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Synchronous Online Discourse in a Technology Methods Course for Middle and Secondary Prospective Mathematics Teachers

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Abstract

The authors present examples of analysis of online discourse and interactions among prospective middle-grades and secondary mathematics teachers in a technology methods course. The online group met synchronously using Elluminate *Live!* to study data analysis and probability with dynamic technology tools. Analysis of class sessions included broad lesson maps, which captured instructional decisions, big ideas related to content, use of technology, and general discourse. Critical episodes, where prospective teachers seemed to address common misconceptions and develop their own understandings about data analysis and probability, were identified and analyzed further. Trends related to design and management and discourse in the synchronous, online environment are reported, along with implications for further work with online technology methods courses.

Developing prospective teachers' knowledge in teaching and learning mathematics with technology is challenging work. Most would agree that providing them with opportunities to engage in meaningful tasks and discussions with one another is important. However, the means by which teacher educators should facilitate those tasks and discussions in a synchronous, online environment is relatively uncharted territory in mathematics education research.

In this study, a synchronous, online unit on teaching and learning data analysis and probability with technology was designed with these types of meaningful tasks and discussions in mind. In particular, purposeful decisions were made to include whole group and small group discussions at various points during the online lessons. During the implementation of the unit, these discussions were centered on prospective teachers' work with a variety of technology tools as they revisited statistical content, and the opportunities for interaction proved to be a favorite part of the online unit for students. This article describes the ways in which the teacher educator facilitated lessons within a synchronous, online environment and the ways prospective teachers interacted with one another.

Discourse in Mathematics Education

The idea that knowledge is constructed by an individual through interactions is not a new one (Bruner, 1966; von Glasersfeld, 1984; Wertsh, 1985). In the mid-1900s, Piaget's theory about social interaction incorporated the view that the social world has an important role to play in the developmental process (Tudge & Rogoff, 1989). Vygotsky (1978) believed that the social interaction and dialectic process furthered existing knowledge and promoted new insights. The constructivist philosophy supports the belief that learners construct unique knowledge based on their own experiences and understanding. More recent research in mathematics education supports the understanding that discourse and interaction are important components of any learning experience (Clement, 1997; Groves & Doig, 2004; Picollo, Harbaugh, Carter, Capraro, & Capraro, 2008; Yackel, Cobb, & Wood, 1991). Sociocognitive learning theory states that "learning is a social activity and that individuals learn more from their interactions with others than from reading materials alone" (Richardson & Swan, 2003, p. 43). Therefore, cognition is "social and distributed" (Putnam & Borko, 2000, p. 5).

This notion that knowledge is socially constructed is not limited to the mathematics classroom; it applies to mathematics teacher education classes as well. "The view that knowledge is socially constructed makes it clear that an important part of learning to teach is becoming enculturated into the teaching community—learning to think, talk, and act as a teacher" (Putnam & Borko, 2000, pp. 5, 9). This type of knowledge construction potentially results from purposeful discourse and interaction.

A major contributor to interactivity is discussion during class. "There must be time to develop an atmosphere in which they can think for themselves….There must be adequate resources in an environment in which exploration and discovery are supported and ideas are valued and can be freely stated" (Sliva, 2002, p. 80). Among any group of novices, reflective discussion about their practice can be helpful. Teachers are no different. McCrory, Putnam, and Jansen (2008) asserted that in professional communities "teachers learn through sustained discourse with other teachers, sharing their expertise and learning from the expertise of others" (p. 157). Prospective teachers, however, have little expertise to draw upon, which can be an obstacle for productive discourse. It is critical that strategies are in place during class to assist prospective teachers in developing the practice of giving rich descriptions, attending to evidence, and considering alternative approaches (Feiman-Nemser, 2001).

For mathematics teacher educators, much can be gleaned from existing research regarding strategies that have been shown effective in promoting constructive discourse with mathematics students. Research on effective whole-class discussions (Nathan & Knuth, 2003), questioning (Piccolo et al., 2008), and implementing effective small discussion groups (Elbers, 2003; Kazemi & Franke, 2004; Webb, 1991; Webb, Nemer, & Ing, 2006) may be transferred to teacher education. For example, often ideas or actions are discussed and then become objects of discussion in their own right (Yackel & Cobb, 1996). This type of discourse is natural and healthy in developing knowledge for teaching.

Much has also been learned about interaction from face-to-face experiences with prospective and practicing mathematics teachers. Leiken and Zaslavski (1997) reminded instructors to increase task-related interactions to promote learning. Rosales, Orrantia, and Vicente (2008), accounting for cognitive processes involved during interactions with both prospective and practicing mathematics teachers, confirmed the idea that a less teacher-centered lesson results in higher levels of interaction among students. Piccolo et al. (2008) agreed. "Students need the opportunity not only to hear what the teacher is

teaching, but actually converse and articulate their own understanding of the content being presented" (p. 404).

In their work, they also stressed the effect of questioning from students on discourse and interactions. When students ask questions, "they are thinking about their thinking" (p. 381). Those types of reflective activities are important, especially for prospective teachers.

It is important to note that organizing prospective teachers into small groups in itself does not ensure that social and distributed learning is taking place. Even online, networked interaction or social interaction, by itself, is insufficient and does not constitute a discourse-rich learning environment (Larreamendy-Joerns & Leinhardt, 2006; Shea & Bidjerano, 2009). Instead, small-group learning experiences need to be designed intentionally and purposefully. In teacher education, small group discussions should be focused on content and students' thinking (Cady & Rearden, 2009; Groth, 2007; Stephens & Hartmann, 2004).

Prospective teachers should also have opportunities to "engage in practical inquiry, try new things, and reflect in a collaborative setting" (Stipek, Givvin, Salmon, & MacGyvers, 2001, p. 225). Experiencing a task together, working through a solution, and discussing the process allows prospective teachers to reflect critically on a common experience while sharing alternate viewpoints which permits them to anticipate more about how their future students may approach a task differently and what they may do in response.

Discourse and Interaction Promoted Synchronously

Interactions in an online environment are undoubtedly different from those in a face-to-face environment. Web-conferencing programs such as Elluminate *Live!* (*http://www.elluminate.com/Services/Training/Elluminate_Live!/?id=418*) allow users to chat, view live demonstrations, interact with presentations, and more. Advantages of using a synchronous learning environment include real-time sharing of information among students and teacher with immediate access for asking questions. In particular, with regard to environments such as Elluminate, students tend to favor features such as emoticons, virtual hand raising, a shared whiteboard, polling, and application sharing as points of personal engagement. McBrien, Jones, and Cheng (2009) found that with these features, students talked about an enhanced learning experience with improved communication, high levels of satisfaction with the course, and strong group cohesion when compared to earlier asynchronous designs of online courses.

Stephens and Mottet (2008) also showed that increased interactivity with tools such as the ones described in Elluminate enhances participants' satisfaction with the learning environment. Therefore, the interactivity of students in a synchronous, online environment is critical. Online instructors must employ strategies that encourage interaction to allow students to feel socially present in the lesson. One feature in web-conferencing programs like Elluminate that shows promising gains is Application Sharing (Cady & Rearden, 2009). With this feature, participants have the opportunity to view live demonstrations and even take control of the instructor's mouse if permission is requested and granted.

Framework for Analyzing Discourse

While some work has been accomplished in analyzing student contributions in asynchronous, online environments such as discussion boards (e.g., Nandi, Chang, and Balbo, 2009; Topcu & Ubuz, 2008), little research exists on how to effectively analyze

discourse in a synchronous, online environment. Therefore, one must draw heavily upon what has been learned from discourse analysis in traditional, face-to-face environments.

One such work is that of Krussel, Edwards, and Springer (2004), who studied discourse in a geometry course for teachers. They created a framework for understanding discourse moves, which drew heavily upon the work of others: Sfard (2000) studied the foci of mathematics students' talk and Knuth and Peressini (2001) introduced the distinction between univocal discourse and dialogic discourse, which is evaluation authority given to the teacher and to the group respectively.

Krussel et al.'s work defined discourse moves as "deliberate action(s) taken…to participate in or influence discourse" (2004, p. 309). Using existing frameworks, they described discourse by purpose (or intention), setting (including physical attributes), form (verbal and nonverbal), and consequences (or results). While their work was born out of a face-to-face setting, Krussel et al. stated specifically that the framework could be "applied to discourse in distance courses" (p. 311). The particular ideas of purpose and form were used in this study to describe the ways prospective teachers interacted with one another during synchronous, online discussions (e.g., sharing ideas or asking questions or communicating through the use of the online microphone or chat window). For this study, only form and purpose were noted for each discourse move, or "talk turn," of the instructor or prospective teachers.

If knowledge is, in fact, social and distributed, then discourse and interaction may play an even more important role in the development of prospective mathematics teachers than research currently suggests. Implementing whole-group and small-group discussions in ways that elicit understanding beyond simply drawing upon personal experiences is a challenge. However, by allowing prospective teachers to focus on content and students' thinking, they have a common ground on which to stand and base their conversations. Researchers have tried to develop frameworks for analyzing discourse and its effects, each attending to different nuances that exist. They do seem to agree on one thing, however. The way students communicate and interact with one another, either face-to-face or online, may affect the knowledge they develop.

Methods

The primary purpose of this study was to examine the ways prospective teachers were engaged in class discussions within a synchronous, online environment. In doing so, we also needed to consider the role of the teacher educator in the design and implementation of the online unit. The methods presented here were developed as part of a larger study (Starling, 2011).

Context and Participants

Seventeen prospective middle grades and high school mathematics teachers were enrolled in a technology methods course at a large public university. The class met 3 hours once a week for the duration of the 5-week study. Elluminate was used as the online classroom environment so that live interactions and technology demonstrations could take place. During each class session, prospective teachers could participate in class through the use of emoticons, interactive whiteboard tools, typing a message in the chat window, or speaking with their microphone. (Figure 1 shows a screenshot from a sample Elluminate session.)

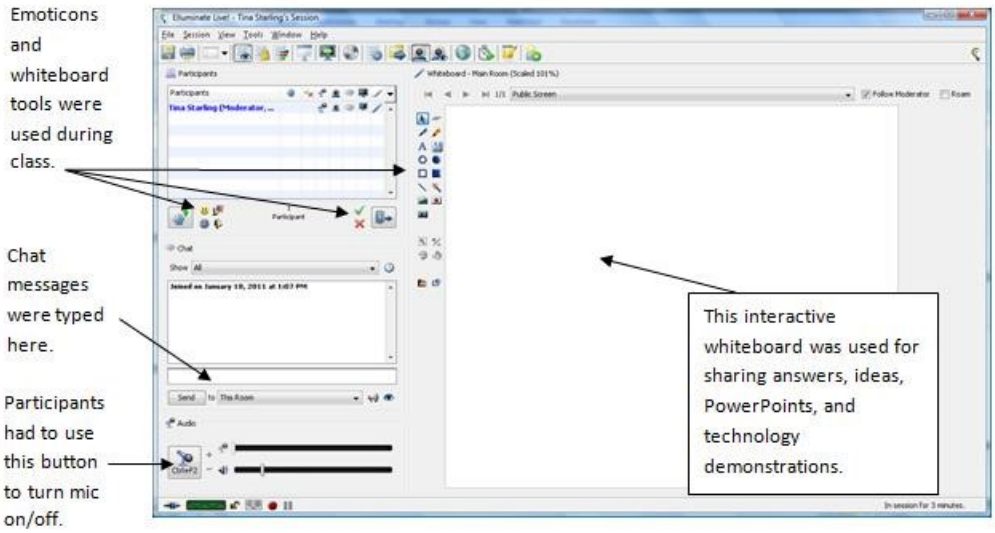

Figure 1. *Sample Elluminate session.*

Each prospective teacher was expected to have access to speakers and microphone equipment to participate during the online class meetings. In addition, prospective teachers needed a graphing calculator, spreadsheet, and all dynamic software programs used in the curriculum text for the course (Lee, Hollebrands, & Wilson, 2010). Live technology demonstrations with these tools were a regular part of the online class.

All prospective teachers in the study participated in whole group discussions. Three prospective teachers also participated as members of a focus group to be studied during small group discussions. This focus group was purposefully selected to include gender and program (middle school and high school) differences. The focus group remained fixed throughout the study so that changes in discourse over time, if any, could be noted.

Data Collection and Analysis

To analyze discourse, recordings of each online class meeting were collected. With each recording, events that happened in the virtual main room of the online environment could be replayed (see Figure 1). Recordings were used to analyze the ways prospective teachers discussed content and pedagogical questions in whole group settings. When prospective teachers moved to work in small virtual breakout rooms within the Elluminate environment, the focus group remained in the main room of Elluminate so that their discussion could be recorded.

While reviewing the recordings multiple times, a spreadsheet was used to create detailed lesson graphs (as in Jacobs, Hollingsworth, & Givvin, 2007) of each class session, which displayed the content and structure of the lesson. In the spreadsheet, each row represented approximately 1 minute of class time. Cells were color coded (e.g., blue for small group activities) and included many details of what was occurring during that minute of the class session. These lesson graphs captured the essence of each class.

We later found it helpful to create additional, more-condensed representations of the lesson graphs. First, a pie chart was created for each class session to determine the

percent of time spent for direct instruction, small group discussion, whole class discussion, independent work, and addressing technical issues (e.g., Figure 2). Second, a color-coded timeline was created where the sizes of the rectangles were proportional to the time spent during class in that type of activity (e.g., Figure 3). These were essentially streamlined representations of the lesson graphs. The pie chart and proportional timeline representations for each class session were helpful in getting an overall sense of the types of discussions that occurred throughout the 5-week study within the synchronous online learning environment.

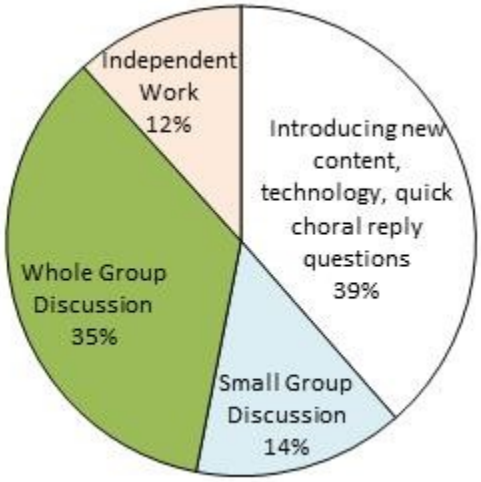

Figure 2. *Opportunities for interaction (Class Session 4).*

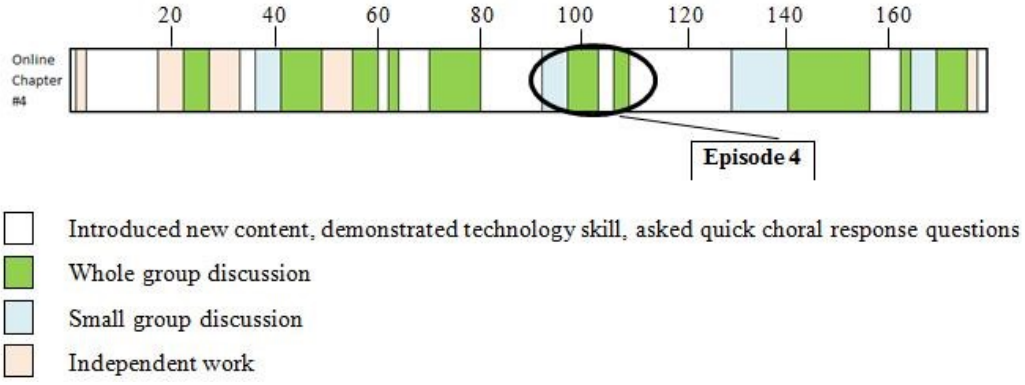

Figure 3. *Timeline of events (in minutes) for Class Session 4.*

Out of the approximately 15 hours of recordings, six episodes, were identified for further analysis. Collectively, these episodes cut across different technologies the prospective teachers were learning over the 5-week period and contained both small group and whole group activities around a single content focus so that discourse could be studied at each discussion level. Transcripts were created for each small group and whole group

discussion in the six episodes. Discussion pattern representations were then created for all whole group discussions (e.g., see Figure 4). These visuals portrayed the number of exchanges during a discussion, as well as the sequence of communication and times when multiple prospective teachers were talking or chatting at once (denoted in Figure 4 by the white lines with arrows on both ends).

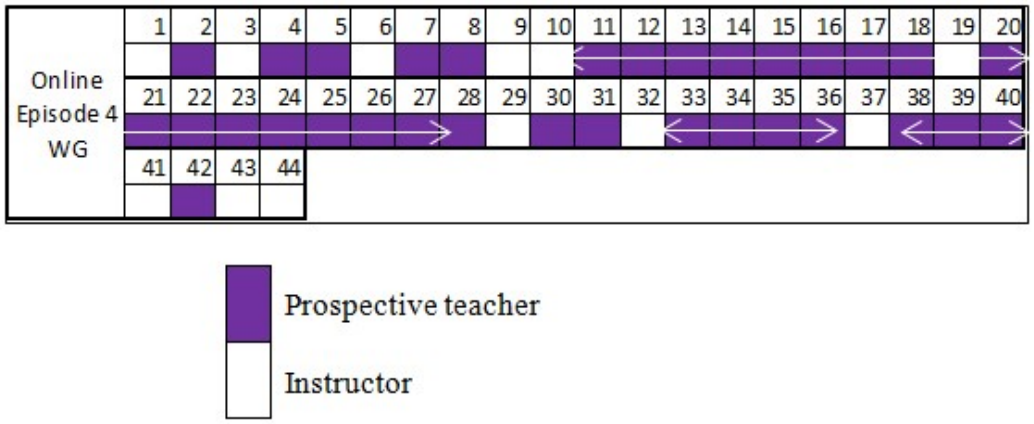

Figure 4. *Whole group discussion pattern (Episode 4).*

Because contributions to a synchronous, online whole group discussion by an instructor or prospective teacher could look or sound a number of ways, we decided that a talk turn would be any move that could be seen or heard by the whole group. A talk turn could include using the microphone to speak to the group, writing in the chat window or interactive whiteboard, or using an emoticon.

To analyze these online discussions, Krussell et al.'s (2004) framework was modified and used to code individual talk turns. Specifically, the instructor's and prospective teachers' direction, form, and purpose were coded and recorded (e.g., Figure 5). Direction indicated whether the instructor or prospective teacher was addressing the small group or whole group. Form included using the microphone to speak in the discussion, as well as using the chat window, emoticons, raised hand feature, and interactive whiteboard within Elluminate. Finally, the purpose of each talk turn was coded as one of the following:

1. Ask a question,
2. Answer a question,
3. Share an idea or concern,
4. Justify, or
5. Affirm.

A partial coding of a whole group discussion related to Episode 4 is shown in Figure 5 and serves as an example of how discourse codes were applied.

In Figure 5, each row represents one talk turn and corresponds to the talk turn with the same number in the representation shown in Figure 4. In other words, Figures 4 and 5 represent the same discussion, with Figure 4 showing the overall back-and-forth nature of discussions and Figure 5 giving more details about the first 15 talk turns. A number 1 was used to indicate the direction, form, purpose, and topic of contributions to discourse

so that frequencies could be easily calculated. Sometimes, other codes were used to depict better what was happening at that particular time.

EPISODE 4 - WHOLE GROUP		Direction				FORM								PURPOSE				
	Time: 7:55 Focus of Questions : TPSK	T-SG	I-SG	T-WG	I-WG	Mic	Chat	Chats w/ symbols or	Emoticons	Demo	Using whiteboard tools	Applause	Raising hand	Ask a Question	Answer a Question	Shares some idea or	Justify	Affirm
1	Instructor				1	1					R			R,N				
2	James			1		1					R						1	
3	Instructor				1	1	1				1			N				
4	Abby			1			1								1			
5	James			1		1									1			
6	Instructor				1	1	1		SF		1			N		R		1
7	James			1					SF		1					1		
8	Roger			1			1									1		
9	Instructor				1	1								N				
10	Abby			1					GC									1
11	Alice			1					GC									1
12	James			1					GC									1
13	Kristy			1					GC									1
14	Chase			1					GC									1
15	Mitchell			1					GC									1

Figure 5. *Partial coding of the online whole group discussion (Episode 4).*

For example, in the emoticon column, "SF" was used when prospective teachers used a smiley face, and "GC" was used when they shared a green check. Often the green checks were solicited by the instructor. Smiley faces, on the other hand, were generally shared without any prompting. In this example, other codes were also used for use of the whiteboard tools (R = referencing a drawing on the interactive whiteboard), asking a question (N = asking a new question, R = restating a question from the textbook), and sharing an idea (R = restating a previously shared answer or idea). When nonnumeric codes were applied, we manually counted the frequencies for those categories of form and purpose.

Face-to-face interviews with individual members of the focus group provided additional information about their ability to perform skills learned in the online class as well as their comfort level working in that environment. Each member of the focus group was interviewed twice by the instructor (i.e., first author), once during the 5-week study and once at the end. Interviews were then recorded and transcribed.

Findings

For each class session of the online unit being studied in this mathematics education technology methods course (Lee et al., 2010), opportunities for discourse were analyzed.

During analysis, trends emerged, which seemed to affect discourse in the synchronous, online environment. Some of those trends resulted from decisions made by the instructor in designing and managing the class. Others resulted from preferences and personalities of prospective teachers participating in the study and are presented as trends in form and purpose.

Trends in Class Design and Management

Viewing timelines for each class session used during the study confirms that prospective teachers had opportunities for small group and whole group discussions throughout the study and that the placement of discussion activities seemed to be consistent (see Figure 6). For example, whole group discussion time was interspersed throughout each lesson and was kept to less than 15 minutes in most instances. In addition, throughout the study, each time small group discussion occurred it was immediately followed by whole group discussion.

Figure 6 also highlights the fact that technical troubleshooting was unavoidable, despite efforts from the instructor to address individual's issues during times of independent work. The cells shaded yellow in the timeline for the first class session indicate that prospective teachers had some problems working in the synchronous, online environment initially and after a short break.

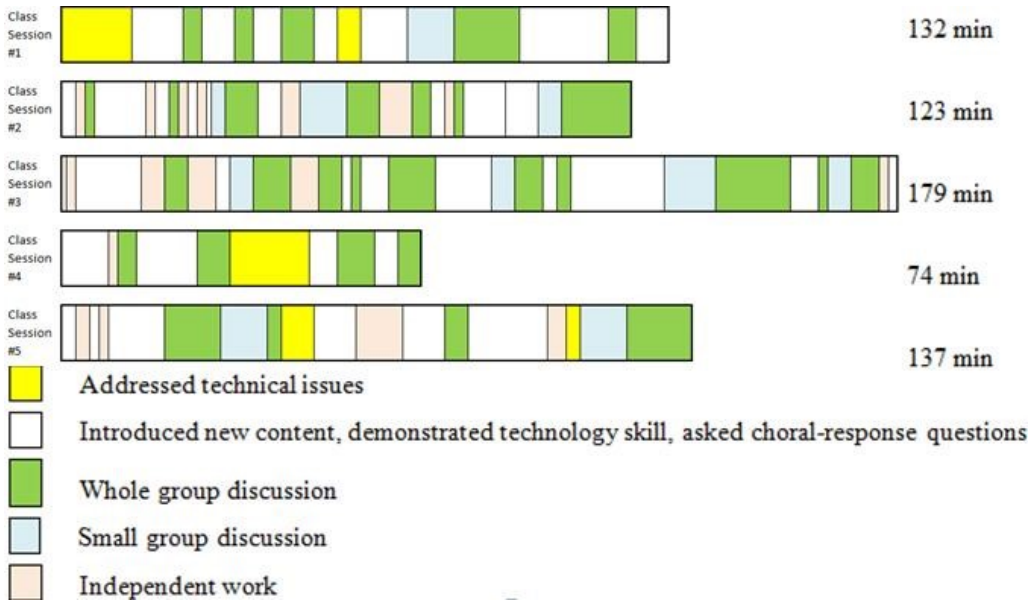

Figure 6. *Comparison of timelines for class sessions during the study.*

The cells shaded yellow in timelines for Class Sessions 4 and 5 reveal additional issues prospective teachers had following instructions in probability activities, which utilized graphing calculators and a dynamic software tool. Using online class time to address these problems was necessary in order for the class to move forward with later activities.

The role of the instructor, as facilitator, also surfaced during the whole group discussions for each class session. In episodes corresponding to work in the first four class sessions,

where small group discussions preceded whole group discussions, the instructor worked to solicit responses from each group. Sometimes, however, multiple prospective teachers would respond simultaneously in the chat window to questions that were not directed toward one participant or one group (e.g., talk turns 21-28 in Figure 4). The instructor would rarely recognize all responses orally, but many times she would acknowledge prospective teachers' responses and ask one of them to elaborate on a shared idea.

The instructor interacted with the online class predominantly through the use of a microphone. When she used chat to correspond to prospective teachers, she was usually helping someone with a logistical matter. For example, during a whole group discussion, she asked the member in each group with the shortest name to be the spokesperson. While one prospective teacher began to share his ideas, the instructor addressed the following concern:

> Alice (chat): Mitchell's mic isn't working so what should group 5 do?
>
> Instructor (chat): oh yeah, debra can go for group 5 this week.

During small group activities, the instructor required prospective teachers to use virtual breakout rooms in Elluminate. She could then move into a breakout room herself. Once in a breakout room, the instructor essentially became a member of that group for a small period of time. She could listen to prospective teachers talking, and read anything they were writing in the chat window or interactive whiteboard, as well as speak to the group or share ideas another way.

The conversation from other groups was entirely absent. However, while in one group, the instructor could see that other prospective teachers were talking and writing in their groups based on icons within Elluminate that turned yellow when participants were actively using their microphones, chat windows, or online writing tools. She could then move from group to group until she had visited breakout rooms for each group. The instructor's ability and frequent use of moving between small breakout rooms also provided closer contact with individual participants and allowed them to ask questions outside the whole group. This was an opportunity that many prospective teachers took advantage of.

At the conclusion of a small group discussion, asking different members of each small group to report back to the whole group was just one way the instructor tried to elicit responses from different prospective teachers. She also used the green check emoticon frequently during each class session to receive feedback from prospective teachers about their ability to perform technological skills. At times during whole group discussions, the instructor would not comment on the correct or incorrect nature of a group spokesperson's response but would rather leave it open for further discussion from the next group or someone from the class at large.

As the discussion patterns for whole group discussions of each episode show (e.g., Figure 4), a traditional back-and-forth pattern of the instructor and a participant speaking sometimes occurred. However, there were also many instances of simultaneous responses. Sometimes, the instructor would specifically ask for this type of response (e.g., "Put your idea in the chat window"); at other times the multiple responses were unsolicited.

During video analysis, another salient characteristic of the synchronous, online discourse that emerged was the presence of pauses. Sometimes these pauses were purposeful, and it

was apparent that prospective teachers were independently working to recreate a representation using the technology. Other times, however, the pauses seemed long and awkward, which was particularly noticeable in the small group discussion with focus group members.

Through analyses of lesson maps and timelines, we could clearly see that the instructor made purposeful decisions when considering the placement of whole group and small group discussions. This study does not intend to make claims about the appropriate ordering of such activities. Rather, data suggested that the predictable nature of small group and whole group discussion activities was beneficial for prospective teachers. In their interviews, focus group members commented favorably on the structure of the class. In an interview with Abby, one of the focus group participants, the instructor asked how she liked the structure of the class:

Overall, I really give it some good thoughts. I wouldn't know how to improve it. You give instruction, we try it ourselves, then we look at things and think about things ourselves, and then our group work….The order of things is working well. I really like it. I'll be honest, I'm enjoying it.

Abby's response showed her attempt to explain the structure in her own words and showed appreciation for designated times of independent and small group work, in particular. Her response indicated that she was cognizant of the structure of the online unit and felt it worked for her.

Trends in Form and Purpose

As expected, during whole group discussions prospective teachers interacted in a variety of ways. During times of whole group discussion, someone speaking for a particular group would always use the microphone, as directed by the instructor. Incidentally, the instructor shared ground rules during the second week of the study asking participants to click the raised-hand icon in Elluminate before using the microphone to minimize technical issues with audio feedback, which was a technology issue in Week 1. When someone was speaking for a particular group, other prospective teachers rarely used the chat window. Yet, when the instructor asked a choral-response type question, most participants seemed comfortable sharing an idea with a quick chat window response. The number of times prospective teachers wanted to ask a new question or share a new idea during more instructor-centered times of the lessons, however, was minimal.

Figure 7 provides a snapshot of one moment in the online class related to the third class session. Prospective teachers had seen a live technology demonstration related to finding the least squares line with a dynamic statistical software tool and were given time to try this new skill out individually on their personal computers. Then, they were asked to return to Elluminate and to click the green checkmark if they were able to successfully add squares to their moveable line using the technology tool and move their moveable line in order to minimize the sum of squares. Figure 7 shows a screen capture of the Elluminate session, including some of the green checks by prospective teachers in the top left corner and an unsolicited sharing of individuals' sums of squares in the chat window in the bottom left corner.

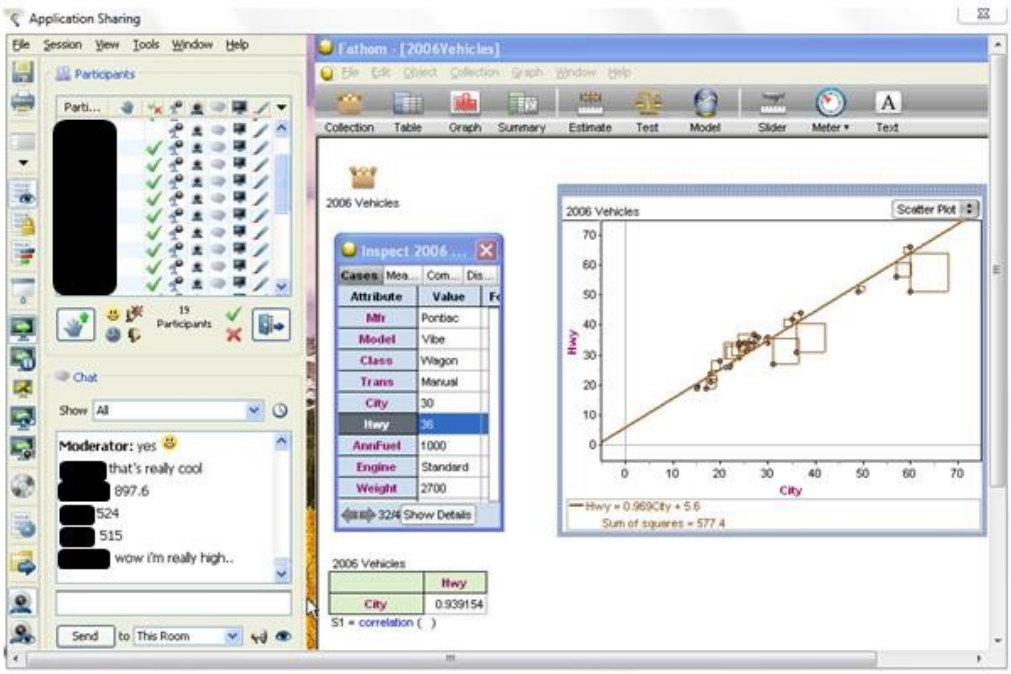

Figure 7. *A screenshot of a live technology demonstration within Elluminate.*

The interactive whiteboard was utilized during many whole group discussions. Usually, this interaction was initiated by the instructor. The next example is one of the few instances where the interactive whiteboard was being used by a prospective teacher more organically. During a whole group discussion about where one might estimate the placement of the least squares line based on a residual plot, he volunteered a solution by drawing a line on the interactive whiteboard (Figure 8).

As the instructor used the prospective teacher's line as a reference, she drew an arrow on the residual plot and circled a group of points in both graphical representations to help prospective teachers see how the two were connected. The prospective teacher, who had voluntarily shared a line, seemed to assist in the explanation by circling a second group of points, using the yellow marker tool, in the scatterplot and the residual plot. He also circled a third group of points, using the pink marker tool, as the instructor discussed how the line fit that data.

During the whole group discussion, 44 communication exchanges occurred during approximately 8 minutes. Table 1 provides an overview of the direction, form, and purpose of discourse during this whole group discussion. Note that while each exchange had one direction, it often contained more than one form or purpose, illustrated in Figure 5. Frequencies of different forms and purposes for the same discussion showcased earlier in Figures 4 and 5 are shown in Table 1.

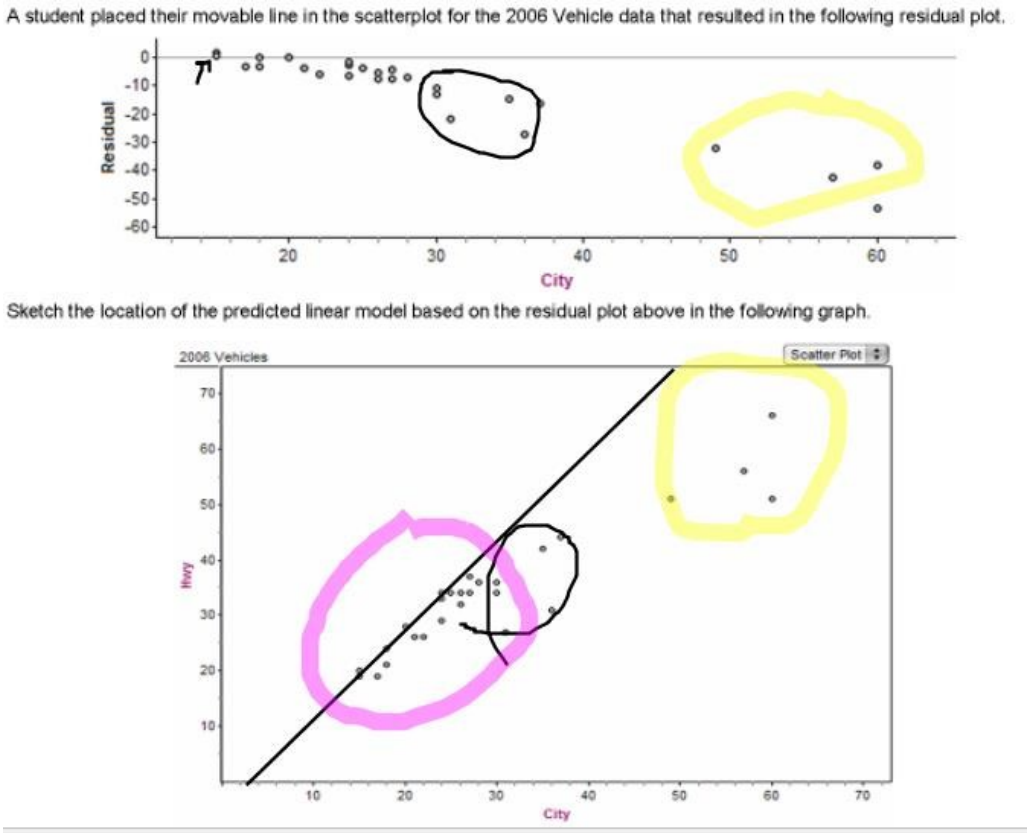

Figure 8. *Use of the interactive whiteboard during an online discussion.*

The number of occurrences for different forms were not unique to activities and discussions related to a particular episode or to whole group discussions, in general. We also found that during small group discussions, prospective teachers continued to interact in similar ways. Members of the focus group, whose small group discussions were recorded, seemed to strike a balance between using the microphone and chat window. However, they had different levels of comfort in communicating with one another online.

This difference in comfort levels, coupled with an apparent lack of confidence in the statistics and probability content being used, seemed to cause awkward pauses in their small group discussions at times. The interactive whiteboard was used occasionally to record ideas during small group discussions, but members of the focus group, admittedly, found typing and editing comments on that whiteboard difficult due to their lack of experiences with the environment prior to this study.

Sharing ideas, answering questions, and affirming one another were all things prospective teachers were comfortable doing in the synchronous, online environment, both in small group and whole group settings. Table 1 shows how frequently these purposes were used in the whole group discussion related to Episode 4, and Table 2 provides more specific details about how these frequencies compare to other discussions throughout the study. It shows the percentage of exchanges, or talk turns, in which specific purposes were coded.

Table 1
Summary of One Whole Group Discussion (Episode 4)

Whole Group Discourse (44 exchanges, 8 min)	**No. of Occurrences**
Direction	
Teacher-Whole Group (T-WG)	35
Instructor-Whole Group (I-WG)	9
Form	
Microphone	11
Chat with words	15
Emoticon - Smiley Face	5
Emoticon - Green check mark	20
Whiteboard Tools - Typed comment on the interactive whiteboard	3
Whiteboard Tools - Referenced the ideas shared on the interactive whiteboard	2
Purpose	
Asked a Question - Asked a new question	5
Asked a Question - Restated a question from the text	1
Answered a Question	12
Shared an Idea or Concern	9
Justified an Idea or Response	1
Affirmed an Idea or Response	21

Note that a single exchange was often coded as having multiple purposes. Thus, the percentages for each row (a small group or whole group discussion) may not add up to 100%. Four episodes included times when prospective teachers shared an idea or concern more frequently than they answered a question. These four episodes were all small group discussions. Another interesting finding is that justification occurred the least. Instead of justifying responses, prospective teachers would often share ideas without returning to them in order to offer their reasoning.

One surprising result in purpose was the number of affirmations. Most of these affirmations came directly from microphone use, particularly from the instructor during whole group discussion and from prospective teachers in small group discussion. However, 35% of all affirmations in the online episodes showcased here were in the form of a chat, and 18.5% were from the use of emoticons when prompted by the instructor.

Table 2
Percentages of Different Purposes Evident During Online Discussions

Episode	Ask a Question	Answer a Question	Share an Idea or Concern	Justify	Affirm
Episode 1 – SG	28%	19%	34%	19%	28%
Episode 1 – WG	45%	30%	25%	15%	15%
Episode 2 – SG	0%	17%	44%	11%	33%
Episode 2 – WG	20%	48%	32%	6%	16%
Episode 3 – SG	25%	25%	38%	0%	63%
Episode 3 – WG	26%	50%	11%	4%	39%
Episode 4 – SG	17%	8%	17%	8%	50%
Episode 4 – WG	13%	26%	19%	2%	49%
Episode 5 – WG	6%	58%	19%	0%	19%
Episode 6 – WG	14%	29%	23%	3%	43%
Episode 6 – SG	26%	26%	22%	0%	35%

The trends in form and purpose described here were confirmed during interviews with focus group participants. For one prospective teacher, Les, this online class setting was the first he had ever experienced. In Les's first interview, which occurred after the first online class meeting, the instructor asked if she might do anything differently to help him learn better in this environment. He responded with, "It's hard to know when to type a response in or when to talk. I guess I don't know when to speak up and when not to. I guess there's a way to raise a hand, right?" As a result, the instructor implemented a plan of using the virtual handraising the following week to ensure prospective teachers knew when to speak with the microphone.

Other comments from focus group members during interviews gave insight into their attitudes about learning technology in a synchronous, online environment. The ability to share a live technology demonstration proved to be an effective tool. Les said, "I like how the instructor can share her screen." Sally said,

> It took me a while to get used to all of the commands. I like that you could see everything going on, with the mouse, and then trying it out ourselves. So, we don't always do that in [our face-to-face] class.

She described working online as being "hands-on." Abby also commented, "I like how you share your screen. I could literally fix my screen so that it's side by side and do it while you're doing it…. I like it. I really do." Technologically, she was able to resize her program windows on a single monitor so that she could see what the instructor was doing while trying a new skill herself.

Having multiple ways of sharing ideas was also a feature of Elluminate that prospective teachers seemed to appreciate. All three members of the focus group explicitly mentioned interacting with others as something they enjoyed and perhaps did not expect.

- I like the whiteboard where people can post stuff. I like how you can have voice discussion and chat discussion too….I like the small group work—I never

would've guessed you could do small group work in an online class….I learn about things from others. (Abby, Interview 1)

- It's been neat how you can interact with people. You can still talk and communicate with people. (Les, Interview 2)
- I really like our groups. Everybody has a little bit of a say. (Sally, Interview 2)

Despite the enjoyment of group work alluded to, we were concerned that during group work often ideas were accepted without question, even when there were obvious discrepancies in responses. In Episode 6, a small group discussion showcased three different ideas from each of the three focus group members, yet no consensus or shared understanding was reached at that time. Thus, though they seemed to value being able to engage in small groups, their actions in the group settings sometimes illustrated a lack of ability to persevere on a question and to construct arguments or justifications for a point of view within group discussions.

Discussion

This study reveals information about prospective teachers' discourse in a synchronous, online environment as they learned about teaching mathematics with technology. The creation of lesson maps and timelines for each class session provided an overall sense of the opportunities prospective teachers had for different types of interactions and resulting discourse. Interaction diagrams further illustrated how a whole group discussion appeared, often with a combination of back-and-forth dialog between the instructor and the prospective teachers and simultaneous dialog through features of the online environment (e.g., chat window).

As expected, interactions within Elluminate looked different than one might expect from a comparable face-to-face technology methods course. Prospective teachers participated in a variety of ways. During whole group discussion, they spoke using a microphone and typed comments and questions in the chat window. They responded to the instructor with quick affirmations through the use of the green check and other emoticons. In many ways, these interactions provided the instructor with formative assessment data throughout class sessions. Many of the responses were prompted by the instructor during lessons. However, the online setting allowed the instructor to know when prospective teachers were naturally and openly self-assessing—data that is not always available to a face-to-face instructor.

Prospective teachers also participated in surveys, controlled the instructor's computer mouse during demonstrations, and typed ideas on the interactive whiteboard. During small group discussion, prospective teachers moved into breakout rooms within the online class meetings in Elluminate and shared ideas by talking, chatting, and typing on the interactive whiteboard.

McBrien et al. (2009) found that students used these features of the synchronous, online setting as points of personal engagement. Prospective teachers in this study also stayed engaged during the class through the use of such features. Many of them commented on how they appreciated viewing live technology demonstrations and the opportunities to discuss issues related to content, technology, and pedagogy with one another. It seemed that the interactive nature of Elluminate, was especially appealing, something that other researchers have also found in their work (e.g., Cady & Rearden, 2009; Stephens & Mottet, 2008, Stipek et. al, 2001). In addition, the use of small groups (or breakout rooms) in Elluminate was a welcomed surprise for prospective teachers. They spoke fondly of the ability to share ideas and "have a say."

If one agrees with von Glasersfeld (1984) and the constructivist philosophy, then prospective mathematics teachers need opportunities to develop their ideas and learn from one another, regardless of the environment in which they are learning. Teacher educators must continue to find ways to apply what has already been proven effective in face-to-face environments and appropriately modify them, if necessary, to online environments such as the one described here. As synchronous, online environments continue to improve, the design and methods for delivering methods should evolve into ones that require less structure (e.g., handraising and control of microphone). Research, therefore, should continue to provide teacher educators with effective teaching practices and methods for capitalizing on the synchronous, online features.

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