Problem-Based Learning Online: Multiple Perspectives on Collaborative Knowledge Construction

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Abstract. Online problem-based learning (PBL) environments afford many opportunities to engage in collaborative knowledge construction. Activity theory is a suitable framework to study such environments and the processes learners go through when using these environments. Two complementary perspectives are blended in this paper in an attempt to create a comprehensive picture of learning using an online PBL system. One perspective is the detailed analysis of tool use and discourse students and facilitator engage in. The second perspective is facilitator reflections about the evolution of the group's collaborative practices and norms.

Keywords: Problem-based learning, online learning, collaboration

INTRODUCTION

Problem-based learning (PBL) is inherently collaborative (Barrows, 2000; Hmelo-Silver, 2004). In PBL, students work in small groups with the guidance of a facilitator learning through solving problems and reflecting on their experience. Moving PBL online can provide scaffolding to further support collaborative knowledge construction. Collaboration allows learners to share ideas and develop new, authentic solutions to problems they are trying to solve, and, while doing so, acquire useful knowledge of theories and concepts (Hmelo-Silver, 2004; Palincsar & Herrenkohl, 1999), In PBL, students collaborate on complex problems, thereby distributing the cognitive load among group members as well as taking advantage of the distributed expertise within the group (Pea, 1993). Exchanging information is an important part of learning together as knowledge is constructed socially through joint efforts towards common objectives. As some would argue, the very essence of collaboration is the construction of shared meaning (Roschelle, 1996). From this sociocultural perspective, as learners participate in activities, they internalize what they have learned from working together (Palincsar & Herrenkohl, 1999; Vygotsky, 1978).

This view of learning also accounts for the important role of tools and discourse in mediating learning. In particular, activity theory serves as a framework for understanding how learning occurs in complex environments (Engeström & Miettinen, 1999). Each activity is composed of a subject, an object, mediating artifacts, community and division of labor and rules. Two basic processes are found in any activity – internalization, a process of shifting the material from the social plane to an individual and, externalization, a process of joint construction of an understanding of an activity, which is characterized by a movement of material from a person to the social environment (Valsiner, 1997; Engeström & Miettinen, 1999). These processes are complementary and intertwined, and help move the knowledge between the individual and one's social environment. In our work, we have moved PBL to an online eSTEP system that provides a number of tools to support individuals and groups as they engage in instructional redesign activities (Derry, in press). In addition, a facilitator works with the group to help guide their learning process. One of our goals of this paper is to understand how the online tools and facilitation mediate these transformations as students engage in collaborative knowledge construction. Because learning in this environment is multifaceted, we take the view that multiple methodologies are needed.

In this paper, we examine two perspectives on collaborative knowledge construction as preservice teachers engage in an online problem-based learning activity. One perspective is a detailed analysis of online collaborative learning through chronologically-oriented representations of discourse and tool-related activity (CORDTRA), which allows us to look in detail at both collaborative discourse and use of various on-line tools to mediate this process (Hmelo-Silver & Chernobilsky, 2004). The second perspective includes the reflections of a facilitator who tries to understand the role of facilitation in this online problem-based learning environment. In introducing the two perspectives we are blending the more fine-grained mixed methods analysis (Hmelo-Silver, 2003) with the traditional, ethnographic approach to studying activity systems (e.g. Cole & Engestrom, 1993).

eSTEP SYSTEM AND ACTIVITY STRUCTURE

eSTEP system is an on-line problem-based learning environment (Derry, in press). The goal of this system is to provide preservice teachers with an opportunity to engage with learning sciences concepts while using video cases as contexts in collaborative lesson re-design. The system consists of three components that are intended to mediate student learning. One component is the online learning sciences hypertext, the Knowledge Web (KW). The second component is a library of video cases that present examples of classroom instruction. These video cases serve as the basis for instruction as they present opportunities for discussion and improvement of instruction depicted in the cases. The video cases are intertwined with the KW. Finally, there is PBL online student module. It is a collection of tools that scaffold students' online individual and group work following a PBL format (Hmelo-Silver, 2004). Some of the tools that are presented in this environment include a personal notebook where students record their initial observations, a threaded discussion board, where students share their research and analysis of the video cases, and a white board where the students post their proposed solutions for the lesson redesign. eSTEP is a complex system because learning occurs during a combination of nine intermingled face-to-face and online steps. Additional details about the system can be found in Derry, et al. (this volume) and Hmelo-Silver, et al. (this volume).

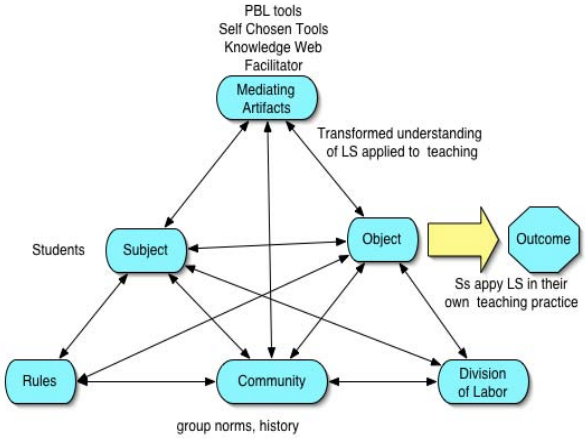

Figure 1: STEP activity system

During eSTEP activities, students interact and engage with various parts of the activity system as depicted in Figure 1. The objective of the learning activity is to analyze a videocase using learning sciences concepts and to subsequently apply those concepts to their own instructional design. In the course of this study, students worked on three online problems. In the first of these problems, the students viewed a video of an inquiry-oriented classroom in which children were engaged in design activities to learn science (Kolodner et al., 2003). In this problem, the students were asked to design an approach to assessment. In the second problem, the students watched two video cases. One showed a traditional physics teacher who used lectures and demonstrations. The other, contrasting video case, showed a constructivist instructional approach. The students were asked to help the first teacher adapt some of the techniques the second teacher used in order to improve the lesson on static electricity. The third problem showed a video of a foreign language teacher who wanted to redesign her lesson to meet new foreign language teaching standards.

PARTICIPANTS

The participants included a group of five students and a facilitator who worked together in three online PBL activities. The facilitator had two roles: to assist the students in the PBL process by guiding them through the steps of the activity through metacognitive guidance (Hmelo-Silver, 2004), and by answering their questions and guiding them in using the eSTEP tools effectively. The group was part of a larger Educational Psychology class in a large Northeastern University. This group was among the top two groups in the class performance-wise. We chose this group and not the other because the first group exhibited consistent performance throughout the semester. This group, on the contrary, revealed a dramatic evolution in group dynamics, involvement in the task, and productivity in face-to-face and online discussions and development of redesigns across the three online problems they participated in. Since our primary interest was in learning how tools mediate activity and learning, we felt that this particular group would be better suited for this purpose.

CODING AND ANALYSIS OF ACTIVITY

The discourse of the group was coded for content, collaboration, questioning, complexity, justification, and monitoring. These categories were chosen because they serve as indicators of cognitive engagement (Hmelo-Silver, 2003). Each category was further broken into subcategories as shown in the examples presented in Table 1. In order to address the issues of complexity, the Bereiter and Scardamalia (1987) scale was adapted. The adapted scale included three categories: telling, elaborated telling and transforming (Chernobilsky, daCosta & Hmelo-Silver, 2004). An utterance was coded as telling when students talked about the concepts without elaboration or clear connection to the problem. Utterances coded as elaborated telling were those where the students provided more conceptual details but where the connections to the case were not evident. Transforming utterances were those where students provided deep elaborations of the concepts together with coherent theoretical interpretations and a clear connection to the problem.

Table 1. Examples of coding categories.

	Category	Example
Content	Task-related utterances	I recommend that you spend a bit more time on discussing EACH proposal and then vote let's say late afternoon on Tuesday.
	Tool-related utterances	Frank and I decided instant messenger may be useful for discussing comprised info and ideas.
	Concept-related utterances	Elaborative rehearsal better equips the student with the information he is rehearsing because it becomes more accessible in his long term memory he has found ways to relate it to other instances and in his own words and he can help his peers understand it on a more simple level.
	Personal talk	Hey, I just wanted to let everyone know that I will might be a little late logging in on Monday morning. I will be in Connecticut until early Monday morning.
Collaboration	New Ideas	Peer assessment done by each student in each group on their group members.
	Modifications	I don't think its necessary to peer evaluate within the groups. We might try to give roles out within the group to make sure that each student has a part in the experiment and is working and not slacking off.
	Agreement	I like Mary's proposal for a hypothesis sheet…
	Disagreement	I don't believe peer assessment should be a factor in the student's grade but it could be done as feedback for both students and teachers to use.
	Summaries	What we have so far: Jack – teacher beliefs, Beth – hands on learning, Ellen - prior knowledge use, Carol – cognitive flexibility theory, Sylvia – collaborative learning
	Acknowledgment	I like Mary's proposal for a hypothesis sheet.
Questions	Informational questions	Should we meet before class at 9:15 so we can go over and refine what we have done?
	Explanatory/ elaborative questions	What do you mean by self-regulated learning?
	Metacognitive questions	What do others of you think?
Complexity	Telling	direct instruction: method of instruction for mastery of basic skills, concepts, strategies, facts, and information. This instruction is done piece by piece rather than all together. …
	Elaborated telling	Games and activities that students are familiar with can help teach specific facts about a country its culture, and its language. … I thought Monopoly would be a good game to use. As long as it was carefully coded as to appropriate linguistic level and maturity level suggested for students.
	Transforming	This idea supports our objective of "Transfer knowledge of static electricity to everyday examples" And so both motivation and transfer can be achieved through Authentic Instruction, two characteristics of which are Students' work has value beyond the school setting. Lessons become more authentic as the connection to the real world is increased. … Thus, one (authentic) activity would be a field experience (trip) to a lab, power plant, etc., which would should real

		world use and is social.
Justifications	Personal experience/ belief	I think a good assessment is to have each student do a mini science project based on static electricity, which I think would encourage students to think more and to not just concentrate on a grade.
	Grounded beliefs (clearly evidence based)	According to Sociocultural theory, "to capture a student's motivation, the culture of school must find a way to be valuable, relevant, interesting, and challenging in the eyes of a child. This may mean engaging the students in authentic activities of the larger society. It also means challenging them with tasks that are meaningful to the larger culture and are relevant to their lives outside of the school environment." …
Monitoring	Individual monitoring	I have made a summary about the stuff I got from the knowledge web that i posted as well as my research and printed it out so we can attach it to our sticky paper on Thursday.
	Group monitoring	Ok, so I think we need to revise or come to a concensus about how we want to word our final proposals.
	Self-directed learning	I will research metacognition. I still need to look up the concept of "self-directed learning"
	Planning (other than SDL)	Let's meet on Monday after class to talk about our gallery walk.

During the activity, students used several eSTEP tools, including PBL-online, KW and research library, video cases, whiteboards and discussion boards, online help, personal notebooks and lesson plans. The whiteboard served as the editable solution space, where students could post and edit their solution proposals during and after discussions.

To make sense of our data, we used CORDTRA diagrams, a methodology adapted from Luckin (2003). CORDTRA is a tool that allows us to examine relationships between the various parts of an activity system, particularly between the students, the discourse they engage in while collaborating, the tools they are using to solve the problem, and the artifacts they produce. An advantage of CORDTRA diagrams is that they can include as many or as few coding categories and tools as needed (Chernobilsky, Hmelo-Silver & DelMarcelle, 2003). Here, we include the various tools that the students used, the particular speakers, and the coded utterances.

To understand the CORDTRA diagrams (Figures 2 – 4) it is important to know that the data are arranged in chronological order. At the bottom of each diagram, there is a running count of lines of codes. Each code is either a tool that a student used or an utterance. For example, in Problem 1, the lines from zero to 200 are showing that the students in the group are mainly involved with the PBL online student module. They are also watching the video and looking into KW. There is some use of "Lesson Plans" tool as well. The tools, discourse categories and speakers are listed on the right of the diagram next to a corresponding string of codes. On the bottom of each diagram the arrows indicate when a certain step was begun by one of the group members. Although we marked the beginnings of each step, these are not the absolute ends of the prior steps – students are free to move between the step they are currently working on and the previous steps of the activity. For example, in problem 1 some students are still visiting steps 1 and 2 as late as line 883.

RESULTS

We present our results in two parts. First, we present the main results of our coding through CORDTRA diagrams that show how the group's pattern of discourse and tool use changed as they worked on the three problems. Second, we present the reflections of the facilitator based on her course journals.

CORDTRA

The CORDTRA diagrams are presented in Figures 2 through 4. Our analysis demonstrated that the group had a very different pattern of interaction from problem to problem. In Problem 1 the group showed limited collaboration (see Figure 2). The facilitator and one student (Jahnvi) were most active during this problem. One student did not participate at all. The participating four students had at least 3 utterances each. However, the quality of their discourse was low. For example, CORDTRA diagram shows that 14 questions were asked during Problem 1. Ten of these questions were explanation questions, with eight out of ten asked by the facilitator. There were very few new ideas (eight) and even fewer modifications (five). Looking at the discourse as depicted by CORDTRA, we see that students do not have any agreements or disagreements during the discussions, and throughout working on Problem 1, gave each other only three acknowledgements. This pattern of interaction suggests that although all students were online, they did not collaborate in solving the problem, but rather worked in parallel. This finding is supported by the fact that very few explanations and justifications (i.e., personal or grounded beliefs) were given during Problem 1.

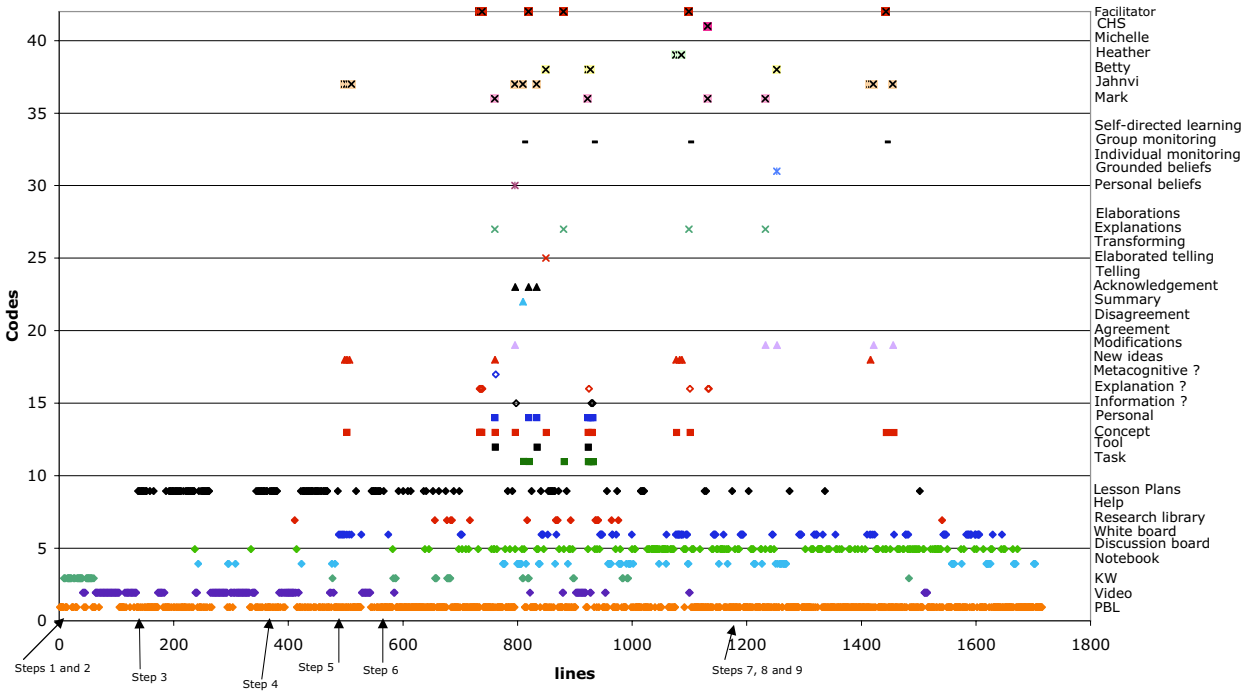

Figure 2: Problem 1 CORDTRA

The pattern of tool use in Problem 1 is also of interest. The most frequently used tools were the discussion and white board. However, at the same time, there was little discussed. This suggests that although students went on to see what was happening in the common tools area, they preferred to watch, not participate. It is interesting to note that the KW was rarely consulted. The students seemed to supplement the use of KW with the use of research library, another eSTEP tool that provides various references and links to the information outside of KW and eSTEP. Students spent a lot of time viewing the video prior to discussion and continued to use it during and to some extent even after the discussion.

In Problem 2, the pattern of tool use changed (Figure 3). Students viewed the video intensively at the beginning of Problem 2, just like they did in Problem 1. However, once the discussion started, the students did not use the video until the end of the problem. The use of the KW was also different. While it was very dispersed in Problem 1, in Problem 2, students used the KW specifically when working on steps 4 and 5, which are the research steps. At the same time, they were talking and discussing some concepts. This indicates that in Problem 2 there is a beginning of a reciprocal relation between the use of tools and discourse. The pattern of interaction and the quality of the discourse was also drastically different in Problem 2 as compared to Problem 1. Everyone actively participated – all students and the facilitator asked a lot of questions. Students brought in new ideas, and modified these ideas extensively, initially on the discussion board, and later on the group whiteboard. There were still no disagreements, but students did acknowledge each other much more than in the previous problem and explicitly agreed about what they were discussing. While students worked on Problem 2, four summaries were posted, three by a single student. We see the use of summaries as an important sign of an emergent successful collaboration. It appears that summaries help students see what they have achieved and assist them in setting further group goals that otherwise maybe difficult for the group to negotiate. In fact, CORDTRA shows that a lot of monitoring is going on, especially group monitoring by both the facilitator and the group members. Students also provided a greater number of justifications, although most of them were not evidence-based.

The pattern of interaction again changed in Problem 3 (see Figure 4). This was the last problem of the semester and students were simultaneously preparing for the "end of the semester" mastery test. CORDTRA thus reveals that the use of the tools continued long after the problem was finished (approximately line 1300). Although students continued to visit the discussion board at the end of the problem, there was nothing posted. This suggests that students continued using the information that had been posted on the discussion board, along with other tools, as a resource in preparation for the mastery test. CORDTRA also shows that the pattern of KW and video use was different. This time students did not use video while talking. Instead the use of the KW increased. This suggests that students better understood when and why they were to use KW in order to improve the quality of their arguments. Again, the facilitator and students in the group were asking a lot of questions, and the students brought in a lot of new ideas, modifications and explanations about their points of

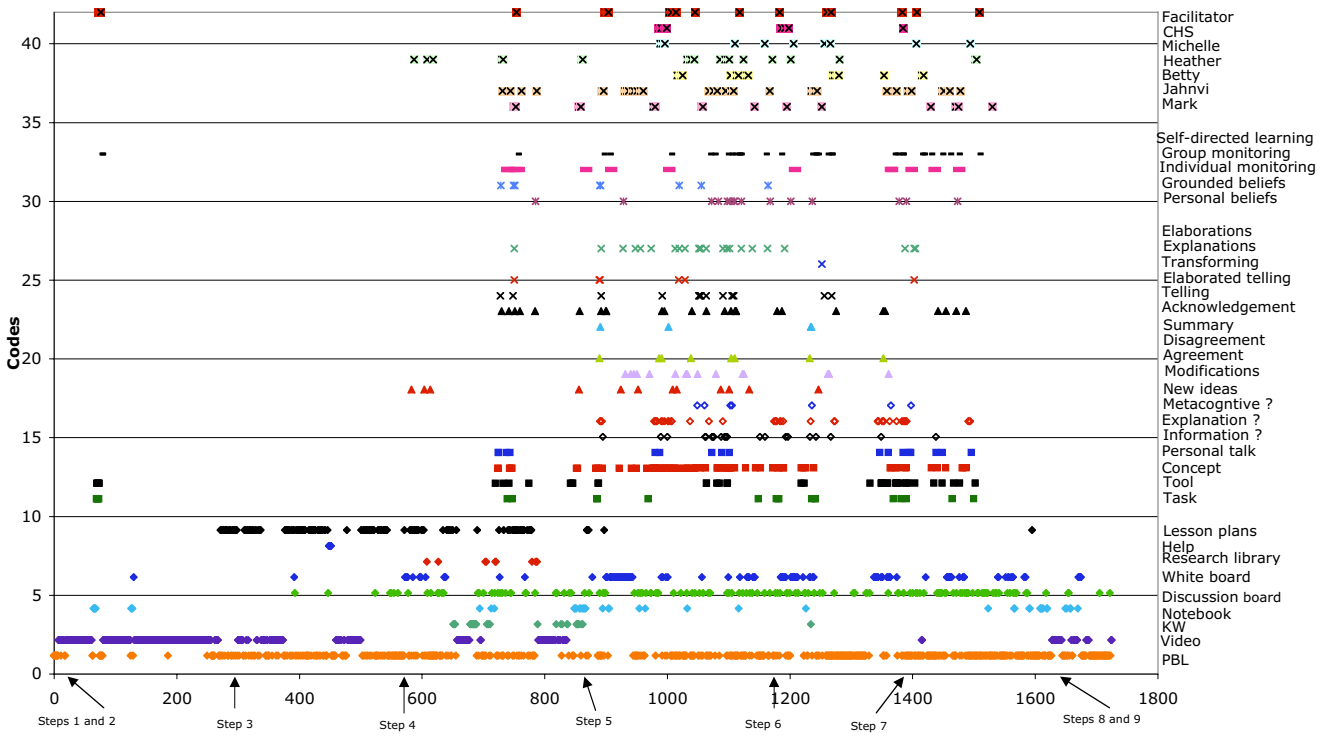

Figure 3: Problem 2 CORDTRA

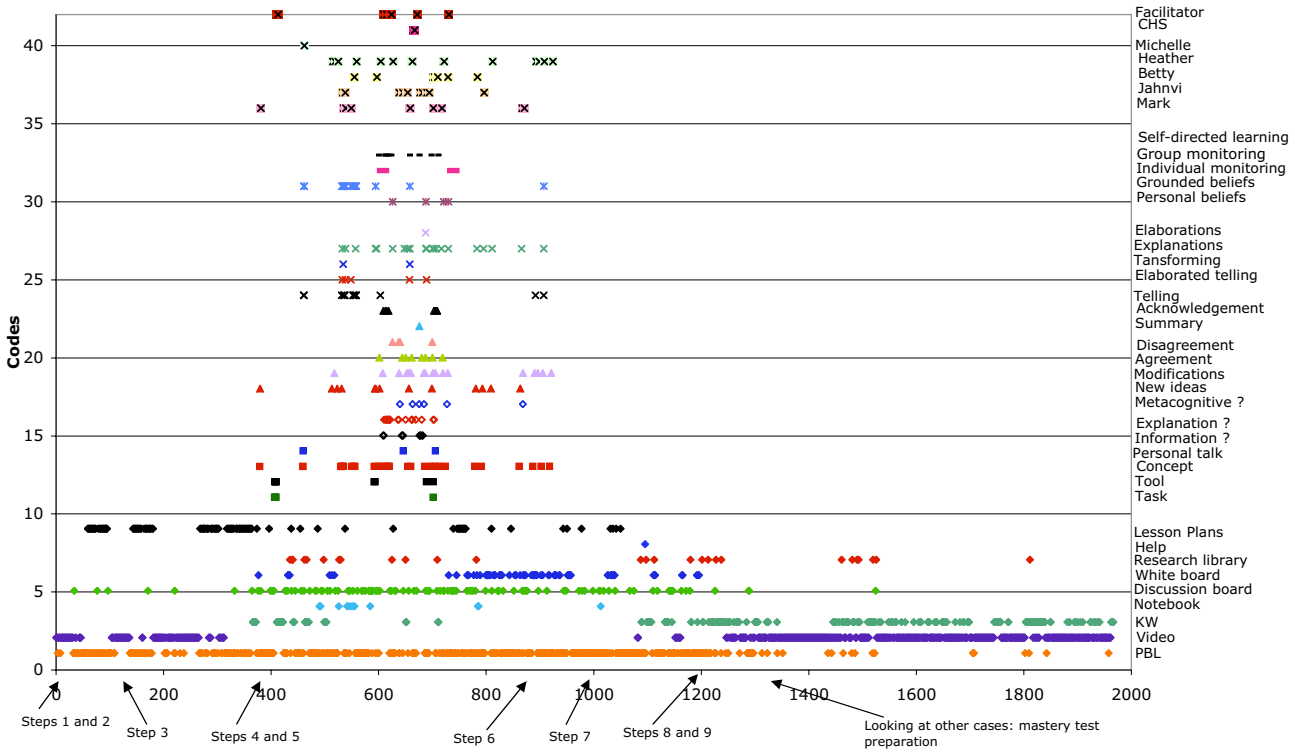

Figure 4: Problem 3 CORDTRA

view. Together with acknowledgements and agreements, there were also some disagreements during the conversations. CORDTRA shows that justifications shifted from personal-belief based to clearly evidence-based. The combination of these two trends may mean that students were more comfortable in online conversation. It may also suggest that the students understood the "rules of the game" that in order to convince someone that their argument is stronger, merely a strong personal belief may not be enough.

While the CORDTRA analysis examined the evolution of group collaboration and discourse patterns from Problem 1 to Problem 3, a look at the individual and group mean scores showed similar trends across the problems. The mean scores ranged from 9.80 (SD = 1.09) out of 12 possible points for Problem 1 to 10.80 (SD = 0.45) for Problem 2 to 11.00 (SD = 0.00) for Problem 3. The group ranked second in the class on the final learning outcomes.

A synergistic look at the collaboration data and the learning outcomes suggests that along with improving patterns of communication among groups, the group solution also improved in quality. In addition, each group member engaged in online conversations to a greater extent and scored higher points by the last problem. Since the primary focus of this paper is on examining the processes whereby tools and activities mediate learning in a group, making causal attributions for this learning or drawing statistical conclusions is beyond the scope of this paper.

REFLECTIONS FROM THE FACILITATOR

Most college students are taken by surprise when faced with a course that is mainly anchored in a PBL format (Hmelo-Silver, 2000). The group chosen for analysis in this study was no different. The second author of this paper (AN) acted as the facilitator for this group, both in face-to-face discussions and online collaboration, and maintained a journal documenting the functioning of the group over the semester. In this section, we discuss some of the insights of AN on how and why the group functioned differently from problem to problem and how her role changed as well.

At the first meeting with this group, the apprehension and uncertainty on each student's mind as they started on their first problem was apparent. The groups worked on two problems face-to-face before using the online environment for the last three problems. We expected that the first two problems would serve as a good "warm-up exercise" before the switch to the online set-up. However, in the case of this group, it was not so. The group had barely started understanding the PBL process and the switch to the online set-up completely threw them off. For the first online problem, there was little demonstration of any online communication and participation. They tended not to question each other; rather each student posted their research and proposals without much interaction with other group members. In fact, when AN asked certain questions to try to get the group discussion going, one of the group members, Jahnvi, responded:

> I understand that you are there to help. However, I just try to clarify anything that you may have missed during our group discussion. I always get nervous that when you ask questions, our group may be on a totally wrong path to solving this problem or else you would not be questioning it. Therefore, I just try to verify what we're doing is ok.

AN subsequently responded:

> The reason for my asking you questions is to see whether you can clearly explain what you're referring to and can adequately justify it. So take it easy and take my cues as constructive feedback- Whenever you go totally on the wrong path, you'll find me spending more time in your group.

On the first online problem, this group had not completed their group solution and was quite unsure of what they were supposed to do when asked to present at the class poster session. They were given extra days to complete their work. The online participation recorded for this group occurred largely after the class deadline, Even so, the level of participation on the first online problem was quite limited compared with the next problem. This was probably because they were still trying to understand the process and expectations of the task. The group found it hard to ask and answer questions in the asynchronous environment. Their first solution was not terribly innovative but they did begin to see how they should be tackling the problems and communicating with each other online.

When this group moved to the second online problem, they were more than caught up with the other groups. The sheer embarrassment of not being ready with their presentation at the first problem and being able to identify *why* that happened led them to strategize well for the next problem. Understanding the expectations of the task, the steps essential to meet those expectations, and a more accurate projection of the time and effort needed to succeed at this task led them to plan better and expend the necessary effort. All students took ownership of the task, laid out the components of the problem clearly, and planned their group solution after thoughtful research and prompt communication with one another. In the first problem, AN was trying to get them to understand the task and model questions they might ask of each other. By the second problem, they were doing most of that, allowing AN to ask them higher-level questions and at times just stay out of the conversation. For example, in Problem 2, AN was able to focus on asking questions that pushed the students to consider how different types of instruction affect learning "now that you've listed three types of learning and the activities and assessments for each, what might be the advantages of using one over the other..how will each

type of learning and/or teaching facilitate understanding…" In fact, one student in the group started asking the very same questions asked by the facilitator at an earlier discussion. Sometime during the second problem, the students were discussing the proposed activities and the need to choose between them. Jahnvi gives the rationale for why she thinks her idea is worth keeping. Her use of language shows that she understands the concepts and that her ideas are based on research evidence. At the end she asks a question inviting other group members to do the same for their proposals in question:

> Self-explanation is supported by research on explanation based learning. Using real-life examples is supported by example based learning (My research). Also, the students must explain it to other students using their own words and to study it using other reference materials, which incoporates them in active learning (Betty's research). The assessment will meet the objective of understanding the concept and also is supported with research on transfer. So do we want to keep it or go with the other activity? What is the other activity supported by?

The second problem was, by far, the most complicated problem of the semester and this group participated in the online discussion with a strong commitment and motivation to succeed. When they moved to the third problem, the group had a clear understanding of the task and had a set of strategies that they could use to tackle the given problem. They also had somewhat defined roles wherein two students acted as joint leaders trying to make sure that the group was on task and on target. Two other students in the group contributed by identifying relevant research and connecting previously learned information to the current problem. Even the one student who didn't participate as much in the first problem started engaging and communicating in the online discussion board. Overall, the group had converged in their collaborative efforts and worked together effectively and efficiently. The two "leaders" of this group were amongst the top five students in the class and the other three also received high grades. A major factor contributing to this group's success was their motivation and willingness to learn from their mistakes.

As with the students in the group, the functioning and role of the facilitator changed across the three online problems. When the group failed to present the group solution at the gallery walk in class, AN held a private meeting with the group to understand what went wrong. Based on this meeting, it became clear that the students did not understand what was expected of them and how to go about planning a group solution. In addition, the group was unskilled at questioning one another and carrying on an online conversation. AN clarified the task expectations as well as expressed her concern at the limited interest and participation from the group and offered her help to resolve any conflicts or misunderstandings with the task. Once the students were attentive and expressed an interest to rectify the mistakes, AN encouraged and motivated them to work on the problem for an additional number of days so that the group could come up with a reasonable solution. During the first problem, AN spent a lot of time providing words of encouragement, answering technical questions about the STEP site, and modeling different questions that could elicit reflective answers and promote collaboration. In her attempt to make students participate and make their thinking explicit and visible she posted the following comment on the white board in response to one of the proposals: "elaborate on each of these forms of assessment and relate it to the research. FOr [*sic*] example, what will a lab report look like and how will that demosntrate [*sic*] what students' have understood. What types of assessments do each of the above mentioned fall under?" Prompt response and feedback to e-mail and online discussions helped the students to move at a faster pace and develop their group solution. By the second problem, the focus largely shifted from managing the task to getting the students to think intellectually, find reliable sources of evidence, justify their proposals with appropriate research, and continue with higher-level reflective questions. AN also encouraged disagreements on issues among group members and pointed that disagreeing and debating with evidence was a useful component to expanding one's thinking. By the last problem, AN spent even less time facilitating the group as the group discussion was initiated and continued by the students in the group. Overall, the synergistic effort and commitment of the group and the facilitator contributed to the success of the group in this PBL course.

DISCUSSION

Our analyses demonstrate that group collaboration in online PBL evolves and becomes more complex over time. Both the evolution of student discourse and use of the video cases change over time. Although the use of other tools remains relatively unchanged throughout the semester, the use of video as a tool is different in every problem. It is possible that as students gain more experience with the online PBL course, they get better at watching videos and noticing the details they initially do not pay attention to. By noticing more details appropriate for the group discussion, they eliminate the need to go back and view the video again during discussions. It is also possible that as the semester goes on, the students learn that their focus is not a "video" per se, but the "problem" that they need to solve and that is presented in the video. Thus, once they are familiar with the problem they learn to shift their focus from the video to the problem itself.

The CORDTRA diagrams indicate the dramatic change in the interaction pattern after Problem 1. There are a few possible explanations for these changes. The reflections of the facilitator indicate that during the first online problem students were lost and did not realize that active involvement in the problem-solving process was necessary for successful online collaboration. By failing to solve Problem 1 effectively and on time, the

group was forced to re-think their performance and consider the reasons for doing poorly. The facilitator continued to show them what was expected of them and made them understand what the task required them to do. This renewed understanding of the task motivated them to engage with Problem 2 at a different level. The modeling of various questions provided by the facilitator allowed the group to both ask a variety of good questions and appropriate some of the necessary language. In addition, data depicted in CORDTRA diagrams suggests that the usage of tools (such as the KW) in subsequent problems mediated student learning. CORDTRA shows that as the group's learning progresses, the usage of tools not only shapes the interactions but is also transformed during the activity.

One can argue that it is natural that students improved in their performance as the semester progressed. The improvement in performance may be due to the fact that the students figured out the "rules of the game" and in subsequent problems knew exactly what to do and how. It is possible, however, that on top of this natural tendency to improve due to the familiarity with the task, in problems 2 and 3, the students put in more effort, engaged more with the task and as a result saw more value in it. This is corroborated by the reflections of the facilitator. In addition to increased student effort, the encouragement and support provided by the facilitator may have contributed to the performance leap between the problems.

The role of the facilitator, thus, seems to be extremely important in an online learning activity. The facilitator reflections help us see "between the lines" of CORDTRA diagrams and help us understand what indeed happened during the learning process. For example, the facilitator insights made it clear that much of the work on Problem 1 happened after the poster session and that the students needed that opportunity in order to fully understand the task. The facilitator also helped explain why students kept working online at the end of Problem 3. This explanation confirms the belief that the task of preparation for the final test was meaningful. It helped the students master the material by engaging in learning even after the last problem was solved.

Learning collaboratively, yet asynchronously has specific challenges. While this group is a specific example of what the students go through during the online learning, some general approaches towards asynchronous discussions can be seen from the example of this group. The facilitator reflections clearly indicate that the group would not have been successful had they not understood that working online requires a different level of commitment than face to face meetings. It requires an increased responsibility in being prompt to reply to other members, increases the dependency on others and on the technology that students are working with. It also places a certain responsibility on the facilitator. The facilitator needs to recognize the importance of encouragement for the students and provide prompt feedback. The facilitator also needs to be patient in explaining the importance and function of multiple tools that the system provides.

The fact that students need to engage in learning the online tools at the same time they are engaged in learning the material may be of special challenge to both the facilitator and the group as students experience additional cognitive load. For the students, there is a tension between learning to use the eSTEP tools and engaging in PBL. It is critical that course instructors adequately prepare and support students in working with the online system and its multiple tools to ease students' transition to the online learning environments.

Online PBL environments can extend facilitation resources and allow a single facilitator to work with many groups (Steinkuehler et al., 2002). This is important in the typical class when one instructor may have a number of groups working at the same time. PBL online allows the facilitator to respond promptly to many groups which is impossible in large face to face classes. Another advantage of online environments is the discussion trace. Such archives become an additional resource that the students can draw upon when forming their solution to the problem. The availability of the discussion trace also assists the students in monitoring their progress as it allows students to see what they have already done and what else needs to be accomplished.

Finally, online learning formats such as eSTEP provide effective scaffolding through tools that help communicate the problem-solving process, elicit student articulation, and provide hints about the kinds of concepts that need to be explored (Collins et al., 1989; Hmelo-Silver, in press). In the case of the eSTEP system, the steps themselves serve as a scaffolding device that help students know what is coming and what else needs to be done before the problem is completed. PBL online also allows for the creation of both personal and group spaces, which are essential for the processes of internalization and externalization. The white board also triggers externalization by providing each student with a place to not only propose their ideas for solution, but also comment on each other's proposals. This helps make their thinking visible and open for renegotiation.

Tools such as CORDTRA provide specific mechanisms for thinking about learning in light of activity theory. Reflections provided by the facilitator give an additional perspective into group and help understand how a group engages in collaborative knowledge construction. Blending the two perspectives can help us understand how different aspects of an activity system mediate collaborative knowledge construction.

ACKNOWLEDGMENTS

This work was made possible by an NSF ROLE grant # 0107032 to Sharon Derry and Cindy E. Hmelo-Silver. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. We would like to thank Olga Mastov for helping us with the coding and Mikhail Chernobilsky for his help with proofreading.

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