Understanding Collaborative Activity Systems: The Relation of Tools and Discourse in Mediating Learning

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Abstract: The goal of the current research was to establish a methodology for examining students' learning processes in online collaborative environments. In particular, we examine the relation between tools, discourse, and learning from the perspective of activity theory. We apply this methodology to examine the interaction and tool use of two groups of pre-service teachers who participated in an online video case analysis activity using STEP system – a collaborative environment designed to guide students through online problem-based learning tasks. The goal of the activity for both groups was to collaboratively analyze the video case and then individually apply learning sciences concepts to a lesson design. To examine how tools shape the activity, while the activity shapes collaboration and discourse during the task, we employed chronological representations of discourse and tool-related activity (CORDTRA) to compare learning processes in two groups.

Introduction

A sociocultural view of learning proposes that interaction among learners, teachers, and mediating tools supports active thinking and promotes knowledge construction (Engeström, 1999; Kozulin, 1998; Vygotsky, 1978). This is particularly crucial in studying technology-mediated learning, which often involves the design and analysis of activity systems to promote knowledge construction. Activity systems have often been studied using ethnographic case studies (e.g., Cole & Engeström, 1993). Another approach to studying activity systems can be accomplished with mixed methods that permit fine-grained analyses of learning discourse and its relation to tool use. In this paper, we briefly summarize activity theory and articulate a methodology, adapted from Luckin (2003) that can be used to examine how collaborative discourse and tools mediate knowledge construction in an online problem-based learning activity.

Activity Theory

Activity theory provides a framework for understanding learning activity as it tries to explain the changes in human practices over time. This is consistent with an increasing realization that learning does not happen in isolation but is embedded in activity systems and their sociocultural context (Engeström, 1999). Learning environments are complex activity systems that involve multiple agents, physical artifacts, and psychological tools that mediate learning. According to this theory, each activity system is composed of a subject (a person or persons directly involved in activity), an object (the goal of an activity), mediating artifacts (including material and psychological tools that aid in the achievement of the goal), community (people who are involved indirectly), division of labor, and rules (the socially established regulations that drive the activity). The notion of tool use and mediation is a cornerstone of activity theory. Tools shape the subject's interaction with reality and also reflect prior experiences of others. Tools are used and transformed during the activity itself. Therefore, they serve as a means of enculturation and transmission of social knowledge. One such tool that groups use in problem solving is discourse. Discourse is important for internalization and externalization, two basic processes that can be found in every activity. Internalization is a process of transferring material from social to personal domains, while externalization is the process where the material is introduced back to the social environment (Valsiner, 1997; Engeström, 1999). These intertwined processes provide for the transformation of knowledge from social to individual and back. Developing analytic tools is a challenge for understanding how knowledge transformations are mediated.

Chronologically-ordered Representations of Discourse and Tool-related Activity

Understanding multifaceted activity systems is complex because it is difficult to capture the chronology and simultaneity of events. One way to accomplish this is to construct parallel timelines that permit the

researcher to look at the relationship between collaborative activity of interest, such as discourse and patterns of tool use. Luckin (2003) developed the CORDFU methodology to document the relation between dialogue and features used in a hypermedia system, and has since extended it to look at collaborative technology-mediated activity. Hmelo-Silver (2003a) generalized this tool to construct chronologically-ordered representations of discourse and tool-related activity (CORDTRA) to examine the dialectical relationship between students' drawing activity and their collaborative discourse in a problem-based learning session. The CORDTRA diagram helped uncover important relationships between drawing activity and causal discourse. In this paper we apply the CORDTRA methodology to examine mediated learning using the STEP system. The STEP system provides a suite of tools and an activity structure for computer-supported collaborative learning (Derry, in press).

The STEP System and Activity Structure

The STEP system is an online learning environment, designed to support students as they engage in problem-based learning (Derry, in press). The goal of the system is to provide pre-service teachers with an opportunity to study the learning sciences using videocases as contexts to engage in collaborative lesson design. The system contains three parts: an online problem-based learning environment (tools that scaffold students' online individual and group work), an online library of video cases and a hypermedia textbook, the Knowledge Web (KW). The KW is a cognitive flexibility hypertext (Spiro et al., 1992), which provides information about learning sciences theories and concepts. The videocases consist of minicases that are indexed to appropriate concepts in the KW. This site has twelve steps that guide students through the activity. Some steps are designed for individual work (e.g. phases 1 and 3), others are designed for group work (e.g., phase 2). Figure 1 shows an example of the road map screen of this twelve-step system.

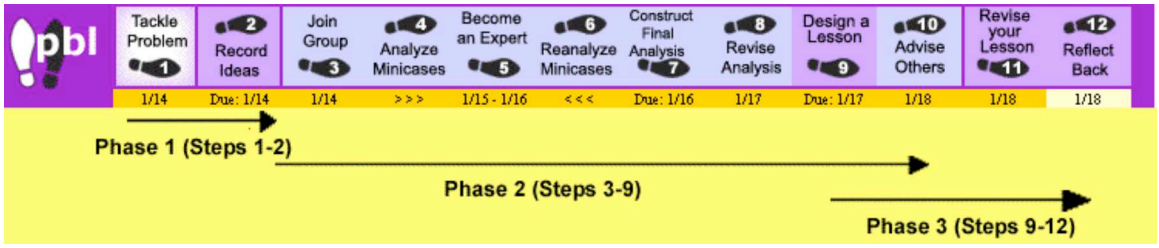

Figure 1. STEP road map

Representing a Complex Activity System in Use

The CORDTRA methodology is well suited to analyzing collaborative activity in a technology-mediated activity system such as STEP. The setting for this research was a preservice teacher education course in the learning sciences at a large Midwestern university. The participants were two groups of preservice teachers who engaged in an online video case analysis activity that lasted seven weeks. One group had five members and the other had six members. The videocase that both groups analyzed showed a student teacher in a social studies classroom using problem-based learning (Hmelo-Silver, 2003b). Both groups had the same tutor to facilitate the learning. The role of the tutor was twofold. First, the tutor's role was to assist the students with the learning process by guiding them through the steps of the activity, asking the questions that encouraged them to think deeply, and monitoring their progress and schedule. Second, the tutor helped guide the students in using the STEP tools.

The goal or object of the activity was to apply learning science concepts to the analysis of a videocase, and later, to individually apply those concepts to design their own instruction. The activity system is represented in Figure 2. The patterns of interactions, tools, and learning were quite different for the two groups. We use the CORDTRA diagrams in conjunction with examples of discourse to examine the relationship between the activity structure that was actually enacted, the STEP tools, and the discourse. The two major sources of data of primary interest to this research were computer generated log files and online student/tutor discourse. The hypothesis that drove the research was that tools shape the activity, while activity in turn shapes collaboration and discourse. Thus, our goals for this research were to develop and adapt analytic tools that would allow us to examine (1) the interaction among the group members and the tutor, (2) the use of technology as a mediating tool in the activity, and (3) how the use of technology affects the division of labor in the activity. We have reported on goals one and three elsewhere (Chernobilsky, Hmelo-Silver, & DelMarcelle, 2003). In this paper, we focus on the second goal as we examine how the CORDTRA technique allows us to examine the relation between discourse, tool use, and the object of the group phase of the activity (constructing a conceptual analysis).

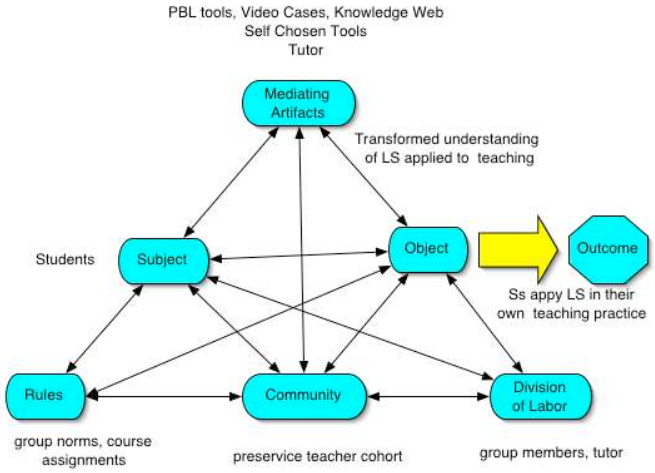

Figure 2. STEP activity system

Constructing CORDTRA

Since the data that we collected were scattered in different databases (e.g. log files, threaded discussion), the first important issue that we faced was to gather and organize the data from these various sources into a manageable and user-friendly structure that would facilitate data analysis. We created a data file for each group. Each file contains three parts. Part one logs the date and time for each hit on the STEP system, the student id and user name, group number, sites attended during each log-in, students' online discourse and the personal journals that students kept while working on the problem. All these data were compiled in chronological order. Part two contains the group work that the students produced as a result of their research and discussions. Group white boards are placed in this section of the data file. Part three of each file contains analytic coding for each entry in parts one and two. Since many of the entries were more than one sentence long, it was possible for more than one idea to be discussed in a single entry. If an entry contained multiple ideas, these were parsed when the topic changed.

Coding the Discourse

The discourse of each group was coded for student collaboration, questioning, monitoring and statement complexity. These categories are indicative of different aspects of cognitive engagement (Hmelo-Silver, 2003a). Each of these categories was broken into further, more detailed subcategories. Examples of each category are shown in Table 1. Student collaboration included introduction of new ideas, modification of previously stated ideas, agreement or disagreement with other group members, acknowledgement of other group members, and summarizing ideas. Summarizing ideas serves an important purpose in this setting as it helps the group establish common ground. In addition the content of the talk was coded into task, tool, and personal talk. The complexity of an idea was coded as either a simple assertion or a more complex explanation. Statements were coded as monitoring if they involved group or individual monitoring, planning, and self-directed learning. In addition to coding statements, we were interested in the questions that the students and tutor asked. We coded two categories of questions: meta-questions/ prompts and informational questions. The first type of question is important because it suggests that the students were engaged in high-level thinking about their task and the second type suggests that they are engaging with each other as sources of information. The information questions include both low-level factual requests and higher-level questions that make connections between concepts and between concepts and cases. An example of the latter type of question is show in Table 1.

Students used several online tools during the activity: the twelve-step online learning environment, the video library with the case to be analyzed, the hypermedia textbook—the KW, discussion board, research library, group report tool, lesson plans, notes and help tools. The group report tool served as a shared space for students to post and edit their mini-case analyses. For ease of analysis, only tools that were frequently used are included in the CORDTRA diagrams. One issue in constructing the CORDTRA diagrams is to include enough

information so that they are useful but not so much information that the analyst is overloaded. In our initial attempt at this analysis, we included additional types of coding, the individual student and tutor contributions, and finely coded analysis of conceptual discourse and specific concepts browsed on the KW (Chernobilsky et al., 2003). What we learned from that is that less can be more. Although this initial analysis allowed us to see some gross patterns in the interaction, we needed to zoom in to better understand the relation between the tools and the learning activity reflected in the discourse.

Interpreting CORDTRA Diagrams

Our analysis here focuses on two groups of preservice teachers in their final year of a teacher education program as they constructed video case analyses as a group followed by individual lesson plans. These groups demonstrated different patterns of interactions, tool use, and group products. The CORDTRA diagrams are shown in Figures 3 and 4 and reflect the seven weeks that the students were working on the system.

Table 2. Examples of coding categories

	Category	Example
Collaboration	New Ideas	I think that another concept in this case is teacher-centered learning/instruction.
	Modification	But, maybe instead of doing so many worksheets every day, you could incorporate some games or something for learning the vocabulary.
	Agreement	I agree with Max in the fact that we need to learn how to professionally critique a colleague.
	Disagreement	I am still going to have to say 3 & 6. I know a lot of people want 2, but I haven't been convinced that it is the best case to take more indepth look at. (referring to which minicase # to select for further analysis)
	Acknowledgement	I have been following this discussion and I think Jack makes an excellent point about argumentation needing a goal but not take it to a personal level.
	Summaries	What we have so far: Jack – teacher beliefs, Beth – hands on learning, Ellen- prior knowledge use Carol – cognitive flexibility theory Sylvia – collaborative learning
Content	Task-related	I don't know if I really understand what we are researching for exactly. A little clarification on this would be appreciated
	Tool-related	I know the other day I went back to refer to something in a previous posting only to lose what I was currently writing, so I hesitate to look it up now.
	Personal	I am at home this weekend and busy with family type stuff and sick relatives…
Complexity	Simple	In case 8 I like the concept of questioning.
	Explanation	I feel like the discomfort we seem to have had with the line of questioning in this minicase may stem from having a goal that was very personal to Kyle. This line of questioning my have taken on a trumped up sense because of Kyles intentions and likely his inexperience as a teacher.
Monitoring	Monitoring and planning	I still want to research prior knowledge with mc#2 but I see that Sam and Dina want to do classroom management, so I think I may research transfer?
Question	Meta and prompts	Does that seem right to you? What other concepts should we consider for this case?
	Informational	Does teaching argumentation facilitate critical thinking?

Group 1 began with some initial discussion that was divided between personal, task, and tool talk. They spent time exploring the KW, video, and PBL-online. The group continued to engage in discussion as they explored the affordances of the system. Many new ideas were thrown out to the group at this time and the group moved through cycles of simple statements and explanations as they were figuring out their task and trying to make a decision about which minicase to choose for further analysis. For example, one student wrote during this phase of discussion:

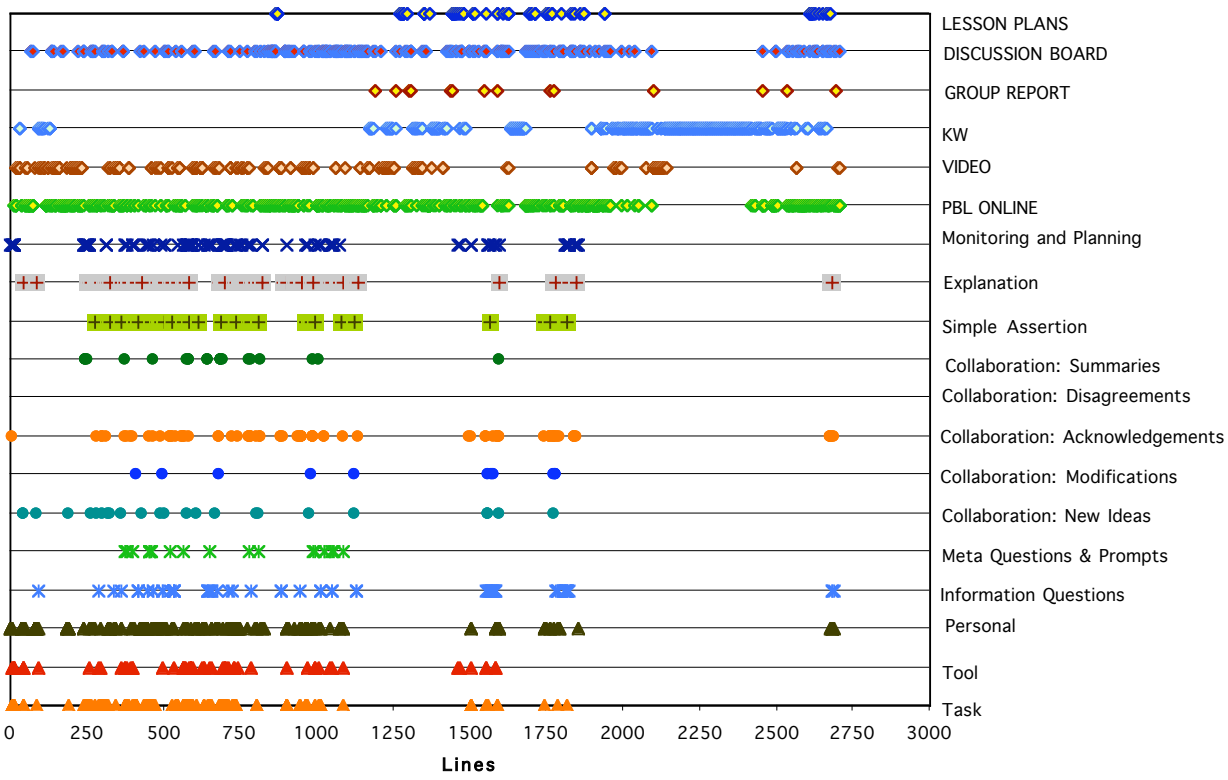

Figure 3. Group 1 CORDTRA

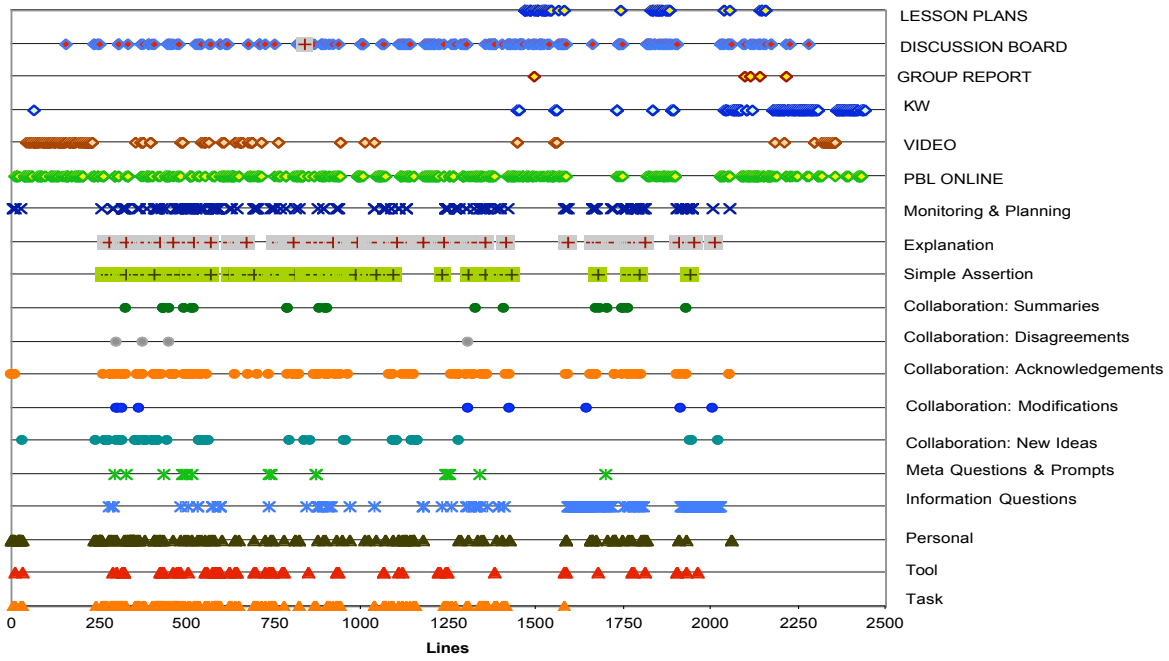

Figure 4. Group 2 CORDTRA

> I think Jack is right about minicase eight because seeing what the students learned about whatever topic is rather the whole point of teaching something. At least in language acquisition, the steps are reception (hearing ((easiest? skill to acquire)) and reading) and production (speaking and writing ((hardest))) so even though we don't have written results in case eight we do have students verbally elaborating on their understandings.

After their initial exploration of the Knowledge Web, they moved their focus to the video cases and the PBL-online activity environment. Thus, the CORDTRA diagram suggests that there was an initial exploration and proposal of ideas to the group. This group was respectful to each other throughout the activity—there were no disagreements and they regularly acknowledged each other's ideas. During this phase of work (approximately lines 250-1100) there were many questions being asked, both to obtain information from each other and to monitor their activity as another student noted:

> I would agree with Jack in that I think 2 of the most important concepts in 8 are questioning and modeling. I also think that the concept of discourse is important. I guess I would like a better definition of the word though- all the glossary said is something about verbal communication, but I think there are other ways of looking at it For instance, is the discourse just teacher questions, student answers? Or should the teacher try to get the kids to build on one another's ideas and responding to one another's comments rather than just answering the teachers questions? i guess that whole idea could go under questioning though

There was a break in the discussion activity once the students identified the concepts they were going to individually explore. At this point they went to the KW to research their concepts. The scribe was entering information into the group report, as the information was being reported and agreed upon by the group. They made extensive use of the KW and continued to examine the video, which suggests that they were trying to connect the learning sciences concepts they were researching to the case. The next phase of the activity began as the group needed to finalize their case analysis. Several new ideas were introduced and refined. The students slowed their use of the video first, and then reduced their use of the KW as they refined their group report and finished the group phase of the activity. At around this time, discussion of the tools ceased, perhaps as students were both comfortable with them and their use became a norm that no longer needed to be discussed. At around line 2100, the students moved to the individual phase of the activity and constructed individual lesson plans. The students focused on the KW and left the PBL online until they posted their lesson plans so other members of the group could comment on them. Group 1 had fairly delineated phases of activity. Even when the discussion ended, group members went back to the discussion board and used the PBL online scaffolding for the activity structure. A great deal of deliberation went on in the group before they began developing the group report. The final phase of the activity was the phase where students refined their knowledge, prepared their individual solutions, and provided the learning sciences evidence that their solutions were sound. Virtually no conversation took place (at the very end of this phase a student posted some comments, but no reply was given to her). Instead, students were busy learning from the KW.

The other group was less effective both in their communication and in their writing of the final group product. The CORDTRA diagram for group 2 is shown in Figure 4. It shows that only three phases of the activity are clearly identifiable. These students blended the introductory phase with their discussion phase as this next example demonstrates:

> Well, I may be the last one to introduce myself, so I am sorry if you have all been waiting for me. Anyways, I am Sam Eringburg. Like Dina, I am in the field of Mathematics. Let me start out by telling you how I decided on teaching and mathematics… … OK now to the moment you have all been waiting for, the minicases I chose were 2 and 8. But to be honest with you, there were a couple of others I could have chosen too. I would just like to choose one with some classroom discussion in it. I think that is the most interesting thing to look at.

There was minimal use of the KW until late in their activity, The only tools that students in group 2 used during this phase were the PBL online environment, discussion board, and video presented for analysis. No exploration of other tools or the general affordances of the system took place during this phase. Instead, the students were focused on discussing various concepts. All students, as well as the tutor, were active in the

discussion during this phase. As in Group 1, these students brought in a lot of personal talk. At the same time, they remained focused on the discussion of the task and the concepts presented in the video. Most of the questions that students raised were information-seeking questions. During this phase, students brought in a lot of new ideas (with some modifications). They frequently acknowledged each other and agreed with other group member's ideas. Unlike Group 1, during this phase, students expressed some disagreements mostly about the minicases they wanted to analyze and what concepts were important to research in those minicases. It is notable that this group continued to engage in tool-related talk but shut down the task-related talk. They were not questioning the tool use, instead were referring to tools they could use: "If you go to the Prior Knowledge Use page in the kweb there is a short but good explanation of why it's important for teachers to do KWL activities."

The "research and share phase" began at about line 1400. During this phase, students researched concepts, and reported on the results of their research. During their discussion, they continued their research on the KW and also began working on their final individual lesson plans. They looked at each other's individual work and commented on it. At the same time, the frequency of KW use was low; students looked at just a few concepts, mostly once or twice per concept. There was a break in the discourse as the students did their research and began the group report. They monitored their progress in the task as they shared their information with simple assertions as well as more complex explanations. Again, most of the questions were information-seeking questions that students asked when they reviewed each other's lessons. The students acknowledged each other extensively, but brought in very few new ideas and modifications. The last phase of Group 2's activity was similar to the last phase of Group 1's activity. There was no discussion taking place. The students were busy searching the KW for the concepts they were using in their final lesson plan.

The final products were different for the two groups. Group 1 stayed closer to the task of providing a conceptual analysis. They used each minicase to illustrate different concepts that they discussed. In the example shown below, the students connect their conceptual learning to the case as they give examples of how the teacher in the video, Kyle, modeled metacognition for the students.

Closely related to metacognition is modeling. There are several times when Kyle tries to demonstrate metacognition through the modeling process. Kyle overtly models target cognitive behavior asking: What do we know? What do we need to know?" to allow the students who are new to the self monitoring process to see what thinking processes are involved. The internalization of higher –order thought processes such as analysis, evaluation of arguments, perception, awareness and problem solving provides stronger critical thinking, better performance in specific domain, and greater possibilities of transfer.

Group 2 was more critical of the teacher and less analytical. They used the same concepts for both minicases. The following examples are from their analyses for minicases two and six. There was little elaboration of conceptual information and more suggestions for the teacher to do things differently. There is a great deal of overlap in their analyses for the different minicases.

> In order to facilitate good argumentation in his class Kyle could have set up norms for class discussions and teach students how to successfully argue in an academic situation. At the beginning of the year/semester, Kyle could have worked with the students to develop a set of classroom norms….One idea is to develop a "classroom constitution" and then have the students and teacher sign it.

> It is suggested that Kyle may have prevented this had he set classroom norms right from the start of his student teaching experience. These norms would have power and respet [sic] from students if they helped create them by means of classroom constitution. In order to facilitate good argumentation in his class Kyle could have set up norms for class discussions and teach students how to successfully argue in an academic situation. At the beginning of the year/semester, Kyle could have worked with the students to develop a set of classroom norms….One idea is to develop a "classroom constitution" and then have the students and teacher sign it.

Discussion

Overall, Group 1 was more effective than Group 2. Although they ostensibly had the same object of their activity, a conceptual analysis of the case, the groups used the tools in different ways. The CORDTRA

diagrams make salient how the different groups demonstrated different patterns of tool use, and while we are careful to note that no causal claims can be made, the different patterns of tool use suggest hypotheses that might be explored in further research. Group 1 stayed close to the video and the KW throughout much of the activity. There appear to be cycles of watching the video and conducting research in the KW. They summarized their thinking frequently in the beginning of the activity as they established common understanding of the task. Alternatively, Group 2 used these tools more sequentially. They spent time initially watching the video and then they went to the KW. They continued summarizing until fairly late in their discussion, and much of this was the tutor helping to be sure that the group had a joint understanding. They did not begin working in the group report until fairly late in the activity and did not appear to spend much time there. This is in contrast to Group 1, which went to the group report at the same time they started their independent research.

This representation raises issues that can be addressed in other analyses. For example, the contrast in the tool use and coded discourse between Groups 1 and 2 suggested a need to zoom in on particular segments of talk and activity to better understand the pattern that is observed on a gross scale (e.g., Chernobilsky et al., 2003). In addition, these observations in the CORDTRA diagram allow us to form hypotheses that might be tested in different approaches to facilitation and in how students are oriented to the tools. In addition, we have since taught the course with different variations on the activity structure and can examine the relationship between these patterns of tool use and effective learning processes. The differences in these patterns provide suggestions for helping students use the tools effectively —which should in turn help learners see how concepts and cases can inform understanding of each other. For example, Group 1 was more likely to research their concepts in the context of the KW so that may account for the more coherent final product they generated.

Activity theory provides a conceptual tool for thinking about learning environments. Research tools, such as CORDTRA, provide a practical mechanism for looking at activity systems in general, and patterns of mediation in particular. Most importantly, they can help researchers see order in the midst of the complexity of learning.

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