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From Parallel Play to Meshed Interaction: The Evolution of the eSTEP System

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Abstract. In this paper, we describe the evolution of the eSTEP system. The eSTEP system is an integrated online learning environment for teacher education that provides videocases of classroom practice, an online learning sciences hypertext, and a collaborative problem-based learning environment. The central tool in the problem-based learning environment is the group whiteboard. In face-to-face PBL activities, a whiteboard serves to focus negotiation and represent current understanding. Seeking to offer the same functionality online, we adapted the structure and functionality of a basic whiteboard to easily allow students to exchange and develop ideas online, and effectively represent current understanding. This tool serves as the focus of negotiation in face-to-face PBL but required considerable adaptation to serve this function in an online environment. This paper describes the refinement of the whiteboard and the concomitant refinement of our theory of how students learn through meshing the conceptual ideas of the learning sciences with perceptual information from the problems of practice.

Keywords: problem-based learning, scaffolding, design principles

INTRODUCTION

Problem-based learning (PBL) is an effective approach to collaborative learning in professional education environments (Hmelo, 1998; Hmelo-Silver, 2004, Derry & Hmelo-Silver, in press). It provides a cognitive apprenticeship in which students learn through solving problems and reflecting on their experiences. Students work in small collaborative groups with a facilitator who scaffolds the learning process. PBL promotes effective transfer because students repeatedly bring together conceptual ideas underlying a domain with visions and plans of professional practice as they construct what we call a meshed schema representation (Derry, in press; Derry & Hmelo-Silver, in press). In PBL, learners study and discuss concepts in depth, applying them to practical problems and they become highly practiced in recognizing how these ideas and reasoning are used in varied problems across many *cases* of practice. In our work with pre-service teachers, many instructional video cases are provided, to give pre-service teachers opportunities to experience and encode them perceptually within complex contexts similar to what they will actually experience (Derry, Hmelo-Silver, Feltovich, Nagarajan, Chernobilsky, Halfpap this volume). These activities help learners build up schemas in which different and varied kinds of knowledge (declarative, procedural, and perceptual) are meshed together in ways that emphasize the deeper conceptual themes). This concept of mesh was not a part of our initial instantiation of the PBL in the eSTEP system. The goal of this paper is to present a design narrative that shows how our design of the eSTEP system evolved, as well as how our theory about learning from video was refined. All the design and testing rounds were with different groups of preservice teachers, both at Rutgers University and at University of Wisconsin-Madison (see Chernobilsky, Nagarajan, & Hmelo-Silver, this volume; Derry et al, , this volume). Our goal was to help the preservice teachers understand how the learning sciences applied to classroom practice. Our data for the initial rounds of work were indicators of engagement—posts in the eSTEP environment. For later rounds, we collected detailed process data (Chernobilsky et al; this volume; Hmelo-Silver, Chernobilsky, & DelMarcelle, 2004) as well as information about learning outcomes (Derry et al., this volume).

PBL has its origins in medical education. In this environment, typically a group of 5-7 students work with their own facilitator (Barrows, 2000). The facilitator provides instructional guidance by scaffolding the learning process. Much of this scaffolding is in the form of metacognitive questions that help structure the group's learning and problem-solving processes, help them manage their time, and push them to think deeply (Hmelo-Silver, 2002). In addition to the scaffolding provided by the facilitator, a structured whiteboard helps support the group's learning and problem solving. Typically, this whiteboard has four columns: facts, ideas (hypotheses about causes of problems and solutions), learning issues (concepts that the students need to learn more about to solve the problem) and an action plan (a "tickler" list). The whiteboard provides a focus for students to negotiate and represent their understanding of the problem and possible solutions, and it inherently then guides discussion (Dillenbourg, 2002; Hmelo-Silver, 2003; Suthers & Hundhausen, 2004). Other settings are not as privileged and require additional scaffolding to support PBL in larger classes. Because of the small group nature and close instructional interaction of PBL, it is resource intensive, requiring a larger instructional staff to support the same number of students than a more traditional instructional method (Steinkuehler, Derry, Hmelo-Silver, & DelMarcelle, 2002). The first author had engaged in PBL in her face-to-face educational psychology class for two years using paper cases and had identified some areas of weakness that computer-based scaffolding might address (Hmelo-Silver, 2000). Rather than an assigned facilitator, Hmelo-Silver used a wandering facilitator model. This only allowed short periods of time with each of the groups and reduced the amount of scaffolding and monitoring that could be provided. In addition, the paper cases were not always sufficiently complex for students to see how concepts applied in a variety of cases. Thus, prior to creating an online PBL version, we identified several problems that we hoped an integrated online environment could address. But just putting PBL online required careful consideration of how the environment could serve to structure the process.

A major adaptation was a move from synchronous face-to-face discussion to an asynchronous online discussion. There were two reasons for this adaptation. First, students in an asynchronous discussion tend to be more reflective (Andriessen, in press; Bonk et al., 1998). Second, it is easier for `a single instructor to facilitate multiple groups in an asynchronous environment than in a synchronous environment. Research on scaffolding suggested that domain specific scaffolding might be more effective in the online environment (Hmelo & Guzdial, 1996, Hmelo-Silver, in press, Reiser, 2004) than the general whiteboard used in face-to-face PBL. To accomplish this, we needed to design a whiteboard that would specifically promote principled instructional design activities. Thus we wanted to use an online whiteboard (and other tools) to help structure the collaborative PBL process and promote productive learning interactions (Dillenbourg, 2002). We wanted to strike a balance between productively constraining the group interaction while allowing the process to remain student-centered.

ROUND 1: MOVING ONLINE WITH PARALLEL PLAY

Our initial goal was to do a simple online adaptation of a modified PBL activity structure to help preservice teachers learn how to apply the learning sciences to teaching practice. This activity structure focused on having students use the learning sciences to interpret, evaluate, and redesign actual video cases of k-12 classroom instruction. We wanted to use video cases to make the problems more realistically complex than our paper cases afforded. To support small group interaction, the initial online environment included a personal notebook for individuals to record case analyses and reflections, a structured group whiteboard to serve as a focus for negotiation as the whiteboard did in a face to face environment, and an asynchronous threaded discussion to allow students to engage in less structured discussion. For instructional resources, in addition to standard textbooks, students had access to the Knowledge Web, which is an online hypertextbook focusing on the learning sciences. In sum, our initial system had five parts: an individual notebook (see Figure 1a), a group whiteboard (Figure 1b), a threaded discussion, a videocase library, and a learning sciences hypermedia, the Knowledge Web (DelMarcelle, Derry, & Hmelo-Silver, 2002; Derry, in press).

<table>
<tr><th colspan="4">Individual Whiteboard</th></tr>
<tr><th colspan="2">Observations</th><th colspan="2">Initial Redesign Ideas</th></tr>
<tr><td>What facilitated learning?</td><td>What hindered learning?</td><td>What should be done.</td><td>Why it should be done.</td></tr>
</table>

Figure 1a. Round 1 Individual Whiteboard

The first implementation of PBL was a pilot activity that required students to analyze a video case of science instruction. In this case, the teacher was not achieving the learning outcomes that he had hoped for. The problem required students to redesign the video case, based on an analysis of the case from a learning sciences perspective. To facilitate students' initial analyses and subsequent group analysis and redesign, we designed a structured individual notebook designed to scaffold the initial analysis. To promote argumentation, the group whiteboard provided a space for students to post their ideas and a place for students to post notes that identified strengths (pro) and weaknesses (con) of the proposal.

The specific prompts chosen in these scaffolds created representations that we had hoped would bias the discussion in productive ways. The initial activity structure was quite simple. It had three phases. Students were asked to do an individual case analysis, a collaborative analysis in the threaded discussion, and to develop a redesign proposal in the whiteboard. This activity design was tested in two groups that were experienced in using PBL in a face-to-face format. This particular PBL activity was their last of six that they were required to complete for their educational psychology course. The activity occurred entirely online.

While both of these groups had functioned effectively over the course of the semester in a face-to-face format, they were not terribly effective online. We identified three potential reasons. First, we observed a parallel play phenomenon—that is, the students did not coordinate their postings. Students were moving through the activity on parallel paths without meaningfully interacting with one another. For example, one student might post, another student might post another note 1-6 days later as the facilitator (CHS) noted in her journal "I am still frustrated with the parallel play aspect of the activity. I think that first few times students do a problem like this they will need a lot of structure in the task, in terms of milestones and required numbers of notes in which part of the site. As I have said before, a big problem is the disconnect between the web board and whiteboard. I don't know if we could use the idea of anchored collaboration…" The students' proposals for solutions tended to be somewhat independent of each other. This is antithetical to the central tenet of PBL, that ideas are collaboratively reviewed, negotiated, and decided upon. Second, the structure of the activity was very broad. Norms of interaction did not simply translate to the online environment. Although two weeks were allotted for the group phase of the activity, the students tended to think of that as a deadline and some students did not post anything until the final date. Unlike a face-to-face format in which silence is awkward, in an online environment silence is difficult to break. The facilitator spent a great deal of effort emailing students to encourage them to get online and join the discussion Third, it was difficult to facilitate because of technical issues. For example, the facilitator could not post to the group whiteboard. So, if a student posted something to the whiteboard, the facilitator could only question that in the threaded discussion and the context for the question was lost.

<table>
<tr>
<td rowspan="2">Peter: I think we should instill more questioning in the class. The questions the teacher asks at best seem to be short answer.</td>
<td>Pro:
Peter: Engaging students in dialog transforms the teacher directed monologue into an interactive process where students are encouraged to analyze synthesize and evaluate information
--The Knowledge Web

Camilla: Engaging the students in dialogue about the topic is a good idea because it gets the students really thinking about and processing the information they are being taught as opposed to just listening to the teacher lecture them on the topic.
-- Knowledge Web.</td>
</tr>
<tr>
<td>Con:
Peter: Some problems that might occur are that the teacher or discussion leader needs to be aware of the dynamics of the group which may be hard to do if their on a limited schedule and only spend limited time in the classroom.
--The Knowledge Web

Camilla: When the students do have a group discussion or multiple group discussions, whoever is facilitating or leading the discussion MUST have a complete understanding of the topic. If there are multiple groups, then 1 person in the group has to understand the topic fully and that may be difficult for the teacher to find. And if there is just a class discussion, then the teacher may not be able to get everyone to participate, depending on the class size.
--Knowledge Web.</td>
</tr>
</table>

Figure 1b. Round 1 Group Whiteboard

This initial experience identified several important issues, both theoretical and practical, that would need to be addressed before the next implementation round. First, the activity structure needed to more forcefully encourage interaction and discourage parallel play. Second, we needed to recalibrate our expectations for how norms of interaction would transfer and develop online. Third, from a cognitive apprenticeship perspective, the representations and activity structure needed to better scaffold the students' learning and problem solving (Collins, Brown, & Newman, 1989; Hmelo-Silver, in press). The activity structure and multiple workspaces were not integrated in a meaningful way that communicated an approach to learning and provided an impediment to the human facilitator trying to work online, which is a frequent challenge in developing CSCL environments (Dillenbourg, 2002). Thus, this initial experience demonstrated the need for distributing some of the facilitation onto the interface and activity structure (Steinkuehler et al, 2002).

ROUND 2: GETTING STUDENTS ENGAGED

For the next round, we redesigned and structured the activity to address the concerns mentioned above. Yet we still needed to embody a student-centered learning process that provided more milestones for the students' activity. First, we reconceived these phases of the activity and their milestones as timeframes rather than as deadlines to try to make this a continuous activity rather than one with discrete deadlines. We divided the activity into 12 discrete steps to help the students manage their time and effort as shown in the roadmap in Figure 2a. Second, the titles of the steps more clearly communicated what students might expect in each part of the PBL activity. In addition to better structuring the task, the task itself was simplified. Rather than having students redesign a lesson, they engaged in a collaborative conceptual analysis of two small minicases, chosen from a complete video case that contained 10 minicases. The prompts in the individual notebook were designed to help students focus on pertinent aspects of the case and to help them make decisions about what minicases they would analyze and the concepts they would explore in depth (Figure 2b). After the group analysis, students were required to design their own individual lessons incorporating what they learned from the analysis. The threaded discussion board was the place for students to (1) decide on the minicases they would analyze, (2) choose concepts to explore, and (3) make comments for a scribe chosen by the group to incorporate into the conceptual analysis in the whiteboard tool (Figure 2c). Again the whiteboard was supposed to be a shared context that provided a focus for discussion. The activity was designed to be completely online with initial individual analysis, joint group analysis of a section of the case (the "minicase") and then individual design of a lesson. This design overcame the parallel play problem—students posted and responded to each other's ideas (DelMarcelle & Derry, 2004; Hmelo-Silver & Chernobilsky, 2004). There was also a great deal of interaction—but this occurred entirely in the threaded discussion.

Figure 2a. Round 2: The road map

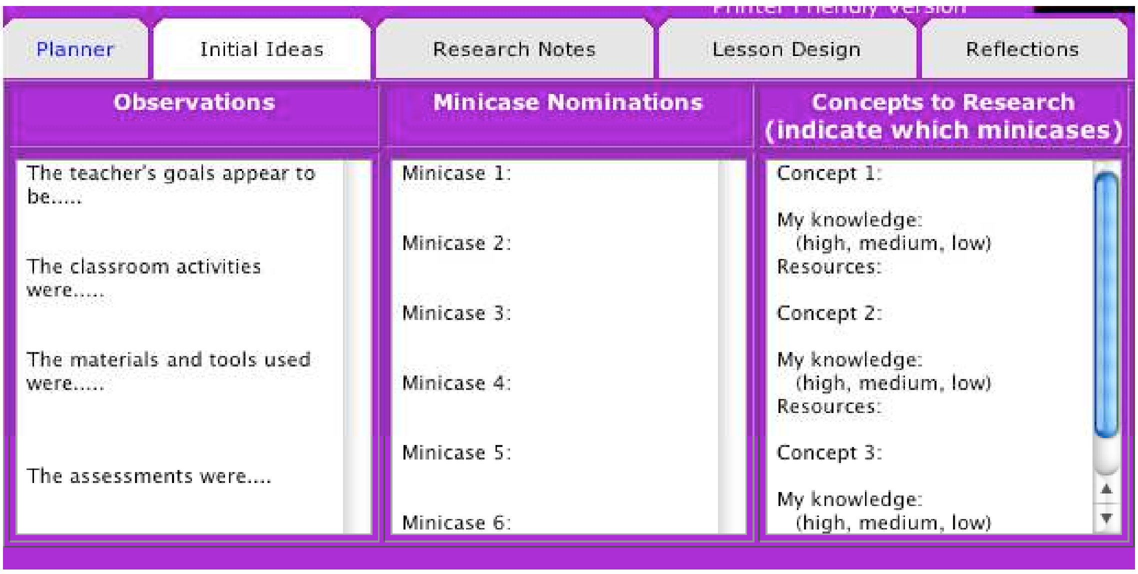

Figure 2b. Round 2 Individual Notebook

Reflecting on this implementation we identified two major problems with this design. First, the whiteboard itself did little to focus group discussion in productive ways. We had succeeded in getting students engaged in the activity but not always productively. Often their posts involved either elaborated conceptual discussion without strong connections to the case or alternatively, were very grounded in the case with superficial connections to conceptual ideas. For example, Figure 2c shows the students using a lot of vocabulary to describe what the teacher, Kyle, should be doing. They make some connections to the specifics of the case (Kyle controlling the discussion) but they do not provide evidence to back this up. Although the students exhibit a clear preference for a student-centered discussion, it is not clear how well they understand why this should enhance student learning. From a procedural standpoint, the roles that students needed to play in this activity were somewhat inauthentic and not optimal for learning. For example, one student had to be designated as the scribe to put up the entry for the entire group. Negotiation had to be conducted in the threaded discussion. This made it difficult to integrate the threaded discussion with the conceptual analysis on the whiteboard. The lack of integration made facilitation difficult. In the example above, the facilitator might have wanted to push students on their understanding of the concepts that they had mentioned but lack of integration made this difficult. This experience made it clear that the design had to provide representations that could support and guide anchored collaboration (Guzdial et al., 1997; Hmelo, Guzdial, & Turns, 1998; Suthers & Hundhausen, 2004). In anchored collaboration, discussion is "anchored" around the artifact being discussed—i.e., the students needed to be able to comment directly in the whiteboard, which was not possible in this implementation.

Second, the activity provided structure, albeit a complex one. The discussion was the major place where students worked, as this particular group posted 147 notes in 18 threads over six weeks but it offered no guidance to focus the students. Many posts were devoted to choosing the specific minicases to examine and deciding which concepts would be explored (DelMarcelle & Derry, 2004). The next round needed to address getting students beyond procedural issues and towards deep discussions that engaged students in wrestling with knowledge. In addition, the conceptual analysis was not clearly connected to the students' goal of designing an individual lesson, thus the activity structure needed to be more coherent.

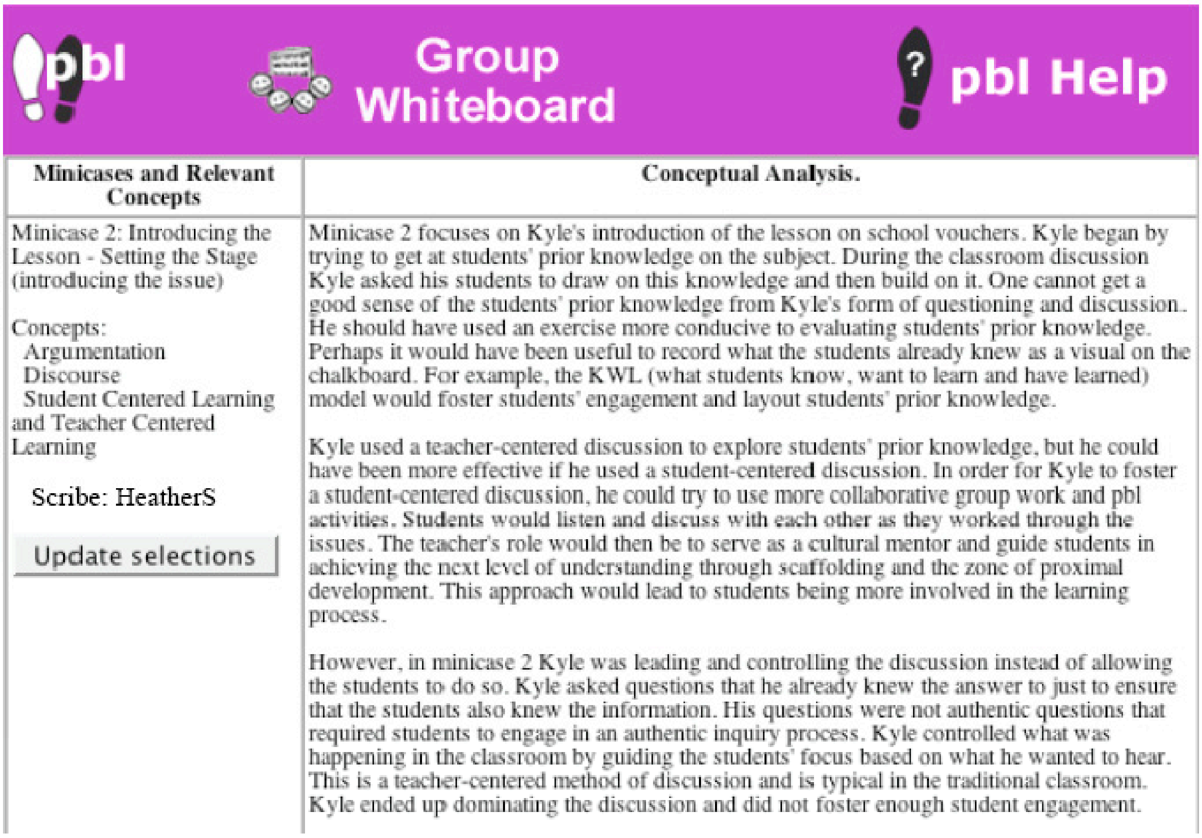

Figure 2c. Round 2 Group whiteboard

In addition to addressing the practical problems we identified during round two, we also developed theory about how students learn in complex knowledge domains. Derry (in press; Derry et al., this volume) argued that transfer of ideas from the classroom to future practice requires helping students develop representations that support complex forms of cognitive "meshing" among concepts, skills and perceptual visions of practice. We conceptualize both pre-professional learners and the practitioners as people who experience their environments through cognitive processes that are essentially perceptual in nature. These processes involve (1) perceiving situations in the environment, which activates complex cognitive patterns within individuals, and (2) responding to those perceived situations with understanding and actions, in ways that hopefully apply previously acquired course knowledge. It is important then to teach so that ideas, including concepts (e.g., attention, metacognition), and skills (e.g., scaffolding, reciprocal teaching) covered in our courses, are later assembled both to explain situations encountered in later professional practice, and to support planning and appropriate actions in those situations. This evolving theory started initially as a refinement of early ideas about PBL, cognitive flexibility theory (Spiro et al., 1988), and cognitive apprenticeship (Collins, Brown, & Newman, 1989) but became something quite different as we compared our intentions in design, the actual implementation of our first two rounds, and comparisons with the interactions that occurred in face-to-face discussions (Derry, in press; Hmelo-Silver, 2000; Chernobilsky, DaCosta, & Hmelo-Silver, 2004). We needed to support interactions that *meshed* ideas about the perceptual information from our instructional redesign problems with conceptual ideas about the learning sciences through both our whiteboard design and activity structure. We attempted to address all these issues in the next round of design.

ROUND 3: TOWARD MESHED INTERACTION

We made a number of changes for our third design round. First, we reduced the complexity of the activity structure, as the revised road map shows in figure 3a. This new activity structure also was more authentic than prior activities. Rather than focusing on a conceptual analysis task, we structured the problems to be either redesigns of the lesson in a video or adaptation of techniques shown in a video. Thus there was a clear problem for the students to work on. We also used a hybrid activity structure in which some of the activity occurred online but steps that required students to discuss procedural issues occurred face-to-face (e.g., deciding which concepts to explore). We very explicitly embedded the backward design process, developed by Wiggins and McTighe (1998) throughout the online activity beginning with the preanalysis recorded in the individual notebook (Figure 3b). This helped provide a structure for the activity as a whole and for the whiteboard and notebook tools in particular as it provided a principled model for instructional planning. In this approach, students began by identifying the big ideas worth knowing, considering what might be evidence of that understanding, and then planning instructional activities that would provide that evidence.

Figure 3a. Round 3 Road Map

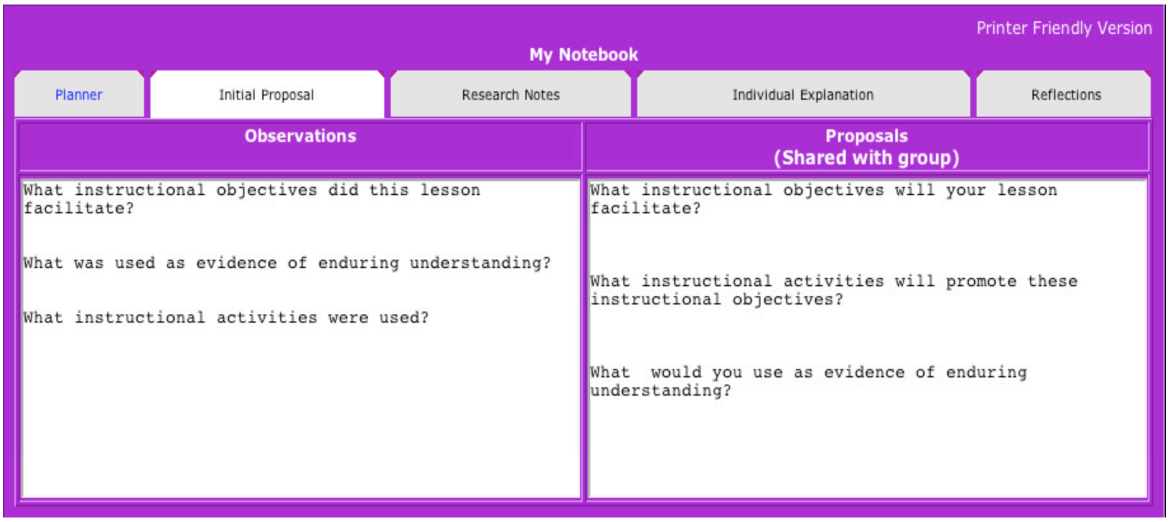

Figure 3b. Round 3 Individual Notebook Example

With mesh as a goal, we reflected back on prior implementations. Because the earlier activity structures and group whiteboard seemed to hinder complex discussion, we redesigned the group whiteboard to more seamlessly connect design and adaptation proposals to discussion spaces. In this round, the whiteboard included an integral discussion space as shown in Figure 3c. In the example shown here, students were using contrasting cases of lessons about static electricity. The students were told that the first teacher had attended a workshop given by the second teacher and, as a result, that he wanted to redesign his own lesson. In practice, students would post ideas or proposals for redesign and the board would automatically attach a comment space for each group member to reflect on, evaluate, and provide feedback on the proposal. This design addressed two critical issues. First, it clearly and effectively represented potential solutions to the problem along with the associated discussion of each solution. In prior implementations, solution ideas and the discussion of them quickly diverged. Second, these two spaces were physically connected allowing students and facilitators to easily interact with one another. In particular, this allowed the facilitator to help support perceptual-conceptual meshing by being able to ask questions that are anchored to the students' comments. After a student entered a proposal, each group member had a space to comment on that specific proposal. Not shown in Figure 3c is the facilitator's comment "Great discussion folks-- what is the psychological rationale for having students work on experiments? See Sally's comment below as well." As this example shows, the students were all able to post responses to this proposal for an activity as well as posing questions to the rest of the group ("What does everyone else think?"). In addition, although the software had the limitation of only being able to provide one comment on any proposal, this group developed norms to maintain all their comments in their response boxes. This design accomplished making the whiteboard the focus for negotiation. In this particular problem, which the students worked on for two weeks, there were 50 posts in the whiteboard and only 20 posts total in the discussion board, mostly for the purpose of sharing research. Students appeared to be engaged in productive ways as demonstrated by the number of posts and detailed analyses of student discourse (Chernobilsky et al, this volume). Over several semesters of using this learning environment design, students in the eSTEP environment demonstrated significant learning gains compared with students in a comparison group (Derry et al, this volume).

This design clearly accomplished the goal of creating interaction focused on the students' proposals for assessments and activities. What evidence then do we have that they are meshing the conceptual and perceptual ideas? In the proposal below, Maria talks in somewhat general terms about trying to apply a cognitive apprenticeship to design a learning activity, specifically using the notion of scaffolding as well as the need to apply what they learned to a real life situation. Carrie proposes the idea of a prediction sheet and then Maria, in her comments, talks a little more about the need to help structure the activity. Carrie jumps in at one point to ask about the connections to the video they watched. The group works together to clarify their understanding of what they saw in the video as well as to refine and specify an activity that might fit their notion of a cognitive apprenticeship, in particular, focusing on scaffolding and context. Sally later posts, in response to Carrie's ideas about experiments and adds the notion of deliberate practice to help the students learn inquiry skills:

> I think that it's a good idea, but I think them actually doing the experiment would be much more beneficial to the students. It would give them a way to critically think and plan out an experiment then test it out and see what works and what doesn't. Then they can modify it to make it work or work better. I think them having hands on experiments helps them really learn the concepts and helps them make connections to things they might not by just thinking about it. You may think something'll work, but when you try it you realize that you missed something or something is wrong….If they don't test them out they should be able to write something or explain to the class and teacher why they feel it would work and be able to answer questions about it… it! The teacher could walk around and give feedback throughout the experiment. In How People Learn it says that "learning is most effective when people engage in 'deliberate practice' that includes more active monitoring of one's learning experiences" (58-59) I think that hands on activities allow students to deliberately practice what they are learning and can be very beneficial to learning.

Elsewhere, Linda proposed that the teacher engage the class in concept learning and initially provides a fairly decontextualized description, concluding with "Blair Johnson should use this idea so that static electricity does not become an isolated concept in students minds that they will not be able to use. Finally, teachers should use concepts in "REAL LIFE SITUATIONS" as this has been shown to "increase chances of transfer, link ideas to prior knowledge, and decrease chances of misconceptions." Here Linda was meshing notions of concept learning with general advice to the teacher.

Proposal 6 by MariaM

Last edited: 04/05/2004

Proposal:
I think one way we can incorporate all these ideas into an instructional activity would be to break the class up into groups and have them discuss the concepts of static electricity. We could design a question and answer sheet that would help the students in "cognitive apprenticeship. In other words e need to facilitate or even initiate a discussion that would help the students to inter act and create a scaffolding. Once the teacher observes the students displaying the evidence of enduring understanding she can then implement fading and allow the students to act as the facilitators gaining knowledge be explaining to others what is not understood

Second and experiment could be designed for the groups and a prediction sheet should be handed out. Each student can then explain why he/she thinks their predictions will work and hw they will go about testing the materials. Each group should then present to the class
Why they chose the method that they did
What worked and what didn't
What were their misconceptions and what did they already know.

Lastly a real life scenario should be given to each student and they should be asked to apply the concepts they learned to this situation. For example why a person's hair sands on enc when static electricity is applied to the body. The students should e able to explain why this happens in concrete terms using the concepts they have explored during experimentation.

Research Findings:
http://stellar.wcer.wisc.edu//step/theories/TheoreticalPerspectives/SocioculturalTheory/CognitiveApprenticeship

2 of 0 users. Included in Final Product

Do you support the inclusion of this proposal in the final Group Product?
Yes No Vote

Comments by SallyA:
I see where Maria is coming from when she discusses the above! I feel that they are really good ways of handling the situation at hand ands I was thinking along similar lines when she talked about the real live scenario and the questions and answer sheet! I never thought of a prediction sheet, but now that she mentions it, it seems like a great idea! What else does everyone think?!

Comments by MariaM:
I think having the students design the experiment is a good idea however we are talking about Mr. Johnson's class. These students may not have enough knowledge to design an effective, thought provoking experiment. Having a discussion on how to test concepts might work, however we want them to learn about the components of electricity, (opposites attract, same charges repel) I think it would be difficult for them to design any activity when we are trying to get them to learn. Designing the activity is a part of structuring their abilities. We need to provide some structure in the initial fazes. However, we could ask them to design an experiment to test their findings as a step towards summative assessment.

Comments by CarrieM:
New comment: Maria, I know what you are talking about with the whole developing a experiment being a good idea to do but then again, in Etkina's class she did not have the groups design their own experiment – she gave them the task/experiment of the tape for them to work on in groups to determine which of the 3 hypotheses they came up with prior to the experiment where true in the end. So what I am wondering is are we saying we want Blair Johnson to have students develop their OWN experiment or use an experiment he assigns to them as Etkina did??? Either way, I think the experiments assist the learning process because it gets students to work with the material.

Old comment: I did not remember either, Patricia. I went back to the clips and watched the ones about the tape experiment. Etkina gave the introduction tot he experiment to the class as a whole and said: "Professor: Imagine… here it goes… imagine you can pull these tapes that are stuck to the table off the table… what do you think should happen, based on all your knowledge of electric processes, to these two tapes if you put them close to each other?" After that, the class has a discussion about what they thought would happen, and after the discussion came to a conclusion of 3 possible predictions about what the tape experiment would illustrate. Then the next clip showed them go into their groups and do the experiment themselves to figure out which one of their predictions were going to be true.

Figure 3c. Round 3 group whiteboard

These are just a few examples of many that could be used. We attribute part of the success in creating mesh to providing this anchored collaboration environment, in which students' (and the facilitator's) contributions and reflections are connected to authentic planning activities and the rich perceptual experiences the video cases afford. In addition, in this round, the facilitator became a full participant in the group work. Because of the specific place allocated for the comments on the white board, the group members respond to the facilitator's efforts at scaffolding learning. The group shown in these examples was particularly good at meshing their conceptual and perceptual ideas. But they also demonstrated some limitations in the system. They developed a norm of labeling their comments so they could keep track of their discussion as they labeled their comments as old and new. As groups engage in lengthy discussions, we need to keep the advantages of the integrated space but find a way to give them room to grow. Although there is still work to be done and variability among how groups use the whiteboard, we have constructed a whiteboard design that meets our initial practical goal of a providing a space for negotiation and our later theoretical goals of supporting conceptual-perceptual meshing.

DISCUSSION

This paper tells the story of the evolution of our design through hypothesis generation about what features would support the kinds of discussion we hoped to promote, implementation of the design, followed by critical analysis of interaction patterns. Our experience in designing for productive interaction led us from a focus on pragmatic issues of taking an effective instructional model and adapting it for online use to one of instantiating a theory of how people effectively learn from cases. We went from an under constrained environment to a very highly scripted version and found an appropriate middle ground that met our instructional and theoretical goals (Dillenbourg, 2002). As Dillenbourg notes, CSCL designs need to create activity structures that integrate disparate individual and collaborative activity phases as well as face-to-face and computer mediated communication. Such designs need to consider landmarks for managing time and the important role of the facilitator. There are risks in such designs, several of which were experienced in the evolution of eSTEP. In particular, our first two rounds of design disturbed the kind of natural interactions that needed to occur. In Round 1, the interface did not make it clear how the whiteboard and the threaded discussion were related so these tools failed to shape the collaboration in productive ways. In Round 2, breakdowns occurred when the activity structure did not help the students come to consensus on their choices of what concepts and minicases to focus on. In addition, the complexity of the activity structure in Round 2 may have served to increase the cognitive load of the group members.

In the tradition of design experiments, our goals were twofold: to develop and refine theories about learning and to “engineer” the means to support that learning (Cobb, Confrey, DiSessa, Lehrer, & Schauble, 2003). Our iterative design process was a reflexive one in which our instructional theory both informed and evolved from our system design. In the beginning, having never implemented a collaborative activity in an online environment, it was expected that we would make a few mistakes. Simply learning the constraints and affordances of the technology and how students would interact with it was an initial goal. As we began to see how we could effectively use technology to support PBL, we refined important components of the instructional environment and we began to better understand the connection among the activity structure, the group whiteboard, and the students’ collaborative knowledge construction. We developed a theory that connects three critical components of our instructional environment and describes how they contribute to effective learning that promotes transfer to professional practice. The first component, the learning sciences or conceptual component, was the foundation that we began with. In the beginning, the primary goal was to teach students the learning sciences and how they can be used to inform instruction. To this end, we utilized face-to-face problem-based learning activities that required students to analyze and design instruction. The second component is the planning or design component. We wanted students to learn the connection between instructional theory and design, but we also wanted them to develop design skills that fluently blended the two. As we moved activities online and began to experiment with video cases, we began to understand the need for students to ground their conceptual and design knowledge in knowledge of actual classroom practice. Unlike paper cases, however, video provides an unparalleled perceptual experience. The latest round of eSTEP attempts to authentically and meaningful connect these components of the instructional environment. Our theory suggests that the rich conceptual and perceptual meshing that the eSTEP affords will help teachers transfer their learning sciences knowledge to their future teaching practice.

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