted PBL as the primary mode of learning for their students. **Maastricht University** is a well-known example, and a valuable **bibliography of online resources** from Maastricht is available that shows how pervasive PBL has become and how it has been implemented. At the **University of Delaware**, we have been working for the past decade on adapting the medical school model of PBL to an undergraduate setting, in particular to the first-year experience (Duch, 2001). Exploring the role of technology has been an important part of our progress in developing PBL at Delaware.

Integrating Information Technology and Problem-Based Learning

Increasing numbers of faculty members in higher education are beginning to look beyond content objectives for their courses. The **Institute for Transforming Undergraduate Education** at the University of Delaware encourages faculty to embrace a series of process objectives, or **active-learning objectives** (A), regardless of their course content. PBL has been identified as an approach that helps faculty guide students toward these process objectives. In addition, universities and colleges are beginning to articulate goals for their students in the area of information technology. An excellent example of **technology objectives** (T) comes from **George Mason University** in their **Technology across the Curriculum Program**, where the goal is to "promote the most effective uses of technology to enhance learning" (**2002**, ¶ 1). Coupled with the content objectives for a course, the two sets of objectives above pose an intimidating and overwhelming task for the typical instructor. Fortunately, the A-objectives and the T-objectives overlap with each other, as shown in **Exhibit 2** for the first six objectives in each list.

At the University of Delaware we have learned that information technology can promote success in PBL courses and that the integration of PBL and instructional technology is important for student learning. Our students need to hone their skills as problem solvers; PBL is an excellent tool for developing those skills. In addition, students must develop facility in using information technology tools in solving those problems. When students leave our classrooms for the real world, most will find themselves in workplaces where information technology is embraced as an essential tool. PBL provides an excellent context for the development of problem solving and technology skills that will serve them well in their careers.

The possibilities and benefits of the integration of PBL and technology expand each semester as technology advances and our ideas for integrating it with PBL evolve. Many faculty members have adopted course Web sites and Web pages to organize their courses and to deliver course materials to their students. Web authoring tools have become easier to use and growing numbers of technology support staff and centers on campuses have made it easier to publish materials on the Web. The use of the Web in PBL courses plays a critical role in their success in two major areas: (a) the organization of the PBL course and (b) the use of online resources to support a PBL course.

Using Course Web Sites to Organize PBL Courses

As shown in **Exhibit 3**, a course Web site helps organize a PBL course in several areas: (a) organizing the syllabus, (b) organizing groups, and (c) organizing student projects and reports. Many ideas for using a Web site for organizing a PBL course can be found by examining online syllabi for other courses. A beneficial feature of the availability of course materials on the Web is the opportunity to adapt and incorporate what is found into one's own Web site, with appropriate recognition and credit to the authors and instructors who are the source of the material.

Faculty members experienced with teaching PBL courses recognize that a critical element of success is achieving student "buy-in" with the process. A significant amount of time should be spent explaining the process of PBL, why it is important for learning in the course, and the support structures that are available for student success. Actually, there is often more material available than can be comfortably reviewed in a given class devoted to introducing PBL. A Web site makes it expedient to provide as much supporting documentation to the students as one wishes, without burdening them with additional discussion or superfluous paper during class time. A good example is the

online syllabus for SCEN103, "Silicon, Circuits, and the Digital Revolution," an introductory PBL science course. In addition to schedule and contact information traditionally included on a syllabus, many informative pages (see **Exhibit 4**) can be linked from the syllabus Web page.

Organizing communication with the class, particularly with groups, can be facilitated electronically. Efficient communication between the group and the professor, as well as between group members themselves, has been evolving with the development of increasingly powerful technology solutions. A decade ago, the available alternatives were limited to electronic bulletin boards and newsgroups; however, these tools were limited in their effectiveness, often because of poor usability. The first breakthrough in managing groups online came from ventures such as **eGroups.com** (with its relatively easy-to-use interface to organize small groups), chatrooms, filesharing, and meeting schedules. Course management systems (CMS) now provide a superior package for organizing and communicating in groups. These packages include controlled discussion forums, collaborative space, and whiteboard capabilities. An additional attractive feature of a typical CMS is the ability to control the release of one document based on a previous action of a student or group—perfect for staging a PBL problem in a distance-learning environment.

Organizing electronic communication for student groups and providing communication tools empower students to engage in electronic collaboration (T1), an important technology objective. Since cooperative learning is fundamental to PBL and instructors are responsible for ensuring that appropriate channels of communication are available for groups to work, satisfying this technical objective helps bring success to the PBL classroom. A PBL course makes an excellent context for students to develop skill in mastering tools for electronic collaboration.

At the conclusion of a problem, groups are typically required to report their findings to the class or prepare a written product for the instructor's review. In a PBL-intensive course, the weekly cycle of problem/work/report can take its toll on student enthusiasm and energy. By relying on a variety of reporting mechanisms, however, an instructor can alleviate this difficulty, while at the same time satisfying several additional technical objectives. For example, students can be encouraged or required to use presentation software to report their findings in class, thus satisfying technology objective (T3). Alternatively, groups may prepare a collaborative Web site with multiple, interlinked Web pages, thus exercising objective (T2). Unquestionably, a well-organized course Web site, presenting a wealth of hyperlinked material, will provide students with an excellent model of structure and ease of navigation to emulate. A quantitative requirement within the final product, such as a graph or table, will offer students an opportunity to use graphing or spreadsheet programs, thus exercising objective (T5). Additional requirements of multimedia elements in the presentation will lead the students to create images and use editing software.

Using Online Resources to Support PBL Courses

As shown in **Exhibit 5**, online resources can support a PBL course by providing several elements: (a) ingredients for writing problems, (b) inspiration for problem design, and (c) information for solving problems.

The availability of engaging, relevant, real-world problems is a critical element in the success of a PBL course. In the absence of suitable problems, an instructor is compelled to write his or her own problems, often awaiting inspiration and the raw ingredients. Here the Web abounds with support. Inspiration for a problem can come from

international newspapers, often more readily available online than as newsprint in the campus library. Online newspapers from the region of a breaking story offer local flavor and additional human-interest sidebars hard to achieve otherwise. In turn, the variety of global views and regional perspectives can elevate the different stakeholders in a given situation or scenario. If extreme positions are sought, the Web is replete with fanatic sites and quack sites that should provide ample raw materials to fuel a good problem statement. Scripts and supporting character material are available from a large number of film and television Web sites; basing a problem on a popular media character or situation familiar to students may transform a good idea into a more engaging scenario for their consideration.

Ingredients for the problem design and statement can originate from a variety of sources. Background facts to support a problem can be effortlessly obtained from networked databases available through most campus libraries. Online encyclopedias and almanacs provide additional biographical and geographical information needed to portray the scenario as accurately as possible. Scholarly journals are also becoming more readily available online, making access to the latest results in a discipline just a few keystrokes away.

Students naturally turn to the Web in pursuit of information to solve the problems in an intensive PBL course, thereby fulfilling objective (T4) on using appropriate tools for research and evaluation. The old thinking that the Web is full of misinformation and biased representation and that students should shy away from it for serious research must be put aside. The new thinking should be that the Web is an excellent proving ground for developing critical thinking skills. Evaluating online resources critically and executing Web searches effectively are important lessons to learn for students, and prepares them to be lifelong learners.

Also not to be overlooked is the promise of computer simulations to engage students actively in their learning. A wide variety of **educational games and simulations** exist that represent a PBL approach to learning. These simulations range from an **emergency room** to a **virtual hospital**, from an **archaeological dig** to the **halls of justice**. Interactive Java applets and Flash animations are also an excellent way to bring the power of technology to the PBL classroom; one of my own is a **Flash Circuit Simulator** that emulates a laboratory for studying the properties of electric circuits.

Summary

Looking beyond traditional content objectives, PBL and information technology together provide exciting new contexts for achieving active learning and technology objectives associated with higher education. Integrating technology and problem-based learning is a winning strategy and is well worth the investment of faculty time and energy to benefit student learning in our classrooms and courses.

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