Interactions in Online Courses about Mathematics, Science, and Teaching

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At Michigan State University, we are offering an online Masters degree to practicing teachers, giving them the convenience of anytime, anywhere virtual courses combined with the rigor for which our programs are known. In the first year of our online program (2000-2001), several faculty members had great success with their online courses. In these courses, a major part of the work was participating in online discussions on bulletin boards where students post written comments, questions, and responses to each other and the instructor. The early success of these courses prompted other faculty members to join in, eager to experiment with the potential of this new medium for supporting teacher learning in ways consistent with current thinking about professional development.

In this paper, we explore early results from a research project studying teacher learning and faculty teaching in two online courses. We focus on the interactions among students in online small-group discussions. We will argue that three aspects of these online courses impact the way that students enter into discussions online, and consequently, what they have an opportunity to learn. These are the subject matter itself, the representations and media through which the subject matter is engaged, and the tasks students are asked to carry out online. In addition, we argue that students' dispositions to engage in constructive discourse (or not) is an important and only partly controllable factor in what happens in online discussion.

To build this case, first we lay out the assumptions that ground our approach to online learning. Next, we describe the two courses from which data for this study is drawn. Finally, we use four examples from the courses to illustrate our emerging claims about learning through discourse in online courses for professional development.

**Assumptions**

_The social nature of knowledge and of learning._

We begin with the assumption that interaction with others around content is essential for meaningful learning. Current theories of learning support the idea that knowledge is built through social interaction about ideas, tools, and representations of subject matter (Bransford, Brown, Cocking, & National Research Council, 1999). Such interaction provides opportunities to learn by expressing one’s own thinking, by listening and responding to others, and by negotiating conflicts in understanding (Brown & Palincsar, 1989; Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989). In online learning environments, interaction among participants is an essential element in creating opportunities to learn that go beyond individual interaction with materials made available online, the “correspondence course” mode of instruction common to earlier versions of distance learning in which interaction at a distance was
limited (McIsaac & Gunawardena, 1996). To move beyond the correspondence course, online learning environments need to offer not merely opportunities for interaction, but opportunities to learn that include discussion of complex ideas and negotiation of meaning (Scardamalia, Bereiter, & Lamon, 1994).

Similar assumptions underlie, in part, recent arguments that a valuable approach to teacher learning and professional development is creating professional communities in which teachers learn through sustained, thoughtful discourse with other teachers (Feiman-Nemser, 2001). Teachers participating in professional communities can share their expertise and learn from the expertise of others, bringing professional development closer to the real work of teaching. As Feiman-Nemser describes it,

The kind of conversation that promotes teacher learning differs from usual modes of teacher talk which feature personal anecdotes and opinions and are governed by norms of politeness and consensus. Professional discourse involves rich descriptions of practice, attention to evidence, examination of alternative interpretations and possibilities…. [Teachers] create new understandings and build a new professional culture. (p. 1043)

Developing teacher communities characterized by thoughtful and challenging engagement with ideas and issues of teaching practice is not easy. For example, Grossman and colleagues (Grossman, Wineburg, & Woolworth, 2001; Wineburg & Grossman, 1998) note that in their efforts to foster a community for teacher professional development, teachers had difficulty moving beyond polite discussion and recognizing disagreement as an opportunity for learning rather than a sign of interpersonal conflict. These difficulties resulted in part from the lack of experience in having discussions about teaching and learning that involve intellectual challenges. This research makes clear that it is important both to establish professional communities of teachers and to foster thoughtful, meaningful discourse within those communities.

The ability of computers and the World Wide Web to support communication across time and space have led some to argue that virtual environments provide unique opportunities for fostering such professional learning communities (Barab, MaKinster, & Moore, 2001; Derry & The STEP team, 2002; Schlager, Fusco, & Schank, 2002). With virtual communities, teachers can interact with other teachers with similar students, subject matter, or goals without being limited to the teachers in their own school or district. The technologies also have the potential of keeping records of the group’s interaction and thinking, and of sharing ideas and experience through multiple media, such as video and graphics. Of course, there is much to be sorted out about the nature and functions of online community, including fundamental questions about what constitutes community and whether an online group, separated in time and space, can be a community in the ways that research suggests are valuable for professional development.

Although developers and instructors of online courses report success in fostering interaction and a sense of community among participants, they have met with limited success in enabling online interaction of the sort described by Feiman-Nemser. The few studies that have systematically examined the content of student discussions in online courses have found that these discussions rarely move beyond sharing of information and viewpoints. Gunawardena,
Lowe, and Anderson (1998), for example, developed a model and coding scheme for categorizing online interactions in terms of knowledge construction, positing five phases of knowledge construction:

1. Sharing/comparing of information
2. Discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements
3. Negotiation of meaning/co-construction of knowledge
4. Testing and modification of proposed synthesis or co-construction
5. Agreement statement(s)/applications of newly constructed meaning.

In online discussions examined by Gunawardena and colleagues and by other researchers using similar schemes interaction typically remains at the first level—sharing/comparing of information—and only rarely moves beyond the second level.

We know from the research on teacher professional development and learning that both establishing community and fostering engaging, productive discourse are important and must be addressed in the development of virtual communities that can support teachers’ learning and development. While recognizing that both are important, our research focuses primarily on the nature of discourse in online environments that may contribute to teachers’ learning. The issue of whether or not these online course environments constitute community is not taken up in this study.

The intertwined nature of teacher knowledge.

Also important in our research is the assumption that the domains of knowledge needed for improving teaching are complexly intertwined. A key issue in improving teaching is enhancing teachers’ knowledge of subject matter, of technology, and of teaching (Darling-Hammond & Ball, 1998). Subject-matter knowledge in mathematics and science is important, as is knowledge of new technologies and how they can enhance learning. But the knowledge needed for teaching is not simply the knowledge of mathematics, science, or technology typically taught in university courses. Rather, to be useful, teachers’ subject matter knowledge needs to be intertwined with their knowledge of students, learning, and pedagogical contexts (Grossman & Stodolsky, 1995; Ma, 1998; Putnam & Borko, 2000; Wilson, Shulman, & Richert, 1987). Making connections among, for example, mathematics, technology, and pedagogy, is a critical ingredient in effective professional development for teaching with technology (Zhao, Pugh, Sheldon, & Byers, 2002). In our courses are three strands of content in which we expect teachers to learn: (a) mathematics and science content, (b) technology for teaching and learning mathematics and science, and (c) pedagogy for using the technology with students.

Keeping appropriate balance and connections among these strands is not always easy. In what they call the "essential tension of teacher community," Grossman and Wineberg discuss the pull between improving professional practice and "continuing intellectual development in the
subject matters of the school curriculum," (p. 951). While professional development has long attended to improving practice through workshops, summer institutes, and other short-term, outcome-focused formats, less attention has been paid to teachers' ongoing learning of the subjects they teach. The two are in tension in many ways, as time is short and attention given to one naturally means less time for the other. This essential tension is fundamental in our work. The tension is apparent in the design and implementation of the courses, and in the work teachers do online. Although our ultimate goal is to help teachers improve student learning in mathematics and science through the use of new technologies, we need to help them learn both subject matter and technology content while keeping pedagogical issues in the forefront.

The importance of representations in learning.

The representations of ideas and events play an important role in learning. Representations are fundamental to the learning of mathematics and science (Bransford et al., 1999; Kilpatrick, Swafford, Findell, & the Mathematics Learning Study Committee of the National Research Council, 2001; National Research Council, 1996). Reform standards in mathematics and science call for increased attention to subject matter representation, especially in light of the new forms of representation made possible by electronic technologies (National Council of Teachers of Mathematics, 2000). Using multiple representations of ideas and interactive representations available through computers can significantly change both what can be learned and how it is learned (Edelson, 1998; Roschelle, Kaput, & Stroup, 2000; White & Frederiksen, 2000). Similarly, how ideas and knowledge about teaching, learning, and pedagogy are represented is important in learning to teach. In recent years, teacher educators have begun to develop tools and techniques for helping novices use new technologies to develop more complex representations of their work. For example, video and multimedia representations of teaching have been effective tools for teacher education (Derry & The STEP team, 2002; Lampert & Ball, 1998). A potential strength of online learning environments is the possibility of using multiple and varied representations of the content to be learned. At the same time, interaction around these representations is sometimes limited by the online environment.

Focus of This Study

In this study, we look at discourse among students in two courses designed from the foundational assumptions explained above. Our starting point for these courses was that meaningful interaction was important, that attention to multiple aspects of teacher knowledge was required, and that multiple representations of content were essential. Our initial analyses have focused on understanding what constitutes meaningful engagement by students in these courses, and what might explain its occurrence in some cases and not others.

As we examine the online discussions in our courses, we are looking for evidence of student discourse that moves beyond the minimal level of information sharing. We think it is important to look at this both individually and collectively. In other words, we look for evidence both of discussion participants working collectively to negotiate meaning or come to agreement, and of individuals questioning or rethinking their own ideas.
As we designed our courses and as we began to look for variation in participants’ engagement, we focused on a number of features of the course design and how the courses played out that would be important. These were the subject matter itself (mathematics, science, technology, and pedagogy); the nature of the tasks we asked students to carry out; the representations entailed in the subject matters and tasks assigned; and organization and structure available in the online environment to complete the assignments and tasks. We discuss each of these briefly.

1. **Subject matter.** As discussed above, subject matter is a primary concern in designing and implementing professional development. The tension between the disciplinary content, technology content, and pedagogy seemed quite important in designing these courses, although we had few conjectures about what difference these subject matters would make in the actual discourse.

2. **Tasks.** Tasks are the specific activities learners are expected to carry out in the classroom. The tasks implemented in face-to-face classrooms are an important determinant of both what and how students learn (Blumenfeld & Meece, 1988; Doyle & Carter, 1984). According to Doyle, tasks entail (a) the products students are to produce, (b) the operations they use (e.g., memorizing a list of terms or solving a problem); and (c) the resources available to the student (e.g., models of completed work by other students, reference materials). We expected that differences in tasks for students in online courses might influence the nature of their engagement with the course content, but in designing the courses, we were unsure of what kinds of tasks would provide the greatest opportunities for student learning.

3. **Representations.** As discussed above, representations are a key aspect of learning in mathematics and science, and, in the online environment, we conjectured that representation of content would also be a significant issue in teaching and learning about technology and pedagogy. The technology available to us for producing these courses was a Web-based, and thus primarily text-based, environment. We asked students to use other representations and media offline in their assignments, and experimented some with other shared online representations (video, audio, and multimedia presentations). We expected that using multiple representations of content offline and discussing them online might be problematic to the extent that shared artifacts were unavailable.

4. **Communication structures.** Students and teachers interact in classrooms through activities shaped by school-specific and more general discourse structures and patterns. Classroom researchers have shown activity structures—distinct kinds of classroom activity and interaction, such as lecture, small-group structures, and discussions—to be important in determining the interactions and learning that take place (Leinhardt & Greeno, 1986; Stodolsky, 1988). Interactions at a finer level of detail have been examined through discourse structures and routines, which give shape to the interactions of students and teachers to create the fabric of classroom communication. Experienced teachers in face-to-face classrooms rely on myriad discourse structures and routines to accomplish the communicative work of teaching and learning. Whether it is the ubiquitous Initiation-Response-Evaluation pattern that pervades elementary and secondary classrooms or the implicit rules for arguing for or against a particular interpretation of a text in a graduate seminar, the discourse patterns of the classroom shape the
communication and thinking that take place (Cazden, 1986). Because the overall structures available in online courses are so intertwined with the more specific kinds of discourse patterns that can arise, we refer to this entire constellation as *communication structure*. Communication structures in online courses are radically different from those in face-to-face classrooms (Kanuka & Anderson, 1998). Text-based interactions, such as chat rooms, e-mail, or threaded discussions, can support neither the usual nonverbal and paralinguistic cues that signal turn-taking and comprehension, nor gestures, which sometimes carry important communicative content (Koschmann & LeBaron, in press). Even with visual or audio added to the mix, the asynchronous nature of interaction in online courses makes discourse significantly different from face-to-face interactions. Developing workable new discourse structures and routines through which learners can engage meaningfully with subject matter and through which teachers can monitor and guide learner’s thinking is essential for successful online learning environments. We anticipated that we would need to experiment with different discourse structures to assess student engagement and to develop routines for our own interaction with students in different structures.

In the sections below, we first describe the two courses from which our data were taken, and then we give four examples from student discussions to illustrate our emerging hypotheses about student engagement in online discourse.

*The Courses*

Our data come from two online courses taught by the first two authors in the fall of 2003. Course A, "Technology, teaching, and learning across the curriculum," was designed for elementary teachers teaching the mathematics, science, social studies, and language arts. Course B, "Teaching and learning mathematics with technology" was designed for K-12 teachers of mathematics. Each course consisted of approximately 10 units, most two weeks long, in which students completed assignments using various technologies, came together in small "study groups" of 3 or 4 and sometimes in whole class formats to discuss their assignments, and then completed individual papers and assignments. All course materials and interaction were conducted online. This three-part organization was consistent across the two courses, and across units within each course.

Students in the courses (numbering 21 and 25 respectively) were primarily practicing teachers (18 and 20 respectively) enrolled in Masters programs at Michigan State University. Some of the students were in an online Masters in Education that consists entirely of Web-based courses. Others were part of a cohort in a Masters in Educational Technology that is offered in both online and face-to-face courses. The classes had no face-to-face meetings, although some of the students in the Ed Tech Masters knew each other from previous classes and were concurrently enrolled in a face-to-face class meeting on campus. A total of four students did not live in Michigan. There were five international students living in the United States.

The two courses had one common unit in which students completed a problem from the Jasper series (Cognition and Technology Group at Vanderbilt CTGV, 1997), read about Jasper, and explored the range of ideas the Jasper project entails. The Jasper book, which was a required text for both courses, included a CD with the "Rescue at Boone's Meadow" problem, examples
of other parts of the Jasper program, and classroom video from schools using Jasper. In each
course, students first solved the Boone's Meadow problem on their own, working with a partner
of their choosing (a friend, student, child, or spouse, for example). They could get "hints" from a
Web page created for the course that pointed them toward common errors, oversights, and
creative solutions seen by the first author in face-to-face use of the Boone's Meadow problem.

The other unit investigated in this study is a two-week unit in Course B in which students
read an article by Erlwanger (Erlwanger, 1973) that examines the mathematical understanding
of a 5th grade student in a classroom using Individually Prescribed Instruction (IPI). This
student, Benny, works through the programmed text rapidly and successfully, but on closer
scrutiny, seems to be inventing and learning incorrect ideas about mathematics and incorrect
procedures and algorithms for working with fractions. We selected this unit for the study
because of the medium through which the content is delivered: In the Jasper unit students are
asked to use a technology, learn from and about the technology by reading and exploring video,
and apply ideas about teaching and learning to the technology. By contrast, in the Benny unit,
the work is entirely text-based. Students read the article and contribute to a discussion of the
ideas raised about teaching, learning, and mathematics. In this unit, all of the work is done via
text.

**Examples**

**Example 1: The impact of subject matter**

Students responded differently to parts of the Jasper unit, which included work on both
mathematics and pedagogy. As students of mathematics, they worked the Jasper problem taken
from the video CD, wrote up a solution for their study group, and discussed their solutions
together to come to agreement for a "best" solution to present to the whole class. In some
groups, these discussions were substantive, moving beyond merely sharing to actually
disagreeing, discussing, and finally agreeing on a joint solution. As students of teaching and
learning, they engaged in a discussion of pedagogical aspects of Jasper, with somewhat different
assignments in the two courses. In course A, the assignment for the pedagogical discussion is
shown below, in Figure 1.

In this discussion, please focus on the [question below, taken from the reading
assignment]:

*Although Jasper is primarily focused on mathematics, the ideas behind the series
might be applicable in other parts of the curriculum. As you read, think about
problem-based, or project-based, or inquiry learning in other subjects that you
teach. What are the similarities and differences among the subjects with respect to
such approaches to teaching and learning? Are there things about this approach
that are unique to mathematics?*

Your group coordinator should lead off the discussion, and you should each
contribute, aiming for some consensus on a few ideas you can share with the whole
The group coordinator should post a summary of your ideas to the whole group, Unit 4 WebTalk.

**Figure 1: Second assignment in Jasper, Class A**

Group 3 in Course A included three students who were practicing elementary school teachers. They posted their solutions and then launched into a discussion of the evidence, the mathematics, and the contextual issues that frame a best solution to the problem. For example, they discussed the weight of gasoline, an issue in the problem because of a limitation on the payload of an airplane. One student asked if the weight was part of the evidence on the video (it was, through a simple calculation using data in the video), and the other two responded with their interpretation of the evidence. One of them went to the Web to verify their calculation. They discussed the weight of one of the characters in the video who was a possible pilot for the airplane, and how much extra gas was needed for the flight. They talked about alternative solutions and whether or not the evidence in the video would support them. In this series of 15 postings, these three students came to agreement on a best solution, which they posted to the class discussion.

Here is an excerpt from their discussion of the weight of the gasoline to illustrate the kind of discussion that took place:

| 1.  | Caitlin (9/26, 13:20): (After presenting her solution, which was the first one up and included an explanation of why she thought some other solutions would not work.) *I am not a math person, but the combination of flying and driving seemed the best solution to me. What do you guys think?*
| 2.  | Mike (9/26 14:19): (In response to Caitlin, asks a question about her solution.) *I must have missed this in it myself, but did it say how much a gal of gas weighs? ...*
| 3.  | Caitlin (9/26 14:57): (In response to Mike, answers his questions.) *Mike: I figured the weight of the gallon of gas this way. The net weight of the fuel tank is 30#. It holds five gallons of gas. A gallon is equal to 64 ounces and 16 ounces is 1 pound. So...if one pound is 16 ounces and there are 64 ounces in a gallon...one gallon weighs 4 pounds. The tank holds 5 gallons or 20# of gas. Make sense? Therefore a full tank of gas weighs 50 pounds.*
| 4.  | Kiki (9/26 16:08): (In response to them both.) *I figured fuel at 8 lbs per gallon, same weight as water.*
| 5.  | Mike (9/26 18:58): (Answering both Kiki and Caitlin.) *Looks like I was way off on the weight of gas, it never seems that heavy when I need to fill up the mower.*
| 6.  | Caitlin (9/26 20:02): (A final answer on the weight of gas) *Okay...I just searched the web and discovered that one gallon of gas weighs just under 8 pounds, so Kiki’s estimate is right in the ballpark.*
| 7.  | Mike (9/27 7:54): (Asking two questions) *I wonder about the 30 lb for the gas tank. Does that mean 30 lb full, or is that the weight of the empty tank. If it is the empty tank, should that be part of the 250 lb that the aircraft weighs, it can’t be removed from the air tank.*

**Figure 2: Jasper problem solving discussion, Group 3 Class A**

As students of pedagogy, however, there was little substantive interaction. In the same group, students posted their thoughts in response to the assignment, but there was no evidence...
that they processed each other's ideas in any way. Of course, it is impossible to know from
the data available (a) whether they read each other's posting, or, (b) if they read them, whether
the ideas had any impact on their thinking. These data suggest, however, that the task of
discussing the pedagogical implications of Jasper failed to engage this group in ways that went
beyond simple sharing of ideas.

In these contrasting discussions, there are several confounding factors. One hypothesis is
that it is easier for teachers in the online environment to work on the mathematics than on the
pedagogy. If this hypothesis is correct, it may be in part because of the nature of the work
entailed by the Jasper problem. The mathematics in this problem, while challenging to several of
the students in the class, was relatively easy to discuss because it was contextualized and did not
require elaborate symbolic representations. Contextualization lets them refer to the weight of
the gas tank or Emily's weight rather than to a graph or other abstract representation. The
mathematics itself entailed only basic operations of addition, subtraction, multiplication, and
division: relatively easy to talk about and to represent with typed characters. It is possible that
the students could problematize the issues in the Jasper work because there is not a single
solution and because the context itself lets them ask questions that do not reflect on their
understanding of the mathematics. In short, the nature of the Jasper problem creates a non-
threatening environment in which teachers do not need to admit mathematical shortcomings to
engage in the work.

In contrast, the discussion of pedagogy may have directly threatened teachers’ ideas and
beliefs about teaching and about mathematics, making it more difficult for them to disagree and
challenge each other’s ideas. Although this is only a conjecture at this point, it is a point worth
pursuing as we continue to design and teach online courses.

In the next section, we consider another hypothesis to explain differences in
conversations about mathematics and pedagogy: the tasks assigned.

Example 2: The impact of task

Students responded differently to the diverse aspects of the Jasper discussion in Class B
as well as Class A. In both classes, the first task required a negotiated solution to the Jasper
problem, shown in Figure 3 below. The final task in both classes entailed a discussion of
pedagogical issues, with slightly different assignments reflecting the differing course purposes.
The assignments are shown in Figures 1 (above) and 4 (below).

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**TASK A:** All the members of your group have posted a solution to the problem on
your Group WebTalk. Now it is time for you to discuss your solutions and come to a
consensus about what you think is the best solution to this problem and why. Keep in
mind that a solution may be "best" for reasons that are not entirely mathematical.
Your solution needs to be mathematically correct, but you can make non-
mathematical as well as mathematical arguments about what is best!
Your group coordinator should post your group's consensus solution AND the reasons why you think it works and think it is best to the class WebTalk, Unit 4 discussion.

**Figure 3: First assignment in Jasper, Classes A and B**

**TASK B:** This discussion should focus on the learning of mathematics (and other things) that might take place when students work with Jasper. In your reading assignment (Part 1, Assignment 4), you thought about the questions repeated below. Draw on that thinking to discuss here what problems/dilemmas in mathematics learning Jasper is intended to solve. Discuss also how Jasper does (or does not) exemplify ideas of problem solving, reasoning, and mathematical communication from the NCTM Standards.

1. What are the problems with learning that the Jasper series was designed to solve? Are these problems that you see in your classrooms? How do these problems relate to the current standards for mathematics education in the NCTM's Principles and Standards? Are there other solutions to these problems that you have tried, or that make sense to you?

2. If you think about the affordances of technology for learning (information, representation, transformation, collaboration/communication), where does Jasper fit? What "kind" of technology is it? What are its most important affordances for learning in your mind? How do the affordances of Jasper for learning fit with the standards in the PSSM?

Your group coordinator should lead off the discussion, and you should each contribute, aiming for some consensus on a few ideas you can share with the whole group. The group coordinator should post a summary of your ideas to the whole group, Unit 4 WebTalk.

**Figure 4: Second assignment in Jasper, Class B**

Of the five groups analyzed so far (2 out of 7 in course A and 3 out of 8 in course B), only one showed evidence of engaging in discussions beyond the sharing of ideas (Gunawardena's level 1). In this case (Group 1, Course B), the students made 8 postings, the last three of which pushed each other's thinking. In the 6th posting, Dennis wrote,

Lynn, Sorry, I have no experience with problem solving skills of students in American elementary schools. But, don't you think Jasper problems are complex for fifth graders? I was just wondering what type of approach they used in solving problem such as economical way of filling the swimming pool and cost calculation/revenue collection? I think Jasper activities are best where we give our students an opportunity of trying
complex problems and apply their knowledge of classroom learning to real-life problems (Dennis, 10/04/02, 18:23).

Dennis seems to be challenging a comment Lynn made earlier, that she’s “itching to try this in her classroom” (post 2, 10/01/02, 23:15). Lynn takes up Dennis’s challenge with her reply in the 7th post:

Dennis, I agree that the problems are a bit complex for 5th graders. I think the problems in general would be not too easy for my high school students. Perhaps with a great deal of guidance a 6th or 7th grade class would do OK. I do find, however, that many materials claim they are for a grade level actually below what I would use them for. Most of the materials I use in my high school algebra and geometry classes are designed for middle school students. I don't think my students are "behind", I just think the publisher is overly optimistic.

In a related note, it is in those 5th and 6th grade years that students could most use focused problem solving experiences. Perhaps that's why Jasper chose to aim for that grade level (Lynn, 10/04/02, 18:29).

We classified this as a level 2 interaction, "Discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements." In the next posting, Dennis initiates an interaction that might have led to a higher level interaction, but Theo does not respond.

Theo, It was interesting for me to read about the challenge that you gave your students to weigh a vehicle using a bathroom scale. You might have enjoyed seeing how they came across different solutions individually and agreed later in one best solution in their group. I was curious to know, how long it took them to figure out. How frequently do you use problems like Jasper CD in your science classroom? Dennis (Dennis, 10/04/02, 18:32)

One way of interpreting Theo’s lack of substantial interaction is through the lens of subject matter. Alternatively, it is possible that he wasn’t as concerned with interacting as closely with the group over the teaching conversation, since the group wasn’t required to agree upon a group posting.

In the other groups analyzed, there are no instances of higher level engagement in the second task discussions. A typical example is Group 3 in Class B. The group leader posts two declarative messages, laying out what she perceived as important items in response to the assigned question:

I went through and highlighted some ideas on the goals of the program and the problems they are trying to solve through this program. They have 7 goals that center around the education of the child. They are.. (Laura, 10/03/02, 07:54)

According to the four affordances. Communication: group work and collaboration Transformation: transferring skills and knowledge into problem solving steps and solutions
Representation: Students represent the situation in their solution using technology. Information: all presented to the students, just need to make sense of it: also present concepts and applications of materials. Also does a great job of supporting technology and NCTM standards. Student oriented, hands-on focused, skill and problem solving mastery rather than rote memorization, and applications galore. These projects make their information more meaningful to the students lives. (Laura, 10/03/02, 21:14)

These rather traditional responses to a question posed by the teacher elicited only one posting from other group members, and that posting did not directly address any of the issues mentioned by Laura. In contrast, this same group had a substantive discussion about the solution to the Jasper problem, disagreeing with each other, correcting each other's errors, and reaching a consensus about a best solution (Gunawardena Level 3).

While this evidence parallels the evidence presented in Example 1, these data could also support our alternative hypothesis, that the requirements of the task is a major factor in the level of discussion that occurs. It is possible that the students were more likely to critique the ideas of one another when they had to agree upon a group solution.

**Example 3: The impact of representation**

A different task in Course B resulted in considerable engagement about issues of learning and pedagogy. Students read a written case—the Erlwanger article about Benny, described above—and discussed it. As preparation for reading the Benny article, students were given the following introduction and set of questions to guide subsequent discussion:

### Introduction to Reading

The article you’re about to read is from the 1970s—the heyday of individualized instruction. A number of curriculum development efforts at the time involved intricate systems of objectives and assessments to tailor instruction to individual children. The idea was that a child should not be wasting time with a group on things he or she had already learned; each child should progress at his or her own rate through the curriculum. Children worked independently on particular learning objectives until passing a mastery test, then moved on to the next objective. One of these curricula was Individually Prescribed Instruction (IPI).

For his dissertation research, Stanley Erlwanger interviewed a number of students in a sixth-grade IPI mathematics classroom to see what they were learning. Benny was one of these students. As you’ll see, Benny was doing well in math class, making good progress in the IPI curriculum by completing the requisite worksheets and passing tests at what was considered the mastery
Although this research is almost 30 years old, it raises issues that are important today for thinking about mathematics teaching and learning—and their relationship to technology! Here are some questions to think about as you read. We’ll be using these questions to structure small-group discussion:

1. What was Benny learning?
2. Was Benny an active learner? In what sense? What's your evidence?
3. For Benny, what is mathematics? For Benny, how do you decide whether something is true or correct mathematically?
4. Why was remediation difficult with Benny?
5. Was Benny's teacher teaching?

In their small-groups, students were directed to have two discussions, one focusing on learning issues and one on teaching issues:

**Discussion 1: Benny-Learning Issue**

Begin your first discussion by addressing this question:

1. Was Benny an active learner? In what sense? What's your evidence? 
If it seems to follow naturally, you can also address this one:
2. What was Benny learning?

**Discussion 2: Benny-Teaching Issues**

Begin Discussion 2 by addressing this question:

3. Was Benny's teacher teaching?
Although some groups posted individual responses to the questions with little interaction, most interacted to think through the ideas, some showing clear evidence of individual or group challenging and rethinking of ideas. The students in Group 5, for example, clearly read previous postings before contributing, referred to the arguments of others in the groups, and showed evidence of grappling, both individually and collectively with what it means to be an active learner. The following excerpts from Group 5’s conversation illustrate this interaction and cognitive engagement. (Note that these quotes have been pulled from considerably longer postings to illustrate engagement and interaction. The “speakers” development their ideas more fully in the full postings. Italics have been added to highlight engagement with ideas and other speakers.)

**Course B, Group 5, Discussion of Benny-Learning Issues**

**Post: 3 From: Calvin Date: Wednesday September 04, 2002 - 21:10 PM**
*I am not sure if I feel that Benny was an active learner or not.* In a sense, he was very active in his learning. He seems to have been fully responsible for his mathematical education, with little or no teacher interaction. . . . Conversely, Benny was not very active in getting any type of confirmation about his work. . . . I suppose that my final analysis would lead me to conclude that Benny was not an active learner. . . . If one of my students was complacent enough to be satisfied with constant failure, and manipulation of a system, I would not consider them to be very active in their learning process. . . .

**Post: 4 From: Sarah Date: Wednesday September 04, 2002 - 23:46 PM**
. . . I completely agree with the points you brought up, Calvin. He learned how to succeed in the program that was presented to him. . . . I would like to politely argue your statement that active learners are students who strive to find the correct method of solving problems. I think if nothing else, Chicago Math has taught me that there isn’t a "correct way" to solve problems. . . . No, but really active learners understand the concepts that are being presented and find new ways to support their understanding. . .

**Post: 5 From: Calvin Date: Thursday September 05, 2002 - 11:29 AM**
. . . Sarah, thanks for bringing up your disagreement. What I meant to suggest was that I consider my "active learners" to be the students that strove to find the correct answer to solving a problem. I couldn't agree more about finding several ways to solve a problem. . . . It's kind of strange to label such a hard working student as not being an active learner. I would have loved to have had a classroom full of kids with Benny's work ethic. He just became too set in his ways :)

**Post: 6 From: Sylvia Date: Thursday September 05, 2002 - 20:55 PM**
*O.K. let's see if I can figure this out. Active or not- active? It is hard to decide.* I agree with Calvin's statement about Benny's work ethic. Benny actually wanted to go to the library to look information up to find out about "the 100 rules." He was thinking about mathematics. Unfortunately he was thinking wrong. Is an active learning one that truly understands? . . .
A number of things may explain why course participants engaged with one another about ideas of teaching and learning in this unit, in contrast to the general lack of such engagement around pedagogical issues in the Jasper unit.

First, the content to be discussed here was presented as a written case, rather than as a multimedia problem presentation and individual activities in Jasper. As we began our online teaching and research, we suspected that written materials might prompt cognitively engaged interactions among students. The successes reported anecdotally by colleagues in getting good small group discussions going in online courses typically involved discussions of written cases and other materials. It may be that written materials are familiar to students as typical material to be discussed and thus prompts such discussion. The ideas in the written case, because they are expressed in words, may be more accessible and easier to write about. The Benny case was framed to focus on issues of learning and pedagogy—the author was trying to raise awareness of issues about learning and curriculum. As such, it may have been easy for students to “latch onto” ideas to discuss.

Second, the way the task was framed may also have prompted discussion. As in the previous example, groups here were expected to come to some agreement on what to post about their discussion of each of a small number of questions.

Finally, the content of the case was likely a factor. The Benny case often evokes strong reactions from teachers who read it—about whether the teacher was “doing her job”, about what kind of student Benny was, and about curriculum. A number of students made such comments as “This case really upset me.” Thus the students (who are teachers) may have become engaged emotionally as well as cognitively in the issues raised by the case.

**Example 4: Student norms & dispositions**

In Class A, different groups responded in quite different ways to the same assignment. For example, in the Jasper unit, Group 1 merely posted their solutions and then let the group leader post her solution to the whole class. One student suggested a correction to an error in a calculation. Although the solutions themselves were in conflict, the students made no attempt to arrive at a mutually acceptable solution. By contrast, Group 3, described above, worked together in a series of exchanges in which they considered evidence, resolved disagreements, and came to a mutually acceptable solution.

What are the differences between these two groups that seem to be factors in the noticeably different ways they engaged in discussion of the Jasper problem? We suggest three factors that seem to matter in these two groups, and in other groups in the two classes: (a) norms set in initial postings; (b) the dispositions of students in the group; and (c) the timing of postings.
relative to each other. These three are quite interdependent, as will be clear in the discussion below, contrasting Groups 1 and 3 in Class A.

(a) Norms set in initial postings

In Group 1, students began the discussion by posting solutions without posing any questions to each other or asking for others' ideas or help. In the first posting, Albert writes "Here is my thinking about the problem..." and goes on to post a solution with no questions or doubts expressed. Cathy responds, writing,

I am writing this before I have read your solution Albert as I didn't want my original thoughts to be influenced by yours. I thought it would be fun to read what each of us came up with by ourselves. I am by no means saying this is my BEST solution but a plausible solution after considering all of the information.... (Cathy, 9/26. 9:16)

The third group member posted her solution over ten hours later, ending by writing, "I can't wait to see what everyone else came up with!" In spite of that declaration, the students did not respond to each other. They used some information from each other's postings to correct their own solutions. Two days after her initial posting, Cathy wrote:

As I mentioned in my posting I did not read the other postings until I posted my solution. Well, after reading them I realized I didn't have ALL of the information. I couldn't figure out how Albert knew that Emily weighed 120 lbs. Flying from Cumberland to BM wasn't a possibility in my mind because with Larry's weight he couldn't fly to BM and carry enough fuel to make it over to even Hildas let alone Cumberland. I could not SEE what Emily's weight was on the CD. Clarity was the issue. I thought they had done that on purpose. I checked in Appendix A and found it. The bottom line is that I agree with flying from Cumberland to BM, flying from BM to Hildas, and driving from Hildas to Cumberland. I also agree we don't have enough information to use the truck option. We know the fuel mileage for a car but common sense and experience tells me we can't expect the same from the truck. (Cathy, 9/28, 7:34)

The group leader, who was responsible for posting a final solution to the class discussion, wrote a "best" solution which she posted for the group to consider. It is not clear whether she took Cathy's comments, or Albert's solution, into account. Cathy suggested one correction to the proposed solution (a misreading of the distance on a map), and without further discussion, the corrected solution was posted. These students did not engage in a discussion with each other but rather posted their own monologues that occasionally acknowledged what other group members said.

In contrast, Group 3 started off with a posting from Caitlin describing her solution and other solutions that she considered and why she thought they did not work as well. She ends her posting with a personal disclaimer and a question that seemed to set the tone for the rest of the discussion:
I am not a math person, but the combination of flying and driving seemed the best solution to me. What do you guys think?

As described above, Group 3 then discussed several details of their solutions, going back and forth and responding to each other's ideas. Some excerpts give a sense of the tone of this discussion:

Mike (9/26, 14:19): I must have missed this in it myself,... How did you see that?... I like the idea of having Doc drive to meet the bird, I never considered that. ...

Kiki (9/26, 16:08): I also liked the idea of having Doc drive to get the bird. Didn't even think of it. ...

Mike (9/26, 18:58): Looks like I was way off on the weight of gas...

Caitlin (9/26, 20:02): I think the fastest way...

Kiki: (9/27, 7:27) Yep, I figured it at...

Mike (9/27, 7:54): I wonder about the 30 lb... Also I wonder about video quality....

Kiki (9/27, 8:00): Yep, I agree...

Kiki (9/27, 8:02): We kinda had this discussion in the other thread, but let's just make sure we're on the same page...

Mike (9/27, 8:59): I think the best solution is just to go with Caitlin's am I right.

Caitlin (9/27, 12:55): Cool" And I am not even a math person! And I did it on my own! Yippee! :-)

(b) The dispositions of students in the group

Another explanation for these differences is that the students in various groups bring different dispositions to the discussions. In Group 1, for example, it may be the case that these students are equally unlikely to engage in discussions in other settings, such as face-to-face classes. In contrast, students in Group 3 may be inclined to discuss and share in any forum. This would support an argument that the particular make up of the group -- students personalities, inclinations, and interests -- is an important factor in determining how they participate online. Further analysis of our data may shed some light on this hypothesis as we analyze groups over time and look comparatively across the classes and units within the classes.

(c) The timing of postings relative to each other.

One clear difference between these two groups was the timing of the postings. Group 1 posted sporadically over the course of four days, completing eleven postings to determine the best solution. Group 3 completed their work in 24 hours with a total of 13 posts. The compact
timing of the postings seemed to support the interactive nature of the discussion. Students asked questions of each other and got timely answers. No questions, even apparently rhetorical ones, went unnoticed.

In the end, these very preliminary hypotheses about the factors affecting interaction in these discussions support one major conclusion: the students themselves have the final say in what happens in the discussions. What they bring to the table, what they want to accomplish, how they respond to each other, and how they time their responses all contribute to the nature and substance of the discussion in ways that may sidestep aspects of course design and task requirements. In many ways, this is true in all classrooms: the students themselves are ultimately the actors who must cause their own learning. It is particularly notable in an online environment, though, where the instructor has few ways of influencing and impacting student norms and behaviors.

**Discussion and Conclusions**

Our work on analyzing factors influencing engagement in online discussions in these two classes is just beginning. What we present here is exploratory, the start of an endeavor to develop a more rigorous conceptual framework for understanding learning through discussion in online environments, and from which we hope to gain a better understanding of the circumstances and conditions that result in meaningful student engagement. We are convinced that studying interaction in online courses from the perspectives of learning and pedagogy is important and only beginning to emerge. This focus on learning and pedagogy stands in contrast to and complements other research about online courses that focuses on the development of community, on the structure of conversations, and on the design of online environments.

From our work so far, we offer preliminary conclusions, based on the examples above and the surprises and affirmations that have been notable in our analyses to date.

1. Student engagement in discussions is more variable and unpredictable than we anticipated. Students are in control of how they participate and can exercise that control no matter what structures are in place, or what assignments are given. Other faculty members teaching online courses corroborate this conclusion, suggesting that the online space is "teacher-centered and student-controlled." (Anagnostopoulos, Basmadjian, & Wallace, 2003). A key issue for teaching online thus becomes establishing norms that invite students to participate, and that establish routines and conventions to support student engagement. In face-to-face settings, classroom norms and routines follow relatively predictable patterns, known to students and teachers alike. Online, the interactive environments are new and open to interpretation, making the results in any given discussion somewhat unpredictable.

2. We realized in teaching and then in analyzing data from these courses that the course structure is much less deterministic than we anticipated. Structure can support engagement, but seems to be less deterministic than in face-to-face settings.

3. Subject matter does seem to matter, but not necessarily in the ways we anticipated. We expected it to be more difficult to talk about mathematics than about teaching, assuming that
talking about abstract or symbolic representation might be more difficult than discussing ideas. In the case of Jasper, the opposite was true (although whether this was because of the subject matter or the task is an open question.) Certainly, the Benny unit in Course B suggests that the subject matter is an important factor in the kind of discussion that takes place.

4. We expected that technologies used offline, especially those that provided complex representations of subject matter, would be harder to discuss than printed material. While the jury is still out on this conjecture, it is clear that there is different work to do to be able to discuss content presented through different media. Doing the Jasper problem was an essential part of the work of understanding that technology, and discussing it required establishing some common understandings of non-print materials.

5. As expected, task is an extremely important factor in what students engage in and how they engage. This includes not only the task as set by the instructor, but how students interpret the task. In the case of Jasper, we intended for the final task to be a collaborative activity, but the students seemed to interpret it as an individual task of posting their own ideas. The issue of task seems as important online as it is face-to-face: students engage with and learn what the task, as they interpret it, requires of them. In some ways, student interpretation of task may be harder to manage online than face-to-face, where the teacher can intervene and redirect students to the intended task. Whether more or less difficult to manage, though, the task was certainly a major factor in students' discussions in our online courses.

References


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