Technology Support for Collaborative Learning in a Problem-Based Curriculum for Sustainable Technology

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Abstract

Sustainable technology has been defined as technology that provides for our current needs without sacrificing the ability of future populations to sustain themselves. Designing sustainably engineered solutions requires weighing the qualities of different proposals from a variety of different perspectives and handling a variety of tradeoffs simultaneously. Of necessity, these problems must be solved in multidisciplinary groups. Students, therefore, need to learn not only what their own disciplines have to say about the issues, but they also need to be able to recognize other issues that arise and to know which disciplines can contribute to their solutions. Thus, students need to learn how to recognize new issues and to work collaboratively.

One possible solution is for students to learn by working on cases in multidisciplinary teams These multidisciplinary groups provide opportunities for collaboration and reflection that have the potential to greatly enhance student learning. Technology plays an important role in supporting such collaboration and reflection. In particular, this curriculum makes use of the Collaborative and Multimedia Interactive Learning Environment (CaMILE) to scaffold collaboration and reflection.

Keywords — case-based methods of instruction, tools to support teaching in collaborative settings, instructional strategies and approaches.

1. Introduction

"Sustainable Development" is an ill-defined concept. In fact, part of the educational challenge is the ambiguity and imprecision of the term. As our point of departure, we take it to mean "meeting the needs of today without compromising the ability of future generations to grow and prosper" [1]. As we head into the 21st century, this concept of sustainable development will become increasingly important.

The curriculum in sustainable development and technology cuts across all engineering disciplines, within a multidisciplinary environment incorporating the latest advances in cognitive science and computer-supported learning. This curriculum introduces major changes in the way engineering students learn within a problem–based collaborative learning environment. To make a difference, engineers need to become better informed about the world in which we live, and the social, economic and environmental problems we face in the future. They need to formally incorporate environmental planning at all stages of project development.

The new curriculum is intended to develop and strengthen students' integrative skills in analysis, synthesis, and contextual understanding of problems. Part of the initiative in sustainable technology includes support for the design, development and assessment of teaching and learning tools. A specific tool being used for this curriculum is CaMILE (Collaborative and Multimedia Interactive Learning Environment) an en vironment for sharing electronic media (e.g., video, spreadsheets, world wide web resources) and structuring discussion. The educational approach being adopted consists of starting with a three course sequence, and then migrating the ideas and concepts from these courses into the general curriculum. The first course is intended to expose the students to a framework in which questions about sustainability can be posed. This framework is based on four dimensions of sustainability: technology, economics, ecology, and ethics (Stan Carpenter, personal communication 1994). The second course in the sequence will employ this background to focus on a series of case studies using a problem-based-learning (PBL) approach [2]. The third course will involve more open-ended problem solving by an interdisciplinary team of students.

The content, educational goals, and methods of the second course, are the focus of this paper. The structure of the paper is as follows: An overview of problem-based learning is presented which is followed by a discussion of technology support for collaboration and reflection. We then discuss the curriculum in sustainable technology and the problems that have been developed. Finally, we present the lessons that we have learned regarding the use of the collaboration environment and the future directions for our work.

1.1. Problem-based Learning

Problem-based learning is a student-centered, contextualized approach to schooling. In this approach, learning begins with a problem to be solved rather than content to be mastered. This is consistent with new models of teaching and learning that suggest the emphasis of instruction needs to shift from teaching as knowledge transmission to less teacher-dependent learning. Learning needs to occur in problem-oriented situations if it is to be available for later use in those contexts [3]. PBL was originally developed to help medical students learn the basic biomedical sciences [2]. PBL includes among its goals: (1) developing scientific understanding through real-world cases (2) developing reasoning strategies, and (3) developing self-directed learning strategies. Since its origin in medical education, PBL has been used in other settings such as engineering and architecture [4].

As students articulate and reflect upon their knowledge in PBL, they develop more coherent understandings of the problem space [5]. In addition, the acquisition and indexing of examples that occurs during PBL should allow later problems to be solved by case-based reasoning [6]. Finally, the active learning used in PBL should promote the self-directed learning strategies and attitudes needed for lifelong learning [7]. The self-directed learning objectives of PBL are particularly important in science and engineering because PBL may facilitate development of the lifelong learning strategies necessary to stay current in the face of rapid technological advances. The use of PBL requires collaboration. Unlike the model used in the medical schools, the Georgia Tech students are taking this course along with several other traditional courses. This makes collaboration outside class difficult. Moreover, in the limited amount of time in class, the students do not have sufficient time to reflect. For these two reasons, we felt that a computer-supported collaborative learning environment would help make our PBL course more effective. The next section of the paper will discuss the technological tool we are using to support the students' collaboration, reflection, and learning.

1.2 Technology for collaboration and reflection

Collaborative learning is a key part of the PBL approach. As students articulate and reflect upon their knowledge, learning and transfer are facilitated [8]. Group problem-solving allows students to tackle more complex problems than they could on their own. Students do not necessarily collaborate well nor do they necessarily take opportunities for reflection [9]. The techniques that teachers use to support students engaging in an activity and learning skills are called scaffolding [10]. The goal of scaffolding is (1) to enable students to carry out a reasoning process or achieve a goal that they would not be able to do without help and (2) to facilitate learning to achieve the goal without support. As students learn the skill, they need less support, so the scaffolding can be faded. Research on software-realized scaffolding shows that some of the help traditionally given by individual coaches can be provided through software [10].

The major tool we use to support collaboration is CaMILE, an interactive, distributed, collaboration environment that scaffolds learning, reflection, access to materials, and problem-solving tools [11] This environment supports collaboration through the NoteBase in which students enter comments of various types. Students reflect on their thinking as they choose the type of note they enter. The students can attach documents of various forms to the their notes and can create links to the MediaBase, a multimedia repository of additional information, and to resources on the World Wide Web.

CaMILE provides software-realized scaffolding by the use of procedural facilitation. Procedural facilitation in CaMILE encourages students to think about the role their contribution is making to the problem-solving process itself. Students use this environment as a tool at times when they need to collaborate to complete a project and when it is integral to an assignment. When students click on the attached documents the document and its application is opened allowing students to work collaboratively on shared documents. By encouraging reflection as students collaborate, the students are more likely to construct usable knowledge and to transfer what they have learned to other problem-solving situations. [8]

2. Overview of Curriculum and Pedagogy

Using our experience in chemical engineering, mechanical design, and problem-based learning, three case studies in sustainable development have been developed (Table 1). Each case includes a factual case text, supplementary material that provides case enrichment, and a guide for the facilitators. Students are expected to expand the study of cases beyond these materials by identifying issues and exploring resources on their own. The role of the class instructor is (1) to facilitate discussion around issues of technology, environment, economics, and ethics and (2) to encourage the use of fundamental principles and tools to address these issues.

Table 1. Case Studies and Issues in Sustainable Development.

CASE:	ISSUES:
1. Learning from Industrial Accidents - Bhopal.	Accidental chemical releases; chemical toxicity.
2. Sheet Molding Compound Manufacture.	Impact assessment and reduction; sustainability and economical trade-offs in industry.
3. The sustainability of Chlorine use - A Pulp and Paper Mill.	Overall approach to chemical use.

A goal of each case is to expose students to a broader perspective of real-world problems while having them draw upon their disciplinary knowledge to collaboratively develop solutions. Three cases have been developed for use in the problem-based second course. A common theme in these cases is that they involve the production and use of chemicals and their fate and transport in the environment. Application of principles of mass and material balancing, dynamic and steady state response, and life-cycle assessment is required in each case to assess issues of technology, economy, environment, and ethics. Cases 1 and 2 focus on particular sites. Case 3 is broad, addressing issues at the global, national, or industrial level. In all cases, emphasis is given to the recovery and reuse of product, raw material, and/or energy. Topics addressed include the technical feasibility and economic tradeoffs of alternative processes and products; preservation and efficient use of material, energy, and space; and uncertainty in data in material properties, global, regional and local inventories, and health risk information.

This course is being taught as a 3 credit problem-based elective. There are a cross-section of students from a variety of engineering disciplines enrolled in the class. To introduce students to the concept of sustainable development and sustainability dimensions, three cases were selected for study: Learning from Industrial Accidents- Bhopal, Premix' Sheet Molding Compound Manufacture, and Chlorine Use in a Pulp and Paper Mill. Throughout the course, students were encouraged to use CaMILE to assist them in their collaborative efforts by encouraging them to post their questions and to engage in dialogue around these questions and their collective problem-solving efforts.

3. Assessment Issues

In examining the success of this program, we considered the students' learning from both group and individual perspectives. Group assessment examined collaboration and consideration of sustainability issues. This was accomplished by analysis of the groups' activities, student logs, and case reports. In addition, the students' collaborative discourse via CaMILE was considered. We assessed individual learning and transfer of both the content they have learned and the values of sustainable technology to new problems by written pre- and post- testing of the students' knowledge of sustainable technology. Finally, we assessed the students' understanding of the nature of the issues in sustainable development by having them develop and present cases that can be used for future reference. This provided an opportunity for students to make their thinking visible and provided a way to assess thinking that was also a learning opportunity for students.

The first time this course was offered was in the spring quarter of 1995. We had some successes and some disappointments. In general, the students learned about the issues of sustainable technology [12]. The students became better at examining the ethical, environmental, and economic issues of sustainability. They did not however learn to apply their technical knowledge. One reason for this may have been that the students construed the technical issues narrowly and thus failed to reflect upon how broadly applicable their technical knowledge was. Another explanation is that the students divided up the issues such that one person in each group handled the technical issues and did not successfully communicate that back to the working groups.

4. Lessons Learned

The first time through the course, our use of CaMILE was not very successful. The students did not collaborate very well nor did they appear to reflect on broader issues. Some of the students noted in their logs that they were not sure they understand what sustainability meant. CaMILE would have been an excellent forum for reflection on these issues. Several attempts to start discussions were made by the course faculty and an occasional student but discussions never got longer than 2 notes.

There were a variety of explanations for the lack of success. This may have been caused by (1) access problems, (2) hardware platform incompatibilities, (3) failure to adequately integrate the collaboration technology into the course.

The version of CaMILE that we were using only ran on a Macintosh. This caused two types of problems. First, students needed to use the public computer clusters to access CaMILE. This was inconvenient for many students. In addition, students wanted to be able to access CaMILE from their dormitories which was not possible with the Macintosh version of CaMILE. Another barrier to use was that many of the students used PC-compatible hardware platforms and did not want to learn to use a Macintosh. These students also had to deal with software incompatibilities because the PC versions of some of the software were higher than the Mac versions that were available in the clusters.

Finally, the lack of explicit integration of CaMILE into the course was probably the major reason for our lack of success in using CaMILE. Students were encouraged rather than required to use CaMILE but the benefits to the students were not made clear. In the students' logs, they noted how difficult it was to collaborate and to meet outside class. They also noted that it was hard for them to do more than attach their documents together the day that a paper or case study was due. The reports that the students handed in were consistent with the lack of integration. Despite the collaboration difficulties, the students had no idea how CaMILE might be of benefit.

5. Future Directions

Our pilot implementation of this course has provided data that will inform subsequent instructional practice. Based on further analysis of our experience, we are working on developing better ways of integrating CaMILE into the course. Some barriers will be overcome by the new version of CaMILE which runs on the World Wide Web. Understanding the nature of collaboration and the role of technology in supporting collaborative problem-based learning is an ongoing issue in our work. Computer-supported collaborative learning environments have the potential to enhance PBL in exciting ways, but to realize that potential will require consideration of how they should be integrated into the classroom environment.

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