Analyzing collaborative interactions: divergence, shared understanding and construction of knowledge

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Received 26 April 2004; accepted 21 October 2004

Abstract

One of the most important facets of collaborative learning is the interaction between individual and collaborative learning activities – between divergent perspectives and shared knowledge building. Individuals bring divergent ideas into a collaborative environment. While individuals bring their own unique knowledge and perspectives, the second important aspect of collaborative learning is how they move from seemingly divergent perspectives to collaborative knowledge building. This is clearly a social process among group members who could adopt various strategies for resolving differences including asserting dominance, acquiescing, or some form of reciprocal sense making. An important aspect of collaborative learning is the move from assimilation to construction, i.e., creating new understandings based on the discussions that they have had. Documenting this change from divergence to collaborative knowledge building to possible construction is therefore important in understanding the nature the collaborative interactions. In this paper we discuss our analysis of the process of collaborative interactions based on three dimensions – divergence of ideas, collaborative knowledge building and construction. Our aim was to document as well as to understand how collaborative interactions develop over time: whether students raise new issues (ideas) more frequently as they become more familiar with the discussion and discussants, and whether shared knowledge building becomes richer over time, and subsequent evidence that students were able to construct their own understanding based on their interactions with others. Our analyses were conducted in the context of an online graduate course conducted using the learning environment that we designed, CoDE, (Constructivist, Distributed learning Environment). In this paper, we will first describe the design of CoDE. We will then describe a study in which CoDE was used to offer an online graduate course in learning theories. We then
discuss our analyses of both individual and collaborative learning as it progressed through the duration of the course.
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Keywords: CSCL; Shared understanding; Divergence; Collaborative interactions

1. Introduction

In recent years several approaches have been put forth to document interactions in a collaborative environment. Researchers have analyzed thread lengths and interaction patterns (Hewitt & Teplovs, 1999) as well as learning outcomes. Guzdial (1997) presented an information ecology perspective of collaborative interactions describing the flow and use of information, analyzing the notes written, notes read and the thread lengths in two CSCL tools. Analysis based on several categories of collaborative knowledge building such as idea diversity, improvable ideas, etc., (Law & Wong, 2003), and social network analyses (Nurmela, Palonen, Lehtinen, & Hakkarainen, 2003) have provided insights into how collaborative learning develops over time.

Perhaps one of the most important facets of collaborative learning is the interaction between individual and collaborative learning activities – between divergent perspectives and shared knowledge building. Individuals bring divergent ideas into a collaborative environment. Divergence of ideas has been identified as having a significant impact on collaborative interactions (Hoadley & Enyedy, 1999; Stahl, 2002). While individuals bring their own unique knowledge and perspectives, the second important aspect of collaborative learning is how they move from seemingly divergent perspectives to collaborative knowledge building. This is clearly a social process among group members who could adopt various strategies for resolving differences including asserting dominance, acquiescing, or some form of reciprocal sense making. Thus a student coming to a discussion with her own understanding of the domain might take away a deeper or a broader comprehension of the topic, and apply it in other situations. An important aspect of collaborative learning, according to Schwartz (1999), is the move from assimilation to construction, i.e., creating new understandings based on the discussions that they have had. Documenting this change from divergence to collaborative knowledge building to possible construction is therefore important in understanding the nature the collaborative interactions.

In this paper, we discuss our analysis of the process of collaborative interactions based on three dimensions – divergence of ideas, collaborative knowledge building and construction. Our aim was to document as well as to understand how collaborative interactions develop over time: whether students raise new issues (ideas) more frequently as they become more familiar with the discussion and discussants, and whether shared knowledge building becomes richer over time, and subsequent evidence that students were able to construct their own understanding based on their interactions with others. Our analyses were conducted in the context of an online graduate course in which students were provided with tools for individual reflection as well as collaborative discussions. The course was based on a problem-based constructivist approach. We designed the learning environment, CoDE, (Constructivist, Distributed learning...
Environment), with tools for individual and collaborative learning, which we used to offer the online course. In this paper, we will first describe the design of CoDE. We will then describe a study in which CoDE was used to offer an online graduate course in learning theories. We then discuss our analyses of both individual and collaborative learning as it progressed through the duration of the course.

2. Design of CoDE

CoDE is based on a constructivist, problem-based approach and its design includes a set of problems that can be customized for any domain, and a set of cognitive tools (Lajoie & Derry, 1994), to facilitate both collaborative knowledge building and individual reflection.

Constructivists believe that learning is constructing knowledge from one’s experiences rather than directly receiving information from the outside world (e.g., Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989; Collins & Green, 1992; Resnick, 1987). The basic tenets of constructivism are (a) learners construct their own understanding; (b) new learning depends on current understanding; (c) learning is facilitated by social interactions and (d) meaningful learning occurs within authentic learning tasks. Solving authentic problems is one such constructivist approach (e.g., Barrows, 1985; Barrows & Kelson, 1995). Problem-solving environments are richest when drawn from the world of practice, from real world learning situations, so that as students work on solutions to complex problems, they have the opportunity to construct and generate rich meanings (Perkins, 1986; Piaget, 1954). Providing an authentic context also enables students to reflect on their ideas and solutions, provide explanations and justifications, thereby helping foster interactions among learners. CoDE is an integrated environment to present students with problems, and to help them solve the problems with the help of cognitive tools for reflection and collaboration.

3. Learning by problem solving

Problem solving has long been regarded as a generative activity that could promote deep learning (e.g., Barrows, 1985). Recent research shows that, indeed, students learn content knowledge deeply by solving relatively complex, real world problems that can have multiple solutions (Barrows & Kelson, 1995). Real world problems have several features that make them ideal for promoting learning and vehicles for connecting theoretical knowledge to issues in the outside world.

(1) They are complex and ill structured and have multiple solutions or methods of solving them.
(2) They are generally underspecified, thus requiring the learner to generate multiple hypotheses, and explore for more information in order to refine these hypotheses to move towards a solution.
(3) They are complex requiring the learner to acquire knowledge and skills to resolve them (Barrows, 1985).
(4) Ill-structured problems come from the world of practice, therefore helping learners to make the connections between the theories they are learning and their application in the real world.
(5) They provide opportunities for collaborative learning in which learners can engage in collective meaning making. Thus one way to encourage deep learning is to have students engage in solving complex, ill-structured problems. Problems from the real world are at the center of the
design of CoDE, so that, as students discuss these problems, they learn the relevant domain knowledge. However, in order to solve the problems, students need to be provided with tools that support collaboration, reflection and articulation. For example, CSILE (Scardamalia & Bereiter, 1994) supported knowledge building by providing a networked environment in which students can post their responses or “notes” and link their notes to those of others. If learning is a process of actively constructing meaning in a social environment, distributed learning via an online interactive environment should offer numerous possibilities for electronic apprenticeship. As described in the next section, CoDE was designed to afford such opportunities.

4. Cognitive tools

We used two tools to help students work on the problems. First, we designed the reflective notebooks to help students reflect and articulate their thoughts before they came to the collaborative discussions. Second, we integrated a discussion tool, the WebBoard, (O’Riley, 1999) to help students to discuss the problems and the theories that they were learning.

5. Reflective notebooks

Researchers have demonstrated the importance of reflection to enhance learning. For example, Pirolli and Recker (1994) suggested that reflection on problem solutions that focuses on understanding the abstract relationships between problems is related to improved learning. Collins and Brown (1988) used abstracted replay in which the learners’ solution procedure was reified to help learners examine their solution trees. Research on self-explanations (Bielaczyc, Pirolli, & Brown, 1994; Chi, Bassok, Lewis, Reimann, & Glaser, 1989) suggested that students learn better when they generate explanations thereby monitoring their understanding.

We designed ‘reflective notebooks’ to help students to analyze ideas, explore, articulate and reflect on solutions to problems. Based on the notion that “making covert, abstract processes visible, public and manipulable, serves as a necessary catalyst for reflective metacognitive activity” (Derry, Tookey, & Chiffy, 1994), the notebooks made thinking visible and recorded students’ journey through the problem solving process. Students could brainstorm their ideas before posting them for class discussions, and prepare their responses in the reflective notebooks. The instructor could post prompts in the notebooks to help students prepare their responses. Students could note their responses, append or edit what they had written earlier. Each entry was date stamped and was saved in a database. Students used the notebooks to generate ideas and learning issues on their own, before they engaged in collaborative discussions.

Another important function of the notebooks was that they supported students to write a reflective essay at the end of each problem that required them to summarize the main aspects of the content (domain knowledge) and the other required them to explain how they had applied the theory in order to resolve the problem. The reflective notebooks were therefore an excellent source of assessment that enabled students as well as the instructor to understand students’ progress in: (1) a problem; (2) across problems.
6. Discussion tool

The importance of the social context in supporting an individual’s understanding of her own learning (i.e., metacognition) was emphasized by Brown and Palincsar (1987). Working in groups provides many opportunities for exploration, reflection and articulation. Collaborative work allows students to successfully tackle problems more complex than what any group member could do alone (Hmelo, Narayanan, Newstetter, & Kolodner, 1995). Collaborative discourse not only supports learning but also helps build a community (Brown & Campione, 1990; Scardamalia & Bereiter, 1994).

We used the WebBoard which is a commercially available discussion tool, to help students engage in online discussions. Web Board, a threaded discussion tool, allowed students to post new topics, respond to topics already posted, and also attach documents. The WebBoard was integrated with CoDE and it opened in a separate window so that students could go between the WebBoard and the reflective notebooks or the problems. The WebBoard allowed the posting of many conferences, each of which could have many subtopics. This feature was used by the instructor to post conferences corresponding to aspects of the problem solving process such as initial ideas, issues to consider, solutions etc. and also to raise questions regarding the theories that students were learning to solve the problems. For each problem, students discussed their solutions based on the theories that they were learning.

7. Context of use of CoDE

CoDE was used to offer an online graduate course in ‘learning theories’. This was a 15-week (semester long) course. Students and the instructor met face-to-face three times during the course, and the rest of the course was conducted online. Out of a pool of 16 problems taken from real world scenarios, seven problems were selected for the course. Twelve participants took part in the selection process and rated each problem for difficulty, application of theories, and relevance to the student population taking the course (students in the educational psychology department). Based on the ratings, seven problems were selected in which the inter-rater agreement was over 95%. In this way, we could compare student responses across the seven problems. Students had ongoing discussions on the WebBoard every week and wrote reflective essays at the end of each problem.

For every problem, individual and collaborative learning was integrated throughout the problem solving process. Students started with individual work (brainstorming) in the reflective notebooks. This brainstorming continued in the first WebBoard discussion at the end of which a set of issues were identified as being critical to solving the current problem. Students could then use the resources (textbook and web sites) to get more information about the theories that would help them solve the problem. This allowed students to write down their initial ideas for solving the problem independently in their reflective notebooks. This individual work was important so that students came to group discussions with their own ideas to solve the problem and refined them as they discussed these in the group. The ideas were then reviewed and critiqued in the group discussions, in light of the theories that the students were learning. During these discussions, the instructor as well as the students could raise important issues that helped them understand the theories.
<table>
<thead>
<tr>
<th>Type of learning</th>
<th>Supporting tool</th>
<th>Activity supported</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>Reflective notebooks</td>
<td>Phases in the problem solving process such as problem understanding, generating ideas, identifying major issues, etc</td>
<td>Prepared students for collaboration in small groups and whole class. Also helped reflect on their own</td>
</tr>
</tbody>
</table>
| Collaborative    | Whole class discussions | Discussions during at least three stages in problem solving:  
• initial discussion of issues  
• raise issues important to the problem  
• discussion of solutions for the problem based on theories | Opportunities for peer collaboration  
Facilitation by instructor and other students to help students solve the problem |
| Individual       | Reflective notebooks| Reflective essays                                                                   | End of problem reflection by individual students                     |
Finally, students wrote the reflective essays justifying their solutions and summarizing the important aspects of the theories. Therefore the discussions were not ad hoc, but were built into the problem solving process in such a way that they supported knowledge building and a lot of interaction. Table 1 summarizes how the tools were integrated in the problem solving process.

8. Data and analyses

Twenty-six students were enrolled in the course and data from 24 students was complete and used for analysis. As indicated earlier, students solved seven problems. Therefore, we analyzed seven sets of discussions and essays. We analyzed the student interactions on the WebBoard as well as their reflective essays. An average of 134 WebBoard responses per problem, and 24 reflective essays per problem were analyzed. Our questions were:

- How does collaborative knowledge building progress over time? Does the occurrence of divergent ideas increase over time? Do students’ responses show a richer understanding based on the discussions?
- Do students construct their own understanding of what they are learning and apply it in other situations?

9. Analysis of webboard discussions: divergence and shared understanding

9.1. Divergent perspectives

We were interested in examining the WebBoard discussions for themes indicative of divergence of perspectives among participants. Scardamalia and Bereiter (1994) described that in collaborative knowledge building communities, students increasingly take charge of their own learning, lead discussions, offer new perspectives, and learn in a dynamic social environment. According to Hiltz and Benbunan-Fich (1997), one of the important aspects of a learning community is that rather than a one-way transmission of knowledge, students are encouraged to raise new topics, ask questions, and to respond to each other’s contributions. A response was considered as providing a divergent perspective if students raised an issue that provided a novel perspective in the interpretation of the problem or the application of theory to that problem. Sometimes this came in the form of a question; at other times it was a comment that brought a different understanding of the issue being discussed.

Table 2 shows examples of student responses in which students had interpreted problem, the readings or the comments from other students in a variety of ways. In the first example, the student raised questions about the differences in the theories of Piaget and Vygotsky. The second example in Table 2 is from a discussion on schema theory. A student raised an interesting issue about cultural and sexual biases and schemas. She went on to relate her own experiences in the later part of the discussion that provided another interesting insight into the topic. In the third example, students were discussing information processing theories. The problem that they were
Table 2
Examples divergent ideas

**Example 1.** First, could you explain or clarify what you mean: “Vygotsky focuses on the social basis of the mind, while Piaget focuses on the individual as the starting point”? I'm confused because it seems to me that Piaget would agree that exposure or interaction with the environment is essential to develop schemes and build constructs.

Second, when you say “development promotes social development” (Piaget) do you mean physical development? The way I understood it, Piaget believed that social experiences as well as physical maturation are necessary for development of knowledge.

**Example 2.** I was particularly interested with the information regarding cultural and sexual biases spoken about pages 255–256. Taking this into account that people sometime miss information which they find erroneous to their own schemas and scripts, I wonder how often educators actually are able to change these biases. I was wondering what others thought about this?

**Example 3.** On the surface, this case is about teamwork and the results to be gleaned when teachers and students work with each other. In Lisa West’s class, individuals are repeatedly taught that working with one another, sharing ideas and exchanging information will lead to an understanding of events and concepts.

Beneath this successful surface, however, lies another level of meaning: This class is also about storytelling and creating a means of expression. The vignette opens with Lisa’s concerns about her students lacking the “language proficiency” to understand or comprehend how and why we construct or use graphs – and what these graphs represent. At the beginning, Lisa is openly worried that her students do not have the right words to understand these pictures. She worries that their words will not decipher or decode the story told by these pictures.
solving had a vignette about a teacher using graphical representations for teaching problem solving. The response in this example offered a completely different perspective about ‘story telling’ from graphical representations. This led to many interesting responses about the role of representations, language proficiency and story telling.

9.2. Evidence of divergence

To examine how divergence progressed over the duration of the course, trends in the discussions were analyzed by looking at the number of responses indicative of divergence of ideas. For each of the problems, we noted the number of responses indicative of ‘divergent perspectives’ – i.e. students posting a new topic, or shifting the focus of the discussions by offering a new perspective. We computed the percentage of student-initiated responses as a proportion of the total number of responses for each problem. Two raters read every response to determine whether there was evidence of divergence. Inter-rater reliability ranged from 0.85 to 0.92 (see Fig. 1).

Results indicated that the percentage of responses in which new perspectives for a given topic were discussed was more or less similar for the first six problems, but increased for the last problem. However, on the whole, the percentage of responses indicative of divergence of ideas ranged from 13% to 18% for the first six problems and 28% for the last problem. This percentage was very small compared to the total number of responses. Post interviews conducted after the course shed some light on this, and will be discussed later in the paper.

9.3. Shared understanding

Another crucial aspect of a collaborative learning is that students not only respond to a contribution made by a teacher and other students, but also incorporate into their responses relevant aspects of the comments made by others in the group. In his analysis of group interactions, Bohm (1990) emphasized the importance of shared meaning, which is obtained through dialogue and negotiation. The joint understanding occurs by taking into account each other’s perspectives in
a social learning situation. The electronic discussion tool provided a shared space for students to exchange ideas, but did it also lead to a shared understanding of the theories that they were learning? We examined the WebBoard discussions for evidence of a shared understanding. Student responses showed evidence of such joint understanding. Responses showed that after listening to the multiple and divergent perspectives, students integrated their understanding of the theories and indicated in their responses that they “had not thought about it in that way”, or that “I agree with Victor’s explanation that [...]” (see Table 3). In both of these instances, students had integrated others’ perspectives and were rethinking their own understanding of the issues in light of the issues that their peers had raised.

9.4. Evidence of shared understanding

To analyze how shared understanding developed over time, we needed to qualitatively analyze student responses. The WebBoard discussions were therefore analyzed for evidence of shared understanding based on a scoring rubric (Table 4). As can be noted from the rubric, responses that showed evidence of students integrating the responses of other students scored the highest points. A high score indicated that students were not merely responding to an issue posted by the instructor, but were integrating other students’ responses into their own responses. Two raters scored each response and inter-rater reliability was between 0.92 and 0.95.

Students’ responses were analyzed to examine whether they integrated what they learned from their peers into their own responses. In order for students to come to a collective understanding of the domain, it was very important that they learned from the collaborative discourse and integrated the viewpoints of their peers in their own responses. We examined the overall trends for shared understanding in the seven problems (Fig. 2) and also analyzed the significance of differences between the scores. Fig. 2 shows that there was no consistent pattern during the seven problems that students solved. As can be noted from the figure, students’ scores did not increase consistently as the course progressed. Instead, there were two ‘dips’ in their scores (problem 3 and 6). However, there was a rise in the scores for the last problem. The figure also indicates that students used the relevant theoretical constructs to justify their responses and very few responses scored 2 or 4, which meant that to the extent that students had to support their responses with appropriate theories they were successful.

We wanted to analyze whether students progressed from a lower score (2 or 4) to a higher score of 6 or 8 as the course progressed. A higher score was indicative of the fact that students had integrated the issues discussed in the collaborative discourse into their own responses. We conducted a Friedman test to evaluate the differences in the mean scores. A Friedman test is a non-parametric technique frequently referred to as a ‘two way analysis of variance on ranks’ and is used in cases where the actual data consists of ratings. This test was significant, $\chi^2 (6, N = 23) = 18.2, p = .006$ (Table 5). This showed that the overall change in the scores was significant. However, we wanted to further examine the scores to account for the two ‘dips’ in scores for problems 3 and 6. We used the Wilcoxon signed rank test for pair-wise comparisons. We found that for problems 4, 5 and 7, there were more positive ranks, i.e., students with improved scores. The Wilcoxon signed rank test showed a significant difference, $p = .02, .01$, and .01, respectively, for problems 4, 5 and 7 (see Table 5). However, for problems 3 and 6, the negative ranks were higher than the positive, explaining the dip in the average scores.
Table 3
Examples of shared understanding

**Example 1.** Interesting ideas about repetition and rehearsal and the idea of learning a skill. I really had not thought about it in that way, but now that I have read your message – I definitely agree that the old saying “practice makes perfect” is true when dealing with some skills in life. I know that I did not improve in swimming because I elaborated or organized – I improved because I spent close to 20 h in the pool a week. Same is true for any musical instrument or driving a car or learning how to operate a machine. I guess we need both repetition and rehearsal when we are learning.

**Example 2.** I agree with Victor’s opening when he says, “I can think of instances for myself where a personal learning goal was achieved but I was unable to satisfy the performance goal.” Do we ever sacrifice student’s real desire to know and learn by pushing the performance goals? I suspect so, either the performance goal is out of reach or just to easy.

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Table 4
Scoring rubric for WebBoard responses

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Contributions are shallow reflecting little or no thought about the topic of discussion</td>
</tr>
<tr>
<td>2</td>
<td>Contributions reflect limited thoughtfulness, comments are primarily opinions that are not supported by appropriate theory or course material</td>
</tr>
<tr>
<td>4</td>
<td>Contributions show thoughtfulness; comments are primarily opinions however there is limited support from theory and course material</td>
</tr>
<tr>
<td>6</td>
<td>Contributions show thoughtfulness; opinions are supported by appropriate theory and course material</td>
</tr>
<tr>
<td>8</td>
<td>Contributions are extremely thoughtful opinions are supported with appropriate theory from course material. Other student comments along with personal experiences are synthesized and incorporated into a well-developed argument</td>
</tr>
</tbody>
</table>
The WebBoard discussions provided us with examples of student discourse indicative of divergent perspectives and convergence on some issues in which students integrated other’s viewpoints in their postings. But does shared understanding lead to individual learning gains as well? Vygotsky believed that internalization has occurred when processes first performed with others on a social plane are successfully executed by a learner in an independent learning activity. As Dillenbourg (1999) pointed out, in collaborative learning internalization is more of a process than an effect. Citing Werstch, Dillenbourg has argued “the main cognitive change was less the transition from the intra- to the interspsychological plane, but, within the interspsychological phase, when the child becomes able to use the to-be-internalized concepts in his/her conversation with his/her mother”.

Internalization has occurred when processes first performed with others on a social plane are successfully executed by a learner in an independent learning activity. Thus, a student coming to a discussion with her own understanding of the domain might take away a deeper or a broader comprehension of the topic, and apply it in other situations. An important aspect of collaborative

<table>
<thead>
<tr>
<th>Problem1–Problem2</th>
<th>+ve Ranks</th>
<th>−ve Ranks</th>
<th>Ties</th>
<th>z</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem1–Problem3</td>
<td>2</td>
<td>6</td>
<td>15</td>
<td>0.000</td>
<td>0.53</td>
</tr>
<tr>
<td>Problem1–Problem4</td>
<td>8</td>
<td>1</td>
<td>14</td>
<td>−2.181</td>
<td>0.02</td>
</tr>
<tr>
<td>Problem1–Problem5</td>
<td>7</td>
<td>3</td>
<td>13</td>
<td>−0.680</td>
<td>0.02</td>
</tr>
<tr>
<td>Problem1–Problem6</td>
<td>3</td>
<td>5</td>
<td>15</td>
<td>−0.187</td>
<td>0.85</td>
</tr>
<tr>
<td>Problem1–Problem7</td>
<td>10</td>
<td>1</td>
<td>12</td>
<td>−2.575</td>
<td>0.01</td>
</tr>
</tbody>
</table>

10. Responses in the reflective notebooks – construction of knowledge

The WebBoard discussions provided us with examples of student discourse indicative of divergent perspectives and convergence on some issues in which students integrated other’s viewpoints in their postings. But does shared understanding lead to individual learning gains as well? Vygotsky believed that internalization has occurred when processes first performed with others on a social plane are successfully executed by a learner in an independent learning activity. As Dillenbourg (1999) pointed out, in collaborative learning internalization is more of a process than an effect. Citing Werstch, Dillenbourg has argued “the main cognitive change was less the transition from the intra- to the interspsychological plane, but, within the interspsychological phase, when the child becomes able to use the to-be-internalized concepts in his/her conversation with his/her mother”. Internalization has occurred when processes first performed with others on a social plane are successfully executed by a learner in an independent learning activity. Thus, a student coming to a discussion with her own understanding of the domain might take away a deeper or a broader comprehension of the topic, and apply it in other situations. An important aspect of collaborative
Table 6
Examples of knowledge construction

**Example 1.** I strongly agree with the discussion about the importance of real-world learning. Currently I am working on creating a research project that will look at whether or not writing for a wider-audience will help middle school students be more motivated to write. The emphasis on this research project is on “real-world writing situations.” I will try to expose these students to a numerous number of publishing opportunities. The research I have done thus far shows that the introduction of “audience specification” does in fact improve student writing and even can improve student motivation towards writing. I look forward to receiving the results of this study to see whether or not real-world writing does improve the overall quality of student’s writing.

**Example 2.** I found that I am transferring some of what I am learning in this class to my own classroom. I also found in reading some of the material that I have made connections to my previous career as an accountant. It surprised me in some ways because the disciplines are so different yet, once I started to reflect upon it, there are many things I previously learned that have helped me to motivate students and organize my classroom.
learning, according to Schwartz (1999), is that students move from assimilation or internalization to construction. We believed that if students can internalize and incorporate their learning in a collaborative situation, and construct their own understanding, then such a shift from assimilation to construction has occurred. We analyzed reflective essays to understand whether students had assimilated any of the shared knowledge from the WebBoard discussions and constructed their own understanding in their reflective essays.

Table 6 shows example responses that showed evidence of knowledge construction, in which students indicated that they were applying what they learned in their own research and learning as well as in their role as practitioners.

10.1. Evidence of internalization

Analyzing students’ reflective essays at the end of each problem provided evidence for knowledge construction. As described earlier, one of the aims of our study was to examine the extent to which students were able to construct their own understanding and apply what they had learned in their discussions with the instructor and their peers. One way to find this out was to analyze students’ reflective essays in which they were asked to write about the theories that they had learned. Reflective essays could include a reflection on the problem, how the solved it, what they had learned from solving the problem and any relationship with personal experiences. Once again, a scoring rubric was developed to analyze students’ responses as described in Table 7, with a score of one for a response with no internalization and a three for a well integrated argument that showed that students had constructed their own understanding based on the collaborative discussions.

There was evidence in students’ essays that not only had they internalized from the WebBoard discussions but they were also applying what they had learned in their practice as teachers and students. Results showed that there was a decrease in scores for the second problem after which there was an increase in students’ scores, indicative of better essays in their reflective notebooks. The scores almost remained steady for the rest of the problems. Once again, we used the Friedman test for an overall analysis of the significance of the differences in the mean scores. This test was significant, \( \chi^2 (6, N = 23) = 42.6, p = .000 \) (Table 8). The Wilcoxon signed rank test was used for pairwise comparisons in which we compared the scores on all the problems with problem 1. We found that except for problem 2 all of the differences were significant. In the case of problem 2, there were seven negative ranks (students who got lower scores). However, in all other instances, there were fewer negative ranks (Table 8, see Fig. 3).

Table 7
Scoring rubric for the reflective essays

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No evidence of internalization, essay is a description of the theories</td>
</tr>
<tr>
<td>2</td>
<td>Essay shows depth of understanding for each problem. Mention of personal experiences</td>
</tr>
<tr>
<td>3</td>
<td>Depth of understanding of a learning theory its assumptions and implications to explain each of the problems/cases, elaboration of how they are using the knowledge in practice, evidence of integration of the WebBoard discussions into a well integrated argument</td>
</tr>
</tbody>
</table>
10.2. End of course interviews

Interviews to understand student attitudes towards the course – especially about collaboration and using the problem-based approach. We found that 54% of the students had some concerns about the online discussion and the participation of the instructor. A common theme was that they wanted feedback on their responses from the instructor, and did not see the discussions as a forum to construct knowledge based on one another’s responses. 92% of the students said that the biggest strength of the course was that it presented them with real-world problems; however over 66% of the students said that the constructivist approach was a challenge because they expected that the instructor would go over the theories before students were asked to solve the problem.

11. Discussion

In this paper, a study in which students participated in an online course in which students solved seven real-world problems is described. Students’ responses were coded for the occurrence
of divergent, perspectives and shared understanding. It was found that while there was no consistent trend in student responses in both of the categories, there was a substantial increase in student initiated dialogue as well as responding to other students’ comments for the last problem in the course. In the next few paragraphs, I will discuss the results in terms of three factors that may have affected student interactions – nature of the problem, student perceptions and nature of the tool.

One of the factors that may have influenced students’ interactions might have been the type of problem that was presented to the students. Although an authentic problem is important to initiate dialogue and to help students have ownership of the task, in our study the type of problem that the students were working on seemed to have greatly influenced the amount of interaction. As many of the students were (or at some point had been) math teachers, the last problem that dealt with teaching math evoked the most passionate dialogue. This may account for high level of interaction in the last problem. Although all of the problems were chosen based on their relevance to the students taking the course, in future it might be important to enable students to select a set of problems from a database and include only those problems in the course that the majority of students vote for.

A second important factor was students’ perceptions of what they needed in a course. For most students, it seemed that the constructivist format as well as the online discussions were contrary to their expectations of their roles as students and the role of the instructor. Students expected the instructor to take the lead in every discussion and provide feedback on each of their responses. Divergent activities are important to collaborative interactions so that students can explore a variety of perspectives. But students often do not raise diverse ideas. Hübscher-Younger and Narayanan (2002) address the interesting issue of students’ perception of authority in a collaborative learning environment. They found that students often converge on representations that they associate with authority, for example those that they see in a textbook example (e.g., textbook examples). In their study students “converged on an authoritative representation or representational style and ignored the limitations of that representation or style and other representational styles” (Hübscher-Younger & Narayanan, 2002). In his study of students using CoWeb, which allows students to collaboratively build knowledge by writing and editing in a web-based environment, Guzdial (1998) believed that the teacher’s involvement was critical because students often wanted to hear from the teacher. In the study described in this paper too, students’ perception of the role of the instructor as providing the explanations for the issues discussed as well as providing solutions for the problem being discussed seems to have affected their willingness to raise new ideas and discuss diverse perspectives.

Hakkarainen, Lipponen, and Jarvela (2002) have also found that in collaborative learning situations, students’ expectations affect the nature and extent of interactions. They studied the use of CSILE in two Canadian and one Finnish classrooms, and found that the projects undertaken, the epistemological assumptions and the pedagogical practices that were unique to each of the settings led the students in the Finnish classroom and one of the Canadian classrooms towards “focusing on observable phenomena” and factual knowledge, as opposed to the second Canadian classroom in which students engaged in a more meaningful discourse. In our study, students seemed to prefer to “answer” the question that the instructor posted, instead of taking the lead in raising new issues, or offering explanations or clarifications, they relied heavily on the instructor. This was also validated in subsequent informal interviews with students who consistently raised the issue that
they needed more feedback on their collaborative discussions. They failed to see the collaborative
interactions as a way to collectively build knowledge.

Although students showed positive attitudes towards the constructivist nature of the course,
one of reasons that they wanted feedback from the instructor for each of their responses may have
been that students were not used to the constructivist approach to learning in which the instructor
was a facilitator and not a giver of knowledge. Hogan and Pressley (1997) point out that students
may not share the constructivist philosophy of actively constructing knowledge and can be easily
frustrated. Hence making scaffolding strategies explicit to student is very important. Making
expectations clear is therefore an important lesson that we learned.

A third reason that the occurrence of diverse ideas and shared understanding did not develop
over time may also have been the nature of the WebBoard as a tool for discussion. According to
Hansen, Dirckinck-Holmfeld, Lewis, and Joze-Rugelj (1999), a tool can be viewed as having two
roles: as compensating for difficulties and as facilitating processes. In our case, the WebBoard was
not adequate for the facilitative role. Therefore, an important lesson that we learned was that the
discussion tool that we used did not explicitly scaffold or facilitate the students to raise a new issue
or provide new perspectives. These were expected to occur in the natural course of the dialogue.
But results indicated that this was difficult for students because they were not used to the kind of
collaborative learning opportunities that were offered. This is especially true of what Lin and Hat-
amo (2002) call generic and flexible tools such as CSILE: “a danger of generic and flexible tools is
that the learning goals are forgotten more often than when we use tools that have clear and strong
domain specific goals. In a generic tool, the affordances are what we make them: they are depend-
ent on the instructional activities, the task, teacher facilitation and so on. Therefore, in order to
truly understand a particular curricular integration of the tool, there needs to be a clear deline-
ation of the learning goals, the context of its use, and the ways in which the tool will be used. For
example in one of our implementations of collaborative learning tools in middle school class-
rooms, we found that the nature of the tool, i.e., whether it supported synchronous or asynchro-
nous discussions and whether it supported within-or between group interactions affected the
in the form of prompts to encourage students to engage in these activities would help students.
The WebBoard was only a threaded discussion tool that did not provide these affordances. In next
iterations it is important to have a tools that will be built with the intention of fostering more
interactions that students initiate.

Although there were not enough occurrences of students providing diverse ideas or integrating
from different perspectives in their WebBoard discussions, we found that students’ reflective es-
says showed evidence of internalization. Students’ essays showed evidence of drawing from the
discussions as well as their personal experiences. Guzdial and Carroll (2002) raised interesting as-
pects about the lack of dialogue in collaborative interactions. They hold that students may not
participate if others represent their ideas, yet they can learn from the discourse. In addition, stu-
dents might reflect on ideas presented by others, even though they may not actively take part in
the dialogue. It might therefore be possible that although we did not see much evidence of collabor-
ative knowledge building, students did in fact construct their understanding based on the dis-
cussions they had with their peers, as indicated through their reflective essays.

Since collaborative learning is both individual and social, it presents a classic assessment
dilemma concerning how to assign a value to individual participation in-group activity. Whether
each individual is held accountable for each piece of information produced by the group, or whether individuals are allowed to specialize, to divide and conquer problems, presents a complexity that must be analyzed in each case and applied to a theory of CSCL. In addition, most assessments of CSCL appear to be solely summative and for purposes outside those of the collaborative group, such as researchers, designers and teachers. However, Kulikowich and Young (2001) have argued for making the flow of collaboration visible directly to the participants for the purposes of enhancing their performance. From this perspective we would argue that it is important for participants to become better at using the collaboration tools by seeing not only the content of their discourse, but the quality of it. Participants should be both providers and benefactors of assessment data. From this perspective we would postulate that students who were using CSCL tools superficially might be drawn to go deeper if they were provided assessments of their collaborative process and thus able to directly detect that their use was superficial. We would argue that to move toward a theory of CSCL assessments would require targeting both individual and shared components of work, and addressing not only the needs of those external to the collaboration, but seamlessly contributing to the goals of the collaborators as well.

12. Conclusion

In this paper, we discussed collaborative interactions over time as they occurred in an online course. We analyzed student interactions for divergence of ideas, knowledge building and also examined whether there was evidence that students had gained a richer understanding as a result of collaborative knowledge building. Collaborative environments are built with the assumption that students will co-construct knowledge and move towards a shared understanding of the domain. In our study we found that the level of new ideas raised and the incorporation of other’s responses into their own responses did not occur to the large extent. For the most part students were merely providing “answers” to the questions and depended heavily on the instructor for feedback. Factors such as the culture, in terms of students’ expectations, and the nature of the tool play an important role in the development of a community of learners.

References


