The STEP Environment for Distributed Problem-Based Learning on the World Wide Web

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ABSTRACT

Successful elementary and secondary educational reform requires analogous reform in teacher education; however, the standard undergraduate setting in schools of education poses considerable obstacles. In this paper, we describe the STEP environment for distributed problem-based learning (www.eSTEPweb.org), which represents one of many efforts to create a viable model for teacher education reform. Here, we describe our approach to creating a socio-technical infrastructure designed to help foster a knowledge-building community among preservice teachers, practicing teachers, and instructional staff. We highlight the online environment that supports student and staff coursework in the learning sciences component of a secondary teacher education curriculum.

Keywords

Problem-based learning, case-based learning, teacher education, conceptual change

INTRODUCTION

Successful elementary and secondary educational reform requires analogous reform in teacher education and professional development (Loucks-Horsley, Hewson, Love, & Stiles, 1998); if we want teachers to transform their classrooms from traditional "chalk and talk" environments into authentic "knowledge building communities" (Scardamalia & Bereiter, 1994), we must likewise transform ours. However, the standard undergraduate setting in schools of education at large universities poses considerable obstacles to such reform on both the concrete and conceptual level (Derry, Seymour, Steinkuehler, Lee, & Siegel, in press; Steinkuehler, Derry, Hmelo-Silver, DelMarcelle, in press): lack of space, scheduling constraints, insufficient and inconsistent staffing, training limitations, legal credentialing requirements, professional risks associated with instructional innovations, ideational fragmentation (Ball, in press) within teacher education programs that often engenders competing discourses or "voices" (Wertsch, 1991), and, in some courses, students' legitimate fear of theory (Simon, 1992). Together, such factors pose a considerable challenge to efforts to build sustainable knowledge building communities of teachers. The question is not *whether* to pursue such reform, however, but *how*.

No single technology or pedagogy can be a panacea for schools of education; however, well-designed *socio-technical infrastructures* (Barab, Kling, & Gray, in press) that are context- and community-sensitive might at least broaden our conception of what's possible in teacher educational reform. Online environments that are designed to be sensitive to the contexts in which they are embedded can make possible the accumulation of knowledge and practice of the communities they are to serve. Internet technologies hold great promise for teacher education programs by enabling teacher educators to avert many of the concrete barriers to reform efforts; for example, we can now provide students ample space (albeit virtual) for collaborative work and reduce the need to coordinate schedules by enabling "anytime/anywhere" interaction (Benbunan-Fich & Hiltz, 1999). In combination with pedagogies that provide a social structure for collaborative, student-centered activities, such technologies can be a viable solution for teacher educators searching for feasible ways to practice what they preach.

THE STEP SOCIO-TECHNICAL INFRASTRUCTURE

The Secondary Teacher Education Project (STEP) at the University of Wisconsin-Madison represents one of many efforts to create a viable model for preservice teacher education reform. STEP is an ongoing and continuously evolving research and development effort to design a socio-technical infrastructure — technical environment and related social structure and activities — that fosters and sustains knowledge-building communities among preservice and practicing teachers, instructional staff, and disciplinary mentors (subject-matter specialists). As discussed in Derry et al. (in press), our goal is to develop a technology-based distributed professional learning community in which instructional staff mentor teams of students who collaborate on instructional design projects which, when possible, are then implemented in the classrooms of local cooperating teachers. Through these instructional design projects, members of the community construct (and reconstruct) shared knowledge about teaching and learning on the basis of current research and theory and in the context of authentic practice, producing artifacts, such as model lessons, that would constitute an evolving communal knowledge base. This community is slowly evolving, with our current implementation representing an early intermediate stage of progress.

SOCIAL STRUCTURES & ACTIVITIES

This model is currently realized under the rubric of problem-based learning (PBL) and in the context of a foundations course in educational psychology. PBL is a collaborative learning method in which small groups of students, facilitated by an instructor or "tutor," learn content by solving problems (Barrows, 1985; Hmelo & Ferrari, 1997). We chose PBL as a framework for structuring students' collaborative design projects because we wanted to anchor students' design work in the context of real-world problem solving and replace passive acquisition of course content with authentic, student-driven inquiry. Previous experience with PBL in an undergraduate educational psychology course suggests that students engage with the course content and revisit educational psychology content across multiple cases (Hmelo-Silver, in press). Other research suggests that PBL leads to positive learning outcomes (Hmelo, 1998; Hmelo, Holton, & Kolodner, 2001). The design goal for our course is to develop students' propensity to *use* current theory and research in the learning sciences (fields of research on cognition and education such as educational psychology, cognitive psychology, and cognitive science) as tools for designing instruction — to foster *useful* knowledge, not inert information. Moreover, by situating instructional design in the context of collaboration rather than isolated independent practice, PBL activities should afford preservice teachers in our course the opportunity to engage in sustained collaborative work of the type we want practicing teachers to engage in.

Students in our course learn to apply the learning sciences to teaching through collaborative problem solving based on videocases of actual classroom instruction. The problem students are asked to solve is to develop an adaptation or redesign proposal for the instruction depicted in the videocase, based on learning sciences research. In order to solve each problem, students conduct an individual preliminary analysis of the videocase and then meet with their group online to share and negotiate their ideas, generate learning issues, conduct research, and then reason through their preliminary ideas in light of what they investigate. Once the group has completed their deliberations, each student composes his or her own final solution proposal, compares it to other solutions, and then reflects back on the products and processes so generated. This helps prepare the students to develop a flexible understanding of the concepts with the goal of having them transfer it to their professional practice. Students' instructional design projects, then, are the result of their individual and collaborative problem solving; later implementations of those projects in the classrooms of local cooperating teachers (where the students observe and teach) constitute a "test" of the feasibility of the design solutions generated.

In this way, pbl[1], as implemented in our course, serves as one enabling *social* infrastructure for supporting development of a knowledge building community by fostering the joint production and negotiation of community knowledge and skills in the form of shared practices and artifacts. Our modifications to the traditional PBL format were motivated by the work of Scardamalia and Bereiter's (1994) who state, "When we speak of schools as knowledge-building communities, we mean schools in which people are engaged in producing knowledge objects that…lend themselves to being discussed, tested, and so forth…and in which the students see their main job as producing and improving such objects. Restructuring schools as knowledge-building communities means…getting the community's efforts directed toward social processes aimed at improving these objects, with technology providing a particularly facilitative infrastructure" (p. 270).

TECHNICAL ENVIRONMENT

The *technical* infrastructure (www. eSTEPweb.org) we are now putting in place to facilitate both student and staff coursework consists of several overlapping modules designed to support the needs and functions of different categories of members within the community (see Figure 1). Using ZOPE, an open-source web application server, in combination with an extensive SQL database, we have now fully implemented a *Student Module* designed to structure and scaffold student work (discussed in detail below), a *Tutor Module* which provides a suite of tools and resources for instructional staff who tutor pbl groups, a *Course Manager Module*, which allows instructors to adapt elements of the students' environment to suit the local context and needs, and a *Research Module* which supports our own ongoing research and development work. We have yet to fully engage practicing teachers from local schools in our online community, although dialogues are beginning to take place.

Course Manager Module

The Course Manager Module will provide the basic functions necessary for establishing and tailoring our online pbl activities to a given context. Using this module, the "course manager" or instructor will be able to create the instructional unit or course by defining four things: (a) the *community members* and their roles (which students will be working together, which staff will be tutoring them, etc.); (b) *content materials* to be used (which problem and case will be used, whether all groups will work with the same problem or different problems, etc.); (c) which *tools and activities* are to be included; and

[1] We use "PBL" to refer to the Problem-Based Learning technique originally designed by Barrows (1985); we use "pbl" (all lowercase letters) to refer to the modified version of problem-based learning used by STEP. We maintain this distinction throughout our work in order to acknowledge the fact that we employ online *asynchronous* discussions while Cameron, Barrows & Crooks (2000) specify that such discussions should always occur synchronously. Our use of asynchronous rather than synchronous environments was a deliberate design decision; the rationale behind this decision is discussed later in the paper.

(d) the *time frames* in which the community members' activities are to take place. Based on these selections, the system assembles the appropriate tools and resources for both student and staff use.

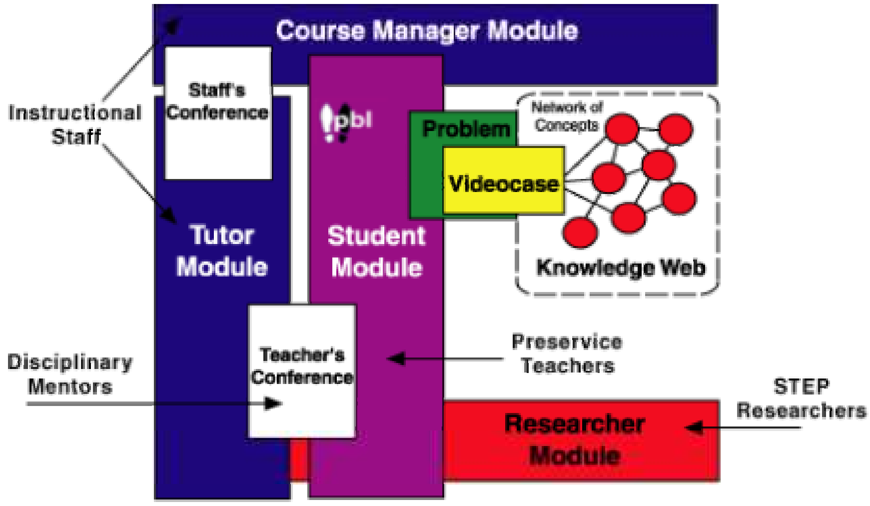

Figure 1. Diagram illustrating the interacting modules of the STEP online environment.

By providing course managers flexibility in selecting which content materials (b above) and tools and activities (c above) will be used, we hope to insure that our technical infrastructure is context- and community-sensitive by permitting adaptation of the system to local context. The resources, tools, and activities that comprise students' and staffs' pbl work help shape the community's accumulation of knowledge and practice; therefore, allowing flexible adaptation of the online environment to local needs and goals is critical. Toward this end, we provide a suite of options for each tool and activity wherever possible. For example, the instructor will be able to select the layout of the interactive tools that students and staff will use during their activities, from a set of pre-built options, and will be able to edit the headings of the tools in order to guide students' learning in different ways (cf. Suthers, 1999; 2000). He or she will also make certain resources available, such as previous successful solutions to the given problem, in order to tailor students' activities to the particulars of the local community goals and practical time constraints.

Tutor Module

In pbl, tutors play a critical role in determining what and how students learn throughout their activities; they monitor the flow of each student's activities, perform metacognitive functions for the group (e.g., probing students' reasoning, asking "why?"), and make educational diagnoses in terms of both product (knowledge) and process (critical thinking) (Hmelo-Silver, 2002). As argued in Steinkuehler et al. (in press), accomplishing these responsibilities is a challenge for the most seasoned tutors; for new staff members with little training who must facilitate several groups at once, it is a tall order indeed. The Tutor Module we are developing is designed to provide instructional staff the assistance, scaffolding and support necessary for successfully tutoring multiple online groups at once. Through this module, instructional staff working with groups can access an outline of suggested group activities, practical suggestions for guiding students' collaborative work "from the side" without being intrusive, and example "conversational moves" that can be used to probe students' knowledge and reasoning. In addition, we are developing online tools for diagnosing group interactions such as an "Interaction Matrix" that provides a snapshot of the level of engagement within each group and indicators of the equity of participation, a *Target Group Report* that summarizes solutions to the given problem that have proven successful in the past, and full access to each group member's products so that educational diagnoses can be made. Together, this bank of online tools and resources will scaffold *tutors* as they, in turn, scaffold *students* through the collaborative process.

Researcher Module

The technical environment of the STEP system not only will serve as the environment in which course activities and community collaboration occurs, it also will serve as our research instrumentation. The online system includes a system-wide monitoring and assessment component that will enable researchers and staff to diagnose and assess students' online products and processes. For example, it captures a "trace" of each user's activities (e.g., sequences of pages accessed) and data entries (e.g., students' responses to reflection questions, discussed below) for basic research, course management, and site/curriculum development purposes. Such data are stored in a protected database that can be "harvested" via the Research Module and easily exported to statistical software packages for subsequent analyses.

THE STUDENT MODULE

The Student Module, currently being tested, is at the heart of the STEP pbl system. It is here that preservice teachers engage in both individual and collaborative work. The interface of the module, shown in Figure 2, consists of three main elements: (1) a representational overview of the activities, (2) a suite of resources that remain accessible at all times, and (3) a center workspace. Together, these elements form a *digital dashboard*: work conducted in the center space is framed by a representation signaling where the individual is in the overall activity (top) and a bank of interactive tools and resources (left). Students navigate through the space using the "sidewalk" overview at the top of the browser or the *next* and *back* buttons; however, the system scaffolds students' progression through the activity space by dynamically tracing what each student has completed and then providing access to the next activity or session in the series based on this trace, thereby guiding students through the appropriate sequence of phases or *step*s and ensuring adequate attention to each.

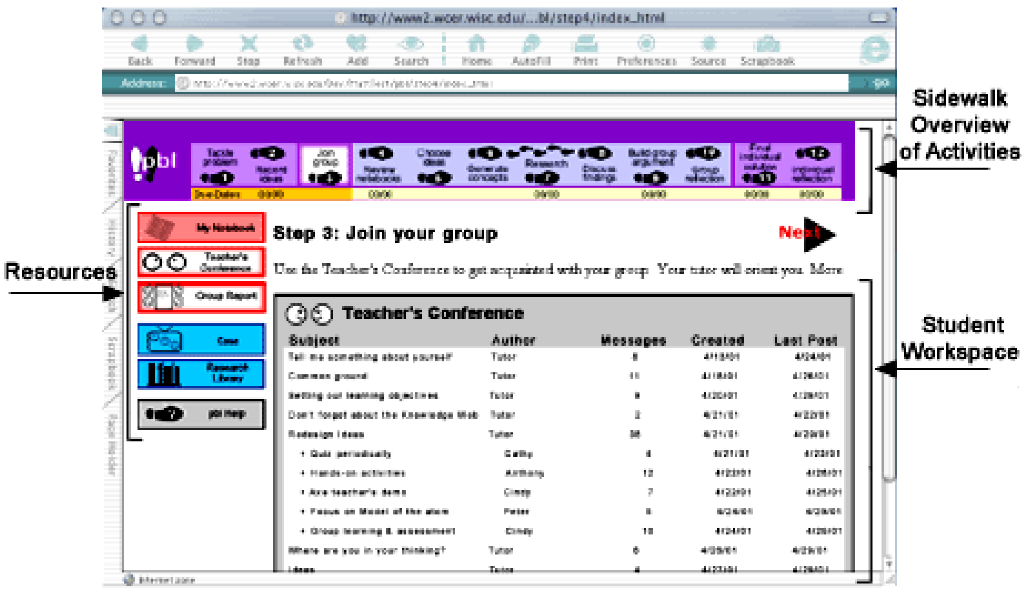

Figure 2. Interface of the STEP pbl Student Module Interface. The third step is active with the Teacher's Conference appearing in the workspace.

Overview of the Activities

Students' activities are represented as steps down a sidewalk and are organized into three main phases, distinguished in the interface by different shades of color. Figure 2 shows a series of 12 activity steps, however, the actual number and order is determined by the instructor, who can enable or disable particular ancillary activities as described above. Together, these three phases of activities are designed to prompt students to explicate the beliefs and assumptions about teaching and learning that they bring to the activity, to engage students in a collaborative activity and environment in which the import of learning science research to instruction can be negotiated and jointly reasoned through, and to facilitate individual belief revision and metacognitive awareness.

The first phase of activities (steps 1-2) is designed to help students mine the videocase in order to construct and make explicit their initial situation model (e.g., Derry, 1996) of the teaching and learning observed therein. During this session, students are scaffolded through a pre-analysis of the videocase designated by the assigned problem. After individuals complete the preliminary individual phase, having gained some initial experience with the purpose of the pbl activities and the opportunity to begin thinking deeply about the problem, they join their group (of five to six other preservice teachers enrolled in the course) and tutor online (step 3, shown in Figure 2 above) to develop a consensus solution to the problem that is justified in terms of the learning sciences. The goal of this central phase of activities (steps 3-10) is to help students *reconstruct* the situation model of teaching and learning they explicated during the first phase based on what they discover through investigation and online interaction with other peers.

Toward this end, members share and suggest solutions to the problem, synthesize a list of solution ideas they will commit to as a group, and then generate a list of related learning science concepts that need to be investigated. Students conduct research using the *Knowledge Web* (described below) and other online and offline resources and then return to the group discussion to reason through the import of their pooled research on the solution ideas they initially proposed, specifying not just *what* was discovered but also *how it bears on* the solution ideas discussed so far. In the third and final phase of activities (steps 10-12), each student writes an individual final solution proposal to the problem, compares and contrasts their solution with others, and then reflects back on both the products and processes resulting from their activities. This final phase allows individual assessment in addition to group assessment, which is necessary since teacher certification is based on individual performance. More importantly, however, these follow-up activities help students come to understand how their own understanding of the relationships among teaching, learning, and instructional redesign has been revised as a result of their group work.

Resources

A suite of tools and resources, located to the left of the workspace, is intended to scaffold and structure students' products and processes. Here, students can access online interactive tools for constructing their individual and group products (My Notebook, Teacher's Conference, Group Report) as well as general resources for the problem (the videocase, a Research Library, and pbl Help). Each resource, described separately below, appears as a second pop-up window that can be accessed at any time during the activities.

My Notebook

My Notebook contains all of the online tools students need to complete their individual work. Appearing as a tabbed sequence of four pages (Figure 3), My Notebook contains an *Initial Ideas* tool designed to structure each student's pre-analysis of the problem and videocase, a *Research Notes* page which provides online space for the student to take notes during their investigation into the research literature, a *Final Solution Proposal* page where each student enters a final individual product, and a *Reflection* page containing open-ended questions which prompt reflection on both product (e.g., "What limitations are there, if any, on implementing the solution you proposed?") and process (e.g., "What would you do differently next time?"). As discussed earlier, the course manager selects the layout and text prompts of each tool contained in My Notebook; which tool structure(s) are most effective for learning, however, is an empirical question we intend to pursue.

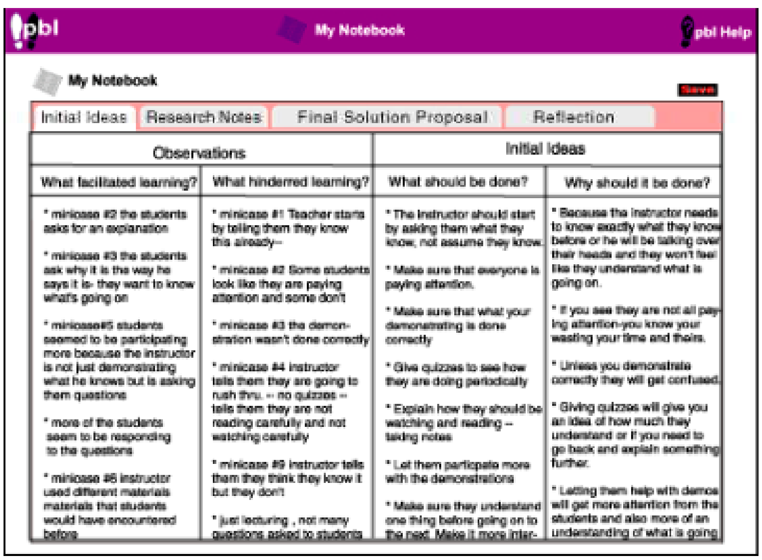

Figure 3. Interface of My Notebook. The first tab is active with the Initial Ideas tool appearing in the pop-up workspace.

Teacher's Conference & Group Report

During their collaborative work, students will make their knowledge and reasoning public through a combination of an asynchronous discussion *environment*, the *Teacher's Conference*, and strategically designed online group *product*, the *Group Report*. Our decision to use this combination of collaborative spaces was strategic (Steinkuehler et al., in press): Together, they translate student reasoning into public artifact.

Previously we conducted problem-based learning activities in the classroom using a face-to-face format. By moving collaboration to an online asynchronous environment, we are able to transform discussion from a temporal unfolding of talk to a cascade of inscriptions. Threaded discussions have been shown to have distinct advantages over synchronous discussions, fostering more serious and lengthy interactions (Bonk, Hansen, Grabner-Hagen, Lazar, & Mirabelli, 1998), more reflective responses (Davidson-Shivers, Tanner & Muilenburg, 2000), increased group interaction (Eastmond, 1992), more equitable communication patterns (Harasim, 1990), and enhancement of the quantity and quality of students' solutions to case-based problems (Benbunan-Fich & Hiltz, 1999). Used alone, however, the hierarchical organization of such tools can obscure rather than expose the group's line of reasoning (Hiltz, Johnson, & Turoff, 1986); because new posts are added chronologically, the content of each thread can become more and more diffuse, leading to "a sense of information overload and confusion about the intellectual focus of the community" (Hewitt, 1997). In order to prevent this outcome, we combine such discussion with a shared workspace for recording the group's consensus argument, the Group Report.

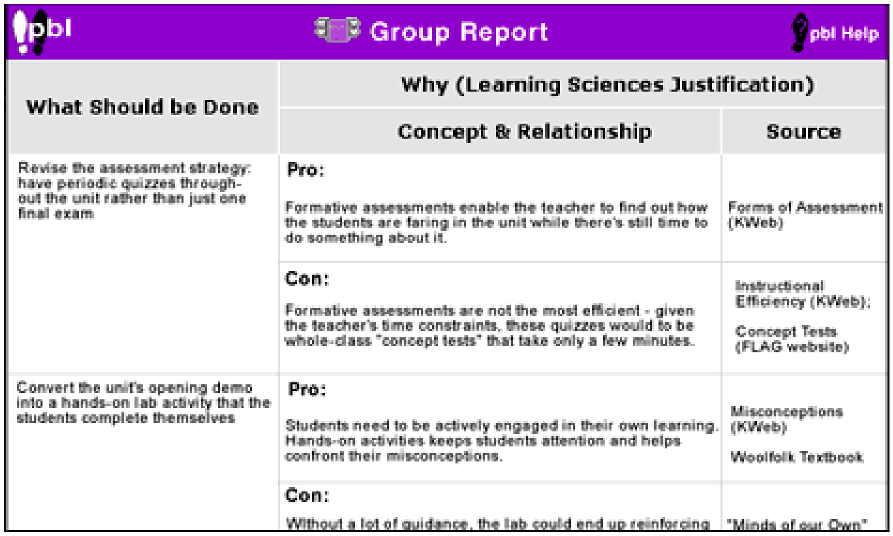

Figure 4. Interface of the Group Report, a collaborative pop-up workspace in which group members post their consensus ideas.

As depicted in Figure 4, the Group Report is a more elaborated version of the two columns of the Initial Ideas tool that individual students use prior to group work to record their initial ideas (i.e., "what should be done" and "why it should be done") with the addition of a space in which to cite both confirming and disconfirming evidence (for a classic discussion of "confirmation bias," see Wason & Johnson-Laird, 1972) and a space in which to cite the source of their claims. Using this tool, each group records its consensus solution ideas and the relationship of these ideas to the results of the group's pooled learning science research, making the group thinking visible for students and staff alike.

As with the Initial Ideas tool, the course manager will be able to select the layout and text prompts of the tool; although, again, we intend to empirically study the effects of different "representation guidance" (Suthers, 1999) on learning outcomes so that the set of options we provide instructors will be based on research. Our research on this issue follows the work of Suthers (2000), which demonstrates how alternative representations of relationships among claims and evidence shape the discussion of groups using them. The Group Report tool presented in Figure 4, for example, coordinates both individual and group activities by (1) making the constituent elements of the group argument (i.e., claims, pros and cons, evidence) salient and therefore more likely to be attended to, negotiated and elaborated upon, (2) making the relationships between these elements explicit, thereby providing a framework within which group members can negotiate how the results of their research bear on their solution ideas, and (3) makes the gaps or absences within the argument conspicuous, hence a topic for discussion. Different Group Report representations, then, should foster different forms of collaborative reasoning, making the design and systematic investigation of alternative tool formats a worthwhile avenue for future research.

Case & Research Library

The problems students solve in our environment will be structured around videocases of actual classroom instruction. We are beginning to develop a *Case Library* that eventually will incorporate a full spectrum of instruction — from innovative, research-based instruction to conventional pedagogical techniques — so that the preservice teachers taking our course are exposed to both *model instruction* (innovative pedagogies that are *not* always represented in the schools where they observe and teach) as well as *instructional problems* likely to be encountered out in the field. Using video rather than text exposes students to the complexities of in situ teaching practice, in all its "buzzing confusion"(Grossman, 1992), thereby deterring reductive bias (Spiro, Feltovich, Jacobson, & Coulson, 1991) and fostering high levels of transfer (Siegel, Derry, Steinkuehler, Kim, & Seymour, 2001; STEP, 2000). STEP research on the design and evaluation of collaborative case-based teacher education is extensive; for further discussion, see Derry & STEP (2002) in this volume.

Once the course manager selects the content materials students are to work with from the Case Library, the appropriate case and case-related materials (e.g., demographic information, the teacher's handouts and overheads, interviews with the teacher and/or students) are automatically made available to students from within the Student Module Interface. The Case Library is part of a larger section of our site called the *Knowledge Web* (Derry & STEP, 2000). The Knowledge Web is a densely interlinked network of learning science concepts connected to each videocase (see Figure 1). Each videocase, then, is linked to related learning science concepts that serve as a "jumping off" point for student research. Each page of this hypertextbook resource contains an overview of a given concept, examples of its application to instructional design, and a list of further resources for more in-depth research. In addition to the Knowledge Web, the Research Library also contains links and references to both online and offline research resources, including online journals, recommended websites, suggested textbooks, and relevant academic journal databases such as the Educational Resources Information Center (ERIC) and the American Psychological Association's Psychological Abstracts (InfoPsych).

pbl Help

Finally, students are also provided extensive online help resources that contain (a) elaborated explanations of each step in the activities, (b) a glossary of terms, (c) worked examples of each product, and (d) directions for how to use each resource and tool. The interface of this pop-up window is similar to the interface of My Notebook (Figure 3); each category of help resources appears as a tabbed page in a sequence of pages. This searchable resource is tightly integrated with the Student Module Interface: when opened, the materials related to the currently active activity or tool appear highlighted and in the main space of the pop-up window; disciplinary "jargon" appearing on activity pages is linked to definitions in a glossary; and each activity step prompting the creation of a product or artifact is indexed to related worked examples of that product.

ACCUMULATING KNOWLEDGE & PRACTICE

Our technology-based model for reform in teacher education has, to date, only been implemented in one course; however, the *socio-technical infrastructure* we are developing through a continual cyclical process of design, development, research, and redesign has tendrils out into the community (e.g., the cooperating teachers in the local schools where our students implement their instructional designs) and into other courses in teacher education both locally (University of Wisconsin-Madison) and nationally (Rutgers University), vertically (courses in different semesters) and horizontally (courses within the same semester) (Derry et al., in press). Our work has focused on the simultaneous development of a *social infrastructure* (pbl) for collaborative production and "worrying" of knowledge through the process of developing artifacts (instructional designs), and a *technical infrastructure* that can support this community in a context-sensitive way. Our current system is in its early intermediate stages and, given the bottom-up needs-based approach we take to its development, will surely evolve in ways we currently do not anticipate.

An intelligent "grounded" approach to development, however, would not be possible were it not for the fact that our socio-technical environment simultaneously serves as our research instrumentation. Behind the interfaces of our interlocking modules is an extensive database with the capacity to generate an ever-thickening history of use (Steinkuehler et al., in press). It is this thick history that guides our development in apt ways. Ongoing analyses of data from preliminary trials of our environment have helped us identify community members' needs, intersections between and within system components where we can increase the system's flexibility so that it remains community- and context-sensitive, and obstacles both students and staff encounter when working within the context of our course. With every such trial on our system, we gain one more layer of description: what the students and staff members did and the ways in which it was successful or unsuccessful, the challenges community members encountered and the ways they moved beyond them, and unanticipated issues that emerge. For better or worse, our monitoring and assessment systems traces and records nearly all user behavior, from minutiae such as which glossary terms Individual A accessed, in what order, and for how long, to more global information such as the percentage of students who successfully accessed the Knowledge Web. The trick is: *putting all these data in the service of current and future communities.*

Our site development strategy stems from our definition of "knowledge-building communities" as those focused on the joint production and negotiation of shared practices and artifacts: *accumulate wisdom and practical skill through repeated trials and then distribute it across resources, tools, and artifacts*. The online resources we are building "artifact" our community's accumulated wisdom; they provide newcomers (Lave 1991), whether they are researchers, students, or staff, access to the experiential knowledge members of our community have developed over time. Students' successful solutions are later archived as worked examples of each product that future students can access; productive research resources are later listed for student use; learning science concepts that previously proved useful for specific problems and videocases are compiled in a *Target Group Report* for tutors working with groups grappling with the same problem; frequent questions, misconceptions, and difficulties populate resources in the Tutor Module so that instructional staff can consider the ongoing deliberations of their current student groups in a broader historical context; and our own research on student and staff cognition within the environment is folded back not only into the course manager resources but also into very structure of the overall system design. In this way, we are able to provide an ever-thickening history for new members to access. Our hope is that, in so doing, we will help foster knowledge-building communities not only *horizontally* within each cohort of system users as they move through the system's activity space but also *vertically* among different cohorts over time.

CURRENT RESEARCH DIRECTIONS

We too are part of that secondary teacher education community though our participation not only as developers but also as *researchers*. We are embarking on three broad strands of research: (1) tutor cognition, (2) group interaction and individual cognitive change, and (3) longitudinal effects of our course on teacher practice. Our research on tutor cognition will include comparisons of expert versus novice tutor performance online, tests of the effectiveness of our Tutor Module system in scaffolding the performance of minimally trained and inexperienced staff, and development of a procedural model of what successful tutors do during group discussion, specifying the schematic conditions that elicit tutoring moves, what tutoring moves are made, and what results from those moves. Our plans for future research on the relationship between group interaction and individual cognitive change include comparisons of online versus face-to-face pbl group collaboration in order to characterize the impact of our system on group discourse, and investigation into the characteristics of the group argumentation our system fosters and the relationships between these characteristics and individual cognitive change (as evidenced by within-subject comparisons of pre-analysis and final solution proposals). Our most extensive research program, studies of the longitudinal effects of our course on teacher practice, entails several investigations and comparisons: assessment of the course's impact on students' concurrent practicum experiences and subsequent student teaching, multiple measures of students' perceptions of and attitudes toward the course, pretest/posttest comparisons and time-series assessments of student performance, attitude, and useful knowledge (i.e., ability to transfer), and examination of the relationship between these longitudinal data and performance on specific activities within the course.

Online technologies hold great promise for teacher education. When combined with the appropriate social structures, they enable us to imagine wholly new forms of community and collaborative work by widening the horizon of viable models for teacher education and professional development. In so doing, they broaden our understanding of what constitutes elusive entities such as "learning" and "community" in the first place. Online technologies make the concrete obstacles to reform in teacher education — limited physical space, uncoordinate-able schedules, physical distance, training and staffing constraints, etc. — more surmountable. Even the more subtle hurdles — professional risk, competing discourses, etc. — may eventually be overcome with the help of technology. Technologies "do not simply cross space and time; they also can cross hierarchical and departmental barriers" (Sproull & Kiesler, 1991, p. ix). Accomplishing this will require substantial time and sustained effort, yet it is our hope that the end, in this case, will be worth the effort. In the words of Michael Fullan (1993), "You cannot have students as continuous learners and effective collaborators, without teachers having the same characteristics" (p. 46).

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