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A central premise across a variety of educational research and policy documents is that students learn with greater understanding in classrooms where they engage in exploring, reasoning, and communicating about their thinking (Hiebert and Wearne, 1993; National Council of Teachers of English, 2016; National Council of Teachers of Mathematics, 2000). With the recent emergency transition to remote online instruction in higher education, opportunities for rich synchronous learning have been diminished in many courses. Most instructors have had to adapt rapidly from in-person classroom settings to online environments without sufficient time and training. Accordingly, college students have shared concerns about the lack of opportunities to interact with others. We offer a design case (Boling, 2010), based on the recent experiences of the first author, capturing an approach to making the transition from in-person to remote learning while maintaining a course's synchronous, dialogic nature. We describe principles of instructional design and implementation that became salient in this case, grounding our account in evidence from student voices and perspectives. We investigate how these principles might make a shift to synchronous online instruction manageable for instructors.

Interaction Patterns in Face to Face and Online Discussions

The importance of dialogic interactions (Bakhtin, 1984) in classrooms has been reported across disciplines (Sherry, 2017; Wertsch and Toma, 1995). While *monologic* discourse is described as the transmission of information from a teacher to students, *dialogic* discourse serves as a thinking opportunity for students to generate new meanings for themselves through communication (Wood, 1998). In a dialogic discussion, students often use the words of their classmates for their own sense making, rather than passively accepting the procedures the teacher provides (cf, Bakhtin, 1984). The emergence of monologic or dialogic discourse is often closely connected to the types of questions that teachers ask (Nystrand et al., 1997) and is related to patterns of classroom interactions such as *recitation*, *funneling*, or *focusing* (Wood, 1998).

A *recitation* pattern, in which the teacher asks a question, students respond to the question, and the teacher evaluates the response for correctness, is often found in teacher-led classroom discourse (Sinclair and Coulthard, 1975, and cf Mehan, 1979, 1980). A shortcoming of this monologic pattern is that students passively learn concepts because teachers show them what to do and then ask them to practice (Meserve and Suydam, 1992). A closely-related communication pattern, called funneling, described by Wood (1998), is illustrated below.

Teacher:	What is 9+8?
Ken:	16
Teacher:	Okay. 9 plus 9 equals 18. And 9 plus 8 is one less than 18. So 9+8 is?
Ken:	17

In the recitation pattern, the teacher might tell Ken that his answer was incorrect and ask another student to provide a response. In this funneling example, the teacher continues to engage with Ken but responds to his incorrect answer by leading Ken through a strategy that comes entirely from the teacher. By replying to the teacher's questions, Ken completes the work and is implicated in the associated strategy. Thus, in the funneling pattern, it may *appear* that learning is occurring (for Ken); however, students involved in funneling may only be responding to the surface questions instead of expressing or justifying their own thinking. Although the teacher may intend to support students' learning by guiding them to correct answers, both recitation and funneling patterns provide students minimal agency, as they follow solution strategies that the teacher has in mind (Wood, 1998).

By contrast, the *focus* pattern supports more balanced and dialogic interactions between students and teachers (Wood, 1998). For example, the teacher may invite students to discuss possible solution pathways with reasoning and justifications. As students present their work, the teacher asks questions that help everyone attend to the work of their classmates and that encourage students to connect their thinking with that of others. In classrooms where the focus pattern often appears, students may come to expect that their provisional ideas will be respected and understand that what counts as learning is developing concepts for themselves (Wood, 1998).

Though rooted in face-to-face classroom studies, analyses of communication patterns have also appeared in the research on online discussions (Sherry, 2017). Similar to in-class discussions, the quality of students' online learning is highly dependent on the types of questions teachers ask (Zhu, 2006). When asked open-ended questions, students tend to express higher-order thinking, whereas with closed-ended questions, they are likely to show lower-order thinking (Sherry, 2017). Studies of discussions in online forums also present the potential strengths and limitations of discourse in online learning environments as opposed to in-person settings. On the one hand, online discussions may encourage participation from less outspoken learners (Larson and Keiper, 2002) and allow more time for students to develop reflective responses (Beeghly, 2005). On the other hand, because online discussions often occur in writing, miscommunication can happen due to the absence of facial expressions or other conversational markers of tone and intent. Students may also be overwhelmed by the large volume of other posts in settings where they are asked to engage and respond to their classmates' posts (Meyer, 2003).

Most previous studies focus on online learning that foregrounds a written modality (e.g., Groenke, 2008; Kim and Bateman, 2010; Sherry, 2017). Further research is needed to study features of real-time interactions online that promote the *focus* pattern. The present study responds to this need, illustrating instructional practices and their outcomes during synchronous online discussions.

Background

This study concerned a mathematical content course for K-8 preservice teachers (hereafter *students* or *teacher-learners*[1]) at a Midwestern university, forced online by the COVID-19 crisis. Data included video recordings and transcripts of synchronous online sessions, students' written work, and their reflections. In transitioning to online learning, we designed sequences of instructional materials and developed conjectures about possible trajectories for students' learning on the basis of the instructional activities. These conjectures were tentative and revised throughout the sessions through ongoing analysis of the instructor (first author) and the outside researcher (second author). We describe the online social norms negotiated by the instructor and students on the basis of their prior relations in face-to-face learning, and we describe episodes that illustrate the nature of dialogic discussions in the synchronous online environment.

Creating Social Norms in the Transition to Online Environments

In face-to-face sessions, the instructor often introduced sets of problems and provided time for teacher-learners to solve the problems in groups, followed by whole-class discussions where the student-generated solutions were the center of discussion. In transitioning to the online medium, she conjectured she could maintain synchronous dialogic discussions with technological supports, such as Zoom meetings, Google Drive, and virtual manipulatives. She decided to negotiate social norms

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[1] We use the term teacher-learner to emphasize that the students in this course are preservice teachers who are experiencing the mathematical content of the course as learners and also as future classroom teachers who will be expected to effectively communicate the content with their students.

explicitly, through mutually constituting expectations and commitments between her and the teacher-learners (Yackel et al., 1991). In the first online meeting with the teacher-learners, she directly asked them what concerns they had and how she could best support their learning. They shared concerns about the lack of opportunities to interact with other students and instructors and mentioned that continued meetings would be preferable. The group agreed to meet weekly through Zoom and then, having recognized the value of the technology, spent time practicing how each participant could share screens to describe their work and exploring ways to write mathematical expressions in Google Drawings.

To maximize the time for dialogic discussions of student-generated solution approaches, the instructor proposed to provide problem sets as homework prior to each Zoom meeting. She explained that, similar to the problem sets from prior in-person sessions, the homework would include non-routine problems new to the teacher-learners. Accordingly, she explained that the homework would be graded for effort, instead of for correctness, to encourage them to show provisional ideas in their answers. By allowing students to express preliminary ideas, rather than presenting her predetermined methods to them, the instructor attempted to strengthen a social norm of the course, in which a variety of solutions were valued and deeply engaged with (Wood, 1998).

Dialogic Discussions in Synchronous Online Learning

The episode below is included to illustrate the dialogic nature of discussions achieved in Zoom meetings. Although the specific mathematical content in these episodes may not be applicable for instructors of other courses, the instructional strategies and outcomes show a way to maintain *discipline-rich* online dialogic interactions, which may translate analogously to other disciplines. The teacher-learners were discussing their methods for visualizing $2 \div \frac{1}{4}$ and $1 \div \frac{2}{3}$. Prior to this session, they had discussed several meanings of division, including repeated subtraction methods (e.g., 10 ÷ 2 interpreted as "How many groups of 2 are in 10?" or "How many times can you subtract 2 from 10?"). The teacher-learners were encouraged to invent and conceptually unpack various division algorithms, for the purpose of learning to teach their future elementary students with a focus on sense making.

Instructor: Did anyone figure out how to solve these problems visually?

Rylie: So what I did… (sharing her screen as Figure 1 below) I did repeated subtraction literally, so up here what I did was I just kept subtracting ¼ just to premise this. I did minus ¼ until I got to nothing left. Then I counted up how many minus ¼ I did, which got me to 8. So that's how I did that.

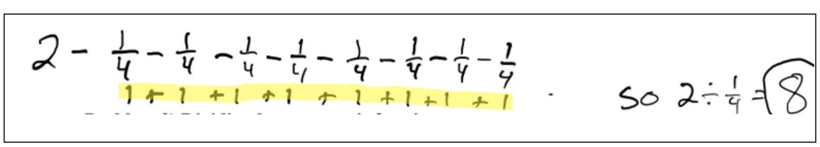

Figure 1. Rylie's screen sharing of her answer to the problem $2 \div \frac{1}{4}$

Rylie: But here (sharing her screen as Figure 2), you can't equally keep subtracting 2/3 from 3/3, and I did one as 3/3 because that was an easier way of doing it. So what I did was I took it in half.

So I did half of 2/3, which is 1/3. So I did 3/3 minus 1/3, minus 1/3, minus 1/3. So since these are all ½ 's, not all ones, I did plus ½, plus ½, plus ½ to get $1\frac{1}{2}$.

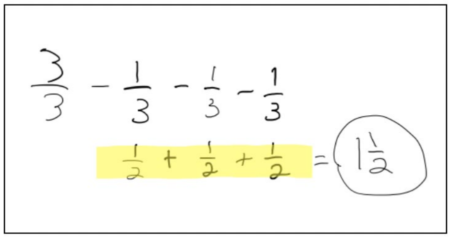

Figure 2. Rylie's answer to the problem $1 \div \frac{2}{3}$

Instructor: Questions? The last one is very interesting. Did anyone understand what Rylie explained for the last one? (pause)

Observing Rylie's work on the screen, the instructor realized that her strategy involved a leap that had not been previously discussed in the course and that this invention could help others explore the different approaches their future students might bring to their classes. The instructor asked the group if anyone understood Rylie's explanation. As Rylie looked at the faces of her classmates on the screen, she realized they did not understand some of her explanation. Therefore, she continued to reason about her methods.

Rylie: I just divided it in half because, like I said, you can't evenly subtract 2/3 from 3/3 multiple times.

Instructor: (Looking at each student's face on screen and deciding that the others still may not understand what she did) Right. So instead of you subtract 2/3 from one, you subtracted 1/3. But where did you get the ½?

Rylie: Because 1/3 is *one half* of 2/3. Because up here [$2 \div \frac{1}{4}$], ¼ is one whole of ¼. Like one of ¼ is ¼. So that's why I could do one plus one plus one plus one.

Instructor: Oh, so one plus means… how many times you subtract ¼ from two, right?

Rylie: Yeah. I took the repeated subtraction literally.

Instructor: So when you said in the problem one [$2 \div \frac{1}{4}$], when you said one plus one plus one plus one, that means the times, right?

Rylie: Yes.

Instructor: Then the bottom [$1 \div \frac{2}{3}$], you are saying because you didn't subtract one full times, but you subtracted half of that, that you are subtracting half of this 2/3…half of 2/3 three times. You got $1\frac{1}{2}$.

Rylie: Exactly. Yeah.

After Rylie justified her approach, the instructor decided to *step in* to highlight important aspects of the solution she felt many of the teacher-learners might not understand (based on their facial expressions). The instructor rephrased Rylie's method for the problem [$2 \div \frac{1}{4}$] and asked a clarifying question, whether each "1" in the expression (i.e., 1+1+1+1+1+1+1+1) meant the number of times 1/4 was subtracted. The use of screen sharing allowed Rylie to illustrate her work and the instructor to focus the attention of the class on the meaning of Rylie's innovation. The instructor continued:

Instructor: This is a really difficult concept and it was very interesting that you had come up with this new idea that is really cool. Let's see if everyone understood this…(pause). Can anyone re-explain what Rylie just said for the second problem? Or both problems one and two?

Kimberly: I can do it using the pattern blocks.

Instructor: Okay. Great.

Kimberly: So what I was looking at is that the whole are three of these (sharing her screen as Figure 3), that [the hexagon shape] would be a whole.

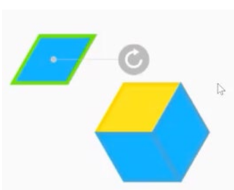

Figure 3. Kimberly's screen sharing of a hexagon compared of parallelograms

Instructor: Problem two or one?

Kimberly: For problem two [$1 \div \frac{2}{3} = ?$]. So the one [hexagon] would be a whole and the 2/3 are these two (pointing out two blue parallelograms inside of the hexagon), because each of these (pointing out one blue parallelogram above) is 1/3, so two of them would equal this much (pointing out the two blue parallelograms). So what it asked is to…I guess if you were doing it like the repeated subtraction then you would take…so this a whole, and 2/3 you would subtract 2/3. So that's one subtraction of 2/3 (drawing red marks around the two parallelogram and writing down 1, as shown in the left side of Figure 4). Then if you were to subtract another 2/3, it would be this one plus one more (drawing additional red marks as shown in the right side of Figure 4).

Figure 4. Subtracting one 2/3 from 3/3 (on the left) and another 2/3 from the remaining shapes (on the right)

Kimberly: But since there isn't physically another whole, then you only have one [parallelogram], because our new whole…but since we only have one of them, it's technically only half, so we only get the $1\frac{1}{2}$.

The instructor showed respect for Rylie's idea and invited other teacher-learners to conceptualize the idea. Kimberly volunteered to share her thinking by using a free online tool (https://apps.mathlearningcenter.org/pattern-shapes/) introduced by the instructor prior to this session. In in-person sessions, the instructor introduced physical pattern blocks for similar purposes, but because students did not have access to the manipulatives, she found a free app that allowed the manipulation of pattern blocks on screen.

Kimberly showed her step-by-step process to solve the problem using the free app and screen sharing. And as the discussion unfolded, it featured increased student-to-student interaction. For example, another teacher-learner asked a presenter, "Can you explain again how you got…I understand the first part of your drawing, but I don't understand how you're multiplying it three times with your drawing." The instructor *stepped back* from the conversation, affording other students the opportunity to understand presenters' work for themselves. In these examples, the instructor's *focusing* questions served to guide the discussion of the teacher-learners' justifications and maintain attention on the presenters' work and explanations (Wood, 1998). Rather than attempting to *funnel* a student's ideas toward her ways of thinking, the instructor tried to monitor what the other teacher-learners might not understand and ask questions that supported persistent attention to innovative aspects of student-generated solutions.

In their journal reflections, the teacher-learners said that features they liked about the synchronous online sessions were sharing provisional ideas and clarifying their thinking to others during the Zoom sessions. One commented:

> I gain a deeper understanding of content and how to approach it in a variety of ways once I hear from classmates during Zoom sessions. I am also able to "teach" the way that I approached the problem which helps in developing my skills as an educator.

When asked what was different about the classroom community in the Zoom context, one teacher-learner responded instead about continuities: "I still feel very connected to my classmates, as if I can reach out to them with questions. The classroom community may be remote, but I still feel like I am learning alongside everyone else." Another teacher-learner shared a similar view regarding the Zoom context: "I found it helpful in the same way that it was helpful when we shared ideas in class." The synchronous online sessions with technological aids allowed the instructor and other teacher-learners to observe everyone's face and tone, read interactive written work, and participate in the ongoing sense-making process, all of which helped to maintain dialogic discussions, resembling prior in-person sessions.

Opportunities to Interact with Students in Synchronous Small Groups

To address the concerns of the teacher-learners about the lack of opportunities to interact with other students, and to extend the course's small-group interactions into the online format, the instructor incorporated alternative instructional practices. In our instructional design meetings, the second author suggested using Breakout Rooms to support possible trajectories for the students' learning through problem solving. The instructor incorporated this idea to allow teacher-learners to discuss homework problems with their team members. The instructor told students, "We are going to discuss these ideas that you shared [in your homework], and we may revise as we discuss and ask questions to each other about what you have written in the document," supporting them in revising their original ideas during these small-group interactions. In addition, she asked the teacher-learners to discuss the different solution approaches they used to solve the problems or jot down their combined solution as well as the assumptions and choices they made to solve the problem in a shared Google Doc.

Monitoring their progress in the Google Docs, the instructor gauged when to invite the small groups back to the whole-group meeting and initiate discussion: "Start with team one. You can explain step by step…while the other teams are listening to what team one is doing, let's write down questions on the same [Google] form." During the whole-group discussion, the instructor encouraged the teacher-learners to copy and paste their mathematical models into a shared folder so they could compare different ideas. At the end of each team's presentation, the instructor asked questions, including "What are the similarities and differences across the solutions shared?" and "What connections do you see between the solutions?" to help students evaluate the results of diverse approaches and build on one another's solutions to construct powerful collective ideas (Stein et al., 2008). Several teacher-learners discussed what they noticed about the similarities and differences, and connected their methods and solutions.

They also shared positive experiences of discussing their ideas in small groups through the Zoom Breakout Rooms. One said, "I liked the breakout because it's similar to when we talk and turn in the classroom which is nice." Another expressed a related idea:

> I like the breakout meetings because they let you share your idea with a smaller group first that can give you feedback in a low-pressure environment. Then I have the space and time to refine the answer that I will deliver to the larger group so that it makes the most sense to everyone.

Most teacher-learners mentioned that they liked the environment, suggesting it was similar to in-person environments in which they shared their ideas in small teams.

Principles of Instructional Design to Facilitate Dialogic Discussions

As we reflect collectively on this experience, we identify several principles of instructional design and implementation that became salient in this case. The first is the focus on maintaining and continual construction of social norms established in mutual expectations and commitments between instructor and students. The regularities in practices of the classroom community that promoted dialogic discussions were built over the rest of the course between the instructor and the teacher-learners instead of merely set up by the instructor at the beginning. The construction of social norms among the members of a classroom community has been studied in face-to-face classes (e.g., Yackel et al., 1991).

However, research rarely shows how such social norms around classroom discussions can be extended smoothly across in-person and online environments, as in this study.

The second principle is promoting communication patterns that foster dialogic interactions, by encouraging the participants to justify their ideas and make connections to diverse perspectives. In this course, discussions revealed a variety of student-generated methods for solving problems and enabled student-led interactions to become the center of each session. Opportunities for teacher-learners to reflect on their own ideas and to reason about mathematics often occurred in the synchronous settings, where they were encouraged to express provisional ideas and clarify their thinking to others. While the use of these communication patterns has been recommended by research (e.g., Wood, 1998), few studies show the possibility of promoting and continuing such opportunities in online learning that this study offers.

The third principle is the use of technological aids to help students visualize and verbalize the ideas they generate and to monitor their progress, rather than conveying the instructor's knowledge to the students. When the instructor decided to choose and use technological tools, such as Zoom sessions, Google Drive, and virtual manipulatives, the first question she considered was how to introduce these technologies to the teacher-learners so that they could express their ideas through them. With this goal, the instructor spent some time with students to explore each tool, as she acknowledged their efforts and difficulties. The use of tools allowed the teacher-learners to observe others' work on the screen, look at the faces of others, provide in-the-moment description of their created methods, and keep track of their work in the shared screen with the instructor during group discussions, all of which promoted dialogic interaction during the online sessions.

Conclusion

The COVID-19 crisis has put universities and their instructors off balance. We are collectively adjusting to a future in which we must invent ways to honor and sustain the intimate, human character of education in general and of teacher preparation in particular. This Spring has given us a first opportunity to respond to a challenge that will be with us into the foreseeable future. This study explored efforts in one course to make a transition from in-person to online learning that emphasized continuities. It suggested the importance of attending carefully to bridging between the two environments to preserve a culture of dialogic interaction. And it indicated approaches for working explicitly to support a classroom group in making that shift together, as a community of learners.

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