

# L. (TECHNOLOGY TRACK): ISSUES IN THE DESIGN OF ASYNCHRONOUS COLLABORATION SYSTEMS

## Exploring the Lack of Dialogue in Computer-Supported Collaborative Learning

Mark Guzdial, Karen Carroll

College of Computing/GVU  
Georgia Institute of Technology

[guzdial@cc.gatech.edu](mailto:guzdial@cc.gatech.edu)

[kcarroll@cc.gatech.edu](mailto:kcarroll@cc.gatech.edu)

### ABSTRACT

Research in collaborative learning has supported the hypothesis that dialogue between peers and between peers and teachers facilitates learning by the participants in the dialogue. Examples of these dialogues show dozens of turns (individual utterances by participants) in a single learning session. In contrast, measurements of interaction from computer-supported collaborative learning environments show that on-line dialogue looks much different, with an average of approximately one posting or less per student per week. Measurements of learning in these environments *do* suggest learning is occurring, but presumably, not based on the same kind of dialogue described in research on face-to-face collaboration. We explore explanations for how the learning is arising in CSCL environments based on the *Vicarious Learning* Project (Lee, Dineen, McKendree, & Mayes, 1999; McKendree, Stenning, Mayes, Lee, & Cox, 1998), but in the course of this explanation, two additional hypotheses emerge. We believe that some of the learning in CSCL environments occurs from the observation of the dialogue, the reflection induced by the *potential* of submitting, and in the interaction between the face-to-face and on-line environments.

### Keywords

Measuring dialogue, measuring learning, empirical measurement of computer-supported collaborative learning

### INTRODUCTION: IS THERE LEARNING IN COMPUTER-SUPPORTED COLLABORATION ENVIRONMENTS?

Dewey (Dewey, 1901) and Vygotsky (Vygotsky, 1978) both argued that all learning begins from a social context. Internal reflection and “monologue” are secondary effects that derive from previous social interactions. A peer discussion is a useful way of encouraging the kind of social interaction that leads to learning. Researchers on collaborative learning have found that collaborative discussions (competitive or cooperative) do facilitate learning (Cohen, 1994).

Learning scientists have described how dialogue leads to learning, especially, collaborative learning where a shared understanding is created through the dialogue (Jeong & Chi, 1997; Roschelle, 1992). Roschelle describes learning as arising from dialogue that follows a cycle of posing hypotheses, testing the hypotheses, and then discussing the results of the test and the formation of the next set of hypotheses. Jeong & Chi describes learning as resulting from a similar process of explaining to one another what each individual’s understanding is, and then refining it based on what the individuals hear. A key characteristic in both the Roschelle and Jeong & Chi studies is that subjects are interacting with one another to a large extent. The posing of hypotheses, testing of hypotheses, and the generation of explanations described do not occur in a single utterance, but instead occur across dozens of utterances, including many non-verbal ones, in Roschelle’s study. Roschelle’s study identifies 49 turns between two students in less than one hour.

In the literature on computer-supported collaborative learning, we see nowhere near that level of interaction. Guzdial (Guzdial, 1997) showed that for a variety of asynchronous computer-supported collaborative learning environments (including CaMILE and newsgroups, Answer Garden (Ackerman, 1994), and CoNote (Davis & Huttenlocher, 1995)), students posted an average of less than one note (a contributed utterance in the shared, on-line space) per week. While we would expect more interaction in synchronous collaboration, asynchronous collaboration is the predominant mode in the research literature. Another way of looking at the interaction is in terms of the length of the discussion, which we can measure as the length of a *thread* (a series of notes posted in response to a single note). In newsgroups, one of the most popular environments for computer-supported collaborative learning (Terveen & Hill, 1998), the length of a thread in 18 classes was measured by Guzdial as averaging 2.2 notes. The implication is that the average discussion consisted of a note and a single note in response. Terveen & Hill found very similar results across hundreds of newsgroups on the Internet

(Terveen & Hill, 1998). A more recent study by Hewitt & Teplov found that in seven graduate courses offered at a distance using the CSILE environment (Scardamalia, Bereiter, & Lamon, 1994) the average thread length was 2.69 (Hewitt & Teplov, 1999).

All of these studies were measures of interaction only. There were little or no learning measures. One might presume that such little interaction implies that no learning is occurring. However, studies of CSCL use with similar interaction levels have demonstrated in the last couple of years.

- Miyake & Masukawa (Miyake & Masukawa, 2000) describe a system, ReCoNote, in which students explicitly create relations between notes, as well as post new notes. In their study, students in cognitive science did research and reported on their results in ReCoNote, and then later posted and discussed their research papers in ReCoNote. 57 students created 310 notes over a 15 week<sup>1</sup> period, for an average of 0.362 notes per student per week. If we consider a link between notes as another kind of utterance (referring to our definition of a note earlier), students posted an average of 0.58 notes per student per week. They mention that the number of logins by students was 749, which leads to 0.87 logins per student per week. Miyake & Masukawa report significant learning in cognitive science among the students, as measured by a qualitative analysis of their papers.
- A detailed study by Hoadley & Linn (Hoadley & Linn, 2000) focuses on a use of the SpeakEasy collaborative learning environment where eighth grade students debated the relationship between color and light over a four week period. Students participated in one of two conditions: An unmodified SpeakEasy discussion about the topic, and a SpeakEasy discussion structured around the perspectives of Kepler and Newton where the goal was to highlight the differences between Kepler's and Newton's views on color and light. In their studies, the average number of notes per student per week was 1.3<sup>2</sup>. The average number of logins per student per week was 0.825 (quite similar to the Miyake & Masukawa study). Hoadley & Linn found that all students learned significantly about color and light, but those using the historical forum learned more (in particular, they related the theories to the scientists). Surprisingly, the number of logins was the only measure that Hoadley & Linn found that correlated with post-test score.
- A new study by our research group at Georgia Tech has focused on a part of Freshman English Composition classes, comparing students using our CoWeb tool in a "close reading" activity with students not using technology for their "close reading" (Rick, Guzdial, Carroll, Holloway-Attaway, & Walker, 2002). Students in the CoWeb generated an average of 2.22 notes per student per week. Students were *required* to participate in the CoWeb, which leads to slightly higher averages, but 2.22 notes per student per week is still not anywhere near the rapid iteration of dozens of comments that we see in the work of Roschelle and Jeong & Chi. Students using the CoWeb did significantly better than the non-CoWeb-using class on class essays, especially in areas of vocabulary and organization of ideas, even though both classes scored about the same on the first assignments.

The finding that these results suggest is that learning is occurring in these computer-supported collaborative learning environments, despite the fairly low rates of discussion. But the interaction is not like what Roschelle and Jeong & Chi are describing, at least not in terms of the amount of discussion. What is the mechanism by which the learners are learning in these studies? Is it the shared understanding described by Roschelle and Jeong & Chi, or do the low rates of interaction suggest that something else is happening? In the rest of this paper, we describe a set of hypotheses for what the mechanism might be, and offer some interviews with students to support some of these hypotheses. Our opinion is that there is more than one kind of mechanism at work, just as there are several different learning mechanisms taking place in face-to-face learning.

## HYPOTHESES ON LEARNING MECHANISMS

The first hypothesis to consider is that the shared understanding mechanism described by Roschelle and Jeong & Chi is also leading *in the same manner described* to learning in the computer-supported collaborative learning (CSCL) examples cited previously (Miyake & Masukawa, Hoadley & Linn, and Rick, et al.). We find little to support this hypothesis. The low rate of postings makes it unlikely that students are engaged in cycles of hypothesis formation, experimentation, and discussion (Roschelle) or in exchanged explanations (Jeong & Chi). One counter hypothesis might be that students are learning in the CSCL environments, but more slowly—that the entire term is a single learning session, and that the rate of discussion is appropriate when distributed across such a long time. We point out, however, that each of the studies is keeping pace with a face-to-face classroom. In the cases of Miyake & Masukawa and Rick, et al., the topics being discussed in the computer

<sup>1</sup> We are presuming here a 15 week semester study. Miyake & Masukawa describe their study as extending over a "half year" and describe their use as having four phases, the middle two of which were three weeks long each.

<sup>2</sup> Based on a reported average of 5.3 (SD=31) notes written per student over a four week period. Students were required to write at least three notes.

environment are appearing at the same time as the topics do in the traditional classroom—it isn't the case that all the observed discussion focused on a single topic so that shared understanding occurred.

We began this exploration with a hypothesis on where the learning was coming from:

- *Vicarious learning for shared understanding:* Students are engaged in the shared understanding mechanisms described by Roschelle and Jeong & Chi, but *vicariously*. That is, students sometimes do not post a note because someone else has already made the response or explanation they would make. Under this hypothesis, the mechanism for each individual's learning is the same as in the shared understanding model, but there are fewer utterances because students recognize their own understanding in others.

But in our search for evidence to support this hypothesis, two other possible explanations arose from the interviewing process:

- *Reflection stemming from the potential of posting:* Students encounter an idea in a forum, and reflect on it in order to create a posting, but in the end, they don't—perhaps because someone else posted the idea, or because they lose interest in the actual posting of a note. But in any case, the *possibility* of responding leads to an inquiry process that facilitates learning.
- *Relating on-line and in-class activities:* In the three CSCL studies cited, the on-line environment was an extension of an existing face-to-face class. Thus, studying the on-line space doesn't provide a complete picture of the learning. Students meet ideas in the on-line CSCL environment that they've heard in face-to-face class, or they take ideas from the CSCL environment into the face-to-face class for discussion or relate them to class assignments or topics.

All three of these hypotheses are consistent with Hoadley & Linn's observation that number of logins correlated well with learning outcomes. Students who log in more often are probably more likely to identify with other students and have vicarious learning opportunities. Students who log in more often may be more likely to be involved and reflective about the discussion. Students who log in more often are more likely to see connections between what's going on in class and in the CSCL environment.

## EXPLORING THE HYPOTHESES

To explore why students were choosing *not* to post in a CSCL environment, we conducted a series of interviews in an English Composition class that was using the CoWeb (in a manner like that described in Rick, et al.) Through log files, we identified students who did post notes frequently into the CoWeb. We then identified a point when a frequently-posting student visited a discussion page and read it (or so we presume, based on length of time spent on the page) *but did not post a note to the discussion*. Because the CoWeb keeps every version of every page, we were able to reconstruct the page as it looked at the moment that the student read the page.

At the end of the same academic term, we were able to identify three students who matched these criteria. We asked them to explain why they chose not to post at that time, providing them with a printout of the page as it looked when they visited it. While the large time gap between the incident and the generation of an example is a problem if we were to consider these data as think-aloud protocols (Ericsson & Simon, 1980), we found that the example page served as a stimulus for a wider ranging discussion on why the students posted and when.

As mentioned our original hypothesis was that vicarious learning explained the learning-without-much-dialogue phenomenon. Our guide for the interview started from this hypothesis. We asked all three students the following questions, with questions added by the interviewer for elaboration or explanation of a confusing point:

- *It looks as if you read comments on this page, but didn't post. Can you remember why?*
- *Did you ever go with something to say and find someone else had already posted it? Did you ever come up with something to say, go away to think about it, and return to find someone else had said it?*
- *When you read comments which sparked something you wanted to say, did you generally post it right away or go away and think about it for a while first?*
- *Did you ever think of something to say and then bring it up later in class instead of posting?*
- *When you went to the CoWeb, did you usually go with something to say, or were you just browsing through other people's comments?*

Three students is admittedly a very small sample. We are not arguing that these students are representative of the whole class, nor that the mechanisms for potential learning that we identify are the only ones—they may not even be the most common ones. Rather, we see these interviews as *suggesting hypotheses* to explore further to explain the tension we point out in the literature between amount of discussion and evidence of learning. We conducted the interviews to develop some evidence for our first hypothesis. The fact that we found students offering stories of their experience that supported the first hypothesis and the two emergent hypotheses is significant in suggesting the *potential* of these hypotheses in explaining how

learning can occur with little observable dialogue. In the sections below, we expand upon each of these hypotheses and offer students' comments in support of these hypotheses.

### **Vicarious learning for shared understanding**

The *Vicarious Learning Project* (Lee et al., 1999; McKendree et al., 1998) studied how well students learned from experiencing the interaction between teachers and students as transcripts or video. The Vicarious Learning researchers recorded tutors working with students, or even students working together, then created transcripts and video segments from these recordings. New students would then study the transcripts and video segments. The result was that the new students learned as well as those recorded.

The goal of the Vicarious Learning Project was to show that transcripts of dialogues are an effective educational resource for future students. The mechanism of learning was that students would "identify" with the student in the dialogue and would benefit from the same explanations, and potentially have the same questions. They point out that "learning, particularly in higher education, requires learning about descriptions of the world, knowledge derived from someone else's experience, and from understanding someone else's arguments." Learning "vicariously" from recorded dialogues gives students the opportunity to practice learning from someone else's experiences.

What may be occurring in the three CSCL studies cited previously is a slight variation on the Vicarious Learning Project setting. Students in the same class are building the dialogue, but they are also observing others' dialogue. Students may not post if someone else has already made the posting that they were considering making. In this case, students recognize a shared understanding with others in the class, and they choose not to post because their contribution is already made. The end result is the kind of shared understanding that Roschelle and Jeong & Chi describe, but with fewer postings because of the identification with others' perspectives as described by the Vicarious Learning project.

Two of the students we interviewed described having this happen to them.

K: Apparently, you looked at this page. My impression from looking at the CoWeb is that you posted pretty frequently. But this is one where you didn't post—where you looked at it and you didn't write anything. Do you remember this?

Student P: Yeah, yeah, I remember this.

K: Do you have any idea why?

Student P: Oh, yeah, I saw this part, and I was going to answer it, but, I don't know, I... before I could answer, somebody already came up with the answer, StudentC or StudentJ came up with the answer.

K: Somebody said what you were going to say?

Student P: Right

K: So somebody already did it. Did that ever happen other times? Was that something that happened more than once for you, where people would answer what you were going to answer?

Student P: It did actually, the open forum, it happened a couple of times, like I come there and I like look at people's questions, or something, and then go back, by the time I come back, like, ten more people have answered it.

K: Did you ever find that you had a question you wanted to ask, and then somebody else had asked it already?

Student P: A couple of times, yeah. Yeah. I guess, even if I did have a question, I mean, the questions were there, but it just didn't come out, somebody had already worded it, so I'm like oh yeah, I wanted to- I was wondering about this, too.

What's interesting in this exchange is that the student identifies that both generating an answer (like generating an explanation in Jeong & Chi's study) and questions (like generating hypotheses and questions in Roschelle's study) are happening vicariously for this student. Other students performed those answering and questioning roles that Student P would have posted, so the learning mechanism for each individual looks like the shared understanding model, but without the same level of interaction being evident in the on-line forum.

K: Did you ever go with an idea of something you wanted to say and find that someone else had already posted it?

Student Z: mm-hmmm. Several times. Yeah, like, with this, the whole Darwin related to creationism, there are some things that I probably could have added but I thought like, I don't know why I didn't, but like in retrospect I probably would have had some interesting discussions myself if I had, but like, I like when Student P, how he, I like reading what he writes, too, 'cause it's very interesting to me, 'cause he thinks sorta like I do; like he likes to have facts to base things up; I understand how he thinks, and like a lot of people in the class, a few of them have the same views and a few of them don't and I like, it just interests me, you know, kind of, I like how people think.

Student Z says that the event occurred several times that he was going to post, but found that his ideas were already posted. He also says that he noted a particular student who “thinks sorta like I do.” Student Z also points out that he doesn’t agree with all the views that he reads in the class forums, but it interests him to read them. That last point is echoed by Hoadley & Linn, “The most common benefit of SpeakEasy identified by interviewed students was that they could hear the opinions of others.” The hearing of contrasting perspectives is an important part of the shared understanding mechanism described by Roschelle and Jeong & Chi.

### Reflection from the potential of posting

All three of the students we interviewed talked about the role that *considering* whether to post and what to post had on their learning process. Students talked about doing research or going off to think about issues raised before making a posting—whether or not they actually did post. The role of the CSCL, then, is to start an inquiry process for the students, and that inquiry might not result in a posting into the CSCL environment. An asynchronous forum is particularly supportive of this mechanism because the delay in response during reflection doesn’t impact the flow of the conversation.

K: Somebody said what you were going to say?

Student P: Right, like, I found stuff on this, I mean I came here, I saw this and I decided to do some research, so I went to some other web page and I looked it up and I found out stuff, I was actually ready to post, I come back, and somebody had already done it.

K: Is that something that you would frequently do, to kind of look at what somebody else had said, and then go away to think about it yourself?

Student P: Um-hmm. That’s probably what I did, yeah. Like I used this as kind of, you know, something that would help me think about a particular topic and a particular direction, like when you just read a book, it’s really difficult to pick a subject and go in a particular direction, like if somebody thinks about something and gives a question, it’s easier to channel your efforts towards a particular thing.

In this quote, student P describes going off to “do some research” in response to something that came up in the discussion. But someone else posted before he got back, so he didn’t end up contributing to the discussion, but the learning benefit for him had already been gained.

K: Suppose that you did have something to say, would you generally, say it right away or is it something you would go away and think about and come back to later, or?

Student T: Generally I’ll probably do it right away unless I’m just there browsing for whatever reason, if I don’t really have that much time, I might go back and say later, and if I do that usually I’ll also have thought about it some more and that may make me not want to write anything or it would give me more to write about.

Student T generally responds immediately, and doesn’t go off to do “research” as did Student P. But sometimes Student T sometimes does carry the issues away to think about them further. In the end, there may be no posting at all, or the content of the posting may have improved due to the reflection.

K: Sometimes people say that they would go and they’d have an idea of something they’d want to say but they’d want to go away and think about it a little bit before they’d come back and write it. But then maybe by the time they’d come back and write it, somebody else had written something to the same effect. Did you ever have that experience?

Student Z: Maybe once or twice. Not too regularly. I usually try to like if I had something good, a good idea to post, I usually try to like, we were doing like group annotations or something I try to do it before the rest of my group so I could have what I already had, but like in the open forum it ended up a lot like that, kinda like I’d get there and I’m like, I see what it’s been said and I try to think of something to add and I go and I come back and it’s already been added.

Student Z sees a benefit in getting a posting in before the rest of “my group,” but “maybe once or twice,” Student Z did go off to think about the posting before making it.

### Relating in-class and on-line activities

In all the CSCL studies cited, the CSCL environment is an extension of the class, an additional place to carry on discussion—or not. We found in our interviews a student who used the on-line space to gain additional perspectives on class discussion, and another student who said that he didn’t post in the on-line space because all the issues were already discussed in-class.

K: If you could just look at this and see if you can remember when you looked at it and why you didn’t post anything.

Student Z: Trying to remember...the majority of the time, when I looked at a page I was also trying to get other ideas from what the class was doing. See how the class was responding to things. 'cause usually from that, the class would pick up on attitudes of the teacher, and stuff like that; that way I can gear myself towards the teacher, 'cause every teacher you write to is different, had completely different writing style than I did in high school, and sometimes when I can go through, I can pick up other ideas and other views of things that are brought up in class, 'cause I think this was on like the open forum, and from that I can kinda understand what other people were thinking, and possibly get an idea of where the teacher wants us to go with things.

K: Ok, so you're kind of using this as kind of an extension of class, in a way, and a way of getting information, more than as a forum for you to necessarily to put stuff out there.

Student Z: Yeah, I probably looked over it and had an idea of something I could have posted but it just ended up that I looked over it and read it all and then kinda looked through it and tried to understand what everybody was thinking and then maybe I thought of something to post but I couldn't get it out or you know, different things happen at different times but I think with this one, I was just interested in what the class was saying, really.

Student Z is saying that he uses the on-line space to get a sense of the attitudes and ideas of the teacher (important for grading) and of the class overall, to better understand the class discussion. The role of the CSCL environment is not just a place to collaborate, but a place to gain perspective on other aspects of the class: Classroom discussion, and what the teacher is looking for on assignments. Benchmarking and understanding the unwritten assumptions are tasks that students struggle with in any class, and CSCL can help with these.

K: Would there ever be a time when something would come up for you and maybe you wouldn't write it down but maybe it would be something you would think about and bring up in class, talk about in class later on?

Student T: Not really, because generally we talk about it in class before we do the Open Forum thing, a lot of times. Except for a few subjects which, I think some of it was like the election and talking about monopolies and stuff, we generally talked about most of the stuff in class before, so most of the things I would have brought up in class I probably would have already said so instead of just waiting for the Open Forum. And so the Open Forum was just generally an afterthought type thing.

Student T is saying that one of the reasons why he doesn't post is because he feels that the discussion has already occurred in class.

The point of this hypothesis is that looking at the dialogue in the CSCL environment is only looking at part of a larger, multi-faceted story. A low rate of dialogue in the CSCL environment may imply that students are focusing at least some of their attention on classroom discussion, on completing assignments, or on some other learning activity in the class. The CSCL environment may serve as effective *support* for these other activities, thus explaining why learning may be occurring without a high rate of dialogue.

## CONCLUSION: MULTIPLE PATHS TO LEARNING

We know from Roschelle and Jeong & Chi that learning can arise from collaboration. We know from Miyake & Masukawa, Hoadley & Linn, and Rick, et al that learning is occurring in computer-supported collaborative learning environments, even though the dialogue doesn't look much like what Roschelle and Jeong & Chi describe. In this paper, we have offered several explanations for where the learning may be coming from, despite the low rates of dialogue.

- Learning arises from the construction of a shared understanding, but students don't have to participate if others represent their questions and explanations.
- Learning arises from the inquiry and reflection triggered by ideas in the forum and the possibility of posting, even if no posting ever occurs.
- Learning arises from the set of activities in a classroom, and the CSCL environment is one support for those activities.

We see all three of these as likely, even among the same students in the same class, as seen in our interviews. In face-to-face classrooms, students learn from discussions, from hands-on activities, from reading, and even from listening to lectures. Learning in a CSCL environment is probably similar, with a variety of mechanisms leading to learning.

This paper is only presenting three possible hypotheses—there are probably others. The evidence for these hypotheses is weak—simply the comments of a small number of students in interviews. Identifying the hypotheses, however, is useful so that some may be further explored, developed into theory, and applied toward better design activities and environments that facilitate learning. Important next steps are to identify other hypotheses and to develop better evidence for explanations such as these for how learning is occurring in CSCL environments with low rates of dialogue.

## ACKNOWLEDGMENTS

Funding for the CoWeb project is from the National Science Foundation Grant #REC-9814770 and the Mellon Foundation. Our thanks to our collaborators Barbara Ericson, Lissa Holloway-Attaway, Brandy Walker, Jim Greenlee, Joshua Gargus, Colleen Kehoe, Jochen Rick, Bolot Kerimbaev, and Kayt Sukel.

## REFERENCES

- Ackerman, M. S. (1994). Augmenting the organizational memory: A field study of Answer Garden. In R. Furuta & C. Neuwirth (Eds.), *Proceedings of CSCW'94* (pp. 243-252). Chapel Hill, NC: ACM.
- Cohen, E. G. (1994). Restructing the classroom: Conditions for productive small groups. *Review of Educational Research*, 64(1), 3-35.
- Davis, J. R., & Huttenlocher, D. P. (1995). Shared Annotation for Cooperative Learning. In J. L. Schnase & E. L. Cunnius (Eds.), *CSCL'95 Proceedings* (pp. 84-88). Bloomington, IN: Lawrence Erlbaum and Associates.
- Dewey, J. (1901). *Psychology and Social Practice*. Chicago, IL: University of Chicago Press.
- Ericsson, K. A., & Simon, H. (1980). Verbal reports as data. *Psychological Review*, 87, 215-251.
- Guzdial, M. (1997). Information ecology of collaborations in educational settings: Influence of tool. In R. Hall, N. Miyake, & N. Enyedy (Eds.), *Proceedings of Computer-Supported Collaborative Learning'97* (pp. 83-90). Toronto, Ontario, Canada.
- Hewitt, J., & Teplovs, C. (1999). An analysis of growth patterns in computer conferencing threads. In C. Hoadley & J. Roschelle (Eds.), *Proceedings of the Computer Support for Collaborative Learning (CSCL) 1999 Conference* (Vol. December 12-15, Stanford University, Palo Alto, CA, ). Mahwah, NJ: Lawrence Erlbaum Associates.
- Hoadley, C., & Linn, M. (2000). Teaching science through online, peer discussions: SpeakEasy in the Knowledge Integration Environment. *International Journal of Science Education*, 22(8), 839-857.
- Jeong, H., & Chi, M. T. H. (1997). Construction of shared knowledge during collaborative learning. In R. Hall, N. Miyake, & N. Enyedy (Eds.), *Proceedings of Computer-Supported Collaborative Learning'97* (pp. 124-128). Toronto, Ontario, Canada.
- Lee, J., Dineen, F., McKendree, J., & Mayes, T. (1999). Vicarious Learning: cognitive and linguistic effects of observing peer discussions : Presented at American Educational Research Association, AERA '99, Montreal, Quebec, Canada.
- McKendree, J., Stenning, K., Mayes, T., Lee, J., & Cox, R. (1998). Why observing a dialogue may benefit learning. *Journal of Computer Assisted Learning*, 14(2), 110-119.
- Miyake, N., & Masukawa, H. (2000). Relation-making to sense-making: Supporting college students' constructive understanding with an enriched collaborative note-sharing system. In B. Fishman & S. O'Connor-Divelbiss (Eds.), *Fourth International Conference of the Learning Sciences* (pp. 41-47). Mahwah, NJ: Lawrence Erlbaum Associates.
- Rick, J., Guzdial, M., Carroll, K., Holloway-Attaway, L., & Walker, B. (2002). Collaborative learning at low cost: CoWeb use in English Composition, *Proceedings of the Computer Supported Collaborative Learning 2002* (pp. Submitted). Mahwah, NJ: Lawrence Erlbaum Associates.
- Roschelle, J. (1992). Learning by Collaborating: Convergent Conceptual Change. *Journal of the Learning Sciences*, 2(3), 235-276.
- Scardamalia, M., Bereiter, C., & Lamon, M. (1994). The CSILE Project: Trying to bring the classroom into World 3. In K. McGilly (Ed.), *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice* (pp. 201-228). Cambridge, Mass.: MIT Press.
- Terveen, L., & Hill, W. (1998). Evaluating emergent collaboration on the Web. In S. Poltrock & J. Grudin (Eds.), *Proceedings CSCW98* (pp. 355-362). Seattle, Washington, US: ACM.